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For further information, please consult our ***call for papers*** at the end of the Journal.

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EDITORIAL

We extend a very warm welcome to authors and readers of this edition published under COVID-19 restrictions in Ghana and all round the world. In the midst of lockdowns and COVID-19 protocols, we did not believe that this edition would see the light of day. ‘Launching’ our call for submissions in August 2019, our original target had been to publish in the first quarter of 2020. However, the challenges seemed unsurmountable and, understandably, a few articles were withdrawn by some authors who decided to seek greener pastures elsewhere. We are grateful to the authors who stuck with us through thick and thin. With hearts full of gratitude, we stretch our hands towards heaven and say, “Thank you daddy.”

Please read our call for papers on the theme, *the Global impact of The Corona Virus Disease on Education.*

Our first article of Volume 8 is written by Inaku Egere. Egere conducted a study in South-south Nigeria. The problem addressed in the study was the amount of time spent on SNS and its effects on the academic performance of male undergraduates. The survey research design was adopted for the study. A sample size of 380 derived from a population of 11,786 was used for the study. The instrument used to gather data for the study was a questionnaire. Face validity technique was used to validate the research instrument. Data obtained were analysed using Statistical Package for Service Solution (SPSS 23.0). The findings revealed that SNSs have become an essential part of the daily lives of male undergraduates. The majority of students spend at least 5-7 hours a day on SNS at lecture halls/theatres and SNS are used mainly for chatting, leisure, music, sports, politics, entertainment, and connecting with family and friends. The study also showed that when a student spends much time on SNSs, there is a corresponding negative effect on that student’s academic performance. Therefore, the study recommended the introduction of a course on media and information literacy moderation in the use of mobile devices during lectures. It also recommended the setting up or expansion of counselling units to help students overcome their challenges.

In our second article, Ogwang, from Uganda, investigated whether shorthand was still practiced by secretaries and instructors and whether shorthand was still relevant to modern secretaries. Telephone interviews and questionnaires were administered to a sample comprising Executives, Secretaries and Shorthand Instructors drawn from both public and private institutions in Uganda, using convenience and snowball sampling. Data were processed and descriptively analysed using SPSS version 20. The results indicated that firstly, secretaries no longer regularly use shorthand. Secondly, stenography was no longer popular among instructors, who largely considered it to be irrelevant. Nevertheless, the researcher recommended that candidates should be selected from people who had a pass grade in English language because this would produce more skilful practitioners.

The study of Richmond and others aimed to develop and validate a proportional reasoning test (PRT) to measure students' proportional reasoning skills on rates, ratios, and proportions in mathematics. Test items were designed to reflect the aspects of proportional reasoning identified in the existing literature. These aligned to the instructional objectives of Kenya's secondary mathematics curriculum. The test was piloted on a sample of 45 form three students from one school. The results showed an internal consistency level (Cronbach's α= .83). The item analysis revealed that all the items had a moderate difficulty level ranging from .39 to .50. The findings suggested that the PRT is a valid and reliable instrument that can be used to measure the impact of a formative assessment intervention on students' achievement on proportional reasoning skills.

Adeyemi and others investigated the effect of citizenship education on Junior Secondary School Students, regarding Civic Knowledge and skills. Two null hypotheses were formulated and tested at 0.05 level of significance. The study adopted a pretest-posttest quasi experimental design. A purposive sample of 50 students participated in the study. “Civic Knowledge and skills Test” and “Social Studies Instructional Guide” were used to collect data. Data were analyzed using t-test statistic. The results suggested that effective teaching of social studies could lead to the development of intellectual and participatory civic skills among Junior Secondary School Students. The study recommended continuous re-orientation and re-emphasizing of democratic values to promote social stability in the society. It also recommended the recruitment of Civic Education specialists to teach the subject. Finally, it recommended regular review of social studies curriculum with a view to instilling democratic values and principles.

