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Research Article

Teaching Method as a Critical Issue in Science Education in Ghana

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Abstract: Science education has received a lot of attention around the world. Given this, several works of literature have been produced to address the issue from various perspectives. Regardless of the investigator's background, there are some universal challenges that science educators are currently facing. This paper identified and highlighted teaching methods as a prevailing crucial problem in science education in Ghana, emphasizing its enormity and long-term consequences. Furthermore, the article proposes a model that can help to address the situation. The study suggests that learner-centered teaching approaches are the best pedagogy for stimulating learners' interests and understanding in science education. The study did reveal the enormity of how science in the nation's education is not seeing the light of day, as well as how science is not becoming more influential in attaining national development goals. The theories adopted for this research are social constructivism and constructive controversy as they see learning as exchanges and interrogation between learners and learners, and teachers and learners. The study again made recommendations of models for implementation to help rebrand the teaching of science education in Ghana.

***Keywords*:** authentic learning, learner-centered, teaching pedagogy, rote learning

1. Introduction

National reports in developed countries such as the United Kingdom (Hoyle, 2016), and the United States (National Research Council, 2012) among others highlight current challenges in science education (Alberts, 2013). There is evidence in all of these reports that science education faces challenges ranging from the need for more high-level scientists, technicians, and engineers (Kaptan & Timurlenk, 2012) to the inappropriate methods often used in teaching (McFarlane, 2013). The latter is a significant challenge because it has long been ascertained that science has indeed been taught and comprehended as nothing more than a single methodological field of study. Since the teacher-centered strategies for science teaching became increasingly debunked and downplayed, it was identified that this method of teaching relied solely on objectivity and empiricism with no reference to subjectivity and creativity among students (Hodson, 2011).

As a direct consequence, science education has now become teacher-centered instead of student-centered. Barrett

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(2008) proposed a formidable solution by asserting that hands-on methods of science education should be regarded as not disruptive. Improving learners' conceptual development is one of the main challenges of science education. This includes helping students to correct previous incorrect notions and/or directing new notions toward professional ones (Osborne et al., 2016). This can be achieved by initially identifying the types of concepts students already have and examining whether they are linked to scientific theories, and if not, which part(s) affect them to change from what others usually understand (National Research Council, 2012). Science education should focus not only on the content of scientific knowledge, but also on how scientific knowledge is created, the role and limits of science, and how scientists work. This provides the basis and key to developing scientific literacy, promoting scientific prosperity, and advancing social progress. To contribute to this discourse, the study examines methodological issues as a teacher factor in science education, emphasizing their enormity and long-term consequences, and recommends a model to address the situation in the Ghanaian context.

There are currently critical issues in science education all over the world, prompting many researchers to contribute to this discourse. These issues are divided into five categories: teacher factors, student factors, curriculum factors, school factors, societal factors, and national/policy factors (Adu-Gyamfi, 2014; Parker et al., 2018; Quansah et al., 2019). According to Parker et al. (2018), one of the main contributors to such challenges in Ghana is teachers' inadequate subject knowledge background which affects how the teacher develops pedagogical content knowledge, in addition to self-confidence and attitudes while instructing topics on Integrated Science. Parker et al. (2018) went on to argue that workshops for teachers to help them handle the course effectively would be appropriate, but they did not mention how this would affect the method used by teachers to handle science courses. According to Boakye and Ampiah (2017), Newly Qualified Science Teachers (NQTs) are confronted with numerous challenges. The most significant ones were (a) inadequate teaching and learning resources, (b) time management, (c) inadequate content knowledge, (d) students' difficulties in comprehending the lessons taught, (e) indiscipline among students, (f) lack of students' interest in a science course, and (g) inability of the science teachers to complete integrated science syllabus. All NQTs were affected by inadequate teaching and learning resources and inadequate content knowledge. Based on the study, participants used methods such as (a) improvisation, (b) adjusting the methods used in teaching and (c) discussion with parents to address the identified issues. According to the recommendations above, talking with parents cannot help to address challenges in science teaching because many parents have little or no knowledge of science. Again, according to Boakye and Ampiah's (2017) study, participants agree that modifying their teaching can help to solve some of the challenges, but they did not provide any effective strategies to help achieve this recommendation. The current study proposed a robust method for addressing methodological challenges that teachers face when teaching science.

