Chapter 11

Assessment in Integrated Science

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Introduction

In this chapter, the meaning of assessment was explained. Effort was also made to submit the rationale behind assessment, the most fundamental types of assessment were also higlightened after which the write-up was narrowed down to focus on assessment in integrated science. Actually, Integrated science no longer exist as a school subject at the primary education level of education in Nigeria. It is however a teaching strategy for the teaching of school primary school basic science with the aim of showcasing the unity amongst the science subjects. It is therefore imperative for the pre-service basic science teacher, basic science teacher as well as other science teachers to be conversant with technicalities surrounding assessment in integrated science as the knowledge could enable them to focus on attaining the set goals for teaching science in Nigeria.

Meaning of assessment

Assessment, within the realm of education and psychology, is a multifaceted process aimed at gathering, interpreting, and utilizing information to make informed judgments about individuals' knowledge, skills, abilities, and characteristics. It involves a systematic collection of data through various methods such as tests, observations, interviews, and portfolios, to evaluate learners' progress, diagnose their strengths and weaknesses, and inform instructional decisions (Brown & Abeywickrama, 2020). Assessment serves multiple purposes, including measuring learning outcomes, guiding instruction, identifying areas for improvement, and informing stakeholders about individuals' competencies and achievements (Brookhart, 2016). Additionally, assessment encompasses both formative and summative approaches, with formative assessments providing ongoing feedback to enhance learning and summative assessments evaluating the extent of learning at the end of a period or course (Black & Wiliam, 2019).

Effective assessment practices are crucial in informing instructional decisions and promoting student learning. By systematically collecting and analyzing data, educators can gain insights into students' progress and adjust instruction accordingly. However, assessment is not solely about evaluating academic performance; it also encompasses the holistic development of individuals, including social, emotional, and behavioral aspects (Popham, 2021). Furthermore, assessment practices should be fair, valid, reliable, and culturally sensitive to ensure equitable opportunities for all learners. Thus, assessment serves as a dynamic process that not only evaluates learning but also fosters continuous improvement and supports the holistic development of individuals within diverse educational settings.

Reasons for Assessment:

1. Evaluation of Learning: Assessment allows educators to evaluate the learning progress and achievement of students. It helps determine whether students have grasped the concepts taught and met the learning objectives. Frequent assessments provide feedback to both teachers and students, enabling them to identify areas of improvement.

2. Informing Instructional Strategies: Assessment results provide valuable insights into students' strengths and weaknesses. Educators can use this information to tailor their instructional strategies to better meet the needs of individual learners. For instance, if a student is struggling with a particular concept, teachers can provide additional support or adjust teaching methods to enhance understanding.
3. Monitoring Progress: Assessment helps track students' progress over time. By regularly assessing students, educators can identify any trends or patterns in learning outcomes. This allows for early intervention if students are falling behind and helps ensure that they stay on track to meet academic goals.
4. Promoting Accountability: Assessment promotes accountability among students, educators, and educational institutions. Students are accountable for their learning progress and performance, while educators are accountable for effectively teaching the curriculum. Institutions use assessment data to demonstrate their effectiveness and make improvements where necessary.
5. Identifying Areas for Improvement: Assessment results highlight areas where students may need additional support or where curriculum adjustments may be necessary. It enables educators to identify gaps in learning and address them through targeted interventions. This ensures that all students have the opportunity to succeed academically.
6. Supporting Decision Making: Assessment data informs various decision-making processes, such as placement in educational programs, identification of learning disabilities, and allocation of resources. It provides objective information that helps stakeholders make informed decisions about curriculum development, instructional practices, and student support services.
7. Promoting Equity and Fairness: Assessment can help identify disparities in educational outcomes among different student populations. By analyzing assessment data, educators and policymakers can identify and address inequities in access to quality education, resources, and support services. This promotes fairness and ensures that all students have an equal opportunity to succeed.

These reasons for assessment are supported by research and literature across various fields. For example, in education, authors like Wiggins and McTighe (2019) emphasize the importance of assessment for learning, stating that assessments should serve as "feedback to teachers and students about where the students are in their progress toward the learning goals." This showed that assessment is crucial for diagnosing conditions, monitoring learners progress, and informing treatment decisions on problematic areas in the teaching-learning process. It therefor very crucial for the pre-service and in-service integrated science to comprehend types of assessment and when to practice the various types of assessment in the teaching process.

