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The Practice of Formative and Summative Assessments in Enhancing Basic Science

Teaching and Learning

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Abstract

The practice of formative and summative assessments plays a crucial role in enhancing teaching and learning in Basic Science Education. Formative assessments, conducted during the learning process, provide valuable feedback to students and teachers; helping to identify strengths, weaknesses, and areas for improvement. Summative assessments, on the other hand, evaluate students' overall understanding and academic achievement at the end of an instructional period. The integration of both types of assessments fosters a deeper understanding of scientific concepts, encourages active learning, and improves overall academic performance. This paper aims to explore how formative and summative assessments can be used strategically to improve in Basic Science Education, emphasizing their role in enhancing students' outcomes, engagement, and mastery of scientific principles. However, integrating formative and summative assessments presents several challenges and considerations that educators must navigate to effectively support student learning and achievement.

Keywords: Assessment Strategies, Basic Science, Formative Assessment, Summative Assessment, Teaching and Learning,

The Practice of Formative and Summative Assessments in Enhancing Basic Science Teaching and Learning

In Basic Science Education, assessments serve as powerful tools that inform teaching practices, shape student learning, and provide insights into students' grasp of scientific concepts. There are two primary types of assessments: formative and summative. Formative assessments are conducted during the learning process to monitor progress and provide real-time feedback, while summative assessments evaluate the overall performance of students after a unit or course of study. Formative assessments are defined as on-going assessments used by teachers to evaluate students' understanding during the learning process. According to Black and Wiliam (1998), formative assessments improve learning outcomes by providing timely feedback, thus allowing students to reflect on their understanding and adjust accordingly. Formative assessment techniques in Basic Science Education include quizzes, peer assessments, observations, and concept maps, which encourage active participation and self-regulation among students (Ani, 2004). Effective teaching involves integrating both formative and summative assessments.

Formative assessments can guide instructional decisions and provide as on-going feedback, while summative assessments can evaluate overall achievement and program effectiveness. Combining both approaches ensures a comprehensive understanding of students' learning and progress (Hattie & Timperley, 2007). By integrating both formative and summative assessments effectively, educators can create a balanced approach that supports continuous learning and provides a fair measure of achievement. Summative assessments are typically high-stakes evaluations that occur at the end of a lesson, unit, or academic year. These assessments help determine students' achievement and understanding of the curriculum. Studies have shown that well-designed summative assessments are crucial for measuring students' ability to apply their knowledge in real-world scenarios (Ani, Ebuoh, & Obodo, 2021). In Basic Science Education, summative assessments are often in the form of final exams, standardized tests, or end-of-term projects that require students to synthesize and demonstrate their acquired knowledge. The combination of both formative and summative assessment provides a balanced approach to

teaching and learning. Formative assessments support continuous learning, while summative assessments offer a comprehensive measure of students' overall academic performance. Research has highlighted the importance of aligning both types of assessments with clear learning objectives to ensure that students are being effectively evaluated (Bransford et al., 2000).

The integration of formative and summative assessments plays a critical role in enhancing Basic Science teaching and learning. Formative assessments support ongoing learning by providing continuous feedback, enabling students to identify and address their learning gaps. Summative assessments, in turn, offer a final evaluation of students' academic achievement and mastery of scientific concepts. By utilizing a combination of both assessment types, educators can create a more dynamic and effective learning environment, fostering deeper understanding and improving overall educational outcomes in science. Both forms of assessment have significant implications for the effectiveness of teaching and learning, especially in the context of subjects like basic science, which require critical thinking and problem-solving skills.

The Role of Formative Assessment in Enhancing Basic Science Learning

Formative assessment is a critical aspect of teaching and learning, particularly in the context of Basic Science Education. It encompasses various assessment activities that take place during the learning process, providing real-time feedback to both students and educators. Formative assessment plays a central role in shaping student understanding, guiding instructional practices, and fostering an engaging learning environment. Formative assessment refers to a range of evaluation techniques used to monitor student learning, offer feedback, and guide instructional decisions. Unlike summative assessments, which are conducted at the end of a learning period to evaluate overall achievement, formative assessments are embedded in the teaching process and serve as tools for ongoing improvement. These assessments are often low-stakes and focus on understanding rather than grading.

