Integrity Journal of Education and Training
Volume 4(3), pages 48-52, September 2020
Article Number: 1201635D2
ISSN: 2636-5995
https://doi.org/10.31248/IJET2020.085
https://integrityresjournals.org/journal/IJET

Review Article

Formative assessment: A tool for rectifying learners' errors and misconceptions in mathematics

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Received 21st August, 2020; Accepted 10th September, 2020

ABSTRACT: Learners' errors in mathematics emanate not only in quizzes, assignment, or end of semester examinations but occur almost every day in the mathematics classroom. The diagnostic use of assessment to provide feedback to teachers and learners throughout instruction is called formative assessment. Whenever teachers respond to learners' errors either during instruction or after instruction, they are actively engaging in formative assessment. This paper intends to show how formative assessment techniques can be utilized in addressing learners' errors and misconceptions in mathematics. In this paper, I describe and analyze two formative assessment techniques: feedback and formative questioning. These techniques are powerful tools in addressing gaps and errors while content is being taught or reviewed.

Keywords: Formative assessment, errors, misconceptions, mathematics.

INTRODUCTION

The premise of this paper is that formative assessment techniques are critical tools for addressing learners' errors and misconception during instruction (Cauley and McMillan, 2010). Formative assessment is the set of all activities that teachers and learners undertake to acquire information that can be used diagnostically to alter teaching and learning (Black and Wiliam, 1998; Mkhwanazi, 2014). Assessment becomes formative when the information gathered is used to adapt teaching and learning to meet learners' needs. Learning from the constructivist perspective is viewed as the knowledge that is not built from experiences only but a combination of experience and current knowledge (Piaget, 1972; Skemp, 1976). According to Piaget, through interaction processes called assimilation and accommodation, mental structures or schemata are developed, and once a schema is formed, it becomes stable and resistant to change. Mathematics learning is cumulative; that is, new knowledge gained is linked to previous experience (Sarwadi and Shahrill, 2014). The authors reiterated that a gap in the learning of concept is created if a student cannot 'assimilate' and 'accommodate,' which in turn leads to mathematical errors and misconceptions. The process of fitting new ideas into an existing schema (what learners already know) is called assimilation, while accommodation is a process of restructuring existing schemata to include new information. Mistakes or errors often lead to incorrect answers when solving problems in mathematics. A mistake could be made for many reasons. Rushton (2014) argued that many mathematical errors occur randomly through calculations or misreading of the question. Similarly, Wijaya et al. (2014) conceived that:

Mistakes could be the result of carelessness, misinterpretation of symbols or text, inability to comprehend what the task is asking, using incorrect operations, misunderstanding the initial instructions, errors in transforming a word problem to a mathematical problem, ……., or the result of misconception (p.6).

Making mistakes or errors when learning mathematics is part of the learning process and should, therefore, not be seen as a failure. Learners do not make a mistake because they are stupid – their mistakes are reasonable and meaningful efforts to cope with mathematics (Ginsburg, 1977). In other words, errors in mathematics are something

that is useful and has the potential to help learners to learn and understand the concept more deeply. An essential aspect of assisting learners in learning mathematics is helping them learn from their errors and mistakes. Engaging with errors is difficult, but the difficulty can be desirable for learning (Bjork, 2012). It is, therefore, important that teachers see learners' errors as part of the teaching and learning process, which needs to be dealt with diagnostically. According to Teba (2017), while considering errors as part of learning, teachers are required to focus on strategies for its correction. Assessment plays a central role in achieving this. The paper aims to shed light on how teachers can adapt formative assessment techniques as error corrective strategies for addersing learners' errors and misconceptions in mathematics.

LEARNERS' MATHEMATICAL ERRORS AND MISCONCEPTIONS

An error is principally formed within the surface level of knowledge: as such, a student's response to a task is procedural and can be corrected by the teacher providing correct alternatives (Ryan and Wiliams, 2007). Learners' errors are causally determined and often vary systematically (Sarwadi and Shahrill, 2014). For example, Kofi and his friends have a bag of candy with 24 pieces of candies. They decide to share it equally if each got six pieces, how many friends are there altogether? If a learner solves this question by multiplying 6 x 24, then that learner did not understand the question or the concept of division even if he or she can work out 6 x 24 correctly. Such learners might be committing a conceptual error. According to Li (2006), student errors are a symptom of misunderstanding. On the other hand, Ojose (2015) observed that misconceptions are misunderstandings and misinterpretations based on incorrect meanings and are due to 'naive theories' that impede the rational reasoning of learners. A misconception could be the misapplication or over-generation of a rule. For example, *a learner solving the problem* $a^2 + a^4$ *and obtains* $a^2 + a^4 = a^6$. The learner's response is an indication of the misapplication of the multiplication law of indices. The learner thinks that since the bases are the same, it is correct to add the exponents for both terms, which is actually a misconception. The source of this misconception lies in retrieving the wrong schema by the learners and not recognizing the retrieval error. The retrieval of the wrong schema is further exemplified by the following well-known teacher-learners' dialogue:

