

# Advancing Teacher Education through the Free Senior High School (Free SHS) Policy in Ghana: An Integrated Framework of Learning Theories

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## ABSTRACT

This article develops a framework by examining how the Free Senior High School (Free SHS) Policy can advance mathematics teacher education at the teacher training institutions in Ghana. Combining Social Cognitive Theory, Constructivist Learning Theory, Contextual Interaction Theory, and Education for Sustainable Development, this framework pays special attention to how teacher self-efficacy, pedagogical practices, and the implementation of the Free SHS policy support the policy system in enhancing student teachers' instructional quality and sustainability competencies. This framework provides a conceptual model that connects policy, student teacher preparation, and STEM outcomes, suggesting guidance for research and practices that can strengthen mathematics education at teacher training institutions, thereby contributing to the promotion of Ghana's national sustainable development goal.

**Keywords:** STEM Education, Sustainable Development, Teacher Quality, Free Senior High School Policy (Free SHS)

## INTRODUCTION

Globally, it is widely believed that the main promoter of economic growth, innovation, creativity and sustainable development is Science, Technology, Engineering and Mathematics (STEM) education (Marginson et al., 2013; UNESCO, 2021). Both developed and developing countries that aspire to long-term competitiveness or further development depend to a large extent on highly skilled STEM teachers who can develop students' critical thinking, problem-solving, and sustainability competencies at all levels of education (Bybee, 2013; Kelley & Knowles, 2016).

In Ghana, mathematics is at the core of all learning, especially those related to STEM subjects (Anamuah-Mensah et al., 2008). Despite Ghana placing so much importance on mathematics education as a means of promoting STEM, the country faces the challenges of teacher shortages, limited professional training, and inadequate resources and classroom facilities. The Free Senior High School (Free SHS) policy, which was implemented in 2017, has increased secondary school enrolment drastically –from approximately 813,000 students in the 2017/2018 academic year to over 1.2 million by the 2023/2024 academic year (theghanareport.com, 2025). Although the policy has promoted equity and access, as captured in some of its objectives (Dzordzormenyoh et al., 2026), it also introduces challenges in classroom management, increases teachers' workload, and raises issues of instructional quality (David & Andrews, 2022).

Despite the policy having increased enrolment at the various senior high, technical and vocational schools, performance in mathematics remains very low. For instance, the recent results in the West African Senior School Certificate Examination (WASSCE) indicate that, considering the national pass grade from A1 – C6, the grade range needed to transition to tertiary education, only 48% of students passed in Mathematics, whilst the national assessment shows that approximately 35% of the Free SHS students were proficient in mathematics (ghanaeducation.org, 2025). Given this low performance, it is imperative to recognize a gap between access and

quality, underscoring the urgency of reinforcing quality mathematics teacher preparation across various teacher training institutions.

With the introduction of the Free SHS policy and the subsequent admission of these graduates into tertiary institutions, there has been limited integration of policy impact, teacher self-efficacy, pedagogical practices, and sustainable development outcomes into a cohesive and comprehensive framework (Ntarmah & Yaro, 2025). This article, therefore, addresses this gap by developing a framework that integrates Social Cognitive Theory (SCT), Constructivist Learning Theory (CLT), Contextual Interaction Theory (CIT), and Education for Sustainable Development (ESD) (Al Anqodi & Elgeddawy, 2025), as shown in Figure 1. This framework conceptualizes the deep interplay between policy (Free SHS) context, teacher capacities, pedagogical practices, policy implementation conditions, and sustainability outcomes, presenting a strong model for research and theory development in STEM education (Asante Opoku, 2025; Gamage et al., 2022). Hence, this article presents a comprehensive framework that examines how Ghana's Free SHS policy influences mathematics teacher education within the context of STEM and sustainable development.

### Theoretical Background

The framework integrates four theoretical perspectives: Social Cognitive Theory (SCT), Constructivist Learning Theory (CLT), Contextual Interaction Theory (CIT) and Education for Sustainable Development (ESD) (Al Anqodi & Elgeddawy, 2025; Liu et al., 2020). These theories are discussed below, detailing how they can influence quality mathematics teacher education in relation to the Free SHS policy.

### A Framework Integrating Social Cognitive Theory, Constructivist Learning Theory, Contextual Interaction Theory and Education for Sustainable Development

A Framework Integrating Social Cognitive Theory, Constructivist Learning Theory, Contextual Interaction Theory, and Education for Sustainable Development to Strengthen Teacher Education under Ghana's Free SHS Policy

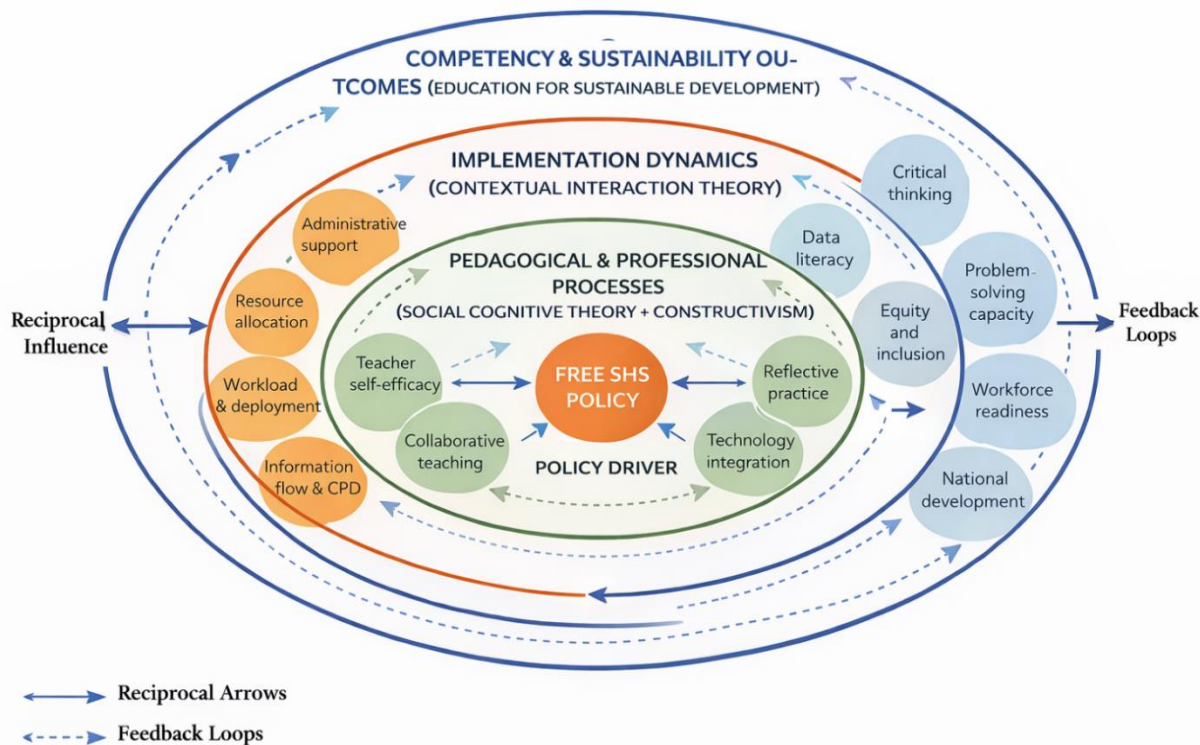


Figure 1: A Framework Integrating Social Cognitive Theory, Constructivist Learning Theory, Contextual Interaction Theory and Education for Sustainable Development (Source: Authors)

This framework positions the Free SHS Policy as the central policy driver that shapes and transforms teacher education through interconnected theoretical and practical processes. At the core, pedagogical and professional

practices are grounded in Social Cognitive Theory and Constructivist Learning Theory, emphasizing teacher self-efficacy, collaborative teaching, reflective practice, and technology integration. Surrounding this layer are the implementation dynamics informed by Contextual Interaction Theory, which highlight how administrative support, resource allocation, workload management, and information flow determine how effectively the policy is enacted within institutions. These interacting processes mutually produce competency and sustainability outcomes aligned with Education for Sustainable Development, including critical thinking, data literacy, equity, workforce readiness, and national development. The reciprocal arrows and feedback loops indicate that outcomes continuously inform policy refinement and institutional reform, making the framework dynamic, adaptive, and responsive to Ghana's evolving educational and developmental needs.

