SCIENCE TEACHERS' AWARENESS AND UTILIZATION OF INNOVATIVE FORMATIVE ASSESSMENT TECHNIQUES FOR ASSESSING STUDENTS IN SCIENCE CLASSROOMS IN ANAMBRA STATE

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Abstract: *The growing need to survive in a 21st century global competitive society has presented the need to restructure the teaching and learning process to not just employ innovative instructional approaches that can promote learning but also formative assessment techniques that can help improve classroom instruction for effective delivery. In this light, the study sought to investigate science teachers' awareness and utilization of innovative formative assessment techniques (IFAT) for assessing students in science classrooms in Anambra state. Two research questions guided the study. A descriptive survey research design was adopted. 150 science subject teachers, drawn using simple random sampling technique, comprised the sample of the study. An instrument titled "Checklist on Science Teachers' Awareness*

and Utilization of Innovative Formative Assessment Techniques (CSTLAUIFAT)" developed by the researchers for the teachers was used for data collection. The 50-item checklist was subjected to face and content validity by three experts and with a reliability coefficient of 0.82 established using Cronbach Alpha. Frequency count, percentages, weighted Mean and standard deviation were used to answer the research questions. The findings of the study revealed that although science teachers are aware of some of these innovative formative assessment techniques, they however do not utilize most of them in the teaching and learning process. Based on the findings, it was then recommended among others that education stakeholders should organize workshops, seminars, symposia, and conferences to educate teachers on these innovative assessment techniques and how to implement them in the classroom.

Keywords: *science; assessment; formative assessment; innovative formative assessment.*

1. Introduction

Science has long been recognized as the cornerstone for present-day technological advancements as it has contributed immensely to the development of the world. This is probably why, Nwuba et. al. (2022) emphasized that the applications of science to every sphere of life has necessitated every nation, both developed and still developing, to strive for its advancements in science and technology. Science is the systematic study of nature or universe, acquired through observation, experimentation, measurement and recording, whose knowledge is applied to every aspect of life (Obidimma & Osuafor, 2019). Anaekwe, Nzelum, Olisakwe and Okpala (2010) defined it as a dynamic process of seeking for knowledge about nature, acquired through systematic observation and experimentation, which is applied to every aspect of life. Hence, science may simply be defined as the systematic study of nature, acquired through the use of scientific method.

As a field of study, which comprises subjects such as biology, chemistry, physics, mathematics, economics, agriculture, science has done a lot for mankind over the years. For instance, with the knowledge of science, man has been able to understand his environment enabling him to manipulate the conditions of the environment to his benefit and that of the society. Supporting this, Nwanguma (2014) stated that the knowledge of science helps man know more about the universe and with the application of this knowledge, it will be easier for man to explore the environment and existence. In light of the premise, it becomes imperative to note that the importance of science to man

cannot be overemphasized, and with this notice, calls for the restructuring of approaches employed in the classroom to promote and foster the acquisition of scientific knowledge and skills. This restructuring, in recent times, has caused a paradigm shift in education shifting emphasis from the normally used conventional methods of teaching and assessments techniques to innovative approaches that aims to impact knowledge, develop skills and foster abilities in learners. This paradigm shift which is geared towards making the teaching and learning process learner-centered and activity-based oriented, implores teachers to employ not just innovative methods of instruction but also innovative formative assessment techniques during classroom instruction to improve classroom delivery.

Assessment is a vital tool in education as it helps education stakeholders ascertain within or at the end of every program or lesson the extent to which learners have achieved the stated objectives. Erwin cited in Bugg (2013) defined it as the process of defining, selecting, designing, collecting, analyzing, interpreting information while using the information to increase students' learning and development. It is a tool that educators are using in classrooms to understand what students are learning, how students are learning, and where students may need interventions (Bugg, 2013). Hence, Assessment may be defined as any tool or technique used in any learning process to determine the extent to which a stated objective has been achieved. Assessment techniques used in various classrooms today, according to Akanwa, Agommoh and Ihechu (2019) are of three forms: diagnostic, summative and formative assessments. Akanwa et. al. posited that although each assessment may serve different purposes, their primary focus is on the students' performance index. In the content of the study, formative assessment was discussed.

