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What Are the Relevant Techniques for Assessing Mathematics in the Context of Competency-Based Curriculum?

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Abstract

Assessment in the context of competency based education has emerged as an area of research interests with debates extending into mathematics education. As other parts of the world, Tanzania, reviewed its curricula at different levels of education between 2004 and 2008. The purpose of the review was to shift the paradigm of teaching and learning from content-based to competency-based. After reviewing the new curriculum, efforts were made by the Government, specifically the Ministry responsible for education, to orient teachers and other education officials on how to implement it. Assessment as one of the important components in teaching and learning process was not given due weight. Paper-and-pencil tests continued to dominate assessment procedures. This paper brings to light what are perceived to be relevant techniques for assessing mathematics in the context of the competency-based curriculum. Before this, the paper outlines the purpose of teaching and learning of mathematics, competency based education as opposed to the content based education, and classifications of assessments regarding mathematics. The paper concludes that the outlined assessment techniques are just a sample of the possible assessments strategies that can be used. Furthermore, no single assessment technique is adequate by itself in assessing all mathematical competencies.

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Introduction

Recently, education reforms across the world focus on the introduction of competency-based education as opposed to content-based education (Darling-Hammond, 2012; Scardamalia, Bransford, Kozma, and Quellmalz, 2012; Roy, 2016), along these reforms has been the development of curricula outlining competencies necessary for learners develop for their effective participation in today's knowledge-based economy. While competency-based education is highly emphasized, there is literature evidence showing dissatisfaction with its implementation and on the attainment of the competencies stipulated in syllabi. For example, as Roy (2016) argues, a clear competency-based assessment is rarely found in education systems. Regarding mathematics education, literature such as Iannone and Simpson (2015), Nortvedt and Buchholtz (2018) and others, reveal emerging concern on the assessment of mathematical competencies specifically, debates have focused on what competencies should be assessed and what assessment techniques are suitable for assessing mathematical competencies

Between 2004 and 2008, Tanzania curricula were reviewed at different levels that is primary and secondary school levels. Similar exercise was done for teacher education programmes. The purpose of the review was to shift the paradigm of teaching and learning from content-based to competency-based. This review was obligated by the increasing need for the education system that is capable of producing graduates who are capable in terms of knowledge, skills and attitudes that are necessary for solving social and economic challenges (United Republic of Tanzania [URT], 2000; Ministry of Education and Vocational Training [MoEVT], 2010). "It was also recognised that the education system could no longer afford to produce graduates who lacked employable skills, which are deemed crucial for academic and social survival in the modern world" (Paulo & Tilya, 2014 p.114). In general, the reviewed curriculum was meant to enable graduates gain necessary competencies for tackling national goals as well as global demands and the challenges of ever changing human needs. In addition, the reviewed curriculum emphasised on the teaching effectiveness through the use of interactive and participatory approaches by creating a child-friendly environment. . In the new curriculum, six areas of competency were emphasised. These were communication, numeracy, creativity and critical thinking, technology, interpersonal relationships and independent learning. After reviewing the curriculum, efforts were made by the Government, specifically the Ministry responsible for education, to orient teachers and other education officials on how to implement it. Major emphasis was put on methodological skills for teaching difficult or challenging topics in different subjects, including mathematics. Assessment as one of the important components in the teaching and learning process was not given due weight. Paper-and-pencil tests continued to dominate assessment procedures, especially in mathematics.

Due to the paradigm change in the teaching and learning process, assessment techniques and the roles and responsibilities of teachers and students should also change. More active, cooperative and participatory teaching and learning approaches are greatly emphasised, and so assessment procedures ought to be fine tuned in the same direction. This paper reflects on what are considered to be relevant techniques for assessing mathematics in the context of the competency-based curriculum in Tanzania. Before considering assessment procedures, it is imperative to highlight the purpose of teaching mathematics.

Methodology

This paper critically discusses the relevant techniques for assessing mathematics. Towards this end, the paper is centred on a critical review and analysis of secondary sources of data by employing content analysis to address the issues of education, policy/guideline documents, for

example the Education and Training Policy of 1995 and 2014, books, research reports and peer-reviewed journal articles. The documents were accessed at different libraries and internet.