The framework suggests that sustainable educational transformation does not occur automatically from policy declaration alone but emerges through the alignment of institutional capacity, teacher agency, and learner-centred pedagogies. When implementation conditions are supportive, and teachers possess strong professional confidence and adaptive skills, the Free SHS Policy becomes a mechanism for long-term systemic change rather than short-term access expansion. The integration of the four theoretical perspectives, therefore, ensures coherence between policy intent, classroom practice, and national development objectives, reinforcing the idea that effective teacher education is the bridge between educational reform and sustainable socio-economic progress.

### **Social Cognitive Theory And Mathematics Teacher Education**

The Social Cognitive Theory (SCT), developed by Albert Bandura, presents a strong theoretical framework for understanding teacher training and pedagogical practices by emphasizing the principle of Triadic Reciprocal Determinism (TRD) (Bandura, 1986, 1997).

### **Triadic Reciprocal Determinism and Teacher Self-Efficacy**

The TRD indicates how personal, behavioural and environmental factors interact to influence the training experts in professional fields (Liu et al., 2020). At the colleges of education in Ghana, the SCT explains how teachers' beliefs about their self-capabilities, which are viewed as teacher self-efficacy, mediate pedagogical decisions, persistence and adaptability in challenging classroom contexts. Teacher self-efficacy is useful for training mathematics teachers in pedagogical practices, classroom management, and the need to employ learner-centred instructional practices (Mapulanga et al., 2025). Teachers who possess strong self-efficacy beliefs are more likely to plan more cognitively demanding mathematics tasks, be more involved in facilitating problem-solving and inquiry-based learning and support learners who experience challenges in the learning process (Tschannen-Moran & Hoy, 2001; Zee & Koomen, 2016). In mathematics classrooms where instruction is STEM-focused, high self-efficacy has been linked to innovative approaches, including mathematical modelling, collaborative learning, and technology-induced instruction (Akosah et al., 2024; Dadzie et al., 2025).

### **Developing and Sustaining Mathematics Teachers' Self-Efficacy: Providing Professional Support Mechanisms amid Environmental Constraints**

The self-efficacy beliefs are constructed through four basic means: mastery experiences, vicarious experiences, social persuasion, and physiological or affective states (Bandura, 1997). In training teachers, these sources of self-efficacy beliefs are developed through initial teacher education, mentoring by experts in the profession through learning communities (as in the case of a community of practice), and attending regular ongoing professional in-service training. Naturally, when mathematics teachers successfully implement quality teaching strategies, they expect to receive positive feedback and motivation from their colleagues and the school authority. This constructive feedback strengthens their self-efficacy and further promotes their instructional strategies, which can lead to students' learning outcomes (Lumpe et al., 2012; Usher & Pajares, 2008).

However, McMinn et al (2021) posit that external factors, such as the environment, can negatively limit the self-efficacy beliefs of mathematics teachers. The implementation of the Free SHS policy in Ghana has resulted in an increase in enrolment at senior high schools and also the colleges of education (Nyadzi et al., 2024). The large class sizes amid limited teaching and learning materials, coupled with high workload for mathematics teachers,

can potentially affect their self-efficacy (David & Andrews, 2022). These environmental factors can affect teachers' personal philosophy and teaching behaviour, thereby reducing their interest in making their instruction learner-centred. As a result, instruction rich in STEM practices, such as inquiry, project-based learning and problem-based learning, that can boost creative thinking capacities will be discouraged. Also, in overcrowded classrooms, teachers who are pedagogically inclined to a learner-centred approach may resort to teacher-centredness as a result of this environmental constraint, thereby negatively influencing their efficacy judgments and behavioural choices (Takyi et al. 2025). Hence, when the self-efficacy of mathematics teachers is deliberately empowered through planned professional and systematic support, it will contribute significantly by boosting STEM outcomes (Dadzie et al., 2025; David & Andrews, 2022)

### **Constructivist Learning Theory (CLT) And Mathematics Teacher Education**

Constructivist Learning Theory (CLT) holds that learners are active individuals capable of creating knowledge for themselves when supported with the necessary resources (Oppong-Gyebi et al., 2023). This makes learning an active, meaning-making process in which learners construct knowledge through the exchange of ideas, processes, and experiences in a more socially relaxed yet resource-rich environment (Fosnot, 2005; Piaget, 1972).