Teacher: *What is three times three?*
Learner: *Six*
Teacher: *What will then be the answer for three plus three?*
Leaner: *Oh! It should be nine*

Replacing a new schema with a previously developed and constructed schema might account for the earlier response by the learner. From the preceding illustration above, it can be observed that an addition schema has been constructed first and developed. Thus, when a question was asked about multiplication, which is a new schema, the learner replaces it with a question dealing with earlier schema (Addition). As cited in Olivier (1989), Bruner argues that "when learner gives wrong numbers, it is often not that they are wrong, as that they are answering a different question. The teacher is required to find out what question they are answering" (p.5). Teachers must understand the mathematical thinking of their learners to provide the needed support to enhance their learning.

Why are learners' errors or mistakes a good thing?

Askew and Wilaim (1995) observed that mistakes or errors should not be seen as a failure in learning or teaching but instead as part of the learning, which is more effective when common misconceptions are addressed, exposed, and discussed in teaching by providing focused teaching activities which tackle fundamental errors and misunderstandings that inhibit the progress of learners. The authors believe that errors have a potential for learning since teachers are likely to adjust their instructional strategy to meet the learning needs of their learners, and this modification of the instructional approach will emanate from mistakes made by the learners. Lai (2012) remarked that by pinpointing learners' errors, the teacher could provide instruction targeted to the learners' area of needs. According to Dowker (2009), teachers' assessment could be used to correct identified errors and misconceptions.

FORMATIVE ASSESSMENT

Formative assessment is a process in which teachers control both content and assessment procedures and can adjust their instructional activities in accordance with the evidence gathered in the classroom (Mellati and Khademi, 2018). It is the process used by teachers to recognize and respond to students learning to enable and enhance it (Prashanti and Ramnarayan, 2019). Formative assessment is also defined as the set of all activities that teachers and learners undertake to acquire information that can be used diagnostically to alter teaching and learning (Black and Wiliam, 1998; Mkhwanazi, 2014). The above definitions indicate that formative assessment is simply an ongoing activity that takes place during teaching and learning processes of which responsibilities are shared between the instructor and learners' in order to elicit information about the classroom activities. It is worth noting that the ultimate goal of formative assessment is to gauge learners' learning, diagnose weaknesses, and to adjust instruction as and when needed. In addition, Coffey

et al. (2011) mentioned that formative assessment aims to help teachers to address their students' thinking during instruction. Through formative assessment, gaps in student learning are identified, which gives the teacher an opportunity to modify or make adjustments in the instruction with the primary aim of supporting teaching and learning. It can be argued, therefore, that formative assessment is a diagnostically oriented instructional strategy that teachers can utilize to aid learners to correct their errors and misconceptions.

Addressing learners' errors and misconceptions using formative assessment strategies

Koshy (2000) stresses the need for teachers to adopt a constructive attitude to their learners' mistakes and that learners recognize that analysis and discussion of mistakes and misconceptions can be helpful to learners' mathematical development (Hansen et al., 2020, p.4). Analysis of errors requires professional judgment to establish gaps in learners' understanding, the reasoning behind errors made, and its effect on their learning and recognition of instructional practices that could help address learners' difficulties (Shepard, 2009). According to Dowker (2009), learners' errors or misconceptions could be addressed through assessment. Shepard (2009), in his work on formative assessment, argued that insights from learners' work could be used formatively to adjust instruction. It is worth noting that errors or mistakes made by learners' are an important dimension of formative assessment. This is to say, through formative assessment strategies, teachers are able to respond to learners' errors. There are five formative assessment strategies mentioned in the literature. The strategies include: 1) Clarifying and sharing of learning intentions and criteria for success, 2) Eliciting evidence of learning through questioning, 3) Providing feedback that moves learners forward, 4) Activating learners as owners of their own learning, and 5) Activating learners as instructional resources for one another (Black and Wiliam, 2009; Leahy et al., 2005). These strategies, according to Wiliam and Thompson (2008) are useful in answering three critical questions; 1) Where is the learner going? 2) where is the learner right now? and 3) How does the learner get there? from the perspective of the teacher, the learners, and their peers. This indicates that teaching is adaptive to learners' needs. In otherwise, evidence about learning is used in adjusting instruction to meet the learning needs of the learners. One of such needs of learners is addressing cognitive gaps in their learning and assisting them to overcome their mistakes by delineating and discussing their errors with them. Therefore, Cauley and McMillan (2010) in their work: *Formative assessment techniques to support students' motivation and achievement*, advance the argument that formative assessment strategies could be adopted to address errors and misconceptions in mathematics.

