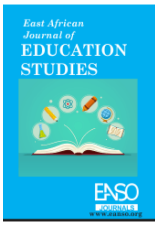

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Original Article

Multiple-Choice Versus Short Answer Items in Assessing Students' Mathematical Skills: Evidence from Secondary Schools in Tanzania

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ABSTRACT

Assessment plays a crucial role in improving teachers' classroom practices. The information gathered from the assessment informs teachers about students' learning progress. Multiple-choice items (MCIs) as one of the assessment tools have been used to assess mathematical skills at different educational levels in the world, including Tanzania. However, there has been an outcry that some pupils pass the Primary School Leaving Examination (PSLE) and join secondary education without mastering basic mathematical skills. This study aimed to (i) determine the extent to which MCIs and Short Answer Items (SAIs) assess students' mathematical skills and (ii) determine whether there is a difference in assessing students' mathematical skills in secondary schools between MCIs and SAIs. 387 Form I students from four public and two private secondary schools participated in the study. Data were collected using two equivalent mathematics tests and analysed using descriptive statistics. The findings revealed that MCIs had a high mean score of 30.44, and SAIs had a relatively low mean score of 26.2028. The study further found that only 7.49% of students-maintained scores in MCIs and SAIs, while 81.65% and 10.85% had scored higher in MCIs and SAIs, respectively. The study recommends that an effective assessment tool should contain more SAIs than MCIs due to their relative advantage in assessing students' mathematical skills as opposed to MCIs.

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INTRODUCTION

Assessment is an important component for students and teachers in the teaching and learning process. It helps them realise the extent to which the intended learning outcomes have been achieved (Popham, 2010). Information from assessment activities serves as criteria for improving classroom instruction and can also be used for decision-making, like promoting students to other levels of education. The assessment ranges from paper and pencil, such as MCIs and SAIs, to alternative performance assessments that include portfolios, peer appraisals, and anecdotal records (Danielson & Dragoon, 2016; Popham, 2010).

Assessing a student appropriately requires a meaningful assessment tool that captures massive amounts of information. To assess the mathematical skills of a student, one needs to use a meaningful assessment tool that uses evidentiary procedures to realise the strengths and weaknesses of the assessed mathematical skills (Kaur & Wong, 2011). Despite the presence of other assessment tools that require students to make arguments and write responses, MCIs is a paper and pencil tool that has been mostly used to assess students' mathematical skills at different levels of education in the world (Al-Faris, Alorainy, Abdel-Hameed & Al-Rukban, 2010) this is due to its ability to cover large content, its objectivity, and its easy marking. However, it is imperative to use an appropriate assessment tool in order to obtain reliable information. For instance, using an assessment tool that may not allow judgment and evaluation of assessed mathematical skills through evidentiary procedures would lead to the production of unreliable information for students, teachers, and policymakers, which would ultimately lead to uninformed decisions (Stankous, 2016). At this stage, it is vital to select the appropriate assessment tool to reliably assess how a student acquires mathematical skills.

Mathematical skills include those that require students to manipulate procedures and apply them in real-life situations. Students should be able to demonstrate multidimensional skills that are to be assessed and evaluated. The real demonstration of these skills is crucial to inform teachers and students of how much they have done and what is remaining to attain the teaching and learning objectives. Kaur and Wong (2011) and Kitta and Fussy (2013) have emphasised the use of appropriate assessment tools that stimulate students' mathematical thinking skills as opposed to inappropriate tools. A well-sought-out tool for assessing mathematical skills allows teachers to capture massive amounts of information about their student's learning as they stimulate students' thinking (Kitta & Fussy, 2013).

The Inception of Multiple Choice Items in the Primary School Leaving Examination in Tanzania

In the past decade, in 2011, the National Examination Council of Tanzania (NECTA) started to use MCIs in the Primary School Leaving Examination (PSLE) in all subjects, including mathematics; all 50 items were MCIs (NECTA, 2011). Students were required to shade the letter of the correct answer on the Optical Marker Reader (OMR) form. The adoption of this technology was in a bid to counterbalance the workload resulting from the increased number of students sitting for PSLE (Kitta, 2014). It ensured the cost-effective running of the examinations as well as simplified and enhanced accuracy in marking and scoring the examinations (NECTA, 2011). An OMR is a special form consisting of letters, which are shaded using hard and black (HB) pencils and inserted into the computer to be recognised. As stated by Loke, Kasmiran and Haron (2018), OMR helps in processing the volume of documents quickly and accurately.

