Reasoning used by isiZulu-speaking children when answering science questions in English

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Abstract

Trend items used in successive TIMSS studies display markedly similar patterns of preference for alternative answers in most countries across all years in which each item was used. Used diagnostically, the patterns reveal common misconceptions, faulty reasoning processes, as well as answering patterns induced by the wording of the questions. South African children's responses are sometimes similar to those of other Anglophone countries, and sometimes markedly different. Low levels of proficiency in English could account for South African children's poor performance in successive TIMSS studies, but Zuma and Dempster (2008) showed that performance amongst a sample of isiZulu-speaking children was not significantly improved by translating test items into isiZulu. Textual strategies successfully explain unusual patterns of preference in multiple choice items which learners clearly do not understand (Dempster, 2007).

The order of preference for alternative answers were compared in three anglophone countries (Australia, New Zealand, England), a multilingual country that has English as medium of instruction (Singapore) and South Africa. Results showed that similar trends were present in some, but not all, questions, but in South Africa, the proportion of children selecting the correct answer was always much lower than other countries.

In order to explain the unusual patterns in South African children's responses to TIMSS questions, interviews were conducted with 36 Grade 9 children who were all first-language speakers of isiZulu. The children first wrote a science test consisting of eight multiple-choice and four free-response items drawn from the TIMSS released items, both in English and in isiZulu. They were interviewed in groups of four after completion of the test, and asked what they did to understand and answer science questions in English.

The results support work done by Probyn (2006) among isiXhosa-speaking children, which shows that Grade 8 children rely heavily on translation into the mother tongue to make sense of instructions, reading and writing in English. In addition, it was noticeable in this study that children had little prior experience of the content tested in the science items, and reported that they 'guessed' the answers. They described a variety of strategies for choosing an answer. When answering free response questions, children said they think of the answer in isiZulu, and then attempt to translate it into English. They concurred that being able to answer questions in their home language would be preferable.

Introduction

Detailed analysis of the patterns of preference in multiple choice questions used in TIMSS studies reveals strong consistency across countries and between years in the order of popularity of alternative answers. Trend items used in two or three successive TIMSS studies are particular useful for illustrating this phenomenon. The results suggest common reasoning processes used by different proportions of the population, the majority of whom reach the correct answer, but stable proportions of children are led to the other distractors.

South African children follow the pattern of other countries in some questions, but noticeably deviate from that pattern in many items. Far fewer South African children select the correct answer than in other countries, and the order of preference for incorrect answers is in many cases, different from that of other countries. This implies that South African children apply a unique set of strategies for answering the MCQ of TIMSS. For example, Dempster (2007) showed that in 20 multiple choice items, more than 40 per cent of South African learners selected one incorrect answer. The most popular choice could often be explained by textual strategies, such as eliminating answers that contained unfamiliar words, or selecting an answer that contained a word that appeared in the stem, thus leading children to the wrong answer.

The language of assessment, which is predominantly English, was found to be a major contributory factor to South African children's poor performance in TIMSS Mathematics questions (Howie, 2001). In TIMSS 2003, about 70 per cent of the 8 912 South African children who participated in the study were African children attending former African schools (n = 6 700 learners). Their average scaled score was 199 compared with 483 for children attending former White schools (n = 741 learners), where teachers have a high level of proficiency in English (Reddy, 2006). Analysis of South African learners' performance on 72 MCQ items in TIMSS 2003 revealed that readability factors, particularly sentence complexity (the number of words per Hunt's T-unit), adversely affected selection for the correct answer (Dempster and Reddy, 2007). The effect was more pronounced in children attending former African schools than in children attending former White, Indian and Coloured schools.

Previously, we have shown that it is possible to translate TIMSS questions into isiZulu without significant loss of meaning, but a sample of isiZulu-

speaking learners did not perform significantly better on the isiZulu version of the test than on the English version (Zuma and Dempster, 2008). Probyn (2006) obtained similar results with isiXhosa-speaking children in the Eastern Cape, where many learners told the researcher that they found it easier to answer questions written in isiXhosa, and when they were able to write in that language. Their free response answers were more detailed than their answers written in English, but overall scores did not improve significantly. Mgqwashu (2004) conducted a controlled experiment with high-school physics learners in Tanzania, and was unable to demonstrate any significant difference in learners' achievement in tests when they were taught and assessed in KiSwahili than in English. He attributed this finding to the fact that teachers teaching in KiSwahili were not using KiSwahili technical terms, but were using a basic non-technical register which did not give learners access to the concepts and technical vocabulary needed for the discourse of physics.

