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Investigating the Challenges Facing the Teaching and Learning of Science and Technology in Selected Schools in the Ashanti Region of Ghana

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ABSTRACT The heightening public apprehension about instructional deliveries and the learning of science in Ghanaian schools have taken a different dimension as many shareholders keep interrogating the Government's pledge to ensure equity and quality science education for primary schools in the country. The study explored and defined the standing and quality of teaching, learning, and assessment of science and technology while finding the challenges faced by science educators at the JHS level in selected schools in the Ashanti region. The study randomly sampled science teachers' views and students in 27 schools from the 27 districts in the Ashanti Region in Ghana. Fourteen (14) and thirteen (13) schools were sampled from rural and urban areas. It was found that Government inadequately funds most schools. As a result, few qualified science teachers can handle the integrated science topics, among many other setbacks. It was concluded that the lack of infrastructure, TLMs, and other factors make the teaching and learning of science practically impossible. These challenges can be mitigated when specific, well-defined measures such as the provision of required infrastructure, teaching, learning materials (TLMs), and a few more are urgently implemented.

Keywords Science, Technology, Teaching, Learning, Challenges

1. INTRODUCTION

The heightening public apprehension about instructional deliveries and the learning of science in Ghanaian schools have taken a different dimension as many shareholders keep interrogating Government's pledge to ensure equity and quality science education for primary schools in the country (Manuh, Gariba, & Budu, 2007). Literature has shown that more significant numbers of learners appear to study little science at school, even though there is evidence that science is the spine of every developed nation (Fägerlind & Saha, 2016; Leite, 2002; DeBoer, 2019). When carefully explored, one gets to appreciate that countries that have a strong base in science and technology are the ones that develop faster. Examples include Russia, Japan, Brazil, China, India, Malaysia, Indonesia, Dubai, etc. (Ramamurti, 2009). In 2001 at the 12th session of the UN General Assembly meeting, where the focus of discussion was on the contribution of science and technology to the development of countries in the South, leaders in the high-level committee agreed that there was an urgent need to renew and upgrade science education in schools. In that regard, they maintained that particular attention should be given to rehabilitating university laboratories in the least developed countries to inspire and facilitate learning science and technology. This proposal can equally be implemented in the second and first cycles of schools in Ghana to whip up interest in the teaching, learning, and assessment of science and technology. The effective use of modern information and communications technologies (ICT) among these less developed countries was also discussed.

Furthermore, the Assembly adopted the stance of launching effective fellowship programs in universities of the South to help graduates and post-graduates to study science at that level. These interventions were essential to draw attention to the world that science is the tool for the 21st century. In addition to achieving this dream, many nations appreciate the need to include science in their educational system. Science and technology's role in improving people's lives on the continent of Africa cannot

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be overemphasized since the benefits have to be reaped in supreme terms all across the globe. Educationalists in science have questioned the quality of science delivery in the classrooms over the years among parents, stakeholders, and the public alike. According to Adepoju and Fabiyi (2007), Ivowi, Okebukola, Oludotun, and Akpan (1992), and Okebukola (1997), even governments of countries over the years have lamented severally on the quality of science delivery in the classrooms. Their claims have ranged from lack of teaching and learning materials to large class sizes in terms of students to teacher ratio, among others. The teaching of science and technology in Ghanaian schools has been disparaged on the bases of poor performance of candidates in competitive examinations in science relative to their counterparts who had their independence in the same year. This is evident from the statistics of results published by the West Africa Examination Council (WAEC) in the 2017, 2018, 2019, and 2020 academic years in both the BECE and the WASSCE examinations (Nmai, 2020). Today's science is the most potent tool at the disposal of researchers, practitioners of science, teachers, and students to reveal the many mysteries blanketing the universe in which we live (Jensen, 2005). All citizens of a country must study science and technology owing to its impact on society and the socio-economic benefits we derive from it. The case of Ghana requires that science and technology literacy goals be modeled to reflect the targets that Ghana has set for itself within the framework of the new curriculum under the new reforms. It is worth noting that defining and applying education policy is the responsibility of every Government of a country within a general framework laid down by the legislature, which, under the constitution, merely establishes 'general principles applicable to the teaching, learning and assessment system.