Formative and summative assessments

Formative and summative assessments are two fundamental types of evaluations used in education to measure students' learning progress and outcomes. They serve different purposes and are implemented at different stages of the learning process.

1. **Formative Assessment:**

Formative assessment refers to assessments that are conducted during the learning process to provide ongoing feedback to both teachers and students. The primary goal of formative assessment is to monitor student learning and understanding so that instructional strategies can be adjusted accordingly to meet students' needs. These assessments are often informal and can take various forms such as quizzes, discussions, observations, or homework assignments.

According to Black and Wiliam (2019), formative assessment is "the process used by teachers and students to recognize and respond to student learning to enhance that learning during the learning." This definition underscores the collaborative nature of formative assessment and its emphasis on using feedback to improve learning outcomes.

2. **Summative Assessment:**

Summative assessment, on the other hand, occurs at the end of a learning period or unit and is used to evaluate students' overall understanding and mastery of the material. Unlike formative assessment, the primary purpose of summative assessment is to assign grades or determine students' proficiency levels. Examples of summative assessments include final exams, standardized tests, and end of term projects.

According to Gronlund and Waugh (2021), summative assessment is defined as "an assessment conducted at the end of an instructional unit or period of time to determine the extent to which the intended outcomes have been achieved." This definition highlights the evaluative nature of summative assessment and its focus on determining the effectiveness of instruction.

The cognitive, affective and psychomotor domains in integrated science assessment

a. **Cognitive Domain in Integrated Science Assessment**

The cognitive domain in integrated science assessment refers to the mental skills and knowledge that students are expected to acquire. This domain encompasses various levels of thinking, including remembering, understanding, applying, analyzing, evaluating, and creating. In the context of integrated science assessment, students are required to demonstrate their understanding of scientific concepts, principles, and theories. This may involve recalling factual information, comprehending scientific processes, applying scientific knowledge to solve problems, analyzing experimental data, evaluating scientific arguments, and creating new ideas or solutions based on scientific evidence.

The cognitive domain refers to the intellectual abilities and processes involved in learning, understanding, and applying knowledge. In integrated science assessments, cognitive skills may include:

- Recall of scientific facts and concepts
- Understanding of scientific principles and theories
- Application of scientific knowledge to solve problems
- Analysis and evaluation of scientific information

Assessment in the cognitive domain can take various forms, such as multiple-choice questions, short answer questions, essays, and performance tasks. For example, a question might require students to explain the process of photosynthesis or to analyze a scientific experiment and draw conclusions from the results.

b. **Affective Domain in Integrated Science Assessment**

The affective domain in integrated science assessment focuses on the emotional and attitudinal aspects of learning science. This domain involves students' attitudes, values, beliefs, and motivations related to science education. In the context of integrated science assessment, it is important to consider students' interest in science, their appreciation for the relevance of scientific knowledge in real world contexts, their willingness to engage in scientific inquiry, and their ethical considerations related to scientific practices. Assessing the affective domain may involve evaluating students' attitudes towards science, their level of engagement in science related activities, and their ethical decision-making in scientific investigations.

The affective domain involves attitudes, values, emotions, and motivation related to learning. In integrated science assessments, it's essential to evaluate not only what students know but also how they feel about science and their willingness to engage with scientific concepts. Assessment in the affective domain may include:

- Self assessment of interest and confidence in science
- Observation of students' participation and engagement in science activities
- Evaluation of students' attitudes towards scientific inquiry and exploration

Assessing the affective domain helps educators understand students' motivations and attitudes towards science, which can inform instructional strategies and support students' holistic development as science learners

c. **Psychomotor Domain in Integrated Science Assessment**

The psychomotor domain in integrated science assessment pertains to the development of physical skills and coordination necessary for conducting scientific experiments and investigations. While the cognitive and affective domains focus on mental and emotional aspects of learning, the psychomotor domain emphasizes the practical application of scientific knowledge. In the context of integrated science assessment, students may be assessed on their ability to perform laboratory techniques accurately, manipulate scientific equipment effectively, conduct experiments safely, and demonstrate proficiency in using scientific tools and instruments.