These studies point to a serious problem in the education of children in African countries, which involves the establishment of conceptual learning in the home language before a second language is introduced. Children acquire basic interpersonal communication skills in their home language, and are then faced with a transition to instruction in their second language at a critical time in their education, in the fourth and fifth years when conceptually dense subjects such as the sciences is introduced. At this stage in their schooling career, they have not yet developed cognitive academic language proficiency in either home language or English (Dalvit, Murray and Terzoli, 2009). Their teachers continue to code-switch, but assessment is conducted in English. Children are disadvantaged in assessment through their lack of language skills in English to comprehend and express themselves adequately in English, which compounds the disadvantage they experience through not having acquired cognitive academic language proficiency in either home language or English. Dalvit, Murray and Terzoli (2009) call for indigenous languages to become the languages of instruction and assessment, as allowed by the Constitution of the Republic of South Africa. Such efforts have not previously met with success because of public perception that English is the language of access to power and social mobility.

While the language of assessment undoubtedly plays a role in the performance of South African children in TIMSS, it does not eliminate poor teaching and learning of science concepts as a contributory factor to poor performance. Holliday and Holliday (2003) question the content validity of TIMSS, given that a common set of questions is compiled for a large number of countries

across the world. In TIMSS 2003, each country submitted a set of items, which were reviewed by a panel of experts tasked with compiling the final set of test items (Reddy, 2006). New items to be added to the existing item bank were piloted in most of the participating countries, including South Africa. Nevertheless, the overall content validity of science items in the final TIMSS 2003 science test was 49 per cent for South Africa as compared with an international average of 67 per cent. Distressingly, for items that were valid in terms of the curriculum, the average scaled score achieved by South African learners was only 22 per cent, compared with 19 per cent for all science items tested (Reddy, 2006).

Pollitt and Ahmed (2001) attempted to analyse students' reasoning through analysis of patterns of answering in TIMSS multiple choice items, and presented evidence that the validity of questions is compromised by the readability of question. They present evidence that focusing on the content words can disturb thinking patterns and lead children to select distracters. Their analysis is based on a 6-step model of question answering, which involves

1. learning the subject,
2. reading the question,
3. searching the memory,
4. matching question to memory,
5. generating an answer, and
6. writing the answer.

Pollitt and Ahmed (2001) postulate that question wording can activate irrelevant concepts in children's minds, leading them to the incorrect answer in the case of multiple choice questions, and that most errors arise during the reading phase of question answering. They point to content words that activate incorrect associations and lead to incorrect choices, which are supported by evidence from some TIMSS questions. A criticism of Pollitt and Ahmed's work is that they did not ask children to explain their reasoning processes, but constructed models based on analysis of answers.

This study investigates isiZulu-speaking children's reasoning process when they answer TIMSS science items in English, by interviewing the children after they had written a test composed of TIMSS trend items. It was hoped that the interviews would help explain the patterns of preference shown in the multiple choice items in successive TIMSS studies, and the cognitive

processing that led to understanding and answering free response items. It was also hoped that children would articulate challenges they face when confronted with science questions written in English, and their strategies for making sense of these questions.

Methods

The 12 TIMSS items selected in this study included eight multiple choice and four free response items from the Life Science items, because it is the content area most familiar to learners. The method used to translate TIMSS items into isiZulu is described elsewhere (Zuma and Dempster, 2008). Briefly, it involved translation of the item into isiZulu, and blind back-translation to check accuracy of the translation. Twelve isiZulu-speaking learners were randomly selected from the Grade 9 class at each of three monocultural schools, where the vast majority of learners and their teachers had isiZulu as their home language.

Learners wrote the test in English and in isiZulu, with half writing English first, followed by isiZulu, and the remaining half writing in the reverse order. After the test, learners were interviewed in groups of four, using a semi-structured format. A total of nine interviews were conducted, spread across the three schools. Code-switching was used during the interviews so that learners felt comfortable and were able to express themselves freely. The interviews were recorded, transcribed and translated into English for analysis.

Percentage choice for each alternative in multiple choice items used in this study were extracted from the International Almanacs database available on the TIMSS 2003 website. Since all MCQ items used in the present study were trend items, data were available for 1995, 1999 and 2003 for six items, and for 1999 and 2003 for two items. Australia, New Zealand, England and Singapore were selected for comparison with South Africa, since these four countries participated in all three TIMSS studies, and used English as the language of instruction and assessment. The percentage of all learners selecting each answer was averaged for Australia, New Zealand and England across the two or three years of use of the item. Singapore has English as the second language of most learners, who come from a diversity of language backgrounds, mostly Tamil, Malay and Mandarin. Despite the disadvantage of answering the test in English, Singapore has consistently been among the top-scoring countries in world. For South Africa, Singapore and the International Average, the

percentage was averaged across the years of use of the item. The International average is constructed from the responses of all countries participating in each study, and includes results from countries where the TIMSS questions were translated into another language.

