

**REFORMING SECONDARY CHEMISTRY EDUCATION:
COMMUNITY-CONTACT BASED, INTERDISCIPLINARY,
AND PROJECT-BASED PEDAGOGIES**

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Abstract

Chemistry education globally and specifically in countries like Nigeria has long been experienced several challenges of poor performance, disengagement, and inadequate preparation of students for applications. The traditional teaching methods that involves rote learning have been contributing to the poor performance of students in chemistry by not encouraging critical thinking skills or positive attitude development. This position paper persuasively argues that different innovative approaches such as Community-Contact-Based Learning (CBL), Interdisciplinary Learning (IDL), and Project-Based Learning (PBL), are required to revise secondary school teaching of chemistry because they are student centered and promote student critical thinking skills, that are needed by every student to contribute meaningfully to the development of their immediate environment. Based on meta-analyses and empirical research, these approaches evidence their higher effectiveness not only in advancing key learning outcomes like academic achievement, critical thinking skills, engagement,

application skills, attitudes, and retention but also outperforming existing traditional learning environments. For example, PBL has large effect sizes for academic achievement, IDL creates synthesis between subjects, and CBL increases engagement by applying concepts gained to everyday life as identified by various researchers. These methods, which have their roots in constructivist theories, are motivated to provide sustainable education. which has been shown to support climate action and high-quality education (SDGs Goals 4 and 13, respectively), which all students who are exposed to these strategies typically accomplish. Fo this to be accomplish, to support the implementation, training, and integration into the policies needed to guarantee change in the way teacher teach chemistry. The method and its implications for developing students into critical thinking and problem solvers are supported by literature both local and international, which discuss the urgent need for reforms to improve teaching and learning of chemistry in secondary school.

Keywords: Chemistry Education Reform, Project-Based Learning, Interdisciplinary Learning, Community-Based Learning, Sustainable Development Goals, Nigerian Secondary Education

Introduction

In Nigeria which is one of the developing countries, the crisis in chemistry education has a profound impact on so many other STEM-related issues. colonial legacies and underfunding have been identified in the past as sustained antiquated curricula that prioritize rote memorization over real-world application, that has resulted in lack of interest among students. According to Lumas (2022), for example, overcrowded classrooms, has makes individualized instruction impossible to achieve and promotes disengagement. This has worsened the situation through the lack of a laboratory with instruments such as beakers, test tubes, or even safe chemicals (Mirsaeidi & Yousefi, 2021). As a result, students seldom engage in practical experiments that help make abstract ideas concrete (Adjetey, 2024). Teaching approaches that are Teacher-centered in which without engaging with students, teachers provide

lectures, further sideline the students, particularly those from low-income families that doesn't have access to some necessary needs such as textbooks and internet facilities.

In rural areas, these issues of socioeconomic factors are pronounced. Low funding by government, few schools, inadequate of teachers, and infrastructure reduced the access to high-quality education and limit students' academic paths in low SES rural communities (Wang & Shen, 2022). In China and Kazakhstan research conducted shows that rural students consistently perform worse on tests and have lower enrollment than their urban counterparts. This is primarily due to the fact that urban schools have more resources, qualified teachers, and digital access, whereas rural schools have fewer resources and weaker teaching staff (Zhixuan, 2025; Sagidolda et al., 2024; Wang & Shen, 2022; Fu & Hashim, 2024). In addition, urban schools frequently face challenges related to high student enrollment and class sizes, which are associated with overcrowding and a strain on available resources (Zhixuan, 2025; Fu & Hashim, 2024).

Another hurdle is the teacher competency. Research on chemistry and science education as identify major obstacles to effective chemistry learning such as teacher shortages, low qualifications, and limited laboratory facilities, in one Ghanaian study, 55.8% identified poor infrastructure and 25% of students identified teacher shortages/qualifications and as key challenges in learning chemistry (Alhassan & Fosu, 2025). Many science teachers lack up-to-date pedagogical content knowledge which targeted professional development significantly improves teaching quality and student achievement as it was reviews and meta-analyses as indicated by (Bustamante, 2025; Fauth et al., 2019; You et al., 2024; Heller et al., 2012; Geletu, 2022; Lynch et al., 2025; Roth et al., 2018). As reported by (Fauth et al., 2019) students report high interest and better academic achievement in science when teachers have stronger pedagogical content knowledge, self-efficacy, and enthusiasm