Purpose of Teaching and Learning Mathematics

In the mathematics education literature, several purposes of teaching and learning mathematics are apparent. However, two are the most pronounced. One of these purposes is the utilitarian or practical purpose, which is related to the role of mathematics in gaining employment in professional areas, such as banking, accountancy, engineering, and the fields of science and technology. It is claimed that mathematics as a branch of science has contributed significantly to advances in science and technology. From history, as revealed by Ellerton and Clement (2012), the first purpose of mathematics education was for this utilitarian function of generating professionals for various fields. This practical function of teaching and learning of mathematics goes beyond the role of mathematics in professions but includes equipping learners with the knowledge and skills is solving real life problems, such as purchasing or selling property and planning and organising events. The other function of mathematics instruction is for developing logical thinking of learners or developing the mind-set and mental skills of learners (Maron, 2016).

Tanzania is one of the countries that have been responding to the changes taking place in the world. It has found it important to provide mathematics education for everyone instead of restricting it to a few people, which has been realised through making primary education compulsory for every Tanzanian child, and so all children are taught mathematics as a compulsory subject Ministry of Education and Culture ([MOEC], 2005). Mathematics is also taught in ordinary secondary schools as a compulsory subject. The mathematics taught at these two levels of education is referred to as *basic mathematics*, which was introduced in 1975. According to Sichizya (1992), this programme emphasises learners being given an understanding of the fundamentals of mathematics and their active participation in learning the realistic use of mathematics. According to MOEC (2005, p. iv), the programme was expected to develop the following competencies in pupils:

1. To think critically and logically in interpreting and solving problems.
2. To use mathematical language to explain and clarify mathematical ideas.
3. To apply mathematical techniques in other fields.

In order for pupils to acquire these competencies, the teaching and learning of mathematics is guided by the following objectives (MOEC, 2005): firstly, to promote the development and application of mathematical skills for solving practical problems; secondly, to apply mathematical concepts to interpret situations at the local and global level; and thirdly, to develop the knowledge, techniques and skills for studying mathematics and related subjects.

Competency-based Education versus Content-based Education

Darling-Hammond, 2012; Scardamalia, Bransford, Kozma, and Quellmalz (2012) have indicated growing popularity of competency-based education, as opposed to content-based education, for developing competencies that are considered crucial for success in both academia and today's knowledge-based economy. The shift from content-based curriculum to competency-based curriculum was designed "to improve the quality of education by enabling learners to develop the competencies that are relevant to real life situations" (Komba & Mwandanji, 2015, p. 74). Competency-based teaching differs significantly from content-based teaching, which emphasises content coverage rather than understanding and application of knowledge and skills. The teacher is considered the sole source of what is delivered in the classroom, whereby transmission of knowledge through lecturing and chalk-and-talk dominate

the classroom discourse for the purpose of covering the overloaded curriculum. Content-based teaching also emphasised the memorisation of lecture notes by learners, which was considered vital for passing examinations through recalling and repeating of facts (Mulenga & Kabombwe, 2019). This implies that their barely time for teachers to provide students with constructive feedback and to support them in their learning needs (Bailey, 1998). Furthermore, in content-based teaching and learning, the focus is to make sure that students obtain high test scores and grades at graduation. Due this state of affairs, the shift from a content-based curriculum to a competency-based curriculum and from knowledge and skills acquisition to knowledge creation and application has been inevitable. The aim is to inculcate in students the habits of being independent and lifelong learners, as well as enable them to apply skills and knowledge learnt to real life situations. For appropriate implementation of the competency-based curriculum, the need of choice and application of a variety of teaching methods and strategies is critical. Therefore, teachers need to be skilful in applying teaching methods that will enable students to learn effectively (Kafyulilo, Rugambuka & Moses, 2012).

In this regard, even the assessment procedures differ in these two paradigms. In the content-based curriculum, assessment is regarded as traditional, while the competency-based curriculum is considered better as it is based on assessing competency.