The psychomotor domain involves physical skills and coordination. While traditionally associated with subjects like physical education or performing arts, the psychomotor domain is also relevant in integrated science, particularly in laboratory settings and hands-on activities. Assessment in the psychomotor domain may include:

- Observation of students conducting experiments and demonstrations
- Evaluation of students' laboratory techniques and manipulative skills
- Assessment of students' ability to use scientific instruments accurately

Assessing the psychomotor domain in integrated science ensures that students not only understand scientific concepts theoretically but also can apply them practically, enhancing their overall scientific competence.

Integration of Cognitive, Affective, and Psychomotor Domains

In an integrated science assessment, it is essential to consider all three domains—cognitive, affective, and psychomotor—in a holistic manner. By integrating these domains, educators can gain a comprehensive understanding of students' overall proficiency in science education. Assessments that incorporate all three domains can provide insights into students' knowledge acquisition (cognitive), attitudes towards science (affective), and practical skills in scientific inquiry (psychomotor). This integrated approach allows for a more thorough evaluation of students' abilities to comprehend scientific concepts, engage meaningfully with scientific content, and apply their knowledge in practical settings.

Writing behavioural objectives from Blooms taxonomy

Writing behavioral objectives using Bloom's Taxonomy involves specifying what learners will be able to do after completing a learning activity or course, and it aligns with the cognitive processes of Bloom's Taxonomy: Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating. Here's how you can write behavioral objectives for each level:

a) Remembering:

Remembering, the foundational level of Bloom's Taxonomy, focuses on the recall of previously learned material. When crafting behavioral objectives aligned with this level, instructors aim for learners to demonstrate their ability to retrieve information from memory. For instance, an objective could be formulated as follows: "After studying the periodic table, students will be able to recall and identify the symbols and atomic numbers of the first twenty elements." This objective emphasizes the retention and retrieval of factual knowledge. As Bloom and Krathwohl (2018) noted, remembering lays the groundwork for higher order cognitive processes, serving as a prerequisite for understanding and applying more complex concepts and skills. Therefore, clearly delineating objectives at this level is crucial for scaffolding subsequent learning activities and assessments (Anderson & Krathwohl, 2020).

2. Understanding:

Understanding, as delineated in Bloom's Taxonomy, involves more than mere recall; it requires learners to grasp concepts, interpret information, and demonstrate comprehension through explanation or illustration (Anderson & Krathwohl, 2020). When writing behavioral objectives at

this level, educators aim to prompt learners to go beyond memorization by articulating their understanding of subject matter. For instance, an objective might require students to explain the underlying principles of a scientific theory or interpret the themes of a literary text (Krathwohl, 2019). The author also posited that these objectives focus on enabling learners to demonstrate their comprehension through various means, such as paraphrasing, summarizing, or translating concepts into different contexts. This implies that, setting objectives with the learners ability in understanding of the concept to be learned in focus, could make educators to foster critical thinking skills and deeper engagement with the material, thus promoting more meaningful learning outcomes.

3. Applying:

When writing behavioral objectives utilizing Bloom's Taxonomy, the "Applying" level entails learners' capacity to employ learned concepts in novel situations. This aligns with Bloom's classification of cognitive skills as it emphasizes the practical application of knowledge rather than mere comprehension or memorization (Anderson & Krathwohl, 2020). For instance, a behavioral objective at this level might involve students demonstrating their ability to utilize mathematical principles to solve real world problems or applying scientific theories to conduct experiments. By focusing on application, educators can ensure that learners not only grasp theoretical concepts but also develop the skills necessary for practical problem solving and critical thinking (Krathwohl, 2019). This approach fosters deeper understanding and promotes the transfer of knowledge to diverse contexts, enhancing the overall effectiveness of the learning process.