These are the conditions that shape how students view chemistry. As identified by the cross-grade surveys and studies conducted in Ukraine and Serbia reveals that, chemistry is widely perceived by students as difficult, poorly connected to daily living, abstract and most times taught with limited experiments, which discourage many students and makes chemistry seem like barriers rather than a pathway to future opportunities, (Pratomo et al., 2025; Khmel&Shpyrka, 2025; Rodić et al., 2025; Alhassan & Fosu, 2025; Musengimana et al., 2021). The decline in interest of students in chemistry and negative perceptions of the subject was attributed to lack of resources, and inadequate teaching practices which was a review of secondary students' attitudes towards chemistry, (Pratomo et al., 2025; Musengimana et al., 2021).

The proposed paradigm shift offers promising solutions. Community Contacts Based Learning (CBL) fosters relevance and community involvement by integrating school lessons with local contexts. For example, CBL teaches chemical reactions through the analysis of water quality in nearby rivers. Interdisciplinary learning (IDL) breaks down silos and improves holistic understanding by relating chemistry to biology (e.g., studying enzymes in biochemical processes) or environmental science (e.g., the chemical effects of pollution). Through practical projects, such as creating environmentally friendly detergents to reduce household waste, Project Based Learning (PBL) empowers students and fosters critical thinking, teamwork, and problem-solving abilities.

On a global scale, this is consistent with programs such as UNESCO's advocacy for sustainable development goals, which emphasize student-centered education as a means of creating innovative societies. These could be put into practice in Nigeria through partnerships with NGOs for resource provision, teacher workshops, and policy changes. Exam scores and engagement have increased in early pilots in a few schools, indicating scalability. In the end, this change may turn chemistry from a hated subject into useful instruments for advancing society, empowering the next generation

to use scientific literacy to address issues like health crises and climate change.

Wijnia et al (2024), evidence supporting the superiority of such methods are from meta-analysis. For example, it has been inferred that PBL has been proven to significantly improve education in science by achieving academic achievement, and there has been meaningful improvement over traditional methods. According to Aunzo in (2025), IDL leads to better understanding, increased capabilities in applying principles of chemistry in broader domains of profession, and CBL leads to long-term improvement in STEM capabilities by involving the community.

In the Nigerian context, the above approach provides valuable lessons to overcome curriculum implementation in the Nigerian context. According to Adesoji et al. (2021), the efforts made by Osun State, such as the adoption of digital platforms like Opon-Imo, give room to incorporate all the above approaches. However, they also meet the goals of sustainable development goals related to quality education (Goal 4) and sustainable communities (Goal 11).

This paper brings together theory and evidence in context to argue for change. With secondary chemistry focusing on such teaching and learning approaches, lessons will feel more interesting and useful for student. It has the potential to be more engaging and relevant to students' future reality, achieving the best through what they have gain in the class.



Figure1: Students participating in interdisciplinary STEM activities in a classroom environment.

Source: SDI Production, Child Science lab stock photos

Theoretical framework

The proposed teaching methodologies are rooted in constructivist theories of learning, according to which, “knowledge is a result of active construction based on experiences, as well as social interactions.” Theories put forward by Yildiz, referring to “Cognitive Constructivism by Jean Piaget and Social Constructivism by Lev Vygotsky,” show the process to be emphasized by the first as assimilation and accommodation, and by the second as collaboration and use of cultural tools, as explained by Yildiz, 2025. The Learning Cycle, according to Kolb, 2021, further promotes the process, explained as:

However, according to Shaki, et al. (2024), in PBL, constructivism is evident in the way students conduct inquiries and develop knowledge from problem-solving activities. Harvie (2020) argues that in IDL, there is the application of an interdisciplinary approach in systems thinking that connects chemistry and other sciences. Nchaga, (2025) argues that in CBL, there is an alignment with the service-learning approach since there is civic engagement and metacognition.