Formative assessment also referred to as "assessment for learning" according to Dodge (2018) is an integral part of effective teaching and learning that enables the teacher to decide how best to help the learners understand the subject matter and support their learning during learning process. It is the name given to assessments which monitor students' progress, without grading, and using this information to adapt teaching and learning to facilitate the students' needs during the task or activity (Cullinane, 2011). West Virginia Board of Education (2018) defined formative assessment as a deliberate daily process used by teachers and students during instruction that provides actionable feedback used to adjust ongoing teaching and learning to improve students' achievement of intended learning outcomes. It is a process in which teachers and students provide feedback during instruction to organize the learning and teaching process in order to increase and enhance instruction. (Prashanti

&Ramnarayan, 2019). Hence, formative assessments are simply tools or techniques employed by teachers and students during classroom instruction to improve learning outcomes, give feedback to students and/or guide their instruction.

Considering the above definitions, one can categorically posit that the importance of formative assessment in the teaching and learning process cannot be overemphasized. Keeley cited in Cullanine (2011) asserted that formative assessment; activates thinking and engages learning, make students ideas explicit to themselves and as well as the teacher, encourages participation of all learners by increasing comfort in making one's ideas public (particularly quieter students who often may not contribute to lessons), presents a stimulus for discussion and scientific argumentation, determines if students can apply scientific ideas to new situations as well as give and use feedback (student to student, student to teacher and teacher to student). In line with the premise, Wuest and Fisette (2012) posited that formative assessment informs teachers whether the students have learned indicating qualification for how the teachers should plan their next lessons. Similarly, Reiger (2012) stated that formative assessment strategies enable teachers' heck for understanding of students learning and to make decisions about current and future instruction. Reiger further stressed that through formative assessment, teachers can discover the rate at which students are learning, the current knowledge of students, what information or skills students still need to learn, and whether the learning opportunities they are providing for students is effective or if they need to change or adapt their instruction. Summarizing the above benefits, Prashanti and Ramnarayan (2019) in their study gave ten maxims of formative assessments as follows: Formative assessment remains faceless, facilitates active learning, encourages feedback, engenders feed forward, reiterates focus on learning and not on grading, provides flexibility, happens fast, occurs frequently, propagates a friendly learning environment and generates fun in learning.

Prior to innovations in education, formative assessment techniques employed in schools have been limited to mostly questions, tests, projects, oral presentations which aim specifically improve classroom delivery for effective teaching. Ritchhart, Church, and Morrison (2011) asserted that although these techniques make students responsible for their own learning, give each student a chance to create their own knowledge of the subject, make students work together with their peers and their teachers, expand student's framework and move towards more complex knowledge and understanding, not all questions, tests, projects, and oral presentations are compelling. In other words, not all the above-mentioned techniques actively involve the learners in activities that

goes beyond classroom instruction that can promote creativity, critical thinking and problem-solving skills for effective survival while fostering classroom delivery in the process. Supporting the premise, Price, Pierson and Light (2011) in their study posited that to promote students learning in an emerging competitive economy, it is important to transform how teachers assess their students' learning in the classroom as the constant use of recall test, or by asking content questions during a lecture has proved to be ineffective in producing 21st century competent citizens. In this light, there arises the need to inculcate assessment techniques that can promote skill acquisition while actively enhancing classroom delivery, hence the innovative formative assessment techniques.

Innovative formative assessment techniques (IFAT) are those novel and creative tools employed by teachers in the classroom to not only efficiently improve classroom delivery but also develop higher mental process skills in learners. They are those newly employed classroom assessment tools used to ascertain learners' assimilation level of a taught concept while developing and fostering learners' problem-solving skills in the process. McMillan (2014) stated the innovative assessment tools adopted in the 21st century classroom has gone beyond tests, projects, oral presentations as educational planners and implementers are continuously searching for tools that can help students engage better, achieve better and become productive members of the society as learning in the world today has gone beyond just classroom applications. Similarly, Price, Pierson and Light (2011) in their study posited that with current trends in the 21st century competitive economy, IFAT should be adopted in schools as high quality teacher-designed assessments provide insight on what and how students are learning in time for teachers to modify or personalize instruction, allow teachers to assess a broader range of skills and abilities in addition to content recall as well as give students new roles in the assessment process that can make assessment itself a learning experience and deepen student engagement in content.