Although the teacher is one element in delivering quality education, he or she is nevertheless a crucial factor. Similarly, one can also not afford to underscore the need for good infrastructure stocked with quality teaching and learning materials for use by both teachers and learners (Ellis & Goodyear, 2016). Therefore, it goes without professing that the consequence of a new system at the implementation stage should depend, to a greater extent, on the training of qualified science and technology teachers to help curb the unqualified teachers teaching in the various schools. The players in designing a curriculum must ensure that the needed human resource designated to implement the curriculum in the classrooms are equipped with the 21st-century teaching and learning skills required in the 21st-century classroom for the teaching, learning, and assessment of science and technology in Ghana.

Above all, they must have a strong commitment to teaching so that they might be a source of inspiration to their students and the community at large (Woods, 1993). This can be achieved through the Government's commitment to providing better service conditions for qualified teachers and incentives for teachers posted to rural areas (Bennell, 2004; Darling-Hammond, 2000).

Teacher education plays a crucial role in empowering a group of people to assist the more significant majority of individuals to adapt to the rapidly changing social, economic, and cultural environment to ensure the development of human capital required for the economic and social growth of societies (Reinders & Balcikanli, 2011; Elliott, 2011; Petersen & Treagust, 2014; Ben-Peretz, 2001). It is said that "if teachers acquire the professional competence and attitudes that enable them to effectively perform their multiple tasks in the classroom, in the school and the community, they will become the single most important contributing factor in ensuring quality educational provision" (Dave & Rajput, 1999). A critical aspect of this professional competence is the practicum. It is the heart of teacher education and an inseparable aspect of professional training. The amount of money being sunk into the educational system, especially in training science teachers, must not be allowed to go to waste. Teacher posting from colleges of education has been bedeviled with favoritism instead of being posted to where services are needed.

The underlying principle of teacher education in Ghana has been outlined. It includes training teachers with quality practical knowledge and skills through hands-on training for the preservice teachers and in-service teachers so that they will be capable of delivering in practical terms in the Ghanaian classroom. Others include giving better incentives to teachers who will apply their knowledge and skills to the advantage of learners by creating an accessible, integrated teacher education and training system that provides a structure for continuous professional development throughout their teaching careers (MOE, 2017).

The contextual challenges of the current system cannot be overemphasized. Lack of infrastructure; spacious classrooms, science laboratories, science equipment, and apparatus cannot go without mention. There is a total disconnection between theory as taught in teacher education institutions and practice in the field; that is, the needs of the schools, including their science and technology teachers, are not matched to the curriculum of colleges of education in the country. In short, one can say that teacher education does not seem to influence the 'native theories' of preservice teachers; the native theories they enter colleges of education with remain untouched (Bullough, 1997).

A solid synergetic relationship among the elements, especially between the practical experiences and the theory, is required for quality science and technology teacher education in Ghana.

Currently, all the 48 colleges of education are affiliated with all the public universities in Ghana. As a result,

teachers are being trained in all major public universities, healthy competition to harness better human resources for science teaching. Other problems include the posting of teachers, provision of quality science laboratories stocked with science equipment, and recruitment of qualified laboratory technicians for quality delivery of teaching and learning to the future leaders of Ghana.

Striving to achieve "Education for All" should be meticulously connected to a universal determination to advance literacy levels in science and technology. This invariably suggests a good proficiency in numeracy, a good understanding of science at the basics, and a practical approach to solving everyday problems in the environment through hands-on teaching, learning and assessment, and ICT integration. The above is essential in a global village where economics, politics, ethical and social flags have become indistinguishably connected with the penalties of scientific and technological advancement. For this course to thrive, the teacher in the classroom must come on board with qualities that support the use of scientific knowledge and principles to solve human problems. According to Shulman (1986), quality teachers should own the qualities in Figure 1.

In a related issue on the qualitative nature of teachers, Gess-Newsome (1999) contends that teachers perceived to be quality have content knowledge and attitudes that conform to the teaching profession's standards. He further states that quality teachers have good pedagogical knowledge and skills, information about students' learning behaviors, and sound acquaintance with curriculum issues. The two arguments, therefore, show the premium placed on quality teachers, making it imperative for every serious curriculum to invest most of its resources in obtaining quality teachers.

Assem (2021), however, introduced an element of ICT integration into Shulman's quality teacher model (Figure 2). He argues that in the wake of information, communication, and technology, teachers must not only be conversant with what they teach but also should be able to acquire adequate skills that will enable them to integrate ICT in the teaching, learning, and assessment of science and technology in their classrooms.