In Basic Science Education, formative assessments allow teachers to monitor how well science students are grasping core scientific concepts such as Biology, Chemistry, Physics, and Environmental Science. For example, formative assessments can include activities such as

quizzes, group work, practical experiments, written reflections, and concept mapping. These techniques help students engage with the material, encourage them to think critically, and improve their problem-solving skills. Formative assessments serve as a vehicle for continuous learning; providing both teachers and students with essential feedback during the learning process. By identifying students' strengths and weaknesses in real time, formative assessments allow teachers to adjust their teaching methods accordingly. This can help ensure that students are not left behind in their understanding of complex scientific concepts.

In Nigeria, where the educational system faces significant challenges such as overcrowded classrooms, limited resources, and varying levels of student readiness, formative assessments are essential. Adedayo et al. (2023) emphasized that formative assessments provide an opportunity for teachers to detect misconceptions early, thereby offering timely interventions that can prevent learning gaps. In science education, formative assessments allow for a deeper understanding of topics such as the scientific method, ecosystems, or chemical reactions, encouraging active participation and fostering a growth mindset. Moreover, formative assessments create an interactive learning environment in which students take an active role in their education. For instance, quizzes and polls can be used to gauge understanding, while feedback from peer assessments promotes collaborative learning and self-reflection.

The Role of Summative Assessment in Enhancing Basic Science Education

Summative assessment plays a crucial role in evaluating students' achievement in Basic Science Education. Unlike formative assessments, which are designed to guide and support learning throughout the teaching process, summative assessments are typically conducted at the end of a unit, semester, or academic year to evaluate a student's overall learning and mastery of the content. These assessments are high-stakes, often influencing grades, progression to the next level, or qualification for graduation. In the context of Nigerian Basic Science Education, summative assessments serve as a significant measure of students' understanding of key scientific concepts, such as Biology, Chemistry, Physics, and Environmental Science. This detailed exploration will examine the role, types, significance, challenges, and strategies of summative assessments in

Basic Science Education, with specific emphasis on the Nigerian educational context.

Summative assessments are final evaluations of students' performance that aim to judge their overall learning outcomes at the conclusion of a unit, term, or academic year. These assessments are typically high-stakes, standardized, and designed to measure how well students have met pre-determined learning objectives. Summative assessments can take various forms, such as written exams, practical tests, standardized tests, projects, or end-of-term assignments. In the context of Basic Science Education, summative assessments are essential in determining whether students have acquired the necessary knowledge, skills, and understanding in scientific subjects. For instance, students are expected to demonstrate their understanding of concepts like chemical reactions, biological processes, or physical laws in these assessments. Summative assessments typically require students to apply theoretical knowledge to solve problems, perform experiments, or explain scientific phenomena.

In Nigerian schools, the Ministry of Education mandates summative assessments in the form of final exams or end-of-term tests. These assessments are designed to measure students' cumulative knowledge and determine their readiness for progression to the next level of education. Summative assessments serve the following critical roles in the context of Basic Science Education, particularly in evaluating students' performance, providing accountability, and maintaining educational standards:

- 1. Measuring Learning Outcomes:** One of the primary functions of summative assessment is to evaluate the extent to which students have achieved the learning outcomes set out in the science curriculum. These assessments allow teachers and policymakers to assess how effectively educational objectives are being met. In Nigeria, Adebayo et al. (2023) argue that summative assessments in science provide a quantitative measure of students' understanding of scientific concepts, thus helping schools to gauge overall educational effectiveness.
- 2. Providing Feedback for Curriculum Improvement:** Summative assessments also provide valuable feedback for educators, curriculum developers, and policymakers. For instance, low scores on specific questions may indicate areas of the curriculum that need to be revisited or

strengthened. In Nigeria, summative assessments have been used to identify weaknesses in the science curriculum, leading to adjustments in teaching methods and the introduction of more interactive and inquiry-based learning approaches (Afolabi & Okoye, 2021).