Innovative formative assessment techniques employed in schools today are vast and wide. For instance, VanVoorhis (2008) listed Exit/Admit cards, Authentic questioning, Brainstorm, Chunking (graphic organizers), concept links, clip board pass around, discuss with a partner, group Q and A, E resources, mental rehearsals, one minute paper, read-write-pair-share, reciprocal questioning, retelling, student generated test questions, think-pair-share, value line-up, whip around, write questions, metacognition, yesterday news among others as examples of IFAT. Similarly, Price, Pierson and Light (2011) identified Rubrics, Performance-based assessments (PBAs), Portfolios, Student self-assessment, Peer-assessment, and Student response systems as

formative assessment techniques particularly relevant to the educational context of developing countries. In the same vein, Reiger (2012) and Lambert (2012), in their respective publications, both agreed that the major forms of innovative formative assessment techniques include ABC brainstorming, Analogies, use of demonstration stations, exit cards, graphic organizers, inside-outside circle, one minute essay, one sentence summary, peer assessment, self-assessment, placemats, think-pair-share, three facts and a fib, three-minute-pause, three things, whip around, concept maps, three things, 3-2-1, four corners, graffiti walls, individual whiteboards, performance tests, portfolios, reciprocal teaching, metacognition, idea spinner, take and pass, list 10 things, problem solving etc.

Having conducted several studies on the various forms of innovative formative assessment tools, Cambridge Assessment International Education (2017) asserted that when IFAT are effectively employed, they are very useful during the teaching and learning to help teachers and students evaluate progress in terms of understanding and skills acquisition, as well as provide guidance and feedback for subsequent teaching and learning. Similarly, McMillan and Hearn (2008) emphasized that in contrast to the traditional teacher-designed, administered and graded tests, which demand a low level of cognition, IFAT involves students throughout the assessing process fostering their metacognition, active participation, problem-solving and higher order thinking skills as these techniques ultimately puts students at the center of the learning process. IFAT when effectively implemented encourages student/teacher relationships, teacher's ability to personalize instruction, acquisition of 21st century skills, student engagement and student metacognition (Price, Pierson & Light, 2011). Supporting the premise, Chu et. al. (2016) stated that in employing these 21st century assessment tools, students' competency is effectively activated enabling them demonstrate their proficiency in various skills in a low-risk environment, thus promoting teaching and learning to the students' advantage. Considering these benefits associated with adopting IFAT in the teaching and learning process, the researchers deemed it necessary to ascertain science teachers' awareness of these techniques and how often they utilize them in their science classrooms.

Statement of the Problem

The growing need to improve and foster effective classroom delivery during the teaching and learning process have driven researchers in search of not only innovative methods of instruction but also formative assessment techniques to employ in the teaching and learning process that can help foster students understanding, retention, academic achievement, higher order thinking skills

as well as acquisition of the 21st century skills of communication, creativity, critical thinking and collaboration in the classroom. This restructuring of the education system has caused a paradigm shift from the normally used conventional methods of formative assessments to innovative formative assessment techniques with the aim to promote school-industry linkage while making assessment an activity-based and integral part of the learning process. In this light, the study sought out to ascertain science teachers' awareness of these innovative formative assessment techniques and the extent to which they utilize them in the classroom.

Research questions

The following research questions were formulated to guide the study:

1. What innovative formative assessment techniques are science teachers aware of for assessing students in science classrooms?
2. To what extent do science teachers utilize innovative formative assessment techniques for teaching and learning in science classrooms?

2. Methodology

The study adopted a descriptive survey research design. 180 science subject teachers drawn from the 262 secondary schools in Anambra State using simple random sampling technique, without replacement, constituted the sample of the study.

A 50-item instrument titled "Checklist on Science Teachers' Awareness and Utilization of Innovative Formative Assessment Techniques (CSTAUIFAT)" which was developed by the researchers from experiences in teaching and different review of literature was used for data collection. CSTAUIFAT comprised of three sections: Section A sought information on the personal data of the respondents, section B contained research question one with its items while section C contained research question two, and its items. Research question one contained a checklist of 25 items with a two-point response options of Aware (A) and Not Aware (NA) while research question two had the same 25 items but with a 5-point Likert-like response options of Always (A), Often (O), Sometimes (S), Rarely (R) and Never (N).