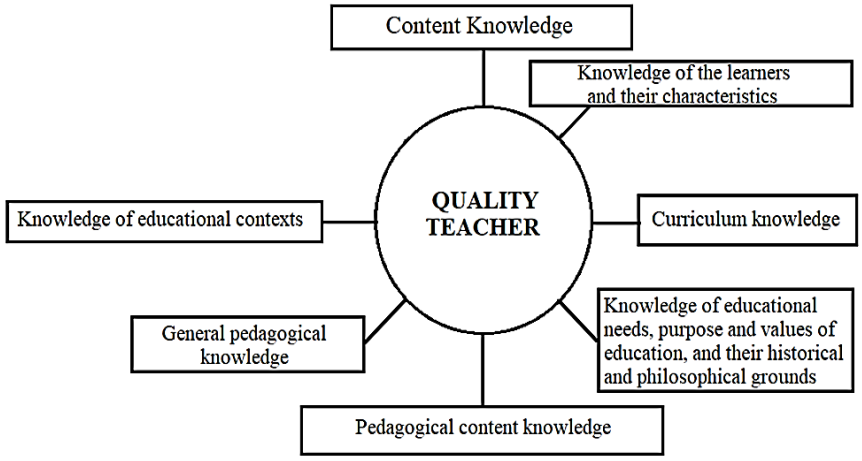

Figure 1 Shulman's quality teacher model (Shulman, 1986)

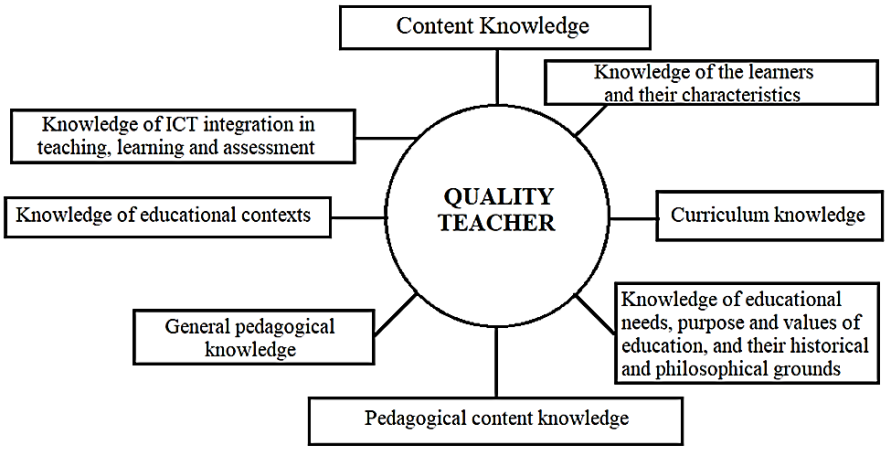

Figure 2 Assem and Co incorporation of ICT into Shulman's quality teacher model

1.1 Statement of the Problem

Research has been conducted on science teaching, learning, and assessment in schools and many learning environments (Fitzgerald & Smith, 2016; Hackling, Goodrum, & Rennie, 2001; Gamoran, 2003; Harlen & Qualter, 2018).

An inquiry into the teaching, learning, and assessment of science and technology has shown that many students find science learning problematic, difficult, boring, and energy-sapping (Salau, 1995; 1996). Arguably, unreasonable class sizes as in learner to teacher ratio, inadequate teaching and learning materials, including inadequate curriculum resources, non-equipped science laboratories, poor pedagogical skills and technical know-how, and inadequate support for science teachers coupled with other limiting factors impede the quality of teaching, learning and assessment in most teaching environment according to Krajcik (2002), Ødegaard, Haug, Mork, and Sørvik (2014), Anderman, Sinatra, and Gray, (2012), and Okebukola (1997).