In 2018, NECTA reduced MCIs from 50 to 40 and introduced 5 SAIs. Students select the correct

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response for the 40 MCIs and shade its letter on the OMR form; each item carries one mark, amounting to 40 marks. For the remaining 5 SAIs, students write the procedures, and each item weighs two marks, making 10 marks (NECTA, 2018).

The pass rate has been on the increase since 2011; it changed from 58.3% to 81.5% in 2019 (URT, 2020). This pass rate shows a great improvement in the educational sector in Tanzania as the majority of the pupils are getting opportunities to join secondary education. However, research indicates that some primary school leavers possess limited mathematical skills (TWAWEZA, 2016; Ngussa & Mjema, 2017; UWEZO, 2019). Furthermore, Kigobe (2019) states that some manage to pass PSLE without mastering basic mathematical skills like addition, subtraction, multiplication, and division. In this case, the pass rate does not signify the mathematical skills students have achieved.

The Main Objective of the Study

The objective of this study was to determine the effectiveness of multiple choice and short answer items in assessing students' mathematical skills in secondary schools in Kinondoni Municipality, Dar es Salaam, Tanzania.

Specific Objectives

- To determine the extent to which MCIs and SAIs assess students' mathematical skills in secondary schools.
- To find out whether there was a difference in assessing students' mathematical skills between MCIs and SAIs in secondary schools

THEORETICAL PERSPECTIVE OF THE STUDY

Assessing students' mathematical skills can be done by providing them with tasks of either low cognitive demand or high cognitive demand. Low-cognitive-demand tasks require students to memorise or reproduce facts (Stein & Lane, 1996). The assessment done using these kinds of tasks is based more on achievement than process. In other words, low cognitive demand tasks do not require students to demonstrate their ability through evidentiary procedures; the judgment of the assessed mathematical skills is based on right or wrong. It is similar to an assessment done through the use of multiple-choice items (MCIs). In MCIs, students are assessed based on the correct answer they get, as no procedures are shown or judged to determine the extent to which the required mathematical skills have been mastered.

On the side of high-cognitive-demand tasks, students need to make connections to underlying mathematical ideas. According to Stein and Lane (1996), high cognitive demand tasks engage students in disciplinary activities of explanation, justification, and generalisation or in using procedures to solve tasks that are open with regard to which procedures to use. For example, an assessment done through SAIs provides vast information, as procedures to arrive at the final correct answer need to be indicated. High cognitive demand tasks are considered to be effective in assessing students' mathematical skills because they make students creative and critical thinkers (Stein, Grover & Henningsen, 1996; Stein & Lane, 1996). In high-cognitive-demand tasks like SAIs, students are assessed on the way they make arguments and write evident procedures. They provide students with the opportunity to demonstrate their self-ability evidently through procedures (Kaur & Wong, 2011). As a result, students' strengths and weaknesses in the assessed mathematical skills are identified for improvement where necessary.

The Cognitive Load Theory

John Sweller proposed cognitive load theory in the 1980s to explain the limitations of working memory as well as the factors that influence learning and problem-solving. According to the theory, working memory has a limited capacity to process and store information, which can lead to cognitive overload and impede learning. This theory led to a comparison of how different types of assessment items (MCIs and SAIs) affect students' cognitive load and mathematical

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performance. Multiple-choice tasks can help students reduce their cognitive load by giving them options that make it easier for them to recall and apply math concepts. Conversely, items with short responses can increase students' cognitive load by requiring them to remember and apply mathematical concepts without prompts or options to choose from. Through this theory, it was possible to study how the type of assessment item (MCIs or SAIs) affects the cognitive load of students and their performance in mathematics.