For face and content validity, the instrument was validated by three experts, two from the Department of Science Education and One from the Department of Measurement and Evaluation, all from Nnamdi Azikiwe University, Awka. The reliability of the instrument was that of internal consistency established

using Cronbach Alpha, since the instrument was polychotomously scored. A reliability coefficient of 0.82 was obtained showing that the instrument was highly reliable.

The collected data were analyzed using frequency counts, percentages, weighted mean and standard deviation to answer the items in the research questions. For research question one, frequency counts and percentages were used to answer the items while weighted mean and standard deviation were used to answer the items in research question two. In taking decision on items in research question one, 50% and above was considered "Aware (A)" while a percentage value below 50 was considered "Not Aware (NA)". For research question two, any item with a mean score of 3.00 and above was taken to be "Utilized (U)" while any with a mean score less than 3.00 was taken to be "Not Utilized (NU)"

3. Results and Discussion

Research Question 1: What innovative formative assessment techniques are science teachers aware of?

Table 1: Science Teachers' Frequency Count and Percentage Responses on their awareness of innovative formative assessment techniques

		AWARE		NOT AWARE		
S/N	**Item**	**F**	**%**	**F**	**%**	**Decision**
1	Brainstorming	89	59.3	61	40.7	Aware
2	Think-Pair-Share	79	52.7	71	47.3	Aware
3	One Minute Summary/Essay	103	68.7	47	31.3	Aware
4	Analogies	87	58	63	42	Aware
5	Performance Test (Authentic Assessment)	92	61.3	58	38.7	Aware
6	Individual Whiteboards	43	28.7	107	71.3	Not Aware
7	Whip Around	23	15.3	127	84.7	Not Aware
8	Concept Maps	138	92	12	8	Aware

9	Four Corners	21	14	129	86	Not Aware
10	Graffiti Walls	45	30	105	70	Not Aware
11	Use of Demonstration Stations	87	58	63	42	Aware
12	Exit Cards	93	62	57	38	Aware
13	Graphic Organizers	99	66	51	34	Aware
14	Inside-Outside Circle	34	22.7	116	77.3	Not Aware
15	Peer Assessment	102	68	48	32	Aware
16	Self-Assessment	112	74.7	38	25.3	Aware
17	Student Generated Questions	142	94.7	8	5.3	Aware
18	Three Facts And A Fib	32	21.3	118	78.7	Not Aware
19	Three-Minute-Pause	82	54.7	68	45.3	Aware
20	Problem solving	104	69.3	46	30.7	Aware
21	Reciprocal Teaching	68	45.3	82	54.7	Not Aware
22	E-Resources (online sources)	148	98.7	2	1.3	Aware
23	Portfolios	57	38	93	62	Not Aware
24	Numbered Heads together	86	57.3	64	42.7	Aware
25	Metacognition	56	37.3	94	62.7	Not Aware

Science Teachers' Awareness of Innovative Formative Assessment Techniques for Assessing Students in Science Classrooms

Table 1 presents the frequency counts and percentages of science teachers' responses on their awareness of innovative formative assessment techniques for teaching in the classroom. Analysis of the collected data shows that majority of the respondents (science teachers) agreed that they are aware of 16 out of the 25 listed innovative formative assessment techniques namely: brainstorming, think-pair share, one minute summary/essay, use of analogy, use of concept maps, performance tests, use of demonstration stations, exit cards, graphic organizers, peer and self-assessments, students generated

questions, three minute pause, problem solving, E resources, and numbered heads together since they all had a percentage value of 50 and above. The respondents however revealed that they are not aware of individual whiteboards, whip around, four corners, graffiti walls, inside-outside circles, three facts and a fib, reciprocal teaching, portfolios and metacognition as they all had a percentage score below 50%.

The findings of this study disagree, and somewhat to an extent, agrees with the findings of Herman (2017) who revealed in his study that most science teachers are not aware of some, if not most, of the innovative formative assessment techniques and hence, cannot utilize what they have no knowledge of.

Research Question 2: To what extent do science teachers utilize innovative formative assessment techniques for teaching science subjects in the classroom?