Results

General themes emerging from interviews

When asked to describe the thinking processes they go through when attempting to answer a question, all but one of the children interviewed said they read the question several times and try to understand what it means. The interviewer then asked whether the children read it in the same language or whether they translate it into another language. For most of the questions, all the children said they translate it into isiZulu in order to clarify the meaning.

This is captured in the following responses:

I first read it and try to understand what the question is about and then translate it into isiZulu so as to explain it well.

I read the question and then think about it in isiZulu so that it can be clearer, trying to analyze it well in isiZulu, then I can choose the correct answer.

When you read the question for the first time you cannot clearly understand what it means, you will have to translate it into isiZulu to understand it more clearly, and then you read it in English again to understand what it requires so that you can think about the answer.

Three children said they would call the invigilator or the teacher to explain the question.

If I don't understand it, I will ask the teacher to explain it in isiZulu because I really don't understand it in English.

Some of the children from one school seemed to be able to understand some questions in English:

I understood it as it is in English, I did not translate it into isiZulu, and it is only the answer that I thought in isiZulu.

I understood it in English: I did not translate it into isiZulu.

In some items, the isiZulu version was more difficult to understand than the English version. For example, one learner gave this answer:

I did not understand the question in isiZulu test but I understood it better in the English test.

Once they had read and attempted to understand the question, the interviewer asked children how they chose their answer. Guessing was a common response, the reason being that the learners did not fully understand the question, or they had not learnt the subject matter before. Guessing was not an entirely random process, as illustrated with this answer:

When you guess, you look at whether the answer you are choosing fits in with the question, see if, when you pronounce it, fits in with the question.

Two different children described strategies of eliminating possible answers:

I chose A. . . . . .because A is the only word I do not know and so I chose it. I know all these other words and how do they function.

I chose C because it is the only word I know and I did not understand what the question requires.

One learner described a strategy of looking for words in the answers that also occur in the stem:

When I have to guess, I first read the question for a couple of times and then when I realize that I cannot understand it, I then read the answers, if I also don't understand the answers, I look at a word, for example red blood cells, so where I see the word blood or red blood cells, I will choose that answer.

Children also commonly said that they thought about the answer in isiZulu, and then translated it into English to choose the correct answer. However, they expressed difficulties with the translation process, such as these:

There are difficult words in English which you sometimes don't understand and you will have to use a dictionary to get their meanings.

I had a problem when I had to select the answer: there were some words I did not know their meanings in the answers given here.

The problem was more acute when free response items were answered. Children repeatedly described thinking of the answer in isiZulu and then translating it into English.

I think about my answer in isiZulu but write it in English.

There is no difficulty when you write the answer in isiZulu because you can think quickly in isiZulu, but when you have to write in English, it gives some challenges since sometimes there are words that you know in isiZulu, but difficult to translate them back into English, and when you write the answer you change your sentence in isiZulu and end up writing what you were thinking in isiZulu, the sentence can be just away from what you wanted to say in the answer.

Lack of subject knowledge was mentioned many times by the learners. Learners rarely said that they understood a question and knew the correct answer.

I did not understand this question because I have never learnt about this thing before.

I have guessed from these words because I did not know any of them, I don't know them even in isiZulu.

I guessed because I could not understand this word 'abdomen'.

(Ten of the twelve children interviewed did not know the word abdomen, and one said a male does not have an abdomen.)

I did not understand the question, this word 'traits' gave me a problem. . . And then I ended up guessing the answer.
. . . I did not know that the red blood cells are, whether they are something in the body or something else, it has been really problematic in trying to understand it.

Explaining choices for particular questions

Selected items are shown in the next section, to illustrate the disparity in the selection patterns of South African learners compared with other Anglophone countries. Results show the form of the original question in English and its translation into isiZulu. The choices of children in previous TIMSS studies and for other countries are shown, together with the results obtained in the present investigation, where the same children answered the test in English and in isiZulu. Some specific comments made by isiZulu-speaking children about how they answered the question are then given. Items were selected to illustrate the variety of strategies that influence children's decisions in a science test of this nature.

Questions where South African children answered similarly to other countries

English version	isiZulu translation
A son can inherit traits A only from his father B only from his mother C from both his father and his mother D from either his father or his mother, but not from both	Indodana ingathola ufuzo A kubaba wayo kuphela B kumama wayo kuphela C kubo bobabili ubaba wayo kanye nomama wayo D kubaba wayo noma kumama wayