A comparison of preferences for real-life situations that could be used in school mathematics in three SADC countries

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Abstract
This article reports on a comparison of real-life situations which learners in three Southern African Development Community (SADC) countries would prefer to be used in school mathematics. The paper is based on data collected in these countries and uses an analytical tool, Rasch analysis, to review the results of these studies.

The results of this analysis reveal that the young people in these countries share similar affective orientations with respect to certain real-life situations. The real-life situations that the learners in these countries prefer most are related to electronic gadgets and personal finance, whilst the items they are least interested in are issues relating to gambling and cultural practices. These results open the possibility of inter-country development and sharing of instructional resources based on real-life situations for use in mathematics. Furthermore, the results can usefully inform the designers of cross-country assessments on school mathematics, such as the SACMEQ, about appropriate real-life situations which appeal to learners that can be used in these comparative assessments.

Key words: Real-life contexts, mathematics curriculum, learners’ preferences, affective orientations, Rasch analysis


Introduction
The use of real-life situations or contexts in school mathematics has been receiving considerable attention globally. For example, an entire issue of the Zentralblatt für Didaktiek Matematik (Vol. 38(2) of 2006) is devoted to the use of real-life situations, albeit in the context of mathematical modelling, in school mathematics in various countries. This has generated debate between those researchers who believe that the use of real-life contexts in school mathematics would facilitate a better understanding of mathematics by learners and those who see it as problematic and not in the interest of learners. Real-life situations or contexts are extra-mathematical situations and defined as ‘textual descriptions of situations assumed to be comprehensible to the reader, within which mathematical questions can be contextualised’ (Verschaffel, Greer & De Corte 2000: ii). Thus, real-life problems or contexts refer to those day-to-day situations or contexts typically located outside of mathematics as opposed to the intra-mathematical environment.

Mathematics education in the last three decades has focused on making the learner the centre of the school academic enterprise and sees him or her as creating his or her own knowledge by interacting with the environment and solving problems through the embedding of real-life situations or contexts. But, as Chacko (2006: 33) notes, the solution by learners of real-life problems demands a higher level of cognition, such as reaching a clear understanding of the problem in terms of the information provided, identifying the adequacy or otherwise of that information to attempt the solution, mathematical modelling, manipulation, conclusion and interpretation.

The preceding discussion presupposes the prominent role played by teachers and mathematics-learning resource developers in the real-life situations or contexts to be used in
specific instances of mathematics instruction. It presumes that these stakeholders will choose contexts which they deem appropriate and interesting and that this will in turn arouse the desire of the learner to participate in mathematics. However, these stakeholders might not always incorporate real-life situations that learners identify and find interesting to deal with in mathematics. By stating ‘our ideas about real-world problem situations [are] not necessarily wrong. But our ideas about the real world were somewhat different from our students’ ideas’ Lesch (1980: 13) draws attention to the need of these stakeholders to have some sense of the contextual situations that learners would find interesting to deal with. Bishop (2008) similarly reminds researchers of the importance of ascertaining what learners’ wants are, since these are related to the values that learners have.

The mathematics curriculum policy documents of the three countries under discussion encourage the use of real-life problem situations in their mathematics curricula. Some researchers see the use of real-life contexts in school mathematics as having the potential to facilitate better conceptual understanding and that contexts can serve as a bridge between mathematics regarded as an abstract discipline and mathematics as a human activity which has relevance in people’s lives and a tool for the solution of their problems (Mbekwa & Julie, 2009: 317).

The goal of this study was therefore to ascertain the real-life situations that learners prefer to deal with in mathematics. For the study we pursued the question, ‘What are the similarities and differences in the real-life contexts that high school learners in Zimbabwe, Swaziland and South Africa prefer to be used in mathematics?’ This is an under-researched area in Mathematics Education locally (see Venkat, Bowie & Graven 2009 for a survey on research in sub-Saharan Africa related to the use of real-life situations in mathematics) and internationally (Julie & Mbekwa 2005).