### **Active Knowledge Construction in Mathematics Education**

In the active knowledge construction classroom, the teacher acts as a facilitator, guiding learners to make meaning of their learning process, rather than remaining inactive, while the teacher is seen as *the sage on the stage, imparting knowledge* (Tang, 2025). In this classroom, learners gain understanding through reflection, dialogue, and problem-solving activities in which they are actively engaged. Tang posited that these processes lead to the construction of new knowledge and often challenge existing ideas, thereby refining learners' thinking. In the context of teacher training, active knowledge construction is emphasized by training teachers to create an enabling learning environment that helps learners explore, reason, and share in the process of knowledge generation (Dadzie et al., 2025).

Mathematics teachers trained in the active knowledge construction classroom mostly employ principles that support inquiry-based learning, critical thinking, problem-solving, and conceptual understanding (Chairwut et al., 2025). Research indicates that in an active knowledge construction mathematics classroom, teachers employ pedagogical approaches rich in activities and meaningful mathematical tasks, encouraging learners to develop multiple solution strategies and promoting mathematical discourse among them. These activities promote deeper understanding and transferable skills and knowledge among learners, as they are often exposed to cognitively demanding tasks (Hiebert, 2007; Stein et al., 2008). There is collaborative learning in this sort of mathematics classroom, ensuring effective learning and teacher development. Directly linked with this is the social constructivist mathematics classroom, where knowledge construction is concerned with interaction with others; hence, collaboration and communication are very important in this learning process (Vygotsky, 1978).

### **Professional Learning Communities: Advancing Constructivist Mathematics and STEM Reform**

The mathematics teacher education program must encourage the setting up of professional learning communities (PLCs), preparation of learner-centred lesson plans, peer collaboration when preparing lessons, reflection on practices and co-construction of pedagogical knowledge (Jaworski, 2006; Stoll et al., 2006). These collaborative approaches support teachers' ability to plan and implement lessons that encourage personal construction of knowledge, such as inquiry-based and problem-solving, and these pedagogical approaches can be sustained over time. These constructivist approaches to learning encourage the integration of real-world problems and promote interdisciplinary STEM applications in the teaching and learning process of mathematics. Situating concepts in mathematics within authentic contexts such as environmental sustainability, technological innovation and societal problem-solving, teachers are helping learners see mathematics as relevant (Boaler, 2015; English, 2017; Latterell & Wilson, 2024). The application of real-world problems in mathematics instruction is promoted when it is situated in a context that links learners' new knowledge to their existing experiences. In the Ghanaian education system, the active knowledge construction pedagogy relates closely to the objectives of the National Council for Curriculum and Assessment (NaCCA) reforms, which emphasize competency-based and learner-

centred instruction (NaCCA, 2019; English & Kirshner, 2016; UNESCO, 2017). If teacher educators align active knowledge construction practices with curriculum reforms and sustainability goals, mathematics teachers will be better positioned to support meaningful learning and prepare learners to apply mathematical knowledge acquired in complex, real-world STEM contexts.

### **Contextual Interaction Theory (CIt) And Policy Implementation In Mathematics Education**

Contextual Interaction Theory (CIT) offers conceptual structures necessary for understanding policy implementation, thereby illuminating the relationships among key actor characteristics, such as motivation, information, and resources, within a specific institutional and socio-political context (Bressers, 2009; Putri et al., 2025). In the CIT, the success of educational policies is not determined by the policy design alone, but rather how stakeholders interpret, negotiate and respond to policy demands in their local context. This view is mostly important for analysing a large-scale educational policy reform, such as Ghana's Free SHS Policy and its effects on mathematics education and STEM teaching (Asante Opoku, 2025).