On the conceptual level, learning outcomes are assessed through the use of the Revised Bloom's Taxonomy, which correlates basic

learning abilities (recalling, understanding) to higher-level learning (analyzing, evaluating, creating) in terms of learning outcomes. Engagement and attitudes are associated with Self-Determination Theory, and retention with Spaced Repetition and application.

Such models converge at the level of the SDGs, where chemistry education advances sustainable development. The principles of green chemistry operate alongside the SDG-13 to ensure environmentally responsible behavior. The models operate in Nigerian secondary education institutions based on cultural and resource needs.

Constructivism, as a foundational paradigm in modern education, posits that learners actively build knowledge rather than passively receive it. According to Jean Piaget's cognitive constructivism, learners integrate new information into preexisting schemas or modify schemas to fit new experiences during the sensorimotor, preoperational, concrete operational, and formal operational stages of cognitive development. When secondary chemistry students come across abstract ideas like atomic structure, they reconstruct their understanding through practical manipulation, resolving disequilibrium to achieve equilibration.

Lev Vygotsky's social constructivism, which complements Piaget, emphasizes the importance of language, social interaction, and cultural resources in the learning process. The Zone of Proximal Development (ZPD), which is the difference between what a learner can accomplish on their own and with scaffolding and guidance from more experienced individuals (teachers or peers), is one of the key ideas. Shifting to Vygotskian approaches, such as community interaction, practical experience, and applying learned material to real-world situations, could address disengagement and promote collaborative knowledge construction in Nigerian secondary schools, where teacher-centered lectures predominate.

David Kolb's Experiential Learning Cycle integrates these ideas into a practical framework: concrete experience (hands-on activities),

reflective observation (analyzing outcomes), abstract conceptualization (forming theories), and active experimentation (applying concepts). In chemistry teaching, this cycle supports inquiry-based labs, where students experiment with reactions, reflect on results, theorize principles, and test hypotheses promoting deeper understanding over rote memorization.

Conceptual Frameworks

By involving students in real-world issues, like creating environmentally friendly detergents, Project-Based Learning (PBL) exemplifies constructivism. Problem and project-based learning improves students' critical thinking, teamwork, and long-term comprehension, according to research in secondary chemistry (Arsyad et al., 2024; Situmorang et al., 2022; Maesaroh & Hari, 2025; Raman et al., 2024; Khambuo et al., 2024; Miterianifa et al., 2019; Halimatuzzahra & Louise, 2025; Aidoo et al., 2016; Pratiwi & Ikhsan, 2024; Putri et al., 2023).

In Nigeria, where resources are limited, PBL using local materials aligns with cultural contexts and addresses SDG challenges. Interdisciplinary learning in chemistry that links environmental systems and chemical concepts to biological, framed by systems thinking and the SDGs, has been shown to break disciplinary gaps, make chemistry more relevant to real-world pollution and foster holistic reasoning of sustainability and health issues (Eaton et al., 2019; Talanquer & Szozda, 2024; Wissinger et al., 2021; D'eon & Silverman, 2023; Celestino, 2023; Mahaffy et al., 2019; Morales et al., 2024; Shidiq et al., 2020; Zidny & Eilks, 2020).

Community Contact-Based Learning (CBL), involves civic engagement, such as community water sensitization on pollution and its effect. It builds civic responsibility and promotes metacognition which reinforce concepts that is in line with Vygotsky's social emphasis.

Assessment via Revised Bloom's Taxonomy progresses from lower-

order to higher-order skills. Self-Determination Theory (SDT), where Nigerian students most time face demotivation which links autonomy to engagement, relatedness satisfaction crucial in STEM and competence.

The principle of green chemistry on waste prevention can be integrated, atom economy and solvents promote safer SDGs like climate action (SDG 13) and clean water (SDG 6). Despite the challenges like inadequate laboratories, insufficient teachers and inadequate teachers training in Nigeria, research have shown that constructivist strategies can improve learning outcomes.

Nigerian schools need teacher's professional development, curriculum reforms and partnerships in order to Implement these strategies in resource-constrained situation. Models that Technology driven (e.g., virtual laboratories) and overcome barriers through localized projects, transforming chemistry education into a major key of sustainable innovation which has been used in different research and confirmed to sustain learning in under developed countries. By grounding pedagogy in constructivism, Kolb's cycle, and SDT, educators can cultivate scientifically literate citizens equipped for 21st-century challenges.