Traditional Assessment vs Competency-based Assessment

It is acknowledged that assessment is important element of the teaching and learning process (Black & William 1998; Huba & Freed, 2000; Masters, 2002). Many studies have shown that classroom assessment is essential for successful teaching and learning (McMillan, Myran & Workman, 2002; Stiggins, 2005). For assessment to be effective, it should be learner-centred, meaning that each student is actively involved in the in the assessment of their learning (Masters, 2002).

The effectiveness of assessment depends on the extent to which students are engaged. In a teacher-centred classroom, student assessment is dominated by paper-and-pencil tests, commonly referred to as traditional assessment, whereby students typically do the selection of the correct answer or memorise information to complete a statement. In a learner-centred classroom, assessment is considered authentic, whereby students are asked to realistic problems that signifies the meaningful application of their knowledge and skills (Mueller, 2005). Fauziah, Mardiayana and Saputro (2018) assert that assessment is assumed to be authentic when students' performance is examined in just way, and is geared towards determining their competency in handling real problems in the world. Thus, it can also be referred to as competency-based assessment.

Competency-based assessment is the process whereby a teacher works with a student to gather evidence of competence using set criteria (Kapambwe, 2010). In competency-based assessment, the students and the teacher agree on the objectives and the criteria for assessing performance. The teacher ought prepare objectives focusing on the attainment of competences and then prepare the relevant task, after which the criteria to be used for marking the task should be agreed on by the teacher and the students (Kapambwe, 2010). This type of assessment is much fairer when the criteria for addressing the performance of students are agreed on beforehand.

Competency-based assessment is learner-centred, in the sense that the student plays an important vital in the assessment process, especially in assessing peers, and in agreeing on the assessment criteria with the teacher. In the competency-based assessment, a student can be asked to do different of activities, which include assignments, projects, tests, lab activities, building up a portfolio and outdoor activities (Kapambwe, 2010). In doing different activities makes competency-based assessment valid and authentic, because it identifies learners' needs,

helps to plan future learning, tracks learners' progress and helps them improve their work (Kapambwe, 2010).

Classification of Assessment as regards Mathematics

Assessment can be classified as large scale and classroom assessments. Suurtamm et al. (2016) argue that the two types of assessment serve different purposes and have different goals.

Large-scale assessment informs systems, as it is often used to monitor systems, to evaluate programmes, or to make student placements (Suurtamm et al., 2016). In different places in the world, students' knowledge of mathematics is assessed using some kind of large-scale assessment such as national, zonal or regional assessments, but could also take the form of international assessments, such as those conducted by Twaweza, the Southern and East Africa Consortium for Monitoring Education Quality (SACMEQ), the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). For the purpose of accountability, large-scale assessments are used to monitor education systems, and they are increasingly playing a vital role in the lives of both students and teachers, as graduation or class promotion often depend on students' test results. Teachers are sometimes evaluated, partly on how well their students perform (Wilson & Kenney, 2003).

Large-scale assessment has traditionally focused on paper-and-pencil, and is primarily concerned with the scores students, rather than their thinking and how they communicate (Suurtamm et al.,2016). Paper-and-pencil testing is concerned with reliably measuring the outcome of learning, rather than the learning itself (Baird et al., 2014). The format is traditionally used in large-scale assessment whereby a mathematics problem typically has only one correct answer (Van den Heuvel-Panhuizen & Becker, 2003). This format is more inclined to the behaviourist or cognitivist perspective, which typically focuses on independent components of knowledge (Scherrer, 2015). Sometimes, the problems that have one right answer conflicts with classroom assessment that emphasises a number of responses and provides opportunities for students to exhibit their reasoning and creativity.

On the part of classroom assessment, its purpose is to gather information and provides feedback to facilitate students' learning (De Lange, 2007) and to improve teaching. Recent viewpoints on classroom assessment encourage the use of different assessment strategies, tools and formats, which provide opportunities for students to demonstrate their learning and make good use of formative feedback on a regular basis while involving students in the assessment process (Klenowski, 2009; National Council of Teachers of Mathematics [NCTM], 2014). Classroom assessment that is conducted by the teacher is considered most effective when closely linked with what and how the students have been learning (Baird et al., 2014). Through classroom assessment, a range of responses are obtained and students are provided with opportunities to exhibit their reasoning and creativity.