METHODOLOGY

Research Approach and Its Design

The study used a quantitative approach. It used a cross-sectional survey design to compare the effectiveness of MCIs and SAIs in assessing students' mathematical skills. In addition, it used a simple random sampling approach to obtain a total of 387 forms of students involving 189 boys and 198 girls from 6 secondary schools selected randomly from Kinondoni Municipality: four public schools and two private schools. The use of simple random sampling techniques ensured an equal chance of inclusion for students and schools.

Data Collection and Scoring Procedures

Forty items were composed; to ensure that items are aligned with the Tanzanian educational curriculum in terms of their validity and reliability, they were selected from NECTA papers from 2017 and 2018. The items were presented in both MCIs and SAIs. The administration of the MCIs test started, followed by the SAIs test, with an interval of 20 to 30 minutes depending on the school timetable.

The time allotted for either test was two hours. For each MCI, a student was required to write the letter of the correct alternative from the given four alternatives in the answer sheet. On the other hand, a student was required to write procedures and the answers on the answer sheets. Furthermore, for consistency, in order for a student to participate, they had to first accept that they would sit for tests in both formats. They sat in more than one class at schools with more than 45 students to ensure that each student wrote the test with self-effort and ability. The answer scripts were collected after each test, and scripts from all schools were marked by a panel of researcher assistants to limit biases in scoring the tests, particularly the SAI test. In the MCIs test, a student received a score for writing the correct alternative letter, whereas in the SAIs test, a student received a score for correctly presenting a procedure and reaching the correct answer. After scoring, scores for each student for each test format were analysed using Statistical Package for the Social Sciences (SPSS) version 25.0.

FINDINGS AND DISCUSSION

Demographic Information of Students

Table 1 shows the distribution of respondents; there were more girls than boys. In addition, four schools had 64 students each with one school having 67 students.

Table 1: Demographic information of respondents

Secondary Schools	Number of Students		
	Boys (%)	Girls	Total
A	33 (51.56)	31(48.44)	64
B	30 (46.88)	34 (53.13)	64
C	32 (50)	32 (50)	64
D	30 (46.88)	34 (53.13)	64
E	31 (48.44)	33 (51.56)	64
F	33 (49.25)	34 (50.75)	67
Grand-total	189 (48.84)	198 (51.16)	387

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Test Scores Distribution.

Table 2 shows how students scored on the test for both formats. The mean score for MCIs was higher than the mean score of the SAIs by 14.24 with a higher standard deviation in the SAIs than in MCIs. It showed that students had performed better in MCIs than SAIs despite being the same test presented in different formats.

Table 2: Students' Mean Scores and Standard deviation in MCIs and SAIs

Mathematics Test	Number of Students	Mean Score (M)	Standard deviation (SD)
MCIs	387	30.44	7.313
SAIs	387	26.20	8.751

The data were also analysed using histograms, as shown in the following *Figures 1* and *2*, to show how the scores are distributed.