Project-Based Learning in Secondary Chemistry

Project-Based Learning (PBL) is an activity where problem-solving is done by using the concepts that are learned from chemistry in practical situations such as sustainable batteries or analyzing pollutants. According to Raman et al. (2024), there has been an effective literature review of laboratory classes in high school chemistry for a period of ten years for PBL concerning misconceptions and understanding.

According to study undertaken by Uluçınar, U. (2023), Meta-analyses show that the massive impact of PBL has been found to have an effect size of 0.441 to 1.063 in science education on students' achievements. PBL assists in the development of critical thinking

skills by analysis and evaluation, engagement by collaboration, skills by experimentation, attitudes by applications, and retention by contextual engagement.

In the secondary schools of Nigeria, various forms of PBL, such as project-based learning, can impact positively on the performance of concepts in kinematics in the subject of chemistry. According to Agbor et al (2025), the flipped classroom method, which encompasses PBL, has shown to increase performance. PBL can also fit into the SDGs, which advocate for innovation (SDG 9) and clean energy (SDG 7).

Meta-analyses and controlled studies show that problem-based learning yields large gains in secondary and higher-education students' academic performance, critical thinking (ES = 1.08), motivation, practical skills, positive attitudes, and longer-term knowledge retention compared with traditional teaching (Liu & Pásztor, 2022; Lu et al., 2025; Wijnia et al., 2024; Dochy et al., 2003; Trullàs et al., 2022; Liu et al., 2019; Ren et al., 2023; Chen et al., 2024; Funa & Prudente, 2021).

Table 1: Showing Outcomes of PBL and its evidence

Outcome	PBL	Evidence
Academic Performance	High (effect size 1.063)	Meta analyses
Critical Thinking	Strong	Problem Solving in projects
Engagement	High	Collaborative activities
Practical Skills	Excellent	Laboratory Based execution
Attitudes	Positive	Relevance reduces anxiety
Retention	Superior	Meaningful application



Figure 2: High school students conducting science experiments in a project-based setting.

Source: <https://www.gettyimages.com/photos/high-school-bunsen-burner>

Interdisciplinary Learning in Secondary Chemistry

This combines the study of chemistry with other fields, like biology when studying biochemistry or environmental science to study sustainability. Osborne, J. (2023), has been found interdisciplinary learning to have increase scientific literacy by connecting ideas that span other disciplines.

Tariq (2024) suggested that interdisciplinary learning promotes academic excellence through holistic mastery, critical thinking through synthesis, engagement through relevance, skills through interdisciplinary labs, attitudes through interconnections, and retention through networking. In secondary school education, IDL equips learners with solutions for problems faced in modern times, such as climate change. In Nigeria, embedding real-world issues may be a remedy for poor performance. IDL aligns with SDG 13 by embedding green chemistry.



Figure 3: Classroom scene of interdisciplinary STEM education.

Source: <https://www.siemens-stiftung.org/en/projects/experimento/experimento-in-south-africa/>

Community-Contact Based Learning in Secondary Chemistry

Community Contact-Based Learning (CBL) involves collaborating with the community on projects related to chemistry, for example, analyzing the quality of water in the community area (2023). CBL is an efficient way of enhancing long-term gains in the field of education. It adds value to academic achievement through application, critical thinking by reflecting, societal involvement, skill development, attitudes by emphasizing values, and retention of learning through experiential learning. Since Osun State is the focus, leveraging the resources within the community would be an added factor. CBL connects or complements SDG 11 with regards to sustainable communities.

Community Contact-Based Learning (CBL) represents a transformative approach in secondary chemistry education by bridging classroom theory with real-world community needs. At its core, CBL involves collaborating with the community on projects

related to chemistry, for example, analyzing the quality of water in the community area (2023). Through practical application, ideas in chemistry that are abstract like testing for the pH of water or solution, dissolved solids, and detection of contaminant has become major and practicable to students daily living. These has replaced the rote learning that are passive with active participation of students, Community Based learning is an effective strategy that help in boosting long term achievements in education. Applying the knowledge acquired in real life situations allows student to strive harder than just memorize them, these foster deeper understanding and retention of concepts for long term. In the situation where the theoretical knowledge is been tested through application to strengthened in real-world situations, academic achievement is enhanced. During community interaction, critical thinking is promoted when reflecting on project results, interpretation of data collected and solving problem faced in difficulty period.

