

Thematic Article

Secondary School Biology Teachers' Knowledge and Practices of Formative Assessment in Tanzania

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Abstract

Using formative assessment (FA) practices in teaching and learning is essential to understanding students' learning and making informed decisions about students' academic performance. This study examined secondary school biology teachers' knowledge and practices of FA in Tanzania. Using a mixed-methods research approach and convergent mixed-methods research design, the study employed simple random and purposive sampling techniques to select the study area and teachers, respectively. A questionnaire and observation checklist used to collect data from 55 teachers in secondary schools. The Statistical Packages for Social Sciences (SPSS) version 26.0 was used to compute descriptive statistics. Findings revealed that though teachers had theoretical knowledge of FA practices, they failed to implement them, particularly Socratic questioning, portfolios, and constructive feedback. This study concludes that teachers did not implement FA practices in the surveyed schools. Thus, there is a need of regular in-service training to develop teachers' practical competences in FA practices to enhance classroom teaching and students' learning in biology.

Keywords: formative assessment, biology teachers' knowledge, questioning strategy, Tanzania

Introduction

In teaching and learning, assessment is vital for tracking students' learning progress and making informed decisions (Black & Wiliam, 1998; Kikomelo et al., 2023; Rahman et al., 2021). This assessments can be either formative or summative. It helps determine the extent to which students have mastered the concepts taught and achieved learning objectives. Without assessment, teachers remain uncertain about how much students understand and whether or not they acquire the knowledge and skills they are intended to gain.

Formative assessment (FA) involves collecting information on students' learning progress to monitor how they learn and to make immediate instructional adjustments. Black and Wiliam (1998) state that FA encompasses all activities practiced by teachers and students in the classroom during teaching and learning that provide information about students' learning and feedback on the effectiveness of classroom instruction. It involves practices such as using questioning strategies to probe student responses, and provide feedback and comments on those responses (Ismail et al., 2022). Probing helps get information about their understanding of the concepts that have been taught in class. Thus, FA practices, should embrace interactions between teachers and students. Teachers need to provide students with ample time to think and respond to questions, and practice self- and peer-assessment. This develops communication skills, argument/debate abilities, and critical thinking (Kim, 2019). FA requires students not only to be active agents in their own learning but also to be facilitators of each other's learning through peer assessment where they get opportunity to judge peer work (Black & Wiliam, 2009).

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FA practices that can be informal or formal, aim to modify teaching and learning activities to maximize academic performance. The primary goal is to provide ongoing feedback that helps teachers assess whether students master the targeted learning objectives specified in the curriculum. Immediate feedback enables teachers to address student weaknesses early and adjust their teaching strategies accordingly. FA practices also include quizzes, homework, classwork, think-pair-share strategies, peer assessment, and self-assessment (Ayalon & Wilkie, 2021). These practices keep students informed about their learning progress and allow teachers to adopt more interactive teaching methods to enhance learning.

Summative assessment (SA), on the other hand, evaluates student learning, skill acquisition, and academic achievement at the end of a specific period, such as a course, unit, semester, or year (Bennett, 2011; Gezer et al., 2021). SA aims to measure the overall level of student learning and understanding after instruction has concluded. It is characterized by finality and formal evaluation, often involving examinations and certifications. Despite the different types of assessments, several studies (e.g., Kyaruzi et al., 2019; Lema & Maro, 2016; Leenknecht et al., 2021; Ndalichako, 2015; Tigelaar & Sins, 2021) recommend using FA during classroom instruction to improve academic performance. FA provides instant feedback and enhances teaching methods, making it a crucial tool for ensuring that students grasp concepts and improve their academic performance. Even the outcomes of SA often depend on how well FA practices have been implemented, as early-stage assessments identify and bridge learning gaps before SA.