Figure 1: The distribution of scores for MCIs

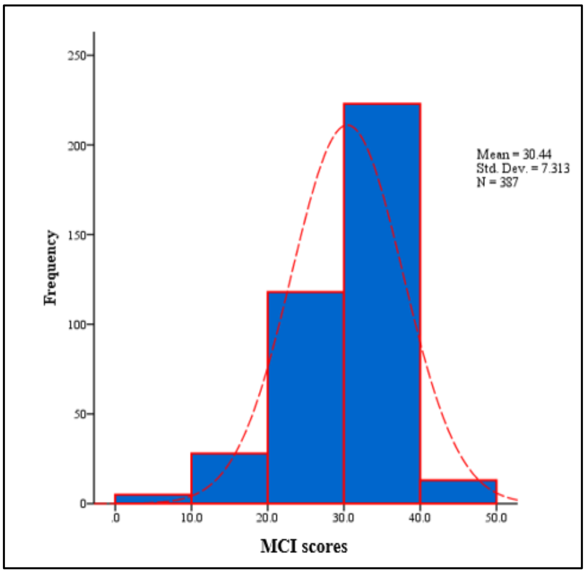

Figure 2: The distribution of scores for SAIs

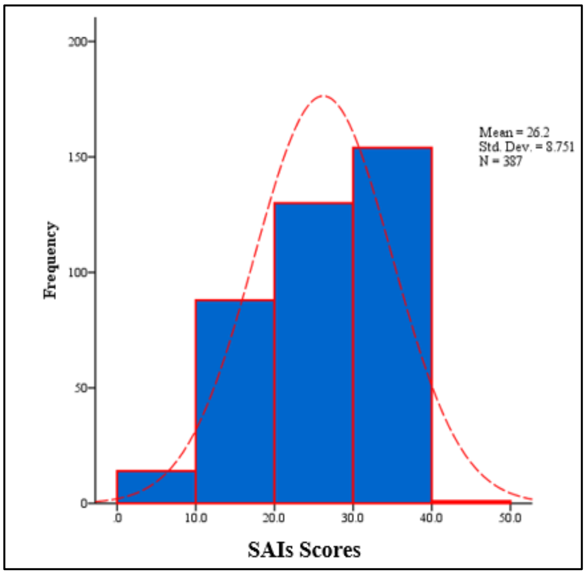

Figure 1 shows negative skewness. This implied that students' scores deviated from the mean score of 7.313. MCIs assessed students' mathematical skills in large proportion because the majority of the students performed with high scores compared to that of SAIs, whose students' mean score and standard deviation were 26.2 and 8.751, respectively.

Figure 2 was fairly symmetric distributed. This implied that few students managed to demonstrate their mathematical skills through written procedures and correct answers. In other words, the high mean suggests that MCIs are more effective in assessing students' mathematical skills as the majority of them performed with higher scores as compared to SAIs, which have a mean of 26.20. The mean of SAIs (26.20) suggests that only a few students managed to demonstrate their mathematical skills despite the formats being similar to that of MCIs.

Comparison of MCIs and SAIs in Assessing Students' Mathematical Skills

The findings revealed further that the majority of the students, 316 (81.65%) out of 387, performed higher in MCIs than 42 (10.85%) of 387 in SAIs. Only 29 (7.49%) students scored equally in both MCIs and SAIs (See *Table 2*).

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Table 3: Student Test Scores in MCIs and SAIs

Performance	Number of Students	Percentage
MCIs	316	81.65
SAIs	42	10.85
Both MCIs and SAIs	29	7.49
Total	**387**	**100**

The analysis was also done using a pie chart to show how the MCIs differed from SAIs in assessing students' mathematical skills, as shown below in *Figure 3*.

Figure 3: Students' Performance in MCIs and SAIs

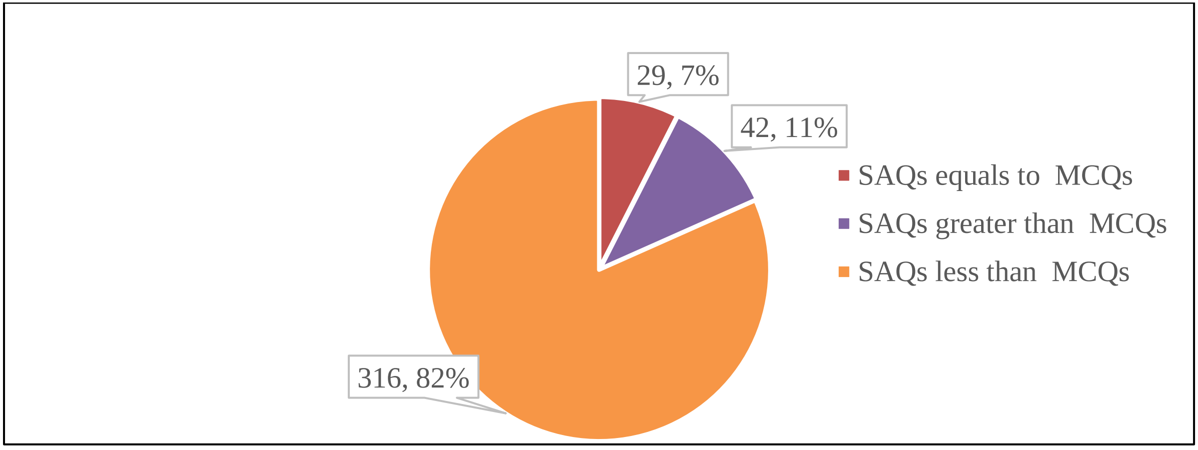

Figure 3 implied that the majority, 81.65% of students, scored low marks in SAIs compared to 10.85, who scored high marks in SAIs, while only 7.49% had performed equally in both MCIs and SAIs. The high performance of students in MCIs and low in SAIs suggests that there is a difference in the effectiveness of MCIs and SAIs in assessing students' mathematical skills.