Moreover, Community Based Learning, promotes student's activeness in their communities by relating directly with the local stakeholders, such as immediate families, farmers, local authorities and residents. A high sense of civic responsibility is promoted through this hands-on engagement. More so, it helps students to build practical skills which is through the collection of samples, conducting experiments, data analyses and results presentations. These boost students' attitudes towards chemistry positively as they can easily connect scientific learning with environmental values, community well-being and ethical practice. In addition, learning retention of students is been improved positively through experiential learning as emotional, sense of experiences which create deep and last long understanding over the conventional lecture-based instruction. Leveraging on community resources is another additional factor, given the focus on artisans like the panel beaters, the battery charger, agricultural foundation, the blacksmith and the rich cultural legacy offer a wide range of wealth of free resources for community contact-based learning initiatives. With the help of

available and accessible resources within the community and knowledge, artisanal mining sites, the blacksmith, and the local soap production sites, for instance, can be used majorly as the study sites for various study areas like soil testing, pollution assessment, water and material testing and water quality analysis without depending on school laboratory equipment that are limited. According to Gudonienė et al. (2021) Community contact Based Learning enhanced Sustainable Development Goal 11 which helps students to be inclusive, safe resilient and assist in sustaining their communities by serving as an ambassador to managing of waste within their locality, sustaining resources used and make water body safe and accessible. In improving academic achievement, this alignment encourages every student to be an agent of change through chemistry class to address societal issues that are very urgent. According to Yao (2023), Community contact Based Learning, provides an effective way to promote chemistry instruction in secondary schools with limited resources while citizenship that are responsible are built.



Figure4: High school students in community-based science projects.
Source:https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcQwlSu3Plxx3_b0Ur2rPERPWMgXMgN7wzk9Q&s

Comparative Analysis and Evidence from Nigerian Contexts

A comparison of creative teaching methods in secondary chemistry education in Nigeria shows that each of the three suggested approaches has unique advantages. In contrast to the typical conventional method that encourages memorization of routes, Project Based Learning (PBL) performs better in terms of performance and skill development, allowing students to achieve higher academic outcomes and master practical competencies (Ibitoye, 2021). Conversely, Interdisciplinary Learning (IDL) is excellent at encouraging higher-order thinking and synthesis, enabling students to make connections between chemical concepts in different subjects for a more profound understanding. In terms of engagement and attitudes, Community Contact-Based Learning (CBL) is unique because it increases student motivation and cultivates favorable views of chemistry.

Crucially, PBL, IDL, and CBL outperform traditional teaching techniques, which frequently rely on teacher-centered, lecture-based instruction that results in lower retention and interest. According to evidence from Bozkurt (2022), hybrids that combine aspects of these strategies yield the best outcomes and maximize benefits across a variety of learning domains.

Strategies like PBL, IDL, and community contact classroom design of instruction have been demonstrated to help improve chemistry results in the larger Nigerian context. While community contact-based learning shifts direct instruction outside of the classroom, allowing for active application during class periods, research on these novel approaches has demonstrated that they promote inquiry-driven exploration. By encouraging student autonomy and interaction, these strategies tackle prevalent issues like packed classrooms and scarce resources. As stated in Mpuangnan & Ntombela (2024), for example, the importance of instructional modification for improvement is highlighted, acknowledging the necessity of adapting national curricula to local realities, including cultural relevance and available community assets.

Table 2: The three strategies comparative strength

Strategy	Comparative Strengths	Evidence
PBL	High achievement. Skills	Kinetics learning are been improved
IDL	Synthesis, relevance	Real world integration
CBL	Engagement, attitudes	Resources used are Community based

Additionally, according to Karadzhov (2025), these cutting-edge approaches (project-based, interdisciplinary, and community contact-based learning) show a strong alignment with the Sustainable Development Goals (SDGs). According to Nguyen et al. (2024), by incorporating sustainability into chemistry education, these teaching and learning approaches support the SDGs. PBL and IDL specifically support SDG13 (Climate Action) by involving students in green projects that investigate pollution mitigation, renewable resources, and environmental chemistry. By involving the community in real-world learning opportunities that go beyond school boundaries, CBL promotes both SDG4 (Quality Education) and SDG11 (Sustainable Cities and Communities). According to Gudonene et al. (2021), sustainability in education and the environment is thoroughly discussed for the case of Nigeria, where environmental issues like waste management and water contamination are common.