3. **Accountability and Standardization:** In a diverse country like Nigeria, where schools vary in resources, infrastructure, and teaching quality, summative assessments help to standardize educational outcomes across different regions and institutions. By using standardized examinations, the government ensures that students across the country are assessed according to the same criteria. Summative assessments provide a measure of accountability to ensure that the educational system meets national standards.
4. **Gate-keeping and Certification:** Summative assessments often act as a gateway for students to progress to higher levels of education. For instance, students who pass final exams in Basic Science subjects are typically eligible to move on to higher education or vocational training programs. In Nigeria, Ogunyemi et al. (2022) highlighted the role of summative assessments in determining eligibility for further study or employment, as these assessments provide proof of students' mastery of essential scientific knowledge.

Effective Strategies for Formative Assessment in Basic Science Education

Several strategies can be employed to implement formative assessments effectively in Basic Science classrooms. The following strategies help maintain students' engagement, facilitate learning, and promote on-going development:

1. **Quizzes and Mini-Assessments:** Quizzes are a common and straightforward method of formative assessment. These can range from short, multiple-choice questions to more complex open-ended questions that require critical thinking. Frequent quizzes, administered online or on paper, help gauge students' immediate understanding of key concepts. According to Okoli & Iwuanyanwu (2022), regular quizzes enable students to reinforce their learning and provide teachers with timely insights into students' progress.
2. **Concept Maps and Diagrams:** Concept mapping is an effective formative assessment strategy that involves creating diagrams to show how different scientific ideas are interrelated.

Concept maps help students organize and visualize their understanding of complex topics, and they allow teachers to assess students' depth of knowledge. In Nigerian secondary schools, concept maps have been used successfully to explore topics such as the water cycle, food chains, and chemical reactions (Eze et al., 2023).

3. **Peer and Self-Assessment:** Peer and self-assessment methods encourage students to assess their own or their peers' work, providing an opportunity for students to reflect on their learning and identify areas for improvement. According to Nwachukwu & Olabode (2021), peer assessments in science classrooms allow students to collaborate and discuss scientific concepts, thus improving their understanding. Peer assessments also help build students' critical thinking and evaluative skills. Self-assessment encourages students to reflect on their own learning, fostering greater responsibility and accountability for their education. Teachers can provide students with rubrics to guide their self-assessments and set specific learning goals for future improvement.
4. **Practical and Hands-On Assessments:** In science education, hands-on activities such as experiments, simulations, and demonstrations are vital for engaging students in learning. Formative assessments through practical work allow students to apply theoretical knowledge to real-world situations. These assessments help students grasp the scientific method and develop problem-solving skills. Adewale et al. (2022) highlighted that practical activities, such as simple chemistry experiments or biology dissections, help students connect abstract concepts to tangible experiences.

Types of Summative Assessments in Basic Science Education

Summative assessments can take various forms, each of which has its unique strengths and weaknesses in evaluating student performance in Basic Science Education. The following are the most common types of summative assessments used in Nigerian schools:

- i. **Written Exams:** Written exams are the most common form of summative assessment in Nigerian schools. These exams typically consist of multiple-choice questions (MCQs), short-answer questions, and essay-style questions that test students' recall, understanding, and

application of scientific knowledge. The West African Examinations Council (WAEC) and the National Examinations Council (NECO) conduct standardized science examinations, such as the Senior Secondary Certificate Examination (SSCE), which test students' comprehensive understanding of science subjects (biology, chemistry, physics, etc.). Ibrahim et al. (2022) noted that written examinations are effective ways to assess students' ability to recall facts and apply concepts learned in the classroom to new scenarios. However, they also highlighted the limitations of relying solely on written examinations, such as their inability to assess practical skills and critical thinking.

- ii. Practical Assessments:** Practical assessments in Basic Science are designed to evaluate students' ability to perform scientific tasks, such as conducting experiments, making observations, and analyzing results. These assessments are especially crucial in subjects like Chemistry and Biology, where students must demonstrate hands-on competence. Practical assessments may be included in summative examinations or conducted as separate evaluations. For example, the WAEC and NECO examinations often include practical tests for subjects like Chemistry, where students are required to perform experiments and record results. Oluwaseun & Uche (2021) argued that practical assessments are invaluable in science education because they provide a direct measure of students' skills and their ability to apply theoretical knowledge in real-world situations.
- iii. Project-Based Assessments:** Project-based assessments require students to complete extended tasks that involve research, problem-solving, and the application of scientific principles. These projects can take various forms, such as research papers, group projects, or presentations. In Nigerian schools, science fairs and project exhibitions often serve as summative assessments for Basic Science subjects. Eze et al. (2022) emphasized that project-based assessments encourage deeper learning by engaging students in active inquiry and fostering teamwork. Such assessments can also promote creativity and innovation, as students explore real-world applications of scientific knowledge.