### **Teacher Motivation, Information, and Resources in STEM Policy**

Teacher motivation remains a critical determinant of effective policy implementation. Extrinsic motivation is influenced by factors such as teachers' workload, class size, professional recognition and perception of institutional support (David & Andrews, 2022; Ryan & Deci, 2020). The astronomical increase in student admissions at the College of Education in Ghana, in recent years, as a result of the Free SHS policy, has put more pressure on the mathematics and other STEM teachers without a corresponding increase in human and teaching and learning resources. Hence, there is more work for the few teachers to do (Nyadzi et al., 2024). These factors can reduce both extrinsic and intrinsic motivation of teachers, thereby affecting their interest, ability and willingness to implement STEM-related teaching and learning approaches such as inquiry-based and learner-centred in the classroom (Spillane, 2021).

The quality flow of information represents the second pillar of the CIT in the implementation of curriculum reforms. For the implementation of the policy to be effective, the flow of information to teachers must be timely, clear, and action-oriented, communicating clearly regarding the expectations, assessment standards, and pedagogical innovations of the curriculum (Bressers & de Boer, 2013). From the perspective of mathematics education, this should include ongoing information about curriculum updates, teaching in alignment with NaCCA standards, supplying instructional materials to schools and the opportunity for targeted professional development for mathematics teachers. Studies suggest that when information flow is fragmented or incoherently communicated, teachers are likely to rely on their previous practices that will be in variance with the reform intentions and therefore dilute the impact of the STEM-related curriculum orientation (Coburn et al., 2016; Takyi et al., 2025)

Resources, both material and non-material, is another major factor hindering the success of the policy. The same disparities that existed and still exist in the implementation of the Free SHS (Nyadzi et al., 2024), such as access to textbooks, laboratory equipment, digital technologies and adequate infrastructure, which significantly affect the capacities of teachers to deliver quality mathematics and STEM-related lessons, also exist in the teacher training institutions (Kofinti, 2025). Non-availability of resources is tied to power relationships between actors, from the national to the school level. This power play influences resource allocations, hence favouring some regions and schools over others. These unfair practices create imbalances in resource allocation, influencing what is feasible in the classroom and how teachers perceive the legitimacy and practicality of policy mandates (Bressers & de Boer, 2013).

Integrating motivation, timely information flow and resources, the gap between policy-makers and teachers will be bridged, enabling the nation to achieve its objective to a very large extent (Chand, 2024). When teachers are well motivated, well-informed and well-resourced, policy implementation is more likely to translate into improved instruction. On the other hand, when these factors are inadequate or misplaced, even a well-planned reform may result in limited impact in the classroom (Nyadzi et al., 2024). The relationship between motivation, information, and resources provides a strong basis for analyzing how implementing a large-scale educational reform can promote the quality of mathematics and effective STEM education in Ghana.

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## Education For Sustainable Development (Esd) And Mathematics Teacher Education

Education for sustainable development (ESD) is the latest transformative educational approach that is aimed at equipping learners with 21st-century skills, knowledge, values and dispositions that support the solution process to complex sustainability problems at the local and national levels (Gamage et al., 2022; UNESCO, 2017; United Nations, 2015). The 21st-century skills emphasize the development of competencies that learners will apply in solving their daily real-life problems, such as collaboration and communication, critical thinking, problem-solving, digital literacy, informed decision-making and love of a nation (NaCCA, 2019). These competencies enable learners to engage meaningfully because they are related to the environment (Rieckmann, 2018).

### Sustainable Development and STEM-Integrated Mathematics Education

The 21st-century competencies are well linked with the objectives of mathematics education, promoting analytical thinking, logical reasoning, and evidence-based argumentation (Cajandig & Ledesma, 2025; NaCCA, 2019). Mathematics education, based on sustainable development, pays more attention to solving real-world problems and ensures that learners develop competencies in data literacy, modelling and interpretation of real-world phenomena. They go beyond abstract mathematics and engage more with practical mathematics (Abanyam et al., 2025). By analyzing real datasets, modelling the mathematics of the environmental systems and quantitatively evaluating technological and economic solutions, learners are developing the ability to apply mathematical reasoning to solving sustainability-related problems (Brown et al., 2024; English, 2023). This method of education strategically places mathematics as a very important subject that will enhance learners' understanding of national issues in areas such as energy production, climate change, environmental management, and technological innovation and therefore devise means of solving them.