Inter-country comparisons of patterns of responses to the questionnaire are made and conclusions based on the analysis of the responses are discussed. Preferences for real-life situations are subjective and fall within the affective domain. The affective domain is a broad field that includes beliefs, attitudes, emotions, values, mood and interest (Zan, Brown, Evans & Hannula 2006). It is well-known that affective issues are important, if not more important than content in terms of improving performance in school mathematics (Julie, Holtman & Mbekwa 2011). Hence in the next section a few observations on affect are made to place the study within Mathematics Education as a research domain.

We need studies which not only investigate what students say about their attitudes to different aspects of mathematics, but also which look at the choices students make in different situations, which will indicate the influence of certain values, as suggested by Bishop (2008).

The affective domain in school mathematics

Over the past decade there has been an increased attention to affective variables in psychological and educational research (Isiksal, Koc & Askun 2009). The strong emphasis on the need for researching issues related to the affective domain in Mathematics Education is strongly suggested by Niss (2007), whose survey on the problematiques of Mathematics Education also points in the direction of the area being under-researched. As alluded to in the introduction, one aspect of affect in learning is interest. Interest is a phenomenon that can be revealed by choices that people make.

This section expands on the notion of interest in learning. The concept of interest as an educationally pertinent disposition is closely related to concepts of attitude in social psychology (Krapp, Hidi & Renninger 1992). In everyday language interest means liking, preference or attraction (Valsiner 1992). In a classroom situation it refers to a learner’s tendency to persist in particular subject content over time and the psychological state that accompanies this commitment (Renninger 2009). Interest is a phenomenon that emerges from
a person’s contact with his or her environment (Krapp, Hidi & Renninger 1992). Included in their definition of environment are object and stimulus. Interest can therefore be triggered by objects or by stimuli. Four developmental phases of interest are: triggered situational interest, maintained situational interest, emerging individual interest and well-developed individual interest (Renninger 2009). Below we discuss the development and manifestation of situational and individual interests.

Something in the immediate environment may evoke situational interest and, consequently, it may or may not have a lasting effect on personal interest and learning (Hidi & Anderson 1992). This means situational interest is generated mainly by certain conditions and/or concrete objects in the environment (Krapp, Hidi & Renninger 1992). It can be described from the point of view of either the cause, or conditions that bring about interest, or the perspective of the learner (Krapp, Hidi & Renninger 1992). Viewed from this angle, situational interest is not unique to the individual but tends to be common across individuals. Thus Hidi & Anderson (1992) refer to it as group interest. Situational interest triggered by environmental factors may evoke or contribute to the development of long-lasting individual interest (Krapp, Hidi & Renninger 1992). Considering that situational interest is common across individuals, two interesting issues related to the present study would be, for example, to see whether profiles of interests of the learners surveyed could bear differential country identities, or whether effects of globalisation could erase distinctive country characteristics. For now it is important to note that values exert strong influence on interests, and the principal sources of values in the mathematics classroom are of society, mathematics and mathematics education (Bishop 2008).

On the other hand, the relatively long-term orientation of an individual towards a type of object, an activity or an area of knowledge can be interpreted as individual interest (Schiefele 1992). Characteristics that are based on mental patterns associating the object(s) of interest with positive emotional experiences and the personal value system are considered as individual interests (Koller, Baumert & Schnabel 2001). Individual interest is considered to be relatively stable and is usually associated with increased knowledge, positive emotions and increased reference value (Hidi, & Anderson 1992). It refers to a person’s interaction with a specific class of tasks, objects, events or ideas. Two components of individual interest, namely feeling-related and value-related, are explained by Schiefele (1992). The former is associated with feelings that precede, accompany or follow activity involving the topic or object of interest and the latter with a value-related (of personal significance) component. In this way interest is a domainspecific or topic-specific motivational characteristic of personality.

In this article aspects of both situational and individual interest are considered (Ngcobo 2011). The contexts learners chose from acted as stimulus objects that triggered interest. On the other hand, learners’ association of the contexts with their emotional experiences and personal value systems could be indicative of individual interest.