Furthermore, studies (e.g., Black & Wiliam, 1998; Granberg et al., 2021; Park, 2022) propose that FA practices are the most effective classroom interventions because they support teaching and learning. FA practices provide ongoing feedback to students, enabling them to understand their learning progress and improvement areas in real time. It has significantly enhanced students' academic performance in countries like the UK, Ireland, Sweden, Netherlands, USA, Canada, China, New Zealand, Australia, Ghana and Ethiopia (Granberg et al., 2021; Kwame Butakor & Ceasar, 2021; Lee et al., 2021; McCallum & Milner, 2021; Tefera et al., 2020; Tigelaar & Sins, 2021; Wang, 2024; Yan et al., 2021). Moreover, to identify and address learning gaps early on, FA helps teachers support students who have not understood the concepts taught promptly, thereby reducing the high gap in achievement between low and high achievers. However, for successful FA practice implementation, teachers need specific knowledge and skills, including domain knowledge, pedagogical content knowledge, knowledge of students' previous learning, and assessment knowledge (Schildkamp et al., 2020).

Many countries, including the United States, the Netherlands, the United Kingdom, Hungary, Turkey, Zimbabwe, Ghana, Lesotho, Cameroon, Malawi, Kenya, Uganda, and Zambia have adopted and implemented FA practices in their educational systems (Anders et al., 2022; Figa et al., 2020; Lee et al., 2020; Nsengimana et al., 2020). The problem arises when teachers have limited knowledge of FA practices, such as Socratic questioning, portfolio use, and providing constructive feedback. This can lead to poor learning outcomes in summative assessments, as teachers cannot identify students' weaknesses at earlier stages (McCallum & Milner, 2021). For example, Ndayambaje et al. (2021) found that the limited FA practices used by teachers were the main cause of low performance in biology. This suggests a close connection between the FA practices implemented by teachers and student performance (Herman et al., 2015).

In Tanzania, biology performance is also unsatisfactory, as many students do not perform well in the Certificate of Secondary Education Examination (CSEE). The pass rate fluctuates, indicating inconsistent student success in the subject. Table 1 shows the national performance trend in biology over five consecutive years (2016–2020).

Table 1. Students' performance in Biology subject nationwide CSEE from 2016 to 2020

Year	Pass rate (%)	Failed (%)	Comments on Performance
2016	55.7	44.3	Average
2017	61.4	38.6	Average
2018	60.5	39.5	Average
2019	55.3	44.7	Average
2020	55.2	44.8	Average

(Source: National Examinations Council of Tanzania [NECTA], 2023)

As shown in Table 1, the performance in Biology varies yearly, with notable fluctuations. The overall pass rate for all the specified years is average. This low performance may be due to various factors, including the

availability of teaching and learning materials in schools and the curriculum itself. However, poor implementation of FA practices has been identified as a main cause of this problem. Poor FA implementation can lead to the wrong collecting of information; thus, teachers need to be competent in FA practices to identify students' learning difficulties.

Studies in many countries have suggested that teachers well-equipped with FA practices are likely to enhance students' academic performance. FA practices like the Socratic questioning style, self- and peer-assessment, portfolio, think – share and quizzes are important as they promote active learning, increase learning accountability, and enhance critical thinking and problem-solving skills, consequently improving academic performance in Biology.

Therefore, this study addressed two research questions:

1. What is the level of knowledge of formative assessment among Biology teachers in Tanzanian secondary schools?
2. What extent do Biology teachers in Tanzania implement formative assessment practices in secondary schools?

Understanding Biology teachers' knowledge of FA practices will contribute the body of knowledge in the existing empirical studies and provide a foundation for enhancing FA practices through in-service training.

Methodology

Design and Participants

This study employed the mixed-methods research approach and the convergent mixed-methods research design to achieve its research questions (Creswell & David, 2018). A total of 55 secondary school biology teachers from 13 schools in Morogoro Municipality, Tanzania, participated in this study, whose demographic information are in Table 2. Teachers were selected using purposive sampling due to their specialty in biology subject, while schools were chosen using simple random sampling.