Editor – in - Chief

CONSTRUCTION AND VALIDATION OF A TEST FOR MEASURING STUDENTS' PROPORTIONAL REASONING ON RATES, RATIOS, AND PROPORTIONS

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ABSTRACT

This study aimed to develop and validate a proportional reasoning test (PRT) to measure students' proportional reasoning skills on rates, ratios, and proportions in mathematics. The test items were carefully designed to reflect the aspects of proportional reasoning identified in the existing literature and aligned them to the instructional objectives as stated in the Kenya secondary mathematics curriculum. The test underwent different developmental processes to establish content-related validity before it was piloted. The pilot was conducted on a sample of 45 form three students from one school in Kenya. The results showed an acceptable internal consistency level (Cronbach's α= .83). The item analysis revealed that all the items had a moderate difficulty level ranging from .39 to .50. The discrimination index for most items ranged from .22 to .44. The findings suggest that the PRT is a valid and reliable instrument that can be used to measure the domain-specific skills on proportional reasoning. More specifically, the instrument can be used to measure the impact of a formative assessment intervention on students' achievement on proportional reasoning skills.

Keywords: Mathematics, proportions, Proportional reasoning, rates, ratios,

INTRODUCTION

A substantive number of studies have shown that students at all levels have difficulties in solving problems that require proportional reasoning and this affects their overall achievement in mathematics (Singh, 2000; Al-Wattban, 2001; Charalambous & Pitta-Pantazi, 2007; Nunes & Bryant, 2015). Although these studies have focused mainly on western countries, learners in Africa for instance Kenya also face similar challenges (KNEC, 2017; KNEC, 2018). As a way of improving education quality and learning outcomes, the Kenyan government introduced the competency-based curriculum (CBC) for basic education in 2018. The CBC focuses on learners' demonstration of an ability to apply the knowledge, skills, attitudes, and values they are expected to acquire as they progress through their education (KICD, 2017). There is however lack of instruments that can help mathematics teachers to gauge students' ability to apply the knowledge and skills. Teachers rely on conventional tests that encourage passive learning devoid of knowledge transfer. The motivation behind this study is to develop an instrument that measures proportional reasoning being one of the competencies in mathematics. The test developed in this study is therefore not just a conventional test meant to test students' knowledge but to tap into students' cognitive ability and knowledge transfer to authentic situations.

PURPOSE OF THE STUDY

This study aimed to develop and validate a test that measures students' proportional reasoning skills in mathematics. The tasks were obtained from the topics on rates, ratios, and proportions which are taught in form three (grade11) and tested in final examination at the end of form four (grade12).

SIGNIFICANCE OF THE STUDY

The education systems across the globe are focusing on 21st-century competencies. The challenge however is how to teach and assess these competencies. This calls for a paradigm shift where teachers need to move away from assessing students for the sake of passing exams to authentic assessment. Learners need to be assessed on their ability to think critically, solve problems, and their responsiveness to authentic tasks. To measure the competencies, teachers are therefore expected to carry out the competency-based assessment (CBA). Proportional reasoning has been regarded as a life skill that is crucial for daily decision making (Howe, Nunes & Bryant, 2010). This study is significant to teachers and curriculum developers in the context of the competency-based curriculum. Teachers will be able to use this instrument as a framework for developing more tasks that measure proportional reasoning in mathematics. The study will also inform the curriculum developers on designing relevant activities on rates, ratios, and proportions.

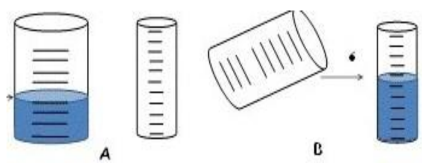
LITERATURE REVIEW

Proportional reasoning is generally regarded as the ability to compare objects using multiplicative reasoning instead of additive reasoning. According to Van de Walle (2006), proportional reasoning involves a comparison of multiplicative relationships between quantities. Studies have revealed that most students have problems with proportional reasoning because they fail to differentiate between situations that call for additive reasoning and those that require multiplicative reasoning (Nunes & Bryant, 2009; Gläser & Riegler, 2015). Whereas additive reasoning originates from actions such as putting together and separating sets, multiplicative reasoning develops from actions such as one-to-many correspondence and sharing (Nunes & Bryant, 2015). The importance of proportional reasoning cannot be overemphasized. This kind of reasoning is applied across all grades and subjects. Children as early as age five already have some intuitions about intensive quantities which form the basis of proportional reasoning (Nunes et al, 2012). Although the perception of proportional reasoning is mainly on ratios, rates, and rational numbers, proportionality is generally applied in other areas involving measurement (Ayan & Isiksal-Bostan, 2019).