Teaching, learning, and assessment of science and technology are confronted with a limitless number of challenges ranging from inadequate teaching and learning materials to the nonexistent of well-equipped science laboratories. Needlessly, curriculum implementation issues also take center stage in the teaching, learning, and assessment of science and technology, especially in primary schools, which should not be the case. Issues of lack of textbooks and inadequate technical know-how of teachers who are supposed to be the curriculum implementers have negatively impacted the teaching, learning, and assessment of science and technology in most government schools. Poor teacher confidence, inadequate pedagogical content knowledge, and lack of pedagogical skills required to deliver science and technology have been equally mentioned as challenges bedeviling the teaching, learning, and assessment of science in schools in Ghana. According to the National Center for Education Statistics in Las Vegas in 2007, complex issues such as the availability of appropriate textbooks and classroom resources, the preparation and training of science teachers, preservice training as well as in-service professional development, among others, have posed challenges to the teaching and learning of science in that parts of the world. It is instructive to know that in our part of the world, internet use, which otherwise would have served as a merger between the real world and the abstract world, is also bedeviled with challenges of lack of access amidst the high cost of data (Madrid, 2011). This investigation was meant to explore the extent to which the enumerated problems above affect science and technology delivery in some selected schools of the Ashanti Region and suggest remedies necessary to curb them.

1.2 Purpose of the Study

This study aimed to investigate and describe the status and quality of the teaching-learning of science and technology in selected junior high schools (JHS) in parts of the Ashanti Region and proffer suggestions to mitigate the problems.

Research Questions

The study sought to interrogate and answer the research questions below.

1. What is a perfect representation of teaching, learning, and assessment of science and technology in Junior High Schools (JHS) as a yardstick for comparison by various stakeholders?
2. What is the current picture of teaching, learning, and assessment of science and technology as perceived by teachers and other stakeholders in the education environment?
3. What issues make up the problems and challenges fighting quality teaching, learning, and assessment of science and technology in Junior High Schools?
4. Are there ways by which these challenges and problems can be solved or remedied if not eliminated?

Significance of the Study

This study professes a remedy to curbing problems hindering the teaching, learning, and assessment of science and technology in the Junior High Schools in the Ashanti Region of Ghana through a first-hand information approach. Thus, it provides curriculum implementors in science with the needed information about the challenges of teaching, learning, and assessment of science and the needed strategy to address them. Curriculum planners, stakeholders, and Government will find this work worthwhile as it will form the ground rules for future development of a science-based curriculum in Ghana, which will make a sound argument for soliciting support from stakeholders when the need arises.

2. METHOD

2.1 Research Design

The research design is a survey. Data were obtained for the actual actions on the ground through responses provided by science teachers and compared with literature. Data for the perfect picture of teaching, learning, and assessment of science and technology were generated through analysis of the research literature, the national science curriculum for primary schools, and a survey conducted on science teachers in some well-endowed schools in the Ashanti Region.

2.2 Population

In investigating the challenges facing the teaching, learning, and assessment of science and technology at the Junior High School in the Ashanti Region, the study randomly sampled 100 science teachers out of a population of 107 in 27 schools made up of 14 rural schools and 13

urban schools. Ten head teachers and principals were also involved in the study. Also, five stakeholders were identified as major stakeholders in the teaching, learning, and assessment of science and technology. These identifiable groups include the West African Examination (WAEC), the Ghana Association of Science Teachers (GAST), and the Parent-Teacher Association (PTA) of the selected schools.

2.3 Research Instrument

The study made use of questionnaires to elicit data from the focus groups. Meetings with groups were scheduled, and interview protocols were honored. The interview guide and the questionnaire were developed with the help of lecturers and science tutors from Wesley College of Education. The questionnaire was designed for the teachers, while the interview was used to obtain data from headteachers/masters and the representatives of the five stakeholders for the study. The research data collected were analyzed using both quantitative and qualitative methods.

3. RESULT AND DISCUSSION

The presentation of the results follows the order in which the research questions were posed. From Table 1, one hundred percent (100%) of teachers opined that government funding of the teaching, learning, and assessment of science is supposed to be continuous in the areas of building more classrooms, equipping science laboratories and libraries, maintenance of school facilities, and in procuring the necessary curriculum resources including equipment and materials such as consumables (reagents) and modern textbooks.

Ninety-seven percent of the respondents supported the idea of quality pedagogy curated to support a viable curriculum. At the same time, 3% did not think it was necessary to think about quality pedagogy woven around a good curriculum.