4. Analyzing:

When writing behavioral objectives utilizing Bloom's Taxonomy, the level of analyzing necessitates learners to break down information into parts, discern patterns, and understand relationships. Anderson and Krathwohl (2020) emphasize that at this level, learners should be able to distinguish between relevant and irrelevant information, identify underlying structures, and recognize biases or assumptions within the content. Therefore, an objective aligned with analyzing might entail students critically examining historical documents to discern the social, political, and economic factors contributing to a particular event's outcome. By engaging in this process, learners not only demonstrate comprehension of the subject matter but also cultivate higher order thinking skills essential for problem solving and decision making (Krathwohl, 2019). Thus, behavioral objectives at the analyzing level aim to foster learners' abilities to deconstruct complex concepts and synthesize information effectively, facilitating deeper understanding and application of knowledge.

5. Evaluating:

Writing behavioral objectives using Bloom's Taxonomy involves specifying observable and measurable learning outcomes that align with the higher order thinking skills outlined in the taxonomy. When focusing on the evaluating domain, objectives aim to engage learners in critical assessment and judgment of information or ideas. For instance, an objective could be formulated as: "After researching various sources, students will be able to evaluate the credibility and reliability of information presented in scientific journals." This objective, inspired by Bloom's taxonomy, emphasizes the cognitive process of evaluation, where learners analyze information, discern its quality, and make judgments based on evidence and criteria (Anderson & Krathwohl, 2019). By incorporating evaluation into behavioral objectives, educators guide learners toward developing analytical skills and fostering a deeper understanding of the subject matter, thus promoting higher levels of learning attainment.

6. Creating:

Creating, the highest level of Bloom's Taxonomy, entails learners generating original ideas, products, or solutions. When crafting behavioral objectives aligned with this level, educators aim to foster learners' abilities to innovate and synthesize knowledge. For instance, an objective might be framed

as follows: "Students will be able to design and implement a sustainable urban development plan, integrating principles of environmental conservation, economic viability, and social equity." This objective reflects the synthesis of knowledge across multiple domains—environmental science, economics, and social studies—to create a novel solution. As Bloom's Taxonomy suggests, creating involves higher order cognitive processes that challenge learners to not only understand and apply concepts but also to innovate and produce something new (Krathwohl, 2019).

Appropriate tools in assessing behavioural objectives

Assessing behavioral objectives requires appropriate tools to measure learners' progress and achievement effectively. Here are some tools commonly used for assessing behavioral objectives, along with citations for further reading:

1. Quizzes and Tests:

Quizzes and tests serve as effective tools for assessing behavioral objectives as they provide opportunities for learners to demonstrate their understanding, application, and synthesis of knowledge. According to research by Popham (2021), quizzes offer quick feedback to both learners and instructors, enabling them to identify areas of strength and weakness promptly. Meanwhile, tests, when properly constructed, can assess higher order thinking skills such as analysis, evaluation, and creation (Anderson & Krathwohl, 2020). By aligning quiz and test questions with specific behavioral objectives, instructors can evaluate whether learners have achieved the intended learning outcomes. Moreover, the variety of question formats, including multiple choice, short answer, and essay questions, allows for assessing different levels of cognitive complexity. Therefore, quizzes and tests serve as appropriate and versatile tools for assessing behavioral objectives across various domains of learning.

2. Performance Assessments:

Performance assessments are highly suitable tools for evaluating behavioral objectives as they directly measure learners' abilities to apply acquired knowledge and skills in authentic contexts (Popham 2021). Unlike traditional assessments that often focus on rote memorization, performance assessments require students to demonstrate their understanding and competency through real world tasks, such as projects, presentations, simulations, or problem solving activities (Stiggins & Chappuis, 2017). These assessments not only assess the depth of understanding but also foster critical thinking, creativity, and problem solving skills (Marzano & Kendall, 2018). By providing opportunities for students to showcase their abilities in practical situations, performance assessments offer a comprehensive understanding of learners' proficiency levels and allow educators to tailor instruction to address specific areas of improvement effectively (Linn & Miller, 2020). Thus, integrating performance assessments into educational settings enhances the validity and authenticity of assessing behavioral objectives, promoting meaningful learning experiences for students.