Proportional reasoning is a very important tool that children learn from early grades until high school. Although a significant number of studies have focused on promoting proportional reasoning in students, these studies have acknowledged the fact that proportional reasoning is not easy for most children (Singh, 2000; Al-Wattban, 2001; Charalambous & Pitta-Pantazi, 2007).

Research has also revealed that proportional reasoning, particularly on rational numbers, is not just a problem for young children but even for adult students. The following two examples which were given to a sample of Germany university students from the science, technology, engineering, and mathematics (STEM) faculty on a pretest (Gläser & Riegler, 2015) prove this assertion.

1. Below are drawings of a wide and a narrow cylinder. The cylinders have equally spaced marks on them. Water is poured into the wide cylinder up to the 4th mark. This water rises to the 6th mark when poured into the narrow cylinder (see B). Both cylinders are emptied (not shown) and water is poured into the wide cylinder up to the 6th mark. How high would this water rise if it were poured into the empty narrow cylinder?



2. Alice and Greta went for bike rides. They started at different times and then rode at the same constant rate. By the time Alice had gone 6 km, Greta had already gone 8 km. How far will Alice have gone when Greta has gone 12 km?

Question one tested students on proportional reasoning whereas question two on additive reasoning. With a sample of 446 students, only 47.7% answered correctly the first question; 45.5% answered the second question correctly; 22.6% answered both questions correctly. Gläser & Riegler (2015) noted that a considerable number of students applied proportional reasoning to the bike problem even when they were expected to use additive reasoning. In this case, the students had difficulties differentiating between scalar and functional relations. These problems have not only been used in Germany but also in other universities in the United States of America to identify difficulties with proportional reasoning. Nunes and Bryant (2009) too observed that students in primary and secondary schools use additive procedures to solve multiplicative reasoning problems and multiplicative procedures to solve additive reasoning problems. When similar items were given to students on a post-test after an intervention, the researchers reported no change in the pattern of reasoning. Those students who used the additive reasoning in the pre-test also used the same reasoning in the post-test. The results suggested that most of the students had not fully developed the ability to reason proportionally.

A study by Van Dooren et al. (2005) presented similar items to the bike ride which tested on additive strategy but students ended up using proportional strategies. An example of a task was: “Ellen and Kim are running around a track. They run equally fast but Ellen started later. When Ellen has run 5 rounds, Kim has run 15 rounds. When Ellen has run 30 rounds, how many rounds has Kim run?” This question leads to different answers depending on the reasoning that the students applied. Students who took it as a ratio problem got 90 as a solution and those who understood it in terms of scalar relations got 40 which was the right answer for this case. Van De Bock and Verschaffel (2010) too observed that students also use scalar relations in solving ratio problems. According to Nunes and Bryant, 2015), children reason more successfully about the problem when they can identify two quantities related by a fixed ratio. Children also tend to use intuitive strategies through experimentation without necessarily being aware of the proportional relationships (MacDonald & Wilkins, 2016). To develop proportional reasoning, students must, therefore, understand functional relations which are essential for mathematical modeling in science. Since scalar reasoning can develop without schooling, teachers should concentrate more on developing functional relations in students.

Theoretical background

Different frameworks have been used by researchers in studies related to proportional reasoning. Lamon (1993) conceptualized proportional reasoning under four semantic problem types as follows: (a) Well-Chunked Measures dealing with the comparison of two extensive measures and resulting in an intensive measure; (b) Part-Part-Whole which involves expressing an extensive measure of a single subset of a whole in two or more subsets; (c) Associated Sets where two sets may have no commonly known connection or an ill-defined connection and (d) Stretchers and Shrinkers which Involve problems requiring scaling up (stretching) or scaling down (shrinking).

Building on Lamon's framework, Allain (2000) developed an instrument testing on seven areas of proportional reasoning among the middle (secondary) school students which involved comparison, missing value, associated sets, part-part-whole mixture problems, comparisons, and graphical interpretation and stretcher. A study by Tjoe and de la Torre (2014) focused on the attributes of proportional reasoning that are relevant to eighth-grade students (13-14 years). They identified and validated six proportional reasoning attributes which are: Prerequisite skills and concepts required in proportional reasoning; Comparing and ordering fractions; Constructing ratios and proportions; Identifying a multiplicative relationship between sets of values; Differentiating a proportional relationship from a non-proportional relationship and Applying algorithms in solving proportional reasoning problems.

The present study builds on the Lamon (1993) and Allain (2000) frameworks and conceptualizes proportional reasoning under five aspects of proportional reasoning (see Figure 1). These five aspects have been carefully considered based on the context of the current study which was done in Kenya. These five areas are thus in line with the instructional objectives as stated in the Kenya Institute of Curriculum and instruction (KICD) for secondary mathematics.

METHODOLOGY

Sample

The study sample consisted of 45 form three students (male=21; female=24) from one averagely performing mixed secondary school which was purposely selected. Since the school was one streamed school, all form three students participated in the study.

Design and analysis

The research design employed in the current study was a development research design that aimed to develop an instrument for measuring students' proportional reasoning skills in mathematics. The items in the test were developed based on the four phases described in the Standards for Psychological and Educational Testing (AERA, APA, & NCME, 1999) which in the case of this study were compressed into three phases. The first phase involved describing the purpose of the test and the scope of the construct; the second phase involved development and evaluation, selection of the items and scoring guide; the third phase involved piloting of the items, discussion of the pilot findings, assembly and evaluation of the test for operational use. Test analysis was done by determining the reliability (internal consistency), item difficulty, and item discrimination. Cronbach's alpha was used to determine the reliability of the test while item difficulty and discrimination indices were computed to determine the validity of the test items (Tjoe & de la Torre, 2014).

Development procedure

Phase one: Describing the purpose of the test and the scope of the construct

The purpose of the test was to assess students' abilities on proportional reasoning related to the topic on rates, ratios, and proportions. The test comprised of word problems that relate to real-life situations covering five aspects of proportional reasoning: missing value, associated sets, mixtures and proportions, comparison problems, and stretcher. To achieve the intended purpose of the test, we, therefore, expected the test to be reliable, valid, easy to administer, and easy to grade.

Phase two. Development and evaluation of the test specifications

This phase involved designing the format of the items, specifying the psychometric properties, considering the test duration, population composition, and the procedures for the test administration. The items together with a scoring guide were developed by the researchers based on the sample problems in the literature (Allan, 2000; Tjoe & de la Torre, 2014; Gläser & Riegler, 2015); instructional objectives in the curriculum; and sample questions from the standardized national tests. The psychometric properties were determined by checking the validity and reliability of the test. The content validity was dete rmined by a team of subject experts and the Item level analysis was done by computing the difficulty and discrimination indices. A total number of 10 items were carefully designed to reflect the instructional objectives as described in the Kenyan form three (grade 11) secondary mathematics coursebook and the different categories of proportional reasoning skills.

The topic of focus was rates, ratio, and proportions which are taught in form three (Grade 11) according to the Kenya Institute of Curriculum Development (KICD). Since the interest of the test was on higher thinking skills, only questions based on application, analysis, evaluation, and synthesis (higher thinking skills) were considered (Haladyna & Rodriguez, 2013). A rigorous revision and consideration of the syllabus and previous questions was done before deciding on the questions for the pilot study. Table 1 shows the areas tested and the problems from each area.

Scoring guide

The scoring guide was created concurrently with item construction. Each item had a scoring guide based on the instructional objective and the response expected. Since the questions were open-ended, varied strategies were expected from students. The scoring guide was therefore flexible and accommodative of different possible strategies that students could use to solve a given task. As noted by Csíkos (2015), children have personal preferences as to which strategy to apply on a given task. Ratios and proportions are topics taught progressively since the early years of primary school. The students could, therefore, have several approaches to solving these tasks. The scoring guide hence gives room for consideration of a strategy that may make sense in solving a given task. All items had the same weight with a maximum of three points. The scoring guide (see table 2) was thus based on a 4 point scale ranging from 0 to 3 which was similar to the one created by Allain (2000). Table 3 shows a sample problem and the corresponding scoring guide.

Expert review

After the test items were constructed, a team of experts consisting of three mathematics graduate students, and a professor evaluated the test items to establish content validity. During the review process, the experts focus`ed on three issues: they first compared the items with various sample problems found in the relevant literature and established whether they were aligned with the Kenyan secondary mathematics curriculum. In the second step, they checked the difficulty level of the items and the third step involved checking whether the questions were correctly worded and appropriate to the sample and study context. The same test was also given to two experienced mathematics teachers from two different secondary schools in Kenya for review. Based on a long term teaching experience, they pointed out some weaknesses related to the phrasing of two questions and suggested how the questions could be rephrased to fit the cultural context of students. This was done jointly so the two experts were both in agreement regarding the test content and its alignment to the curriculum and the expected skills.

Item revision

Based on the reviews from the expert judgment and the two experienced secondary school mathematics teachers from Kenya, two questions which were both adopted from the previous studies were revised to fit the cultural context of the current study. One of the questions was a pizza question which was testing on comparison skills (There are 7 girls with 3 pizzas and 3 boys with 1 pizza. Who gets more pizza)? Since most students were not familiar with the pizza, we replaced the pizza with 'chapati' which is common in Kenya and normally refers to flatbread. The other question which was slightly modified was a question on missing value and required students to identify how many small cups of coffee can be made with 12 cups of water basing on the fact that it takes 8 cups of water to make 14 small cups of coffee. We replaced coffee with tea which is a common beverage in Kenya. The rest of the items were also thoroughly revised and some slight rephrasing was done on them. The final test consisted of 10 items together with the scoring rubric. Each question was given the same weight on a scale of 0 to 3.

Phase three: Item administration (piloting)

After a thorough revision of the questions, the final version of the test was administered to 45 students from one mixed secondary school. The participants consisted of 21 male students (M=1.38, SD=.35) and 24 female students (M=1.27, SD=.32). Before administering the test, students were provided with both oral and written instructions relating to the purpose of the test, how they should respond to questions, and to take the test seriously. The test was done in a controlled classroom under the supervision of a mathematics classroom teacher. The test duration was 60 minutes and all students were able to finish the test within the stipulated time.

Pilot findings and discussions

The results are presented based on the three analyses that were done: reliability (internal consistency), item difficulty, and item discrimination.

Reliability

Cronbach's alpha was used to determine the internal consistency of the test. The overall test reliability for the 10 items was .83 with a mean of 1.30 and a standard deviation of .38 which was within the acceptable range (Cohen et al, 2007). All items had an item-total correlation (ITC) values ranging from .32 to .67 (see table 5) indicating that the items fitted well to the whole test.

Item difficulty

Item difficulty is a measure of the percentage of students answering a test item correctly. It helps in determining how easy the item is (Hopkins, 1998). Item difficulty index (p-value) can also be used to determine the validity of test items. The difficulty index ranges from .0 to 1.0 where the higher the p-values the greater the percentage of students answering the item correctly. The difficulty of each item was computed using the formula for open-ended items (Tjoe & de la Torre, 2014) as illustrated below:

$$p = \frac{\sim fX - nX_{min}}{n(X_{max} - X_{min}}$$

Where $\sim fX$ is the total number of points earned by all students on an item,

n is the number of students,

X_{min} is the smallest item score possible, and

X_{max} is the highest item score possible.

The difficulty index of the test items ranged from .39 to .50 which implied moderately difficult items (see Table 4)

Item discrimination

The item discrimination index was used to measure each test item to distinguish the performance of students. This was done by calculating the difference in the percentage of high achieving students who got an item correct and the percentage of low achieving students who got the item correct. The discrimination index ranges from -1 to +1 where positive numbers above .2 show that an item is positively discriminating. A discriminating index (DI) value less than 0 shows a negatively discriminating item which is not good for a test. Generally, based on the classical test theory item analysis (Ebel, 1979; Hopkins, 1998), items with an index value less than .20 are regarded as poor items and should, therefore, be discarded or completely revised. Items with an index value of between .20 and .29 are marginal items and need some revision; items ranging between .30 and .39 are reasonably good items whereas those with an index above .4 are regarded as very good items. Table 5 shows the discriminant level of items for the test in this study. The discrimination index was calculated using the upper (U) 27% and the lower (L) 27% of the test scores. The possible score for every question ranged from 0 to 3 with a maximum possible total test score of 30 and a minimum of 0. The following formula (Tjoe & de la Torre, 2014) was used to calculate the item discrimination index for every item.

Item discrimination (D) $= P_U - P_L$

Where: P_U is the difficulty indices for the Upper (U) group and

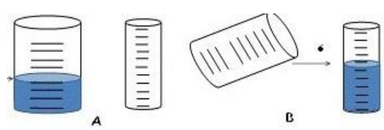
P_L is the difficulty indices for the Lower (L) group.

The item DI ranged from .17 to .44 (see table 4). Item q8 had the lowest DI of .17 with a moderate level of difficulty. It is, however, important to note that the DI should be interpreted based on the purpose of the test. According to Mehrens and Lehman (1991), there are various reasons why items can have a low DI which does not necessarily mean it is a poor item. For instance, a typical classroom test may have a low DI simply because it is measuring a variety of instructional objectives. Haladyna & Rodriguez (2013) too noted that item difficulty should be interpreted based on how the students were prepared for the test or their previous cognitive experiences. In the present study, the items were measuring proportional reasoning and most likely some students did not understand the concept and therefore may have used a wrong strategy.

Tables and Figures

Table 1

Selected problems for the proportional reasoning test

Type of problem	Problem	Source
Comparison	1. Last week, Mary answered 24 out of 30 questions correctly in an exam. This week, she answered 20 out of 24 questions in another exam. On which exam did Mary have better results? Explain your answer	Researcher made
	2. Nafula bought 3 pieces of lollypops for 12 shillings and Anna bought 5 pieces of lollypops for 20 shillings. Who bought the cheaper lollypops or were they equal? Explain your answer	Adapted from (Allain, 2000) and modified
Missing value	3. How many glasses of orange juice can you make with 12 cups of water if it takes 8 cups of water to make 14 glasses of orange juice? Show your work.	Researcher made
	4. Below are drawings of a wide and a narrow cylinder. The cylinders have equally spaced marks on them. Water is poured into the wide cylinder up to the 4th mark. This water rises to the 6th mark when poured into the narrow cylinder (see B). Both cylinders are emptied (not shown) and water is poured into the wide cylinder up to the 6th mark. How high would this water rise if it were poured into the empty narrow cylinder? Explain your answer 	Adapted from Gläser & Riegler (2015)
Associated sets	5. A group of 7 girls shares 3 chapatis equally and another group of 9 boys shares 4 chapatis equally. Who gets a bigger size of chapati, a girl or a boy? Explain your answer	Adapted from (Allain, 2000) and modified
	6. Mary has the option of working in Mombasa or Nairobi. She discovered that the workers in Mombasa work 8 hours per day and receive Ksh 24000 every 15 days and those in Nairobi work 6 hours per day and receive Ksh 20000 every 12 days. If she decides to work for 20 days, which job option will be best for her? Explain your answer.	Researcher made

Mixtures and proportions	7. Your father decides to give a piece of land as an inheritance to your three brothers Joe, Alex, and peter in the ratio 4:5:3. Peter being the firstborn feels he has already accumulated enough wealth and therefore decides to share his portion equally to Joe and Alex. What will be the ratio of Joe's share to Alex's share? Show your working	Researcher made
	8. In a mixture of 60 litres, the ratio of orange concentrate to water is 7:5. If the principal of a school wants to make orange juice for the students in the ratio 3:2, how many liters of water should he add to the mixture? Show your working	Researcher made
Stretcher	9. Two similar rectangles are given. The height of the first rectangle is 6cm and the width is 8cm. The width of the second rectangle is 12cm. Explain how you would find the height of the larger rectangle	Adapted from (Lamon, 1993) and modified
	10. Two trees were measured five years ago. Tree A was 8 feet high and tree B was 10 feet high. Today, tree A is 14 feet high and tree B is 16 feet high. Over the last five years, which tree's height has increased the most? Show any calculations that lead you to your answer.	Adapted from Allain (2000)