Integrating STEM practices with sustainability-focused mathematics education is very important, as it plays a major role in preparing learners for future careers that can promote the sustainable national development agenda (Abanyam et al., 2025). Incorporating a sustainability context in mathematics instruction enables learners to appreciate the importance of mathematical concepts in developing fields such as renewable energy, data science, engineering, and environmental technology (Bybee, 2018; OECD, 2019). The importance of integrating sustainability with STEM practices in mathematics education is very relevant, as it motivates learners to engage in and develop workforce capacities that will be innovative and support environmentally responsible economic growth, such as galamsey – illegal small-scale mining

### Sustainability-Focused Mathematics Teacher Education for SDG-Aligned Learning

For sustainability to be effective in mathematics classrooms, mathematics teacher educators must make conscious efforts in training teachers who will intentionally prepare to integrate sustainability principles in their pedagogical approaches (Olawale et al., 2025). Teacher education in this way must emphasize interdisciplinary thinking, reflective practices, and curriculum designs that link mathematical content to societal and environmental problems (Wals, 2017; Evans, 2019). This kind of education prepares teachers to plan learning experiences that promote the development of sustainability competencies whilst maintaining mathematical rigour.

Connecting mathematics teacher education with the United Nations Sustainable Development Goals (SDGs) further cements the role of sustainability in national education systems. Especially, SDG4 (Quality Education), which encourages inclusive, equitable and relevant learning experiences; SDG9 (Industry, Innovation, and Infrastructure) promote the importance of STEM practices for technological advancement, and SDG13 (Climate Action) propose education system that builds learners' capacity to respond to climate-related issues (Olawale et al., 2025; United Nations, 2015). Mathematics teachers who are well-trained and equipped with sustainability practices are better informed and better positioned to support their learners with these goals by developing quantitative skills and sustainability-oriented ideas that are important for informed citizenship and innovation. Sustainability-focused mathematics education will promote the training of teachers who can prepare learners to apply mathematical knowledge responsibly and effectively to solve challenging daily societal problems (Olawale et al., 2025).

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## Mathematics Teacher Education in Ghana and Its Associated Challenges

In the Ghanaian education system, the training of teachers for the various levels of pre-tertiary education involves both pre-service and in-service training (NaCCA, 2019). The training of competent mathematics teachers for effective lesson delivery follows the same protocol. At the preservice level, teacher training institutions, such as the colleges of education and the universities, inculcate in these prospective teachers a strong foundation in mathematical content knowledge, theories and pedagogical content knowledge necessary to become competent mathematics teachers. These teachers are expected to use their STEM-related skills in mathematics education to solve sustainability challenges.

### Existing challenges of teacher education in Ghana before the Free SHS Policy

There are several challenges in the preservice training phase (Cevikbas et al., 2025). These challenges include inadequate or, in some cases, a lack of laboratory facilities that will support practical lessons for these prospective teachers, teacher educators overly relying on the traditional lecture approach to teaching, limited integration of technology into mathematics instruction, which invariably restricts the opportunities of these preservice teachers to design their lessons to be innovative driven and learner centred (Owusu-Cole, 2023).

For in-service teachers, training is often focused on enhancing their professional standing in the field and keeping them updated on current pedagogical approaches to teaching mathematics content (NaCCA, 2019). In Ghana, the Continuous Professional Development (CPD) sessions organized by the National Teaching Council (NTC) to enrich the pedagogical content knowledge of all teachers at the pre-tertiary level of education in the country is a good example of in-service training for teachers (Salifu et al., 2025). Although the CPD is a national programme designed to enhance teachers' pedagogical skills in the classroom, there are many other helpful opportunities of this kind, mostly online, that professional teachers can access. Although the CPD is a good initiative that contributes positively to the professional growth of teachers, it does not often promote the integration of STEM practices and interdisciplinary skills (Akosah et al., 2024; Darling-Hammond, 2023). In addition to this problem in relation to the CPD, there is also limited exposure to sustainability-oriented mathematics teaching and insufficient training on the use of technology in teaching mathematics, as indicated by many teachers. These limitations affect the adaptability of teachers' orientation to current educational trends (Dadzie et al., 2025).

### Impact Of Free SHS On Mathematics Teacher Education In Ghana

The introduction of the Free SHS policy has increased enrolment significantly at the secondary school level. Nonetheless, this enrolment cascaded to the various tertiary institutions, including colleges of education (Nyadzi et al., 2024). Quite recently, this surge in enrolment has been attributed to Free SHS graduates who sought admission to tertiary institutions (Nyadzi et al.).