Adu-Gyamfi (2014) studied integrated science teachers in Ghana and identified many broad and specific challenges. Among the difficult challenges were the curriculum's dense content, insufficient teaching and learning science materials, and lack of science laboratories. The above challenges were identified to influence teachers' selection of appropriate teaching methods, students' performance and interest in science and students' participation in science lessons. Quansah et al. (2019) identified similar challenges and proposed that Integrated Science teachers should be trained to improve instructional materials by using readily available materials in the environment to teach the course. It is important to recognize that using improvised materials to teach effectively can address methodological issues. Similarly, while the researchers hypothesized that students needed to improve their comprehension of the English language, they did not consider how relevant the local language could be used to encourage students' participation in science lessons.

Based on the few studies delved into, there is evidence that Science as a subject should be taught with practical and suitable instructional resources. However, educators in developing countries have limited access to resources to teach the course to assist students in better understanding the concepts to facilitate their interests. The studies have further revealed that using appropriate teaching and learning method is a challenge to science education in Ghana. The application of appropriate teaching and learning materials with the right methodology can assist learners to understand most of the science concepts that will be taught.

The enormity of methodological flaws in teaching science is affecting students understanding to stimulate their interest in learning the subject. This is because many of the teachers handling the course specialise in science and not science teaching (Omosewo, 2009). In instances where teachers study science education, they are not taking through proper methods of teaching that can assist a smooth transition of concepts from the teacher to the learner. As a result, these teachers lacked effective instructional strategies and relied heavily on the lecture method. It is worth noting that

one of the major challenges associated with the use of ineffective teaching methods in science education is teaching out of the area specialised by the teacher. Appointing teachers to teach subjects they lack appropriate training and qualifications results in this challenge (Ingersoll, 2002). Because the majority of these teachers use lecture-based instruction, they require adjustments in the methods used to teach. The lecture method is chastised because it lacks a collaborating approach, which has resulted in poor academic performance in science education. A typical example in the Ghanaian context is assigning physical education teachers to teach Biology or Integrated Science because of the perceived science background in these areas.

The performance of students in the sciences of late has not been encouraging (Abreh et al., 2018) despite the government recognising how science, math, and technology are relevant in assisting the nation to achieve developmental goals. One of the underlying factors for this poor performance is the teaching methods used by teachers (Abreh et al., 2018; Adu-Gyamfi, 2014; Boakye & Ampiah, 2017). However, these studies did not review some of the teaching methods in science education to determine their effectiveness in facilitating the teaching and learning of the course. Therefore, it is significant to examine some of the methods used to teach science and proposed why there should be a paradigm shift.

2. Methods of teaching in science education

Science is taught in Ghanaian schools using a variety of methods. A teacher is required to employ many teaching methods which can contribute to academic success for science students (Miles, 2015). To produce positive results in this era, a method used must encourage maximum social interaction. Teachers and students must interact socially during learning as this provide the learners with a supportive, open and interactive environment to learn (Nguyen et al., 2012). During science lessons, lecture and demonstration methods are frequently used.

The lecture method is frequently used when much information is provided to students within a short time (Berry, 2008). The lecture method is employed to provide a large number of learners with new information (Gehlen-Baum & Weinberger, 2014). When dealing with a large group, this method works well. Again, this system is effective when one works with a small class. According to researchers, the majority of tertiary institutions and adult learners use this method (Deslauriers et al., 2011). However, in several instances, it has been used inappropriately for children in lower grades.