Ninety-seven percent (97%) of the respondents also agreed that the availability of teaching and learning materials and resources must be one of the critical pillars of acquiring knowledge in science and technology. They opined that the days when improvised materials were used in place of proper and sophisticated equipment must not be revisited if the new curriculum is to chalk any success at all. "We must spend money on providing science laboratories rich with scientific equipment and using virtual laboratories to simulate real-life applications of what we teach in theory". However, 3% of the respondents suggested that the cost of TLMs was something Government could not bear alone. Hence, teachers must be seen as using resources in the environment to aid them in delivering their lessons. "If the government decides to use all her resources to provide for teaching and learning materials to teach science and technology, then obviously, there would be nothing left for other developmental issues, " one of the respondents commented.

Most of these 3% respondents prefer the Government providing modern and quality textbooks for teachers and students to the cost of acquiring science TLMs. They believe that teachers will have a broad knowledge of the science and technology practiced in other countries when the Government provides good and quality textbooks. "Teachers must be well vest in their fields of endeavour". Accordingly, they indicated that small class sizes would motivate science and technology teachers to have complete control of their students hence, taking care of individual differences and learning styles through the use of various teaching styles that suit each learning style. Arguably, well-ventilated classrooms with good seats for the students to sit comfortably were prerequisites for effective teaching, learning, and assessment of science and technology in Ghana.

Furthermore, the population of students offering science subjects should not outnumber the capacities of the teacher. Thus, there is a need for a manageable class size with enough resources to cater to each student's needs. The learning environment should motivate the learner to learn. Therefore, schools should have a conducive learning environment without distraction and noise. Additional information from the interview indicates that teachers generally believe that, under idyllic circumstances, teachers should have the sound subject content knowledge and pedagogical skills to achieve the purpose and goals for which the junior high school science curriculum was borne. Eighty-seven percent (87%) of the respondents believe that the curriculum is hinged around pedagogy. Hence, they believe that when teachers are adequately resourced and introduced to the curriculum proper through their involvement in its drafting, sound teaching, learning, and assessment of science and technology will be achieved. Thirteen percent (13%) of the respondents, however, rejected the claim saying that curriculum and pedagogy do not make any difference in what is being called ideal

Table 1 Teachers' responses to characteristics of ideal teaching, learning, and assessment of science and technology

Item	No. of Yes	Percentage Yes	No. of No	Percentage No
Funding	100	100	0	0
Curriculum & pedagogy	97	97	3	3
TLMs and Resources	97	97	3	3
Facilities	100	100	0	0
Small Class Size	87	87	13	13

Table 2 Stakeholders' responses to characteristics of today's science and technology teaching, learning, and assessment

Item	No. of Yes	Percentage Yes	No. of No	Percentage No
Funding	10	10	90	90
Curriculum & pedagogy	5	5	95	95
TLMs and Resources	10	10	95	95
Facilities	5	5	0	0
Small Class Size	4	4	96	96

Table 3 Stakeholders' responses to characteristics of ideal teaching, learning, and assessment of science and technology

Item	No. of Yes	Percentage Yes	No. of No	Percentage No
Funding	1	20	4	80
Curriculum & pedagogy	5	100	0	0
TLMs and Resources	4	80	1	20
Facilities	2	40	6	80
Small Class Size	4	80	1	20

Table 4 Stakeholders' responses to characteristics of today's science and technology teaching, learning, and assessment

Item	No. of Yes	Percentage Yes	Number of No	Percentage No
Funding	1	20	4	80
Curriculum & pedagogy	5	100	0	0
TLMs and Resources	4	80	1	20
Facilities	2	40	6	80
Small Class Size	4	80	1	20

teaching, learning, and assessment of science and technology. "The panacea to teaching, learning, and assessment of science and technology in teaching and learning resources," they claimed. Thus, an accomplished science teacher should have good professional attitudes and be continuously involved in professional development.

Responses from participants on practical (ideal) science teaching were organized into thematic areas. The thematic areas were similar to those for ideal science teaching, learning, and assessment. These include funding, curriculum, pedagogical skills, learning and skills expected to be obtained, available teaching and learning resources, facilities and small class size, teacher content knowledge of the subject matter, attitudes, and professional learning, including community support.

From Table 2, ninety percent (90%) of science teachers emphasized that schools lack proper funding for building new classrooms and science laboratories, adequate classroom maintenance, and providing resources and facilities. The respondents agreed that the Government does not provide adequate funds for running schools. They further remarked that students learn under harsh conditions in small classrooms with very poor ventilation. In addition, the large class sizes have negatively impacted the teaching and learning of science and technology. On the other hand, 10% of the teachers did not agree with their colleagues. According to these respondents, the Government is doing well and believes that other agencies like the church must help.