Principles of Assessment

According to Suurtamm et al. (2016), certain principles of assessment are relevant to both large-scale and classroom assessment. Even though assessment is conducted for different purposes, for example, reporting on students' progress or monitoring the effectiveness of an instructional programme, a number of authors suggest that the fundamental purpose of classroom assessment or large-scale assessment, should be to facilitate students' learning (Joint Committee on Standards for Educational Evaluation, 2003; Wiliam, 2007). The Assessment Standards for School Mathematics from the National Council of Teachers of Mathematics in the USA (NCTM, 1995) they articulate the principles that the assessment of mathematics is of a high quality, that students' learning is enhanced, that assessment reflects and encourages equitable practices and is open and transparent, that conclusions made from assessments are

appropriate to the assessment purpose, and that the assessment, along with the curriculum and instruction, form a coherent whole, are all still valid for sound large-scale and classroom assessment as regards students' understanding of mathematics.

Besides content, large-scale and classroom assessment should also take into account mathematical practices, processes, proficiencies as well as competencies (NCTM, 1995; 2014; Pellegrino, Chudowsky, & Glaser, 2001; Swan & Burkhardt, 2012). It should be born in mind whether and how tasks are to be assessed, as well as to the complexity of mathematics and the curriculum or standards. In planning for both large-scale and classroom assessment, the focus should be on problem solving, modelling and reasoning. The assessment should reflect the type of activities that occur in instruction.

Classroom Assessment Techniques

Classroom assessment should be an integral part of instruction and an on-going process. The focus of this type of assessment, which is commonly known as formative assessment, "is on learning development, on guiding students in becoming skilful in their own learning by using a criterion approach to assessment" (Voinea, 2018, p. 10). The emphasis is put not on performance and comparison as Black and William (1998) suggest, but on mastering learning, that is, developing each student. Kim and Lehrer (2015) use a system that assesses students' progress in learning to help teachers develop tasks that help them to progress in a particular domain. Their work focuses on developing concept maps that are the outcome of progress in learning Assessment items aimed at generating the types of reasoning identified in the concept maps, scoring exemplars, and lesson plans with contexts that enable students to engage with the representations of mathematics. Thompson & Kaur (2011) and Bleiler & Thompson (2012; 2013) support a multi-dimensional approach to assessing students' understanding, building on curriculum work originating from the University of Chicago School Mathematics Project in the USA. They recommend that, for any content topic, teachers might think about tasks that assess understanding of that content from four dimensions: Skills (S), which deal with algorithms and procedures, Properties (P) which deal with underlying principles, Uses (U) which focus on applications, and Representations (R) which deal with diagrams, pictures, or other visual representations of the concepts. This SPUR approach to understanding and assessing helps to ensure that teachers not only teach from a balanced perspective but also assess from a balanced perspective. Thompson and Kaur (2011) study from an international study on grade 5 students in the USA and Singapore revealed that students' proficiency is often different across the four dimensions, may be because of a different emphasis in the curriculum and instruction. There are various assessment techniques that teachers can use to get adequate information as evidence of their students' learning. This paper could not address them all, but has sought to address those that may be suitable for Tanzania context.

Written Assessments

There is a misconception among a number of educators that by shifting to the competency-based curriculum, written tests will lose their value. In contrast, written examinations and tests, which are popularly known as paper-and-pencil examinations, can efficiently assess students' mastery of a body of knowledge, their ability to reason logically about a range of problems and to apply procedures such as mathematical algorithms, in both large-scale and classroom assessment. These areas cannot be measured successfully by other assessment techniques.