### Enrolment surge and declining mathematics pedagogy quality

The challenges faced at the senior high school due to the Free SHS policy are basically the same at the tertiary level. The large number of students admitted since Free SHS puts undue pressure on the existing facilities at the colleges of education (Kofinti, 2025). As a consequence, there is a need to increase the teaching staff to match the new numbers. However, the increase in student population does not correspond with the number of mathematics teachers, affecting the pedagogical practices that ought to be employed in training prospective mathematics teachers (Nyadzi et al., 2024). The provision of individualized attention, effective monitoring of student teachers' progress, and the use of interactive teaching strategies that typically provide deep learning support for these prospective teachers are significantly impacted due to the increased enrolment.

An overcrowded classroom, coupled with inadequate teaching and learning materials, further exacerbates the challenge of implementing effective pedagogy in mathematics teaching (Bano et al., 2025). When the enrolment in the class is large, it affects the teacher's effective use of learner-centred methods that will promote STEM-related pedagogies, such as group work, where students are supposed to think critically, reflect, communicate and solve problems, engage in full-class discussion after their respective group works and other forms of

formative assessment are negatively affected. Because the prospective mathematics students may not have experienced this kind of pedagogical training, they are most likely to develop a taste for and will be more inclined towards the traditional lecture method of teaching and sustainability problems will continue (Jones et al., 2025). Inadequate classroom facilities, inadequate teaching and learning resources, and inadequate technological facilities also hinder opportunities of prospective mathematics teachers to engage in inclusive mathematical instruction (Nyadzi et al., 2024). These challenges often compromise the quality of inclusive mathematics instruction, especially in the under-resourced colleges of education.

To ensure quality instructional approaches under these conditions, teacher training programmes and Continuous Professional Development (CPD) sessions must be used to address these issues strategically. Both pre-service and in-service training must be used to develop strategies for teaching large classes, using differentiated approaches and making maximum use of limited available resources to make a significant impact on the lives of students. The CPD sessions must also be used to emphasize the use of innovation, classroom management practices for large classes and the use of technologically appropriate materials to support teaching in overcrowded classrooms. If mathematics teachers can adapt to this kind of strategic education, the quality of mathematics will improve, though the class size may remain large (David & Andrews, 2022; MoE, 2018).

## DISCUSSION

This paper developed a framework by integrating four theoretical perspectives: Social Cognitive Theory, Constructivist Learning Theory, Contextual Interaction Theory, and Education for Sustainable Development. Each theory provides distinctive yet interconnected components that guide how teachers design, implement, evaluate and refine teaching strategies to align with 21st-century skills in resource-constrained and overcrowded classrooms. The application of the integrated theoretical perspective can enhance learners' active engagement and promote the development of problem-solving and creativity, which are crucial for sustainable development.

Building teacher capacity, which is based on self-efficacy beliefs, professional identity and their behavioural intentions towards inquiry-based teaching are observed as crucial enablers ensuring that teachers are well prepared to train pre-service mathematics teachers to become learner-centred pedagogists. However, the surge in student enrolment at the senior high school, which clearly affected the colleges of education, has significantly influenced the quality of teaching and learning mathematics. It is therefore important for teacher educators to evaluate their teaching competence, assess their professional disposition and negotiate their everyday classroom practices and be able to explain the changes in their instructional quality as this directly affects students' learning outcomes.

Also, the proposed framework emphasizes self-efficacy as the critical channel through which a large-scale reform, such as the Free SHS, can be meaningfully translated into classroom practice, promoting the idea of a community of practice (Jones et al., 2025). Teachers with stronger self-efficacy beliefs are more likely to adopt adaptive pedagogical strategies, maintain instructional effectiveness and address students' diverse learning needs appropriately, even with limited resources. On the other hand, policy implementation environments constrained by overcrowded classrooms, inadequate teaching and learning resources, and insufficient professional development are likely to demotivate teachers, reduce their confidence and hinder their pedagogical innovativeness (Nyadzi et al., 2024).