Students have been found to retain little information in lecture-based science courses. Bok (2009) asserted that a normal student conserves just 42% of what was taught immediately after the lecture and 20% a week later. As a result, traditional teaching methods such as lectures do not assist students in acquiring adequate practical information (Bernhard et al., 2007). Berry (2008) believes the lecture method is not effective as an active learning method. According to Fagen (2003), the lecture method encourages students to develop poor reading habits. Franklin et al. (2014) agree that students who are taught with lecture methods in class hardly understand concepts more than those who are taught with activity-based reform approaches. Al-Rawi (2013) opined that a lecture method is usually a single approach, with no discussion, questioning, or immediate practice, making it an ineffective teaching method. The lecture method focuses on giving out information rather than stressing the learners (Al-Rawi, 2013). This method instructs students on what to do rather than encouraging them to discover for themselves (Miles, 2015). It is in this regard that researchers argue that the lecture method is not effective for a subject like science that involves hands-on learning and discovery. However, it is this approach that many science educators are familiar with and employ in teaching every day.

In contrast, the demonstration teaching method is thought to be effective since it advances students' comprehension and retention of information (McKee et al., 2007). The demonstration method is effective in teaching science students how to use tools and conduct laboratory experiments (Al-Rawi, 2013). Nevertheless, the time available to do demonstrations in a classroom situation is very inadequate. As a result, rather than engaging students in hands-on laboratory experiments, a demonstration should be frequently designed to allow learners to make observations (McKee et al., 2007). In this regard, other approaches that can help to address this challenge and provide learners with hands-on experiences are relevant.

3. Theoretical models

This study is underpinned by constructivism and constructive controversy theories (Aina & Langenhoven, 2015). Constructivism theory belongs to a subset of cognitive theories that deal with learning and present propositions about information processing (Agarkar, 2019). Learning, according to constructivism theory, is a dynamic procedure whereby learners acquire new ideas or concepts based on current or already acquired knowledge (Brandon & All, 2010). Constructivism is depicted as a circular pattern in the constructive theory model, with students at the center, making students the focal point of learning. Brooks and Brooks (1999) believed that a teacher should promote critical thinking and investigation in students by asking thoughtful, open-ended questions and encouraging students to ask questions. Considering this it is relevant to adopt teaching methods that place learners in the middle of the teaching and learning process and assist them to interact and build on their existing knowledge.

According to Johnson et al. (2006), constructivism entails planned discourse geared at creative problem-solving. Students must, therefore, be skilled partners who follow cooperative norms and cogent argumentation rules. Students are inspired to come up with solutions and exhibit high-level reasoning skills and retention of newly acquired knowledge. They create novel solutions in a high-quality manner. A constructive controversy exists when one's ideas, conclusions, and opinions are incompatible with another's ideas, conclusions, and opinions, but the two compromises to find a solution to the problem or a situation (Johnson & Johnson, 2003). Constructive controversy is devoid of a debate nor a single approach to an argumentative issue. It encompasses a cooperative learning technique in which people with opposing, incompatible points of view reach an agreement grounded on proof and reasoning (Johnson & Johnson, 2007). To Daniels and Cajander (2010), constructive controversy is grounded on the idea that discussion and controversies can serve as a good basis for trying to comprehend a complicated issue. Students' capacity to think constructively and creatively to solve complex problems will improve. According to Smith (2013), the ultimate goal of constructive controversy theory is when one person's ideas, information, conclusions, theories, or opinions clash with those of others-and the two attempt to reach an agreement.

The reason for choosing these two theories over others is that they are the most relevant to the topic at hand. When implementing an effective method for delivering science lessons, it is important to place the student at the center to promote exchanges between the teacher and the students, as well as among students. Efficient instruction and learning within the classroom cannot take place without social interaction, which is the reason social constructivism is the best choice for this paper (Rosenberg et al., 2006). Constructive controversy theory, on the other hand, is pertinent to this piece because, in science education, no approach leads to the right answer, therefore, students must be able to explain the chosen approach to other learners (Mazur, 1997). When the teacher focused on the student-center approach with learners leading discussions at times, any answer must be reached through a logical argument. It is common in science education to see good-graded students struggling to relate their classroom experience to a real-world problem (Crouch et al., 2007). In teaching science lessons, there is a need to use project-based learning and discovery methods that can result in a conceptual change. These methods place the learner at the centre enabling them to construct knowledge based on daily experiences. Despite these methods, it is significant to let student work in groups to arrive at an answer. The above reasons justify why constructivism and constructive controversy theories relate to the teaching of science education. Authentic learning and learner-centred approaches focused on developing the learner and are often used.