DISCUSSION

Based on these findings, MCIs and SAIs assessed students' mathematical skills differently, as there were high disparities in performance. Despite the fact that the two sets of tests were equivalent in terms of the domain of knowledge, content, and number of items, the majority of students (81.65%) failed to demonstrate their mathematical skills in SAIs. In other words, this percentage (81.65%) performed better in MCIs. However, this performance in MCIs does not reflect reality, as the majority of the students did not manage to demonstrate mathematical skills that they had mastered through evident procedures in SAIs. MCIs would be considered as effective in assessing students' mathematical skills as SAIs if the performance was almost equal in both MCIs and SAIs. The findings concur with those of Igbojinwaekwu (2016) and Mckenna (2019), who found that in MCIs, students tend to perform well with high scores as all suggested answers are in the examinees' hands. Even if the student fails to write the procedures in MCIs, he or she can select any suggested answer, and a lucky student can get the correct answer. In MCIs, guessing is dominant compared to SAIs, which require students to demonstrate in writing evident procedures (Xu, Kauer, & Tupy, 2016). SAIs require students to write procedures systematically until the final correct answer is obtained; if this is not done correctly, it becomes very difficult to get the correct answer, and there is no room for guessing. Unlike the MCIs, SAIs provide students with an opportunity to demonstrate the multidimensional mathematical skills they have already mastered (Kau & Wong, 2011). Through procedures, misconceptions are identified for students' learning improvement.

The study's findings support a previous study by Stankous (2016), which confirmed that SAIs give a better understanding of students' mathematical

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skills learning compared to MCIs. Assessment of mathematical skills through MCIs does not reveal the reality of how students have achieved the learning objectives as it lacks procedures to be judged and evaluated. Unlike SAIs, MCIs tend to overestimate the students' ability to use the assessed skills. Assessment done using MCIs is like making the assumption that the assessed mathematical skills are well understood, as there is no demonstrated evidence (Kikomelo, Lyakurwa & John, 2022). It is based on achievement rather than process toward the correct alternative, as opposed to SAIs, which concentrate on demonstration through evident systematic procedures (Kau & Wong, 2011). SAIs provide room for mathematics teachers to cultivate massive amounts of information on students' strengths and weaknesses in assessed mathematical skills.

MCIs are advantageous to mathematics teachers as they help them cover the large content while constructing the test items, thereby assessing the broad range of students' mathematical skills. However, their efficiency and effectiveness in identifying the strengths and weaknesses of mathematical skills are questionable (Sariay, 2017; Medawela, Ratnayake, Abeyasinghe, Jayasinghe & Marambe, 2018; Kikomelo, 2020). Since MCIs deprive students of demonstrating their ability through multidimensional procedures, teachers are unable to identify students' difficulties and misconceptions as a result of an ineffective assessment instrument.

CONCLUSION AND POLICY RECOMMENDATIONS

The study concludes that MCIs and SAIs assess students' mathematical skills differently. The overall students' mean scores in MCIs were 30.44 and 26.20 in SAIs. In addition, the majority (81.65%) of students had higher scores in MCIs than the 10.85% who scored high in SAIs, and only 7.49% scored equally in both MCI and SAI formats. Based on these findings, mathematics teachers at all levels of education should use SAIs when assessing students' mathematical skills. In other words, where necessary, a test should constitute 25% MCIs and 75% SAIs. Furthermore, assessment tools should make students demonstrate their ability through multidimensional procedures to help teachers understand and correct misconceptions students face during teaching and learning.

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