Utilizing feedback to address errors and misconception

The behaviourist theory noted that learners' errors are premised on carelessness, unsureness, or unique situational conditions. However, Radatz (1980) argued that learners' errors occur as a result of previous experience in the classroom. This suggests that incorrect previous learning results in incorrect new learning, and in the same way, correct learning depends on correct prior learning. A review of related literature on formative assessment has shown that feedback plays a crucial role in addressing learners' errors (Kornell and Metcalfe, 2013; Ovando, 1994). According to Metcalfe (2017), corrective feedback is vital when people commit errors. More than 50 years ago, Bloom (1976) explained that "feedback can reveal errors in learning shortly after they occur… a self-correcting system so that errors made at one time can be corrected before they are compounded with later errors". Bloom emphasized that formative assessment must be followed up by high-quality corrective instruction that provides learners with guidance in remedying any learning difficulties the assessment has identified. The phrase "corrective instruction" in this context refers to feedback which is informative and gives directions to the learner by highlighting what was good about the learners' work as well as aspects where they made mistakes in order to improve from it. This means that feedback on learners' work is key in helping them to correct or minimize their errors during learning and assessment. The maximum effect of feedback is realized when feedback is elaborative or supportive (Finn and Metcalfe, 2010). According to Hattie and Timperly (2007), feedback given as part of formative assessment draws attention to existing gaps in learners' desired goals and their current knowledge. Effective feedback enables learners to self- assess, reflect, and monitor their learning. Wragg (2003) notes that "if learners are to learn from their assessment, then corrections of errors and discussion of their work is essential" (p.74). Student mistakes have the potential of fostering understanding and knowledge building during the process of learning (Glendon and Clarke, 2006; Seifried and Wuttke, 2010). Undoubtedly, student errors can be seen as having a formative purpose. This is because of the modification of the instructional approach, which might arise from the evidence generated during classroom instruction. This means that students' errors affect the decision of the teacher; because teachers' belief concerning a student error determines the feedback to be provided to the student. Heinze (2005) explained in his study that teachers' instructional goals affect learners' motivation and learning outcomes, and therefore, how teachers handle learners' errors or mistakes during instruction is very important. Unlike assessment of learning, assessment for learning (formative assessment) does not only aim to understand what learners know, but it also focuses on what learners do not know and what can

be done to improve their knowledge and to address the barriers to learning through constructive feedback.

Using formative questioning to address errors and misconception

Mistakes or errors made by learners may arise from different contexts. For example, through assignment, test, and oral questioning during instruction. Oral questioning, which is an informal formative assessment technique, aids teachers in determining what their learners know and their understanding of what they have been taught. According to Kawalker and Vijapurkar (2013), "teachers' questions in the inquiry classroom not only explore and make learners' thinking explicit in the classroom but also serves to guide and scaffold it" (p.2004). Questions teachers ask and the way they are asked impact learners' thinking as they engage in the process of knowledge construction (Chin, 2007; Kawalkar and Vijapurkar, 2013). Weiss and Pasley (2004) extend the idea and argue that it is through questioning that misconceptions are revealed during the process of teaching and learning. Reflections on how one can learn from errors, Cauley and McMillan (2010) argued that through effective informal formative assessment techniques such as informal observations and oral questions posed to learners during instruction, teachers are able to identify specific learners' misunderstanding and provides feedback to help them correct their errors. Informal formative assessment has been found as the quickest way of finding out learners' progress and for addressing learners' misconceptions (Bell and Cowie, 2001; Black and Wiliam, 1998; Cauley and McMillan, 2010; Gullo, 2005; McMillan, 2007).

CONCLUSION

The paper discussed how feedback and questioning aspects of formative assessment strategies could be employed in addressing learners' errors and misconceptions in mathematics. Formative assessment strategies, particularly feedback and questioning, can be corrective tools for addressing learners' errors and misconceptions. As teachers employ and integrate these strategies in everyday learning activities, specific evidence of learners' misunderstanding can be identified for instructional adjustments. Teachers can use this evidence about errors and misconceptions to provide corrective feedback comments that are specific about errors and give them directions to correct their mistakes.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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