Practical Strategies for Integrating Formative and Summative Assessments in Basic Science Education:

- i. Aligning Assessments with Learning Goals:** To effectively integrate formative and summative assessments in Basic Science Education, ensure that both types of assessments align with the learning goals and objectives. This alignment helps maintain coherence between ongoing feedback and final evaluations (Sadler, 1989). For example, formative assessments such as quizzes and class activities should reflect the same objectives as the final exam.
- ii. Using Formative Data to inform Summative Judgments:** Utilize data from formative assessments to make informed decisions about summative assessments. Formative data can help identify which areas students need to focus on before the summative assessment, allowing for targeted review and support (Hattie & Timperley, 2007). Incorporating formative feedback into the summative evaluation process can also help in understanding Basic Science students' overall performance more comprehensively.
- iii. Providing On-going Feedback and Review:** Incorporate regular feedback and review sessions throughout the instructional period. Use formative assessments to provide continuous feedback and opportunities for Basic Science students to improve before the summative assessment (William, 2011). This approach ensures that Basic Science students are well-prepared and can use feedback to enhance their performance in summative assessments.

Challenges of Formative and Summative Assessment in Nigerian Basic Science Education

While formative assessment is essential for enhancing learning, there are significant challenges in implementing these methods effectively in Nigeria.

- i. Limited Resources:** A major challenge in Nigerian schools, especially in rural and underfunded urban areas, is the lack of resources for conducting effective formative assessments. Many schools lack the necessary infrastructure, including access to computers or laboratories for practical science work. The absence of these resources hinders the use of digital formative assessments such as online quizzes, interactive simulations, or virtual

experiments. To address these limitations, some schools in Nigeria are using low-cost alternatives such as paper-based quizzes, group discussions, and simple classroom experiments to gather feedback from students. However, these methods may not fully support the kind of comprehensive formative assessments that can be achieved with more modern tools.

- ii. Teacher Professional Development:** Effective formative assessment requires teachers to be well-trained in assessment methods and feedback techniques. In many Nigerian schools, teachers lack the training needed to design, implement, and interpret formative assessments. Obasi & Mbachu (2023) noted that teachers often lack professional development opportunities to improve their assessment skills, which may affect the quality of feedback provided to students.
- iii. Over-emphasis on Summative Assessment:** In Nigeria, the educational system often places more emphasis on summative assessments, such as national examinations, rather than formative assessments. This focus on final examinations can undermine the role of formative assessment, as students and teachers may prioritize examination preparation over continuous learning and feedback. According to Musa & Yusuf (2021), this overemphasis on summative assessments often leads to rote learning and reduces the focus on the development of critical thinking skills in science education.

Challenges of Summative Assessment in Nigerian Basic Science Education

Despite the importance of summative assessments, there are several challenges to their effective implementation in Nigerian Basic Science Education. These challenges include:

- i. Over-Reliance on Examinations:** One of the primary challenges of summative assessments in Nigeria is the over-reliance on written exams. This focus on written exams often neglects other forms of assessment, such as practical tasks or project-based assessments, which are crucial for evaluating scientific skills and higher-order thinking. Adebayo et al. (2023) argued that the over-emphasis on examinations leads to rote learning and a narrow understanding of scientific concepts, as students focus primarily on memorization rather than comprehension and application.

- ii. Limited Resources for Practical Assessments:** In many Nigerian schools, especially in rural areas, there is a lack of adequate resources for conducting practical assessments. Laboratories may be under-equipped, and teachers may not have access to the necessary materials to conduct experiments. As a result, students may be unable to demonstrate their practical skills, limiting the effectiveness of summative assessments in science education.
- iii. Cheating and Mal-practices:** Another significant challenge in Nigerian summative assessments is the prevalence of cheating and examination mal-practices. These practices undermine the integrity of the assessment process and the validity of the results. Ogunyemi et al. (2022) reported that examination mal-practice is widespread in Nigerian schools, particularly during high-stakes exams like WAEC and NECO. The government has implemented measures such as surveillance and stricter penalties to address this issue, but it remains a persistent challenge.