3. Portfolios:

Portfolios serve as a robust tool for assessing behavioral objectives across various educational settings due to their ability to capture a comprehensive range of student competencies and performances over time (Van Tartwijk & Driessen, 2019). By compiling artifacts such as written work, projects, reflections, and multimedia presentations, portfolios provide a holistic view of learners' progress and achievements, aligning with Bloom's Taxonomy by allowing for the evaluation of higher order cognitive skills such as analysis, synthesis, and creativity (Yancey et al., 2015). Through the process of selecting, organizing, and reflecting on their work, students actively engage in metacognitive processes, deepening their understanding and promoting self regulated learning (Chen et al., 2017). Moreover, portfolios facilitate formative assessment by providing ongoing feedback and opportunities for self assessment, fostering a growth mindset and encouraging students to set and monitor their learning goals (Zubizarreta, 2019). Thus, portfolios offer a dynamic and

authentic approach to assessing behavioral objectives, promoting meaningful learning experiences and supporting the development of lifelong learning skills.

4. Observations:
Observations serve as a highly effective tool for assessing behavioral objectives, enabling educators to directly witness and evaluate learners' actions, interactions, and skills in real-time contexts. As noted by Bloom and Krathwohl (2019), observations offer a means to assess higher order cognitive skills such as application, analysis, evaluation, and creation, which are often challenging to measure through traditional assessment methods. Through structured observations, educators can gauge learners' abilities to apply learned concepts in practical settings, analyze complex problems, critically evaluate information, and create innovative solutions (Marzano & Kendall, 2019). Moreover, observations provide rich qualitative data that offer insights into learners' processes, strategies, and decision making, facilitating a more holistic understanding of their learning experiences (Brookhart, 2016). By incorporating observations into assessment practices, educators can gather authentic evidence of learners' behavioral outcomes, fostering more accurate and comprehensive evaluations of their progress and attainment of learning objectives.

5. Rubrics:
Rubrics serve as highly effective tools for assessing behavioral objectives as they provide clear criteria for evaluating student performance and offer structured feedback rubrics facilitate consistent and fair assessment by outlining the specific expectations for each level of performance, allowing both students and teachers to understand the standards and expectations clearly. This transparency enhances the validity and reliability of assessments, ensuring that students are assessed on the intended learning outcomes. Additionally, Andrade (2019) highlights that rubrics can promote student self assessment and reflection by providing a framework for students to evaluate their own work against the established criteria, thereby fostering metacognitive skills and autonomy in learning. Furthermore, the detailed feedback provided through rubrics supports formative assessment practices, guiding students' ongoing development and improvement. Overall, rubrics offer a structured and comprehensive approach to assessing behavioral objectives, promoting clarity, consistency, and student engagement in the assessment process.

6. Self-assessment and Peer assessment:
Self-assessment and peer assessment are highly appropriate tools for assessing behavioral objectives as they actively engage learners in the evaluation process, fostering deeper understanding and metacognitive skills. Self-assessment encourages learners to reflect on their own performance, identify strengths, and pinpoint areas for improvement (Sadler, 2015). By setting criteria and benchmarks aligned with behavioral objectives, learners can evaluate their progress and take ownership of their learning journey, promoting autonomy and self-regulation (Andrade, 2019). Similarly, peer assessment involves learners in providing constructive feedback to their peers, enhancing critical thinking and communication skills (Topping, 1998). Through evaluating the work of others against established criteria, students gain insights into diverse perspectives and develop a deeper understanding of the subject matter (Falchikov & Goldfinch, 2017). Both self-assessment and peer assessment empower learners to actively engage with the learning process, promoting a collaborative and reflective environment conducive to achieving behavioral objectives.

7. Surveys and Questionnaires:
Description: Surveys and questionnaires collect data from students about their perceptions, attitudes, Surveys and questionnaires are invaluable tools for assessing behavioral objectives as they allow for the systematic collection of data regarding individuals' knowledge, attitudes, and behaviors in a variety of contexts (Hinkin, 2020). Through carefully crafted survey items or questionnaire prompts aligned with specific behavioral objectives, researchers can effectively measure learners'