Table 2: Science Teachers Mean Responses on extent of utilization of innovative formative assessment techniques

s/n	Item	Mean (X)	Std. De.	Decision
1	Brainstorming	3.17	1.52	Utilized
2	Think-Pair-Share	2.90	1.28	Not Utilized
3	One Minute Summary/Essay	3.25	1.49	Utilized
4	Analogies	3.67	1.39	Utilized
5	Performance Test (Authentic Assessment)	2.31	1.11	Not Utilized
6	Individual Whiteboards	2.01	1.22	Not Utilized
7	Whip Around	2.33	1.25	Not Utilized
8	Concept Maps	4.00	1.13	Utilized
9	Four Corners	2.05	1.10	Not Utilized
10	Graffiti Walls	1.91	0.97	Not Utilized
11	Use of Demonstration Stations	1.82	1.09	Not Utilized

12	Exit Cards	1.92	1.03	Not Utilized
13	Graphic Organizers	2.25	1.11	Not Utilized
14	Inside-Outside Circle	1.83	1.15	Not Utilized
15	Peer Assessment	2.36	1.72	Not Utilized
16	Self-Assessment	2.32	1.23	Not Utilized
17	Student Generated Questions	3.55	1.33	Utilized
18	Three Facts And A Fib	1.59	0.84	Not Utilized
19	Three-Minute-Pause	3.56	1.26	Utilized
20	Problem solving	3.84	1.27	Utilized
21	Reciprocal Teaching	1.80	0.91	Not Utilized
22	E-Resources (online sources)	4.28	0.91	Utilized
23	Portfolios	2.28	1.31	Not Utilized
24	Numbered Heads together	3.00	1.20	Utilized
25	Metacognition	2.51	1.14	Not Utilized

Science Teachers' Utilization of Innovative Formative Assessment Techniques for Assessing Students in Science Classrooms.

Table 2 presented science teachers' responses on their utilization of innovative formative assessment techniques in science classroom. Analysis of the data collected from the respondents in table 2 revealed that out of the 25 listed IFAT, only 9 techniques were agreed to be utilized by of the respondents. That is, the respondents agreed that they utilize E resources, concept maps, problem solving, three-minute pause, analogies, student generated questions, one minute summary/essay, brainstorming, and numbered heads together, since they all had a mean score of 3.00 and above. But disagreed that they utilize Think-pair-share, performance test, individual whiteboards, whip around, graffiti walls, four corners, use of demonstration stations, exit cards, graphic organizers, inside-outside circle, peer and self-assessment, three facts and a fib, portfolios, reciprocal teaching and metacognition, even when aware of the some of the unutilized techniques, since they all had a mean score below 3.00.

The findings of this study agree with the findings of Akanwa, Agommuoh and Ihechu (2019) who revealed in their study that science teachers use most of the conventional formative assessment techniques avoiding sophisticated and upgraded result-oriented strategies that include Listen-Think-Pair-Share, Progress monitoring system, Student self-assessment, and Exit assessment, even when aware of some of them. This inability to utilize some of these techniques, they are aware of, may be attributed to lack of pedagogical knowledge, inadequate time allocation or poor teaching incentives from the state and federal government.

4. Conclusion

The study sought out to investigate science teachers' awareness and extent of utilization of innovative formative assessment techniques for assessing students in science classes. Based on the findings of the study, the study concluded that most science teachers in Anambra State are aware of some of these innovative assessment techniques but do not utilize all of them. That is, out of the 16 innovative formative assessment techniques agreed by the respondents to have knowledge of, only 9 is being utilized in science classrooms. This inability to utilize these techniques could be attributed to many factors ranging from the cumbersome nature of the science curriculum, high workload, lack of practical applications knowledge, inadequate time allotted to science classes to unavailability of instructional materials and facilities to effectively implement these techniques in the classroom.

5. Recommendations

Based on the findings of the study, the following recommendations were made**:**

1. Workshops, seminars and conferences should be organized by education stakeholders for science teachers to educate them on these innovative formative assessment techniques and how to effectively implement them in the classroom.

2. Instructional materials and facilities should be provided for teachers by education stakeholders, for their use, when necessary, in assessing their students in science classes.

3. Teacher training colleges and institutions should foster the use of innovative formative assessment techniques in training (assessing) student-teachers, when in school, to inculcate in them the practical applications of these techniques.

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