Ninety-five percent (95%) of the science teachers believed that science teaching, learning, and assessment must be practical, yet, theoretical aspects are emphasized in the current dispensation. Thus, learners are involved in only a few practical activities. As such, it makes science teaching a teacher-centered one. However, this does not inure to the benefit of learners. Respondents also echoed that the science curriculum as it stands now is overloaded with content.

Meanwhile, the content therein requires a carefully planned series of activities to engage learners, but the time allocation is too limited to allow for it. This has promoted abstract teaching and learning environment in the schools. According to Kuiper, Nieveen, and Berkvens (2013), there is snowballing demand for curriculums to echo changes in society in a fast-growing world to meet evolving societal needs, including financial literacy, digital literacy, and literacy for sustainable development and computational thinking. In light of this, respondents believed that new curriculums should be developed to shift focus from examination but rather provide enough grounds for students to attain skills necessary to meet the demands of the emerging world. The respondents also questioned the academic backgrounds of science teachers. Most respondents explained that most teachers do not have sound background knowledge of the science and

Table 5 Stakeholders' responses to characteristics of ideal teaching, learning, and assessment of science and technology

Item	No. of Yes	Percentage Yes	Number of No	Percentage No
Funding	1	20	4	80
Curriculum & pedagogy	5	100	0	0
TLMs and Resources	4	80	1	20
Facilities	2	40	6	80
Small Class Size	4	80	1	20

Table 6 Stakeholders' responses to characteristics of today's science and technology teaching, learning, and assessment

Item	No. of Yes	Percentage Yes	Number of No	Percentage No
Funding	1	20	4	80
Curriculum & pedagogy	5	100	0	0
TLMs and Resources	4	80	1	20
Facilities	2	40	6	80
Small Class Size	4	80	1	20

technology they teach. Square pegs have been rooted in round holes and vice-versa, courtesy of "posting-gone-bad" in the Ghana Education service. Respondents say this is detrimental to students' interest in science and technology. Furthermore, not all the teachers teaching science and technology are trained to teach science. Only 5% of respondents did not see that as a hindrance to the teaching and learning of science and technology in schools (Table 3-4).

Ninety percent (90%) of the respondents believed there are inadequate teaching and learning materials for science and technology in schools, especially in rural areas. However, 10% did not agree with their colleagues. This minority group believed that teachers could improvise material to teach science and technology if they wanted, thus, attributing any diverse argument to a lack of commitment.

Also, 95% of respondents opined that there is too much pressure on the school facilities due to the large school population and the periods between vacation and reopening. As a result, the few available facilities have been used repeatedly and are in a state of deterioration. This indeed did not motivate them, and as far as they were concerned, their security was not guaranteed. However, 5% of the respondents believed that teaching science and technology does not necessarily require well-equipped science laboratories and big classrooms. According to the commitment to teaching, learning and assessment of science and technology depend on the teacher's interest and motivation in life.

Regarding Class Size, 96% of the respondents agree that classrooms available cannot accommodate the students for the teaching, learning, and assessing science and technology in most schools in Ghana. According to respondents, the student population has increased due to the Free Senior High School policy. They claim that in situations where laboratories exist, many students are packed in them with little or no practical work. The remaining 4% responded that science laboratory size and classroom size did not matter in the teaching, learning, and assessment of science and technology (Table 5-6). They claim committed teachers can explore the internet and the environment for other options for teaching, learning, and assessment resources.

4. CONCLUSION

The teaching, learning, and assessment of science and technology at the Junior High School level have been bedeviled will numerous challenges, including large class sizes, poor funding, lack of resourced science laboratories and classrooms, curriculum implementation challenges, and teacher motivation, and security and inadequate library facilities. However, these challenges can be mitigated when the following measures are implemented—first, provision of adequate facilities such as infrastructure, which range from classrooms, and well-equipped laboratories to libraries. Second, provision of teaching, learning, and assessment materials for hands-on activities. The third is a collaboration between teachers and stakeholders who see themselves as partners in development. Fourth, training preservice teachers as in-service teachers aligns with the 21st-century classroom requirements.

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