Instrumentation, data collection and results

Evolution of the instrument

The instrument used was derived from an initial 61-item questionnaire. Julie and Mbekwa (2005) describe the development and piloting of the initial instrument in South Africa. Briefly, a group of mathematics educators and postgraduate students Preferences for real-life situations in school mathematics 123 from Zimbabwe, Uganda, South Africa, Norway and Eritrea identified possible real-life situations that could be used in school mathematics. A pivotal criterion for selection of real-life situations was that they should be amenable to mathematical treatment. Thirteen clusters of real-life situations such as health, recreation and
security of electronic transactions were identified. Two of the clusters, mathematics and the practices of mathematicians, dealt with issues internal to mathematics, whilst the other eleven clusters focused on issues external to mathematics. The number of items per cluster had a range of 2 to 7, with a general cluster having the highest number of items and sports the lowest number. Students were requested to express their preference on a Likert-type scale ranging from 4 (very interested) to 1 (not at all interested) for interest in dealing with particular contexts in school mathematics. The stem of the items was ‘What would you like to learn about in mathematics?’ and this was followed by a real-life situation. During administration, care was taken to stress that the learners should respond to the use of the contextual situations in their mathematics lessons.

After consideration of the results of the piloting, the 61-item questionnaire data were collected in Zimbabwe, Uganda, Swaziland, South Korea, South Africa and Norway. Ndemo (2006), Mutodi (2006), Ngcobo (2011), Kim (2008) and Julie (2007) report on the results of the implementation in Zimbabwe, Swaziland, South Korea and South Africa respectively. The entire data set of the six countries was analysed by Julie and Holtman (2008) using Rasch analysis procedures. They concluded that there were redundancies in some item subsets, where their replacement by an appropriate single item would not affect the validity and reliability of the instrument. Through a series of discussions between mathematics educators and postgraduate students from Zimbabwe, Swaziland, South Korea, South Africa and Albania, the questionnaire with 61 items was reduced to 23 items. All the items of this instrument dealt with extramathematical situations amenable to mathematical treatment and the responses learners provided to the 23 items were used in the study reported here. The real-life situations learners had to respond to are presented in Table 1.

Analysis was done using Rasch modelling. This technique for data analysis differs from other statistical devices in that a statistical model is not developed from empirical data. Rather, the analysis is centred on how well the empirical data fits a predefined postulated model. The pre-defined model is a logs-odd model. As stated by De Roos and Allen-Meares (1998: 95-96), the Rasch model is: ... a normative model [for] the placement of items on a line that indicates greater and lesser amounts of the variable being measured constitutes operationalisation of the variable. The Rasch model defines the ideal delineation of items that would constitute an objective, interval-level measuring instrument [and] the process is to determine how closely the data fit the Rasch model … Since the Rasch model serves as the standard against which the data are compared, one can determine how closely one’s data approximate this ideal linear standard.

Various measures in relation to how empirical data approximate the Rasch model can be calculated. Those used in this article are discussed below. For the results reported here, the software program Winsteps 3.65.0 (Linacre 2008) was used.

Sample
The learners from South Africa were from urban and peri-urban areas in one province in the country. This sample was a convenient one given the access researchers had to teachers willing to collect data. The teachers taught in schools classed as ‘previously disadvantaged’ and it can be safely assumed that the learners were from low socioeconomic status backgrounds. The Swaziland cohort was from peri-urban and urban environments and the sample was stratified in accordance with school records. Schools in rural and urban low-income areas were conveniently sampled in Zimbabwe. Overall it can be said that the samples leaned towards learners from low socioeconomic status backgrounds.

A total of 1 170, 1 028 and 900 learners completed the questionnaire in South Africa, Swaziland and Zimbabwe respectively. For each country the cohort was analysed for misfitting respondents, i.e. learners whose responses are idiosyncratic in that they do not fit the ideal Rasch model as identified by Rasch misfit procedures. It was decided to avoid these
114 ‘problematic’ persons’ answers deforming the measurements by eliminating them and excluding them from the analysis. The size of the remaining sample, 711, was still large enough to analyse the data and give an answer to the initial question about students’ preferences for contexts. These ‘misfits’ were removed for each country’s cohort through an iterative application of the Rasch procedure to identify misfits. The demographic information of the cohort of students after the removal of the misfits is presented in Table 2.

The removal of misfits from the data set might be perceived as problematic. However, the comparative nature of the research requires that there be as little difference as possible in the operation in the three countries, which led to the decision to remove the ‘problematic’ persons.