Authentic learning is often focused on real-world, complex problems and their solutions, and it employs role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice (Lombardi, 2007). Students are actively working, participating in discussions, and seeking information as this is essential for authentic learning (Mims, 2003). Authentic learning activities aim to provide a "real-world" experience for learners. Authentic learning should be a study of nature that allows students to gain the knowledge and skills they need to succeed in school (Barron & Darling-Hammond, 2008). Authentic learning helps students to think autonomously in a controlled environment in which the teacher can assist and direct struggling students (Schoffstall & Gaddis, 2007). Learning by doing is an example of authentic learning. In this active learning environment, students are not passive. It is an inquiry-based method of learning. According to research, authentic learning is essential for developing critical thinking skills and scientific content (Apedoe et al., 2006).

A paradigm shift in pedagogy is required to facilitate learning in which classroom theory is applied to real-world issues as this can enhance students' success in science education. It is essential to adopt activity-based classroom practice where learners could be more engaged. Science teachers should incorporate approaches that require a higher

level of student activity (Miles, 2015). For learning purposes, the emphasis should be on research-based instruction with a possible student-to-student interaction.

As a result, this paper emphasises shifting the teacher-centered paradigm to a learner-centered one, participatory teaching method where students are involved in class activities and cooperative learning techniques (Rao & DiCarlo, 2000; Lombardi, 2007). Teaching methods such as learner-centered engage students in the classroom and promote high retention, whereas passive students have low retention. This is because they learned to pass the exam by memorizing. Figure 1 depicts the conceptual framework more clearly.

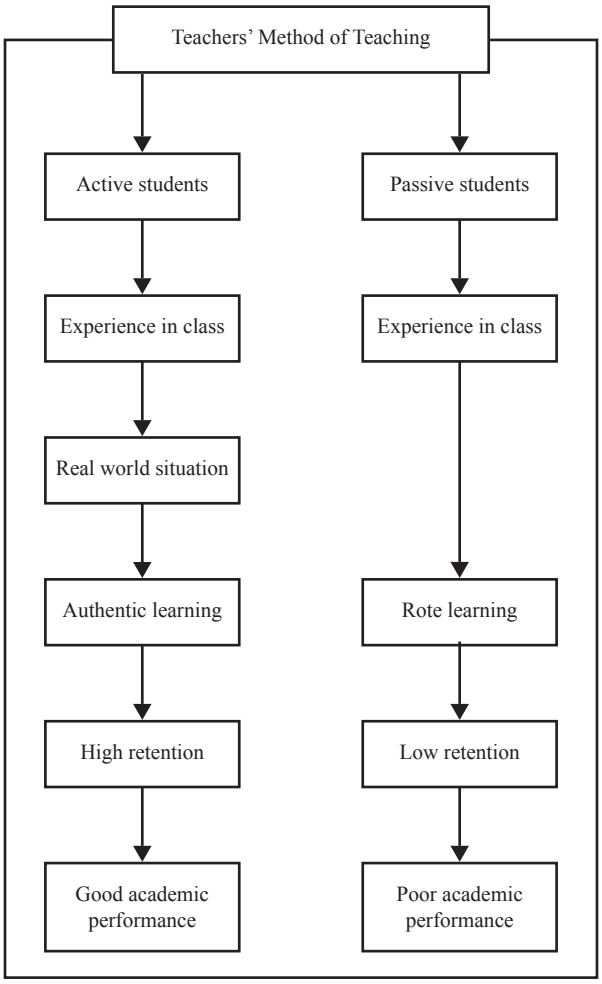

Figure 1. A conceptual framework of authentic learning and learner centered. Adapted from (Aina & Langenhoven, 2015).

Based on the framework, both active and passive students experienced classroom situations. Active class participation allows students to connect their learning experiences to real-life situations. Inactive/passive students, on the other hand, are unable to comprehend concepts and must rely on rote learning. A student's retention rate will be high if he can relate what he has learned to real-life experiences. Regardless, students who memorize information are more likely to have poor retention. High retention leads to good academic performance, whereas low retention frequently leads to poor academic performance. In all of these cases, the teacher's teaching method is relevant and should be learner-centered.

4. Learner-Centered Approach to Teaching (LCT)

The learner-centered approach demanded that the teacher act as a facilitator. Active, cooperative/team-based, inquiry-based, project-based, and problem-based learning are examples of learner-centered approaches (Weimer, 2002). For these approaches to be effective, the teacher must define the course content, design the instruction, create assessments, and assign grades based on the assessment data (Felder & Brent, 2017). The most important aspect of the LCT approach is that learners are no longer passive recipients and repeaters of information. Rather, learners are in charge of their education and can choose how they approach it. In this regard, the teacher does not act as a lone source of knowledge, but rather as a guide whose primary goal is to assist learners in acquiring the necessary knowledge and skills for themselves. Using this method, students become involved in the daily activities of the classroom. Nonetheless, some teachers design their lessons to avoid such approaches. The diagram below will help to clarify this point.

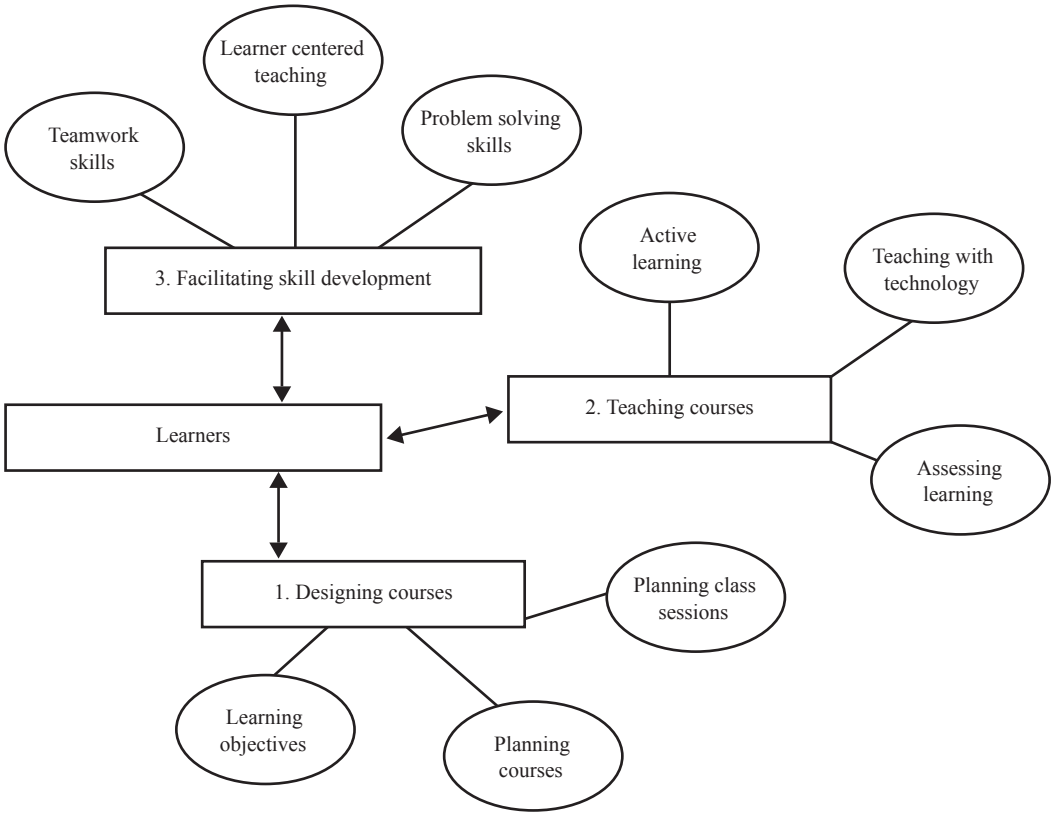

Figure 2. Conceptual Framework of Learner-Centered Teaching. Adapted from Felder & Brent (2017).