The identified innovative teaching strategies in teaching chemistry such as Project Based Learning, Interdisciplinary Based and Community Contact Based Learning promotes student's involvement in the teaching learning process in solving challenges in real-world sustainability. These methods support some of the Sustainable Development Goals and are majorly concern in tackling the current environmental issues in the country and beyond. Apart from the improvement of students understanding of concepts in chemistry, they assist in developing environmentally conscious individual who can serve better to contribute majorly to national growth and development.

The evidence from Amiri (2025) reveals that developed countries like china are using this Project Based Learning, Interdisciplinary Based and Community Contact Based learning, which might be separately used or combined together to promotes student practical understanding in other to revitalize chemistry in secondary school, which leads to better achievement in academics, deeper understanding, and a well-known societal impact than conventional strategy.

Challenges, Limitations, and Recommendations

The challenges, limitations, and opportunities of implementing innovative approaches, such as CBL, IBL, or PBL, within secondary level chemistry education in Nigeria would present major advantages regarding the development of critical thinking, problemsolving, or practical use of scientific concepts, but still, it would meet major setbacks in resourcepoor environments, such as in Nigeria. Resource scarcity, unwilling teachers, and an inflexible curriculum, in addition to challenges in such environments like Nigeria or other African schools, would turn out to be critical aspects.

Among the most prevalent challenges is the resource constraint. This is where most of the secondary school laboratories in Nigeria lack basic equipment, reagents, and learning materials that are of utmost necessity for the interactive learning required in CBL, IBL, and PBL learning approaches. According to Jimoh et al. (2024), Research on the implementation of the chemistry curriculum in Nigeria identifies a shortage of learning apparatus and reagents, hence the inability of the teacher to conduct the learning process using laboratories but rather theoretical lectures or mugging learning. This problem of overcrowded classrooms of about 50 to 100 students per class makes it rather impractical to perform group activities, individual scaffolding, and directing the laboratory classes. In most cases, in the countryside, the lack of electricity and the absence of computer utilization make it rather challenging to adopt the modern approach of inquiry learning.

Another significant drawback of the project is the resistance of teachers. Okpara and Ezeador (2024) reported that in Nigerian schools, many teachers are accustomed to traditional ways of teaching, which regard alternative ways of teaching such as CBL, IBL, and PBL as waste of time and the disruptors of the wide curriculum required in order to prepare students for high-level exams. The lack of adequate knowledge of what CBL, IBL, and PBL are has been regarded as a factor seen in teacher's reluctance. Professional workshops may not be relevant; thus, they are shallow. The culture of Nigerian schools includes authoritarian school architecture and emphasis on preparing for high-level exams, as highlighted by Ibitoye (2021). There was a concern that implementing CBL, IBL, and/or PBL would mean less emphasis on content.

The strict curriculum is a structural constraint because the national chemistry curriculum is overburdened with huge contents in a manner that only encourages rote learning and focuses on examinations. There is little room for the inclusion of extended projects or Challenge-Based Learning in the domain of Sustainable Development Goals, including environmental sustainability and renewable energy. There is a constraint in the form of the time factor in the educational year because PBL and CBL include prolonged exposure, which contradicts the requirement for the completion of the curriculum. Furthermore, in the developing nation Nigeria in this context, the formative assessment in PBL and CBL is restrictive because the paper-based assessment is not well suited for assessing the acquisition of team working, innovation, and critical thinking.

Some other limitations include inequities associated with urbanrural disparities as well as socioeconomic inequalities, with better off schools' pilot testing new ideas while others trail. It can, therefore, exacerbate inequalities in the educational system.

Recommendation

To tackle such problems, specific recommendations are required.