Table 2: Demographic information of respondents

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Unidimensionality of instrument

One criterion a measurement instrument must satisfy is that it must be unidimensional. Questionnaires used in surveys measure a particular construct, latent trait or variable which is abstract and cannot be obtained through direct observation. In this research the variable of interest is ‘preferences learners have for real-life situations to be used in mathematics’. The items operationalise the latent trait and care must be taken that the items do not represent more than one construct. Awareness of this dilemma is clear, for example, from the construction of items for problem-solving tasks by the Programme for International Student Assessment (PISA). They claim that ‘the test designers were conscious of the amount of reading involved, and kept the level of text difficulty as low as possible, with nothing beyond everyday use of language’ (PISA 2004: 51). ‘To avoid this being a reading test, the amount and difficulty of reading required was limited’ (PISA 2004: 51). Although this points more towards the possibility of a different domain being tested, it does not preclude the possibility that more than one issue is inadvertently being focused on by the test-takers. Analyses were conducted to ascertain whether the instrument was unidimensional for each country. In Rasch analysis this is indicated by the explained and unexplained variance. The results of this analysis are given in Table 3.

Linacre (2008: 335) gives the following decision criteria for ascertaining whether the unidimensionality criterion is violated.

Variance explained by measures > 60% is good.
Unexplained variance explained by 1st contrast (size) < 3.0 is good.
Unexplained variance explained by 1st contrast (proportion) < 5% is good.

Table 3: Explained and unexplained variances of the instrument

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For our data set the variances explained by the measures in Table 3 indicate that those for the empirical data do not differ significantly from the expected ideal if the data fitted the Rasch model but they are substantially lower than the 60% criterion. However, it should be expected that the variances will be low because of the homogeneity of the samples of the individual countries. For the latent trait, interest in real-life situations to be used in mathematics, it can be expected that the items will have a narrow range of levels of endorsement for the cohorts of learners. The unexplained variance in the first contrast is well below the cut-off value of 3, although the percentage is slightly higher than the 5%. The statistical indicators and
considerations above are indicative of the instrument measuring a unique construct.  
Differential item functioning (DIF)  
A feature that enhances the acceptability of an instrument is for it to function equally for different categories of respondents. This implies that there should not be differences in how the items comprising the instrument operate for the different categories of respondents. What is at stake are not the normal differences between the categories of respondents. Rather, in differential item functioning, the focus is, as might be the case for this study, whether one category of respondents finds items easier to endorse than another category of respondents. Differential item analysis was done for gender and grades for each country. Table 4 gives the differential item functioning for gender. DIF contrast is the difference between the measures for females and males (female measure – male measure). The DIF contrast ‘should be at least 0.5 logits for DIF to be noticeable’ (Linacre 2008: 266). For Swaziland (DIF contrast = 0.63) and South Africa (DIF contrast = 0.53) differential item functioning is noticeable for item C23 (construction/engineering), with girls finding this item harder to endorse than boys. No differential item functioning is noticeable for Zimbabwe. A similar analysis was conducted for the different grades. Only for the South African cohort was there noticeable differential item functioning for two items. These are for item C8 (community development) between Grades 8 and 10 (DIF contrast = 0.52) and between the same grades (DIF contrast = 0.53) for C17 (personal/business finances).

Table 4: Differential item functioning (DIF) for gender  
<table>
<thead>
<tr>
<th>Item</th>
<th>South Africa</th>
<th>Swaziland</th>
<th>Zimbabwe</th>
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<tr>
<td>C23</td>
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In these cases learners in Grade 8 find it more difficult to endorse the items than learners in Grade 10. However, the DIF contrast is near enough to the criterion for acceptance, so as not to unduly influence comparisons between the different countries. Table 5 gives the DIF contrast for the items not satisfying the differential item functioning criterion across the countries. South African learners found item C5 (agricultural matters) harder to endorse than their Zimbabwean counterparts. The learners from Swaziland found item C15 (youth dances) harder to endorse than South African learners. Zimbabwean learners found item C17 (personal/business finances) easier to agree with than South African learners. Item C21 (planning journey) is easier for learners from Swaziland to endorse than those from Zimbabwe.