To collect data on teachers' knowledge and FA practices, we used both questionnaires, observation checklists and documentary review for triangulation purposes (Creswell & David, 2018). We consulted various sources, including Antoniou and James (2014), Black and Wiliam (1998) and Furtak et al. (2016) to develop the research instruments used in this study to capture teachers' knowledge and FA practices. The questionnaire consisted of closed-ended questions to gather numeric data on teachers' knowledge of FA practices. It used a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). This facilitated effective data collection from a large number of participants and allowed the identification of common trends. Experts in the Department of Educational Psychology and Curriculum Studies at the University of Dar es Salaam validated the research instruments. We involved 100 biology teachers in a pilot study who did not participate in this study. This ensured the reliability of the instruments and improved wording problems of the items. The Cronbach's alpha for the current study was 0.78 for the questionnaire and 0.76 for the observation checklist, indicating reliable measures (Abell et al., 2009; Cohen et al., 2018).

Additionally, we employed an observation checklist to gather data on biology teachers FA practices in the classroom during teaching and learning. A structured observation checklist was constructed based on established FA practices. This checklist involved real-time observation of FA practices, such as the Socratic style of questioning, constructive feedback, and self and peer assessment used by teachers. This method provided first-hand observations in the natural setting of FA practices, making it easier to identify divergences between reported and actual FA practices. Finally, we reviewed students' exercise books to assess the comments provided.

Table 2. Demographic information of secondary school Biology teachers

Demographic Characteristic		N	(%)
Sex	Female	25	45.5
	Male	30	54.5
Age (years)	<30	9	16.4
	30–39	36	65.5
	40–49	8	14.5
	50+	2	3.6
Qualification	Diploma	14	25.5
	Bachelor	41	74.5
Teaching Experience (years)	5–10	11	20.0
	11–16	38	69.1
	>16	6	10.9

Table 2 shows that 14 and 41 Secondary school Biology teachers were diploma and bachelor's degree holders, respectively. It should be noted that the minimum educational qualification to teach in secondary schools in Tanzania is a diploma. Therefore, participated teachers in the current study qualified to teach at this educational level.

Procedures and Analysis

Before collecting data in the selected schools, we made sure to adhere to ethical guidelines. We obtained a research permit from the relevant authorities, including the Regional Administrative Secretary, District Administrative Secretary, District Educational Director, and District Educational Officer in Morogoro municipality. These authorities issued introductory letters to the heads of schools. This study involved only Biology teachers ($N = 55$) from secondary schools ($N = 13$), as they were experts in the subject and thus could provide relevant information.

We informed the teachers about the objectives and benefits of the study and assured them of confidentiality. We requested, they not write their names or any identifying information on the questionnaires. Before participating, the teachers completed a consent form attached to the questionnaire to indicate their willingness to participate. We administered the questionnaires to ensure complete responses, and none of the collected questionnaires had incomplete information. On average, teachers spent 30 to 40 minutes completing the distributed questionnaires. We collected the completed questionnaires immediately after the filling exercise for further analysis.

After the questionnaires were completed, we observed the teachers to determine the extent to which they implemented FA practices in their classes. These observations took place on different days than the questionnaire administration. We visited and observed the teachers three times on three different days, with each session lasting 80 minutes, based on their school teaching timetables. Since we observed six teachers and each had three sessions of 80 minutes each, we spent a total of 1,440 minutes, meaning each teacher had 240 minutes (4 hours) of observation. We finally analysed collected data using Statistical Packages for Social Sciences (SPSS) version 26.0. We computed descriptive statistics such as tables, frequencies, and percentages to present our findings .

Findings and Discussion

Teachers' knowledge of formative assessment

The first objective of this study was to examine secondary school Biology teachers' knowledge of FA in Tanzania. The analysis indicated that the majority of the Biology teachers in the study area had sufficient knowledge of FA practices. They were aware of the characteristics that comply with FA practices (see Table 3).