Moreover, integrating formative and summative assessments to enhance Basic Science teaching and learning involves careful management of several factors. Balancing feedback, maintaining consistency, managing time constraints, motivating students, ensuring equity, and aligning with learning objectives are crucial. By addressing these challenges effectively, educators can develop a more comprehensive and fair assessment system that supports the success of all students.

1. Balancing Feedback and Evaluation: One significant challenge is balancing the roles of formative and summative assessments. Formative assessments are intended to provide an on-going feedback that helps improve students' learning and instructional practices (William, 2011). However, the feedback from formative assessments can sometimes be overwhelming for students if not managed properly. Educators must ensure that the feedback is constructive and manageable, without causing undue stress or confusion.

2. Consistency and Reliability: Ensuring the consistency and reliability of both formative and summative assessments can be challenging. Formative assessments, while valuable for their immediate feedback, may lack consistency if not carefully designed. Summative assessments need

to be reliable and valid measures of students' learning, but they can sometimes fail to account for the diverse needs and learning styles of students (Brookhart, 2013). Educators must strive to create assessments that are both fair and consistent across different contexts and student groups

3. Time Constraints: Implementing formative assessments effectively requires significant time investment from educators. Designing and administering formative assessments, providing timely feedback, and making instructional adjustments can be time-consuming (Wiliam, 2011). Balancing these demands with the need to prepare and administer summative assessments can place additional pressure on teachers, potentially impacting their ability to provide meaningful feedback and maintain instructional quality.

4. Impact on Students' Motivation: Formative assessments are designed to be low-stakes and supportive, encouraging students' participation and self-regulation (Nicol & Macfarlane-Dick, 2006). However, if not handled well, they can inadvertently affect students' motivation. For instance, frequent assessments and feedback might lead to assessment fatigue or anxiety if students perceive them as additional pressure rather than support. Educators need to carefully manage the frequency and nature of formative assessments to maintain student motivation and engagement.

5. Equity and Fairness: Ensuring that both formative and summative assessments are equitable and fair is crucial. Summative assessments, in particular, must be designed to account for diverse learning needs and backgrounds to avoid bias and ensure that all students have an equal opportunity to demonstrate their knowledge and skills (Stiggins, 2005). Formative assessments should also be inclusive, providing support tailored to the varying needs of students to promote equitable learning outcomes (Hattie & Timperley, 2007).

6. Alignment with Learning Goals: Integrating formative and summative assessments effectively requires alignment with educational goals and objectives. Formative assessments should directly inform instruction and support the achievement of learning goals, while summative assessments should accurately reflect whether those goals have been met (Popham, 2017). Misalignment between assessment types can lead to inconsistencies in evaluating students' progress and achievement.

Conclusion

Formative assessment is an essential component of effective teaching and learning in Basic Science Education. It provides students with valuable feedback that helps them understand and apply scientific concepts more effectively. In Nigeria, formative assessments are particularly important in addressing the diverse learning needs of students, offering opportunities for teachers to adapt their instruction and ensure that students progress in their understanding of Basic Science. Summative assessments are a critical component of the educational system, particularly in Basic Science Education. They provide a measure of students' overall learning and mastery of scientific concepts, and they play a significant role in guiding students' academic progression. A more balanced approach, which incorporates various types of summative assessments, including written examinations, practical tasks, and project-based assessments, is necessary to provide a comprehensive evaluation of students' scientific knowledge and skills. However, challenges such as limited resources, inadequate teacher training, and an over-emphasis on summative assessments need to be addressed to fully realize the potential of formative assessments. The challenges associated with over-reliance on examinations, limited resources for practical assessments, and cheating must be addressed to enhance the effectiveness of summative assessments in Nigeria. Despite these challenges, on-going efforts to promote formative and summative assessments in Nigerian schools are crucial for improving Basic Science Education and achieving better learning outcomes.

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