On a first level, there is a need for the integration of conventional teaching and CBL, IBL, and PBL approaches at a hybrid curriculum level to be accomplished. This may be accomplished within a modular integration process, with a focus on developing key topics through small-scale projects that link chemistry with relevant local issues such as water purification and agriculture as examples.

Second, investment in professional development through continuous and relevant training would be necessary. Conferencing, mentoring, and networking with other organizations, such as the Nigerian Educational Research and Development Council, would be beneficial for teachers to enhance capacity and alleviate reticence through evidence of positive effects, such as greater pupil morale and test scores.

Thirdly, the pilots can be carried out in the Osun State, using the experiences of pilots in the previous education projects and ease of observation. This is significant because a small start would offer a chance to test the strategies before scaling based on the success attained.

Fourth, the SDGs can be integrated into assessments using project components and continuous assessment. This is based on the idea that chemistry education can align with the interests of the country regarding alleviating poverty and protecting the environment.

Other enabling approaches could be, enhancement of the use of the local resources that can supplement the deficiencies, facilitating the creation of public-private partnerships for infrastructure development, and evaluation of policies that can address the challenge of reduced class sizes and the syllabus.

Conclusion

The actualization of the reform of teaching chemistry at the

secondary school level within the folds of Nigerian universities and institutions of higher learning through the implementation of the CBL, IBL, and PBL learning methodologies is not only an imperative within the realm of education but also an absolute within the actualization of a generation of critical and skillful compliant students who can effectively assist within the containment of some of the problematic developmental realities within the actualization of this nation. Within a nation where the continuance of low performance within the subject chemistry has not only been perpetuated but actually resulted within the failure of students performing credit passes within the West African Senior School Certificate Examination in the range of 50% within the last two decades, this type of teaching and learning approach is requisite. Findings around the world is evidence that the strategies have been proven to be effective. The identified strategies as a learning process have been proved to promote learning achievement, enhance self-efficacy and reduced misconceptions within the secondary schools' students about chemistry as a science subject. These strategies can without stress focus on goal 4 which is Quality Education, 13 (Climate Action) and 6(Clean Water Sanitation) of the Agenda of Sustainable Development just because of the projects attached to them like purification and renewable energy resources which are fitting for the circumstances in Nigeria. These research as also been carried out in Kenya and Hungary and many others that applied IBL on the improvement of scientific reasoning and the capacities of problem solving amidst any circumstances.

With the Challenges of limited resources of teachers', a strong rigidity to conventional methods, and a rigid curriculum, that are exam focused, the Strategies proposed offer a practical skill, a strong will student and achievable path for implementation. Hybrid curriculum can be developed, by integrating the modules on the Project Based, Interdisciplinary based and community contact-based learning into the existing subjects. These strategies maintain a full coverage of curriculum when integrated, adding experiential and knowledge that are real, for example, when connecting organic chemistry concepts to

sustainable farming practices. Through targeted professionals, programs can be developed to address teacher's resistance. Also, partnering with bodies such as Nigerian Educational Research and Development Council which can provide a concrete evidence that link these innovative strategies to improved motivation and better academic achievement of student. In addition, adopting a project portfolio and assessment system that can deliberately encompass sustainable Development Goals (SDGs) which allows the educators and the students to move faster above rote memorization and developed essential skills in innovation and sustainability.

Additional systemic support would also be critical towards improving the improvisation of low-cost materials to compensate for the shortages of those materials, formation of partnerships to develop the-supporting infrastructural and laboratory expertise, and syllabus workload and class sizes. The current developments in the national curriculum, emphasizing harmonization and closer linkages between technology, computer education, and vocational education, would clearly offer a highly favorable context for this kind of development. Online laboratories and virtual technologies that have been mentioned lately, relative to the issue related to Nigerian Chemistry education, could help to supplement the missing content.

Finally, this is imperative for the development of Nigeria as a country because with the adoption and application of these learning approaches; they are capable of equipping the learner with skills that are key for a 21st-century learner: critical thinking skills, problem-solving skills, and adaptability skills; they are therefore able to turn around the result fortunes and the low uptake in stem disciplines to produce innovators and key players who are able to contribute to the development and growth of the economy and the nation as a whole because the benefits are enormous-an equal and innovative and developed and prosperous Nation.

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