Table 3. Teachers' knowledge of formative assessment in teaching and learning

Aspect		SA		A		D		SD	
		Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)	Frequency
1.	I was trained about formative assessment during teacher education at the teachers' college/university	20	36	35	64	0	0	0	0
2.	I can plan my lesson with appropriate assessment strategies stipulated in the competence-based curriculum	31	56	22	40	2	4	0	0
3.	I can plan my lesson and scheme of work as per competence-based curriculum	23	42	30	54	1	2	1	2
4.	I know different formative assessment strategies which facilitate students learning during instruction	11	20	40	73	3	5	1	2
5.	I attend workshops and seminars that orients biology teachers in using formative assessment practices in teaching and learning	6	11	9	16	10	18	30	54
6.	I can differentiate between formative assessment and other types of the assessment basing their usefulness	13	23	40	73	1	2	1	2
7.	I know the advantages of assessing students using formative assessment during teaching and learning	50	91	3	5	0	0	2	4
8.	I acquired different pedagogy skills in teachers' college/university to enable students understand the lesson	34	62	20	36	1	2	0	0
9.	I know the competency-based curriculum	10	18	41	75	1	2	3	5
10.	I can differentiate between content-based curriculum and competence-based curriculum	27	49	24	44	4	7	0	0

(Note. SA= Strong Agrees; A= Agree; D= Disagree; SD= Strong Disagree)

Table 3 shows that all Biology teachers (100%) received training on FA practices during their teacher education programs at colleges or universities. Additionally, 53 teachers (96.4%) agreed that they can appropriately plan lessons and schemes of work. Another aspect measured revealed that 51 teachers (92.7%) knew different FA practices that facilitate identifying students' understanding of biology concepts during classroom instruction. This means they were aware of various FA practices to employ in the classroom.

These findings align with Herman et al. (2015) who indicated that teachers were knowledgeable about FA practices and employed them during teaching and learning. Having knowledge of FA is essential for implementation in the classroom. As confirmed by Popham (2008), implementing FA requires prior theoretical knowledge to understand how students learn and to assist them where needed. Teachers should have a thorough understanding of the subject content they teach, as this helps them prepare appropriate assessment tools that capture all intended learning objectives. A wide understanding of the subject content makes it easier to use a variety of FA practices during classroom instruction. Teachers should understand the purpose of different assessments, how to apply them, and how to provide constructive feedback based on students' strengths and weaknesses. They should have the knowledge and skills to make decisions that encourage student learning, regardless of students' performance. However, these findings contradict the findings by Arrafii and Sumarni (2018) particularly in the context of English teaching and examined factors related to the teacher assessment in the literacy level. To achieve the intended purposes, a self-designed instrument named Teacher Formative Assessment Literacy Questionnaire (TFALTQ). Their study found that most teachers had limited knowledge of FA and focused on helping their students pass paper-and-pencil tests.

Furthermore, the findings in Table 3 indicated that majority of teachers agreed to have knowledge of various aspects, including pedagogical skills at the colleges and universities where they studied. However, only a few teachers attended workshops and seminars on FA practices in the classroom. Specifically, only 15 teachers (27.3%) out of 55 attended such professional development opportunities. These findings align with the findings of (Perry, 2013), who found that most teachers rarely attended in-service training about FA practices. Their study recommended providing frequent training on FA practices, particularly on using Socratic questioning

strategies, self and peer assessment, and providing constructive feedback to enhance students' learning and academic performance.

Studies (e.g. Cañadas, 2023; Wylie & Lyon, 2020), claim that workshops and seminars for teachers are crucial as they strengthen teachers' assessment competence, ultimately improving students' academic performance. Attending in-service training is vital for teachers to better understand how students' progress in their learning and to effectively use FA practices. A conducive learning environment that encourages participation, such as peer assessment, where individual students assess the strengths and weaknesses of their peers' work, is essential for developing skills such as problem solving, critical thinking, communication and collaboration skills needed in the contemporary society.

Teachers' classroom practices of formative assessment

The second objective was to determine the extent to which Biology teachers implement FA practices in their classes. To achieve this, we conducted classroom observations of randomly selected six biology teachers to see how they implement FA practices. We observed each teacher in three sessions, each lasting 80 minutes, following the school timetable. This totaled 240 minutes per teacher and 1,440 minutes (24 hours) for all six teachers observed.

The frequencies and percentages under the columns WP, P, PP, and NP in Table 4 indicate the extent to which the observed biology teachers implemented various FA practices. These columns represent the number of teachers implemented each FA practice to varying degrees, with each number corresponding to its respective percentage.

Table 4. Classroom observation on practices of formative assessment practices

S/N	Practice Observed	Scale			
		WP	P	PP	NP
1	The teacher continuously observes and listens to whatever is going on in the class	0 (0.0%)	1 (17%)	3 (50%)	2 (33%)
2	Teacher questioning follows the Socratic style in a form of dialogue explanation.	0 (0.0%)	0(0.0%)	4 (67%)	2 (33%)
3	The teacher poses a question in order to probe student's understanding	0 (0.0%)	1 (17%)	3 (50%)	2 (33%)
4	Teachers use questions that use a higher level of the cognitive domain such as the ability to apply, analyze and synthesize	0 (0.0%)	0(0.0%)	4 (67%)	2 (33%)
5	Students follow up with questions that prompt further explanation	0 (0.0%)	1 (17%)	3 (50%)	2 (33%)
6	The teacher gave chance to students to review both correct and incorrect performance	1 (17%)	2 (33%)	2 (33%)	1 (17%)
7	The teacher provides constructive feedback and comments on students' work.	0 (0.0%)	0(0.0%)	1 (17%)	5 (83%)
8	The teacher allows students to be actively involved through self-assessment	0 (0.0%)	1 (17%)	2 (33%)	3 (50%)
9	Students are allowed to do peer assessments such as peer marking	0 (0.0%)	0(0.0%)	1 (17%)	5 (83%)
10	The teacher uses a portfolio as a cumulative record of students' performance that shows learning progress over time in more detail and substance than a mere list of scores	0(0.0%)	0(0.0%)	3 (50%)	3 (50%)

(Note. WP= Well Practiced; P= Practiced; PP= Partially Practiced; NP= Not practiced)

As indicated in Table 4, the findings revealed a deficiency in teachers' proficiency in implementing FA practices, including Socratic questioning, feedback and comments, peer assessment, and portfolios. Teachers failed to embrace the Socratic style of teaching, which involves dialogue and explanation. This style is one of the best ways to assess students' learning as it allows teachers to identify and address misconceptions through dialogue. However, it revealed that the oral questions used were typically at lower levels of knowledge. Assessing

students' understanding of biology concepts by dialogue is crucial as it helps teachers recognize and correct misconceptions. The reviewed exercise books lacked constructive comments; most contained only a tick for correct answers and a cross for wrong answers. The observed comments included: *see me, work hard, lazy*, and *poor* for students who performed poorly, and *very good, good* and *good try* for those who performed well. This suggests that teachers did not have the skills to provide constructive feedback to help students improve their learning (Lema & Maro, 2016).

The current findings align with Mbwana (2024), who revealed that teachers did not implement the Socratic style of questioning, resulting in a failure to understand students' misconceptions. Parker and Bickmore (2020) assert that effective FA practices involve constructing questions that encourage dialogue, providing immediate feedback on students' learning progress. Students need ample time to think and respond during questioning. Allowing adequate waiting time between posing a question and expecting a response gives students the opportunity to participate in discussions, ultimately enhancing the quality of their thinking and responses (Black et al., 2004). However, adhering to waiting time is a challenging skill for most teachers. Despite its importance in promoting student thinking and engagement, waiting longer can elicit a greater range and depth of responses, thereby enhancing the effectiveness of questioning as an FA practice (Greenstein, 2010).

Furthermore, FA practices such as self-assessment and peer assessment are crucial for achieving curriculum goals. These practices facilitate students' learning by using language they naturally understand, placing the learning task in their hands. Black et al. (2004) found that students who did not practice self and peer assessment performed poorly compared to those who did. These FA practices require teachers' competence to implement them effectively. Without proper skills in handling dialogue, self-assessment, and peer assessment, can lead to chaos in the class. Another vital FA practice is the portfolio, which is a tool for assessing student progress. Portfolios showcase student talents, progress, activities, and achievements, enabling teachers to make specific instructional plans and recommendations beyond standardized test scores. They provide a cumulative record of students' performance, showing learning progress over time in more detail and substance than a mere list of scores (Mikre, 2010).

These findings concur with other studies conducted in different countries that revealed that teachers did not employ self-assessment, peer assessment, feedback, and portfolios in their instructional practices (Amalia, 2021; Misiejuk & Wasson, 2021; Yang et al., 2022). Indeed, this is a big problem in ensuring meaningful learning to students. Disengaging students from these practices has several disadvantages: teachers fail to understand students' learning progress, students are deprived of opportunities to build critical skills like communication, problem-solving, and collaboration, and poor performance among students is often perpetuated (Double et al., 2020) with numerous educational researchers advocating for the integration of peer assessment into schools and instructional practice. Research synthesis in this area has, however, largely relied on narrative reviews to evaluate the efficacy of peer assessment. Here, we present a meta-analysis (54 studies, $k = 141$; Ibarra-Sáiz et al., 2020). Students learn better in interactive environments where FA practices like peer assessment, think-pair share are well embraced to allow them to share, critique, and provide constructive feedback on their peers' work. The Socratic style of learning helps students understand their misconceptions as teachers probe their responses. Ibarra-Sáiz et al. (2020) emphasizes that if teachers do not probe students' responses and utilize peer assessment, it not only weakens students' academic performance but also fails to prepare them to be problem solvers in the future.

Limitations of the Study and Directions for Future Study

This study examined biology teachers' knowledge and practices of FA in secondary schools in Tanzania but faced several limitations. First, it did not include teachers' perspectives on the problem. Future research should use interviews and focus group discussions to gather comprehensive findings. Second, the study involved only 55 biology teachers, so future research should include a larger number of participants. Third, the study focused only on biology teachers; future research should explore FA practices of teachers in other subjects. Despite these limitations, the study's findings are significant as they contribute to the body of empirical studies in science education particularly biology subject.

Conclusion and Recommendations

This study sought to examine the knowledge and implementation of FA practices among secondary school Biology teachers in Tanzania. The findings revealed that the majority possessed adequate knowledge of FA practices, which they acquired during their teacher education programs. They were able to write lesson plans and schemes of work aligned with the Competence Based Curriculum demands, they knew different FA strategies and the benefits of FA in enhancing student learning. However, the study also identified very few teachers attending workshops and seminars on FA practices.

Despite the biology teachers possessing knowledge of FA practices, the classroom observations indicated a deficiency in the practical application of these practices. FA practices such as Socratic questioning, providing constructive feedback, and facilitating peer and self-assessments were not implemented. This gap suggests that while theoretical knowledge is strong its practical application in classroom settings remains a problem. Furthermore, the preferred comments in students' exercise books were only poor, see me, and a cross without constructive comments. The inconsistency between teachers' knowledge and their classroom practices suggests the need for providing professional development and support in FA practices. This alignment is crucial for effectively implementing FA practices that can significantly improve academic performance in Biology.

Based on the findings of this study, we provide four recommendations

1. Regular professional development programs focused on FA practices are essential for biology teachers. These programs should include workshops, seminars, and in-service training to equip teachers with the practical skills to implement FA practices effectively in the classroom.
2. The Tanzanian Ministry of Education, Science, and Technology should establish mentorship programs where experienced teachers support less experienced ones in implementing FA practices. Additionally, biology teachers should initiate peer and collaboration programs to share best practices and innovative assessment strategies.
3. School quality assurers should regularly visit schools to see how teachers implement FA practices and identify areas for improvement. This should be done in collaboration with head of schools and school academic masters. The feedback from these evaluations should inform targeted interventions and support for teachers.
4. The Tanzanian Ministry of Education, Science, and Technology should review the ordinary secondary school biology curriculum to ensure it supports the practical implementation of FA practices. This review should focus on eliminating outdated topics that do not meet societal needs, as an overloaded curriculum hinders effective implementation of FA practices due to time constraints.

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