"Written assessments are activities in which the student selects or composes a response to a prompt. In most cases, the prompt consists of printed materials (a brief question, a collection of historical documents, graphic or tabular material, or a combination of these)" (Stecher, Rahn, Ruby & Alt, 1996, p.22). According Rahn et al. (1995), there are three types of written

assessment, one includes selection of responses and two of which involve supply of responses. The selection type includes multiple choice, matching and true-false tests. These are commonly used for gathering information about students' knowledge of facts or their ability to perform specific operations (as in arithmetic). In these types of written assessments, students answer numerous questions in a short time. They provide an efficient means of gathering information on a wide range of knowledge and skills. Multiple choice tests are not restricted to factual knowledge, but can also be used to measure higher-order thinking and problem-solving skills (Airasian, 2001; Miller, Linn, & Gronlund, 2009). However, adequate expertise is needed to construct test items that measure analysis, synthesis, evaluation and other higher cognitive skills. The other two types of written assessment both involve supply of responses. The first consists of short answer tests or questions, whose answers might be a word or phrase (such as the name of a particular piece of equipment), a sentence or two (such as a description of the steps in a specific procedure), or a longer written response, for example, an explanation of how to apply particular knowledge or skills to a situation. The short-answer questions that ask students to produce specific knowledge or facts make very limited cognitive demands, whereas open-ended questions can be used for measuring complex learning outcomes, such as logical thinking, interpretation or analysis. The second type of written supply assessment includes essays, solving a problem and responding to scenarios, which is similar to open-ended questions, except that they make greater demands on students in terms of dealing with more complex learning outcomes that require more logical reasoning and a greater level of understanding. “Problem-based examinations include; mathematical problems and open-ended challenges based on real-life situations that require students to apply their knowledge and skills to new settings” (Stecher et al., 1996, p. 26). Stecher et al. (1996) contends that scenarios are similar to problem-based examinations, but the setting is described in greater detail and the problem may be less well formed, calling for greater creativity.

Practical Worksheet

Toh, Quek, Leong, Dindyal, & Tay (2011) comment about the popularity of practical worksheet in Singapore mathematics classrooms to assess students' mathematical problem-solving. The focus of this assessment is on the processes used for solving problems rather than on the final solution. Based on the problem-solving work of Pólya (1945) and Schoenfeld (1985), the practical worksheet are very useful in the sense that students make precise statements that show how they understand the problem, what plans they developed and implemented in an attempt to solve the problem, what key decisions and detailed steps they took at various points along the plan, and how they checked their solution and expanded on the problem (Suurtamm et al., 2016). Therefore, through students making their thinking obvious to the teacher, their peers and themselves significant information is obtained that can be used to discover misconceptions in their thinking that appropriate steps can be taken to help students move forward. According to Suurtamm et al. (2016), if students become familiar with the scoring rubric coupled with the practical worksheet, it will help them monitor and assess their own understanding and problem-solving underatakings.

Interview

Interview has currently become one of the popular techniques of assessing mathematics. It helps the teacher to determine a student’s depth of understanding of the content. It is not about measuring whether the student can provide the correct answer. Interviews are “effective at diagnosing both strengths and needs. They encourage students to reflect on their thinking and provide additional information on exceptional students” (Alaska Department of Education & Early Development, 1996). The interview can be conducted with an individual student or a small group by asking open-ended questions, and their answers will show whether capable to

perform or comprehend specific mathematical tasks. If students are unable to explain the processes that are used, probably they have not understood them. The interview can also help to uncover a student's misinterpretation of mathematical terminologies or symbols. Culturally-sensitive task-based interviews were used with a diverse group of young children in New Zealand to ascertain the mathematical proficiency (Young-Loveridge & Bicknell, 2015). In this case, the researchers used contexts that was familiar to the children being interviewed, especially, disadvantaged ones, to explore their understanding of concepts, such as multiplication and division, through the contextual cues they were given, although they had not previously studied these concepts.

Observation

Teacher observation is one of the oldest assessment techniques in mathematical skills as its use started since the establishment of the first formal classrooms. As it is well known, mathematics is a subject that consists of step-by-step procedures, therefore, direct observation can be used together with rubrics, to identify step in the learning process where a student has no clear understanding.