Table 5: Differential item functioning (DIF) contrast between countries  
<table>
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<th>Item</th>
<th>South Africa</th>
<th>Swaziland</th>
<th>Zimbabwe</th>
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<tr>
<td>C5</td>
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<td>C15</td>
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<td>C17</td>
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DIF contrast is dependent on the length of the instrument. The average impact (DIF contrast/test length) the various DIF contrasts have on respondents’ level of endorsement is given in Table 6. These are relatively low (less than 5 %) and it can be reasonably assumed that they will decrease with an instrument with more items. However, for the construct under consideration the items are fairly exhaustive in terms of real-life situations that can be mathematised for school mathematics. The refined instrument is thus not unduly biased along country, gender and grade dimensions and this gives confidence that it is a viable instrument for comparing preferences for real-life situations across the three countries.

Table 6: DIF contrast for effect of instrument length of respondent tolerance  
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<th>Item</th>
<th>South Africa</th>
<th>Swaziland</th>
<th>Zimbabwe</th>
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Infit and outfit mean squares (IFIT and OFIT MNSQ in Table 7) are calculated to indicate ‘items which do not contribute to the definition of a coherent and useful variable’ (Wright and Masters 1982: vi). These fit statistics indicate whether there are misfitting items. Item ‘values from 0.5 to 1.5 are productive of measurement’ (Linacre 2008: 221). Table 7 indicates that the fit statistics for all the items fall within this ‘productive of measurement’ range. The measure of an item is the location of the item on the transformed scale related to the Rasch model for the empirical data. It can be viewed as the ‘level of difficulty to endorse’ the item. For this particular instrument the ‘hard to endorse’ items have high measures and the ‘easy to endorse’ items have low measures. These measures should be in the range -2 to +2 logits to be acceptable (Reeves and Fayers 2005).

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Table 7: Instrument fit with productive measurement range by country

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<th>Country</th>
<th>South Africa</th>
<th>Swaziland</th>
<th>Zimbabwe</th>
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<td>Fit statistics</td>
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From Table 7 it appears there are no items for any of the three countries outside this range. Table 7 thus indicates the hierarchical order of preference for real-life situations to be used in mathematics for learners in Grades 8 to 10 (Forms 1 to 3) in the three countries. The easiest to endorse items, those in the last rows of Table 7, are the most preferred real-life situations, and the hardest to endorse, those items in the first upper rows of the table, are the least preferred contextual situations. The measures and fit statistics indicate that the items lie on a hierarchical linear continuum and are representative of the construct, learners’ preference for real-life situations to be used in mathematics. Since this is the case for all three countries it is claimed that the instrument is independent of the country, a crucial requirement to make cross-country comparisons. In order to compare the preferences across the three countries, we draw on Julie’s (2011) postulated model for learner preferences for contextual situations that could be used in mathematics. According to this model, preferences for real-life situations that could be used in mathematics can be classified into four zones of preference. These zones are presented in Figure 1 and centre around the standard deviations of the measures as indicated. Julie (2011) further propounds that one can expect some transitions between the zones and their nature is also indicated in the figure.

Figure 1:

Zones of preference for real-life situations
The distribution of the items in the zones is represented in Figure 2, from which the following observations are evident: the learners from all three countries expressed a high interest in three items: C4 (secret codes), C16 (electronic messages) and C17 (personal/business finances). They also expressed a low interest in the items C1 (lotteries/gambling) and C2 (cultural products). Moderately high endorsement is accorded to four items – C7 (health matters), C12 (physical universe), C18 (recreation/sport) and C19 (emergency responses) – by the learners of all three countries. Items C11 (environmental issues), C13 (pop music), C22 (crime-fighting/warfare) and C23 (construction/engineering) received moderately low endorsement by the learners of all three countries. The other items (C3, C5, C6, C8, C9, C10, C14, C15, C20 and C21) are differentially endorsed, with C5 (agricultural matters) varying from moderately high to low preference.