Table 2

Scoring guide

Score	Description
3	Shows understanding of the concept (1 point) Applies a strategy to solve the problem (1 point) Obtains the correct answer or explains the answer (1 point)
2	Shows understanding of the concept (1 point) Applies a strategy to solve the problem (1 point) Obtains an incorrect answer possibly due to a math error (0 point)

	Possesses some understanding of the concept (1 point)
1	Fails to apply a strategy to solve the problem or shows no work (0 points)
	Incomplete answer or obtained the correct answer probably by guessing(0 points)
	Possesses a misconception (0 points)
0	Applies an incorrect strategy to solve the problem or shows no work (0 points)
	Obtains an incorrect answer (0 points)

Table 3

Sample problem and the corresponding scoring guide

Sample problem	problem objective and expected students response	Scoring guide
Last week, Mary answered 24 out of 30 questions correctly in an exam. This week, she answered 20 out of 24 questions in another exam. On which exam did Mary have better results? Explain your answer	This is a problem that tests students on comparison of ratios *Expected response:* Last week This week 24:30 20: 24 or 4: 5 5: 6 Mary had better results on this week's exam because the ratio is higher Alternatively, some students may just express ratios as fractions and compare which fraction is bigger.	• Can the student express the problem as a ratio form (1 point) • Can the student deduce from the ratios which performance was better (1 point) • Can the student explain the answer? This will help in deducing if the student has an understanding of the concept or could be having some misconceptions (1point)

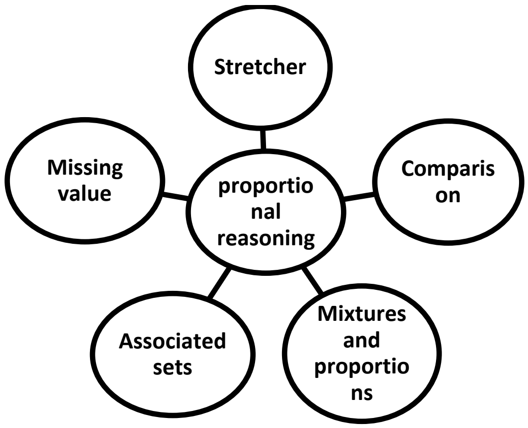
Table 4

Summary statistics for the PRT items (N=45)

Item	M	SD	ITC (r)	DI (p)	ID (D)
q1	1.24	.98	.32	.41	.28
q2	1.36	.53	.60	.45	.22
q3	1.29	.63	.45	.43	.36
q4	1.27	.54	.57	.42	.33
q5	1.29	.51	.65	.43	.25
q6	1.44	.62	.50	.48	.22
q7	1.20	.46	.61	.40	.25
q8	1.20	.46	.46	.40	.17
q9	1.18	.39	.66	.39	.25
q10	1.51	.76	.67	.50	.44

Figure 1

A conceptual framework for the proportional reasoning skills



Conclusion and future steps

This study aimed to construct and validate a proportional reasoning test (PRT) instrument. The target domain to be measured was students' proportional reasoning skills on rates, ratios, and proportions in mathematics. The items were organized hierarchically based on the three areas of competency which represented the proportional reasoning skills. Content related validity evidence was determined by a team of subject matter experts (SMEs) who reached a consensus regarding the items level of difficulty and the accuracy of the scoring guide. All items had a higher cognitive demand since they tested on the application of skills learned to the real-life experiences and therefore received the same weight. The item analysis revealed that all the items had a moderate difficulty level ranging from .39 to .61. The discrimination index for most items ranged from .22 to .44. Based on experts' review and item-level analysis, PRT is a reliable and valid instrument for measuring the proportional reasoning skills among the form three (grade 11) students in Kenya.

This instrument was however only tested with a small sample. The future step is to test the instrument with a larger student population of different abilities. This will improve the reliability of the instrument and make it generalizable to a larger population. There is also a need to analyze the responses of students on each item. This will help in formulating distractors that can cover common misconceptions. From the common misconceptions, it will be possible to make closed items that can be easily computerized hence enabling automatic scoring.

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