Newmann, Lopez, and Bryk (1998) contend that observational assessment is very useful for providing formative feedback to teachers as well as other educational officials, thereby improving the quality of teaching and learning process while supporting teachers' reflection and self-evaluation. According to (Clare & Aschbacher, 2001, p. 40), "Classroom observation is the most direct way to measure instructional quality". What teachers observe depends on what they want to find out about the children in their classroom. They will observe children's skills, knowledge and behaviour to determine whether they are performing according to expectations by age or classroom level.

Observation is applied by teachers watching students' participation in the teaching and learning process in the classroom. In a mathematics class, students often have different abilities of grasping the concept being taught. Some grasp quickly and other lake longer time to do so. Another avenue where observation is vital is on students' reactions in collaborative work. When students are in groups, they are more likely to show their emotions than when working individually. Therefore, observation is only useful if the students' emotional reaction to the material is obvious. It is advised that another form of assessment be applied if the observer cannot rely on the class to react openly and honestly to the lesson,

Structured observation is more specific, and so is easier to implement. Structured observation is the same to what Maxwell (2001) considers as planned observation. According to Maxwell (2001), planned observation is goal-oriented. It focuses on specific learning outcomes which are watched and recorded and are rated on predetermined scales, that is, rubrics. The rubrics help in producing data which can be quickly analysed. The rubrics are constructed so that each specified behaviour to be observed is placed in a scale, whereby favourable reactions are given a high number. The data then can be analysed according to the specific behavioural categories or as a whole. In addition, using the structured characteristics of the rubric enables the observer to rate more than one behaviour at a time.

Portfolios

Portfolios have long been used successfully by teachers in many parts of the world, especially developed countries, to assess a student's work. The growth and development in the mathematics portfolio is associated to the National Council of Teachers of Mathematics (NCTM) (1989; 1991) and its curriculum, which demands all students to: (1) learn the value of mathematics, (2) develop mathematical confidence, (3) become problem solvers, (4) learn how to communicate mathematically, and (5) learn how to reason mathematically. According to Stix (1994), a mathematics portfolio is a collection of students' work that provides evidence of their understanding of the subject, and if collected over a period of time reveals the growth in their

understanding. If properly developed, portfolio facilitates communication between student and teacher and provides additional information concerning a student's progress and needs. What should go into a mathematics portfolio is open to debate. The literature suggests that it should include proof of students' problem-solving ability, projects, mathematical investigations, writing examples, reflections and completed tasks in the three broad categories of problem solving, reflective writing and work selected by the teacher [Lambdin & Walker, 1994; Crowley & Dunn, 1995].

Portfolios give students an opportunity to participate fully in assessing their learning progress. According to Burks (2008), there are several objectives for using portfolio in assessment. First, apart from showing the students the importance of organisation, it inculcates the habits of daily preparation and the development of good study habits. Second, it reminds them that they need to complete their homework and the problems on the blackboard, as well as reflecting on quizzes and exams. Finally, it assesses students' progress rather than grading it at a fixed time.

McDonald (2012) reported that students have a positive perception of portfolio assessment, because much can be learnt from looking at it, and students feel part of the assessment.

Project Assessment

Project assessment or in other words project-based assessment, is regarded as a component of a teaching and learning method commonly known as project-based learning (PBL). The assessment method is claimed to benefit learner due to its features such as; authenticity, motivation, an opportunity for collaboration and others (Trash, 2018). Project assessment involves in-depth exploration into real life topics, and reveals students' ability to apply their skills in planning the project, collecting and organising the data, and then processing, analysing and presenting the data. Hamzah and Koni (2012) state that students' projects to be assessed should be time bounded, and be used to assess students' understanding, ability to apply knowledge and skills, investigate and state things clearly. Empirical evidence suggests that project as an assessment method improves students' learning of mathematics over the traditional assessments. For instance, Fauziah, Mardiyana and Saputro (2018) and Stoica (2015) found that project assessment positively effects students' learning of mathematics. Trush (2018) outline guidelines to make project based assessment meaningful and supportive to learning. first, students need to be given the freedom to choose a topic or real-life problem of their own and plan themselves how to carry out their project. Secondly, the teacher needs to develop in advance the grading rubric and discuss with the students. Furthermore, for collaborative projects, teachers need to devise means for assessing individual student's contribution in the project. Monitoring of students' progress in their project is required to identify areas for scaffolding.