Mathematics teachers' professional learning and pedagogical practices should be rooted in inquiry-based teaching and collaborative Professional Learning Communities. Teachers' professional dispositions are shaped by the integration of technology (STEM tools) and real-world, problem-based learning. Using STEM skills in teaching through inquiry-based, project-based or problem-solving pedagogies allows learners to perceive learning as dynamic and contextually relevant. However, the application of these 21st-century skills in teaching mathematics is directly linked to teachers' self-efficacy, which affects how teachers manage the challenges they face in their teaching methods, sustain new practices, and cater to the learning needs of individual students.

Ongoing professional development also supports this framework by enabling teachers to be creative, explore alternative approaches to teaching concepts, refine their thinking, and adapt to changing environmental needs by utilising a scientific paradigm and available technological tools. This serves as an important reminder for

mathematics teacher educators and professional development organizers to align their training with the demands and realities of the policy-driven expansion of the system (NaCCA, 2019). Theoretical mathematics is not delivering the results Ghana requires, and the introduction of the Free SHS policy has yet to produce the desired outcomes.

Available evidence indicates that although access to secondary school education has increased, there has not been a corresponding rise in mathematics achievement. This highlights a persistent educational tension between the quantity and quality of education (WAEC, 2025). The framework, therefore, provides a useful model for analyzing this tension by promoting the dynamic interaction among the Free SHS policy, teacher capacity development, instructional practices, and STEM practices, which can support sustainability (Olawale et al., 2025). Another important suggestion from the framework is that the success of the Free SHS policy should be measured not only by enrolment figures but also by the effective provision of quality teachers and other factors that support high-quality mathematics instruction.

If policy implementers pay closer attention to this mediating relationship among the variables in the framework, it will strengthen teacher education by demonstrating how these systemic reforms influence decision-making in teacher training institutions regarding pedagogical strategies. The framework encourages teacher education programmes to incorporate self-efficacy development, context-responsive pedagogy, and continuous professional development as essential components of their teaching strategies when addressing Free SHS graduates. When this is followed, the framework could support the broader effort to ensure STEM competencies at teacher training institutions, as it will improve instructional quality and thereby contribute meaningfully to Ghana's long-term sustainability goals.

## CONCLUSION

While STEM education is pivotal to achieving Ghana's broader sustainable development agenda, quality mathematics teacher education is at the centre of promoting STEM education. Although Ghana's Free SHS, implemented in 2017, increased secondary school enrolment, it has, at the same time, introduced more complex challenges than expected. Low instructional quality, teacher preparedness, inadequate teaching and learning resources and low students' learning outcomes have been identified as major challenges affecting the success of the policy. Assessing the impact of the policy means moving beyond enrolment statistics and focusing more on teacher preparedness at the colleges of education. This also calls for organizing directed in-service STEM training for mathematics teachers, supporting them with appropriate teaching and learning materials and providing them with a supportive classroom environment that will enhance the conduct of effective mathematics lessons in a rapidly changing classroom.

As a way of promoting quality mathematics instruction at the secondary school and at teacher training institutions, this article integrated Social Cognitive Theory (SCT), Constructivist Learning Theory (CLT), Contextual Interaction Theory (CIT), and Education for Sustainable Development (ESD), to develop a framework that clearly influence the processes through which education policy can promote the capacities of teachers, improve teachers' pedagogical practices and promote STEM-induced sustainability outcomes. Hence, the framework supports teachers' self-efficacy, professional learning and classroom environment, which are critical mediating factors to the success of effective policy implementation.

As a way of supporting teacher education, the framework serves as a theoretical lens for analysing the relationship between teacher education, in-service training programs and the realities of policy implementation in Ghana. The policy also provides a background for future empirical studies that will be useful in fine-tuning teacher education, promoting professional development initiatives and guiding future policy decisions that aim at promoting quality education and not just access. In the long run, to ensure that the Free SHS policy produces meaningful results in mathematics teacher education and STEM capacity, which will translate into sustainable development, there must be sustained investment in teacher education. This investment will empower teachers, who are major agents in the achievement of educational reforms and national development.

## AI use

Grammarly (version 14.1262.0) was used to assist in grammar, spelling and clarity during the production of this manuscript. It was exclusively used for language refinement. No content was generated or substantively altered using AI. The authors accept the full responsibility for the paper as published.

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