Discussion and conclusion
Responses from the learners in the three countries indicate similarity of expressed interest in 13 of the 23 items. Of those 13 items, eight lie in the intermediate range (moderate zone) in terms of strength of preference.
The three items that appeared in the zone of highest preference (secret codes, electronic messages, and personal/business finances) and the two that appeared in the zone of low preference (lotteries/gambling and cultural products) give an indication that youths in the countries share common and fairly stable interests. This is not surprising, given that the three countries discussed have similar socio-economic realities; low socio-economic status learners from South Africa participated and learners from Zimbabwe and Swaziland are of essentially the same socio-economic class with similar socio-political realities in the two countries. Those phenomena that have to do with secret coding, electronic processes and personal and financial concerns enjoy highest priority and in the same order across the board. This is indicative of the great impact on youth of modern high-technology driven everyday life activities. The availability of multi-function technological communication devices, such as cell phones, is commonplace among the youth and such devices are integral to their daily lives, in terms of learning, communicating and getting around.

It is also observable that two real-life issues – games of chance (e.g. gambling) and activities associated with cultural traditions – received the lowest preference rating. These are often viewed in African society as vices to be stamped out of society and those issues linked to culture are generally regarded by youth as traditional and backward. These attitudes towards gambling and cultural practices expressed by the learners therefore mirror attitudes carried by the wider society in these three countries. According to Julie (2011), preferences in the two moderate zones are characterised by active transitions from one level to the other. They are, in other words, less stable than the other zones of preferences discussed above. It is in these moderate zones that eight (health matters, physical universe, recreation/sport, emergency responses, environmental issues, pop music, crime fighting/warfare, construction/engineering) of the 13 items lie. All eight items are generally linked with formal career or leisure activities in which the individual could be personally involved. Hence learning contexts that could be formulated from these issues are likely to be more effective if they are framed in more personal terms or use an anthropocentric approach, that is to say if they invoke a sense of ‘individual interest’ as discussed in this paper. Among the items that showed differential endorsement in the three countries, an interesting one is that of agricultural matters. This item showed the highest level of endorsement in Zimbabwe, where a strong national land reform movement emphasising social transformation through farming was in progress at the time the fieldwork for our study was being carried out. The lowest levels of endorsement on this item were registered in South Africa, where post-colonial social transformation has largely been urban-driven.

This study illustrates that youth across the three countries do show particular preferences in terms of the context for learning mathematics. The discussion here can only lead us to the conclusion that learning contexts for school mathematics preferred by the youth in the three countries, by and large, reflect similar trends of affective orientations to everyday life phenomena in which they are immersed. It is not surprising that the youth in these three countries share the same affective orientations. It might be seen that these countries are in more or less the same geographical region and hence people tend to interact physically as they move across borders to visit one another’s countries. But again the link with the socio-economic status of participants seems to be a more useful way of interpreting the similarity of preferences for real-life situations to be used in mathematics.

The results of the studies allow for the opening of possibilities of inter-country development
of mathematics learning resources for those situations which learners highly prefer. One such example is learning resources for coding theory to deal with personal identification numbers (PIN numbers), which are important for ensuring safe electronic financial transactions. Another is for dealing with issues for which learners expressed low preferences. For example, the mathematics involved in cultural practices is linked to the current thrust for incorporating indigenous knowledge in curricula. But a word of caution: activities for incorporation of real-life issues cannot be driven solely by the preferences of learners. A careful balancing of the preferences of the different stakeholders must be arranged, as suggested by Julie (2007). Finally, there is currently a thrust for comparative testing of the mathematical competencies that learners master in school. One such test is administered by the Southern African Consortium for Monitoring Education Quality (SACMEQ). Although it can safely be assumed that learners might interpret and attach similar value to items of a strictly mathematical nature, this might not be the case for contextually driven items. One issue that is inherent in real-world problems is language complexity. Learners might experience problems with the language usage in interpreting contextually driven mathematics. Recent efforts are to reduce such language problems in international comparative tests (Carnoy et al. 2011). However, we contend that despite the reduction of language complexity the liking that learners have for contexts can differentially influence their performance on such tests. If, for example, an item is embedded in an agricultural context Zimbabwean learners would be expected to find such an item easier to deal with given the moderately high preference they expressed for this item. South African learners, given their low preference for such a real-life situation, would be expected to find such an item harder to deal with. This points to the fact that in the construction of cross-country comparative mathematics tests using real-life situations consideration should also be given to the selection of these contexts. It might just be that the liking learners from one country have on particular contextual situations might have the unintended consequence of advantaging one country’s learners relative to those of other countries.

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References


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