Performance Tasks

Performance tasks refer to assessment that involves either the observation of behaviour in the real world or a simulation of a real life activity (Weigle, 2002; Suzan, 2013). This category of assessment covers an extremely wide range of behaviours, as clarified by Hibbard et al. (1996, pp. 5-6)):

> "Performance tasks represent a set of strategies for the...application of knowledge, skills, and work habits through the performance of tasks that are meaningful and engaging to students.... Good performance assessment tasks are embedded in the important content, skills, and products in any curriculum; they are not an add-on at

> the end of a unit of study… (but) both an integral part of the learning and an opportunity to assess the quality of student performance" (p. 5-6).

The skills to be assessed in performance tasks may vary considerably. Some tasks may take place in the classroom especially those requiring a student to demonstrate his or her ability in a straightforward way. Other tasks may require real life situations and demand a student to apply the knowledge and skills learned in the classroom (Suzan, 2013; Tejeda & Gallardo, 2017). It is noted that scoring of open-ended performance assessment, in particular the tasks involving complex students' responses, is more difficult. Various scoring methods have been proposed for scoring students' complex performance, by means of both holistic and analytic approaches (Suzan, 2013). In some tasks, the assessment may focus directly on the performance process whereas in others, assessment is on the final product or oral presentation. In other situations, judges may assess both the procedures used together with the final product (by rating presentation and taste). Group work is not judged, only individual responses. Recent research demonstrate how performance tasks can be administered and scored by a computer (Suzan, 2013), but this is still at the experimental stage, although the results these research are promising. Two types of computerised assessment tools require consideration. First, computers simulations have made possible the modelling of real-world problems and provide interactive environments. Second, expert computer systems for scoring constructed responses are increasingly emerging. For example, Bennett and Sebrechts (1996) created a computer system for scoring students' performance responses in algebra. In terms of accuracy for assessing students' responses, this system was found to be almost the same as human judges; however, it was less effective in classifying students' errors. Empirical research on assessment of the performance of tasks in mathematics suggests that students' understanding has improved and they have a positive perception of performance assessment. For example, Iannone and Simpson (2015) revealed that mathematics students found that oral assessment of performance led to a deeper understanding of mathematical concepts, procedures and processes. Furthermore, performance assessment is regarded as authentic and responsive to the immediate needs or knowledge gaps of students.

Concept mapping

In the literature, concept mapping is described as a teaching and learning technique as well as an assessment method. As an assessment technique, concept maps involve a task that learners have to perform to demonstrate their knowledge of the concepts and rubrics a teacher uses to evaluate their knowledge (Mutodi & Chigonga, 2016). Concept mapping can be used before teaching to assess the prior knowledge of learners, or after teaching to assess how learners organize and represent what has been learnt. In the mathematics education context, it has been revealed that concept mapping can be used to assess how learners view mathematical concepts and to reveal their misconceptions. Mutodi and Chigonga (2016) further reveal that mathematics teachers positively perceive concept mapping as a useful assessment method in mathematics, which adds to the list of assessment practices that promote meaningful learning.

Conclusion

The techniques described briefly in the previous sections are just a sample of assessment strategies that classroom teachers can use on a regular basis to discover the types of mathematical problems students find difficult to solve, which will inform their teaching and reveal students' thinking. Numerous other strategies have been identified in the literature, such as journal writing exit slips, learning logs, and "find the errors and fix them". No single assessment technique is proclaimed to be adequate for assessing all mathematical competencies

as each technique may be suitable for some purposes but not for others. The decision to use a particular method should be guided by several factors including the purpose of the assessment, learners, and the learning context. Empirical research may be required on how to best use the various assessment techniques particularly in challenging situations such as large class sizes and pressure national examinations

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