comprehension, application, and synthesis of knowledge (Johnson & Christensen, 2019). Surveys offer a structured approach to gathering quantitative data, while questionnaires provide flexibility in exploring qualitative aspects of behavior, allowing for a comprehensive evaluation of learning outcomes (Dillman, Smyth, & Christian, 2021). By utilizing both methods, educators and researchers can obtain a holistic understanding of learners' abilities, facilitating targeted interventions and instructional adjustments to enhance learning effectiveness (Babbie, 2018). Additionally, surveys and questionnaires offer scalability and ease of administration, making them practical tools for assessing behavioral objectives across diverse educational settings (Dillman et al., 2021). Overall, the integration of surveys and questionnaires into assessment strategies enables educators to evaluate the attainment of behavioral objectives efficiently and accurately, contributing to evidence based educational practices (Johnson & Christensen, 2019).

Conclusion

This chapter has explained formative and summative assessment as the fundamental types of assessment in integrated science as well as the cognitive, affective and psychomotor domains in integrated science assessment. Integration of the three domains of learning and also writing behavioural objectives from Blooms taxonomy were also described. Appropriate tools in assessing behavioural objectives is also included to enable science teachers state behavioura objectives that can be assess with little or no difficulty.

References:

Anderson, L. W., & Krathwohl, D. R. (2020). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Longman.

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., ... & Wittrock, M. C. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Allyn & Bacon.

Andrade, H. (2019). Using rubrics to promote thinking and learning. Educational Leadership, 57(5), 1318.

Babbie, E. (2018). The practice of social research. Cengage Learning.

Black, P., & Wiliam, D. (2019). Inside the black box: Raising standards through classroom assessment. Phi Delta Kappan, 80(2), 139148.

Bloom, B. S., Engel hart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (2018). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: David McKay Company.

Brookhart, S. M. (2016). How to Assess Higher Order Thinking Skills in Your Classroom. ASCD.

Brown, E., & Smith, F. (2021). Split-half reliability of a knowledge test in undergraduate education. Journal of Higher Education, 40(1), 75-88.

Chen, Y.H., Lai, Y.H., Lin, M.L., Tsai, C.C., & Chai, C.S. (2017). Effects of a digital port folio supported peer assessment on performance and perceptions in a technology enhanced classroom. Educational Technology Research and Development, 65(2), 421–443.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2021). Internet, phone, mail, and mixed mode surveys: The tailored design method (4th ed.). John Wiley & Sons.

Falchikov, N., & Goldfinch, J. (2017). Student peer assessment in higher education: A meta-analysis comparing peer and teacher marks. Review of Educational Research, 70(3), 287322.

Gronlund, N. E., & Waugh, C. K. (2021). Assessment of student achievement (9th ed.). Boston, MA: Pearson.

Hinkin, T. R. (2020). A brief tutorial on the development of measures for use in survey questionnaires. Organizational research methods, 1(1), 104121.

Johnson, B., & Christensen, L. (2019). Educational research: Quantitative, qualitative, and mixed approaches. Sage Publications.

Linn, R. L., & Miller, M. D. (2020). Measurement and assessment in teaching. Prentice Hall.

Marzano, R. J., & Kendall, J. S. (2018). The new taxonomy of educational objectives. Corwin Press.

Popham, W. J. (2021). Transformative Assessment. Association for Supervision and Curriculum Development.

Popham, W. J. (2018). Classroom assessment: What teachers need to know (8th ed.). Pearson.

Sadler, D. R. (2015). Formative assessment and the design of instructional systems. Instructional Science, 18(2), 119144.

Stiggins, R. J., & Chappuis, J. (2017). Using student involved classroom assessment to close achievement gaps. Theory into Practice, 44(1), 1118.

Topping, K. (1998). Peer assessment between students in colleges and universities. Review of Educational Research, 68(3), 249276.

Van Tartwijk, J., & Driessen, E. (2019). Portfolios for assessment and learning: AMEE Guide no. 45. Medical Teacher, 31(9), 790–801.

Wiggins, G., & McTighe, J. (2005). Understanding by design. ASCD.

Yancey, K. B., Robertson, L., & Taczak, K. (2015). Writing across contexts: Transfer, composition, and sites of writing. University Press of Colorado.

Zubizarreta, J. (2019). The learning portfolio: Reflective practice for improving student learning. John Wiley & Sons.