Figure 2 illustrates the three broad categories of learner-centered teaching elements. Part 1 describes the means to create effective courses, motivate students to learn what is in them, and get them started on the right foot. Part 2 discusses effective methods of course delivery, testing and grading, as well as active learning, technology-assisted and online instruction. Part 3 delves into strategies for assisting students in developing high-level skills such as analytical problem solving, critical and creative thinking, written and oral communication, self-directed learning, and high-performance teamwork.

In the Ghanaian context, LCT will be more appropriate as it will provide opportunities for the learners to be part of the whole learning process. It can enable them to practice whatever concept the teacher wants to impart. Research suggests that there is a need to move from traditional lecture methods to active learning approaches. Such approaches

focus on the learner through the use of discussion, asking questions during classes and feedback, and interactive technologies that engage learners and facilitate understanding (Yannier et al., 2021). In an attempt to implement and sustain LCTs, Ghana needs more teaching and learning resources that can enable learners to practice all the scientific concepts they will be taught. This will pave the way for the use of hands-on minds on approaches in which teachers conceptualise practical science as a mainly hands-on activity (Ioannidou et al., 2022). Teaching and learning resources such as laboratories with modern equipment should be provided to this effect.

5. Conclusion

The purpose of the study was to identify and highlight teaching methods as a prevailing crucial problem in science education in Ghana, emphasizing its enormity and long-term consequences. The findings showed that the challenges of teaching methods are teachers' inadequate subject knowledge background which affects how the teacher develops pedagogical content knowledge. Again, the curriculum's dense content, insufficient teaching and learning science materials, and lack of science laboratories were other identified challenges. Teaching outside of the area a teacher has specialised which results in the application of ineffective teaching methods was identified as a challenge to science education. This affects the way students comprehend science lessons.

Based on the discussion above, science education teaching can be successfully done if teachers use pedagogies that actively engage students in class. However, the LCT approach to teaching, which includes hands-on activities, project-based learning, and peer-led team learning and is superior to the teacher-centered lecture method, is not being used effectively. Teachers are aware of these approaches; the issue is determining how to use them effectively during lessons. LCT keeps all of the benefits of a teacher-centered approach while applying them in ways that are more in line with how our brains learn. This approach, for example, accepts the teacher as an expert and proposes new effective alternatives to practices that maximize student learning (Doyle, 2012).

It has been established through existing literature that great science education teachers motivate and stimulate their students to go beyond learning barriers to discovering, inventing, and ultimately flourishing in school. Thus, excellent science teachers with deep knowledge of the content and pedagogical skills required to teach these subjects are the most important factor in ensuring excellence in mathematics and science education. To inspire and excite students about science and mathematics, appropriate pedagogical skills must be acquired. Teachers with these skills can help students conduct scientific research, design experiments, and interpret data. According to research, the types of pedagogy that result in excellent science education include collaboration, cooperation, problem-solving, active learning and inquiry-based constructivist methods (Ministry of Education, 2014).

6. Recommendations

Based on the literature reviewed, there is a need for teachers to adopt learner-centered approach. Therefore, it is suggested that all science education teachers in Ghana employ pedagogies that provide opportunities for learners to be actively involved in lessons to facilitate understanding and to make learning more meaningful in real-life situations.

It is necessary to carry out studies in Ghana to determine the effectiveness of using LCT approaches in Science Technology Engineering and Mathematics (STEM) education across various levels in the country. Where teachers are found to lack LCT pedagogical knowledge refresher courses should be organised from time to time to assist in this direction.

Conflict of interest

The authors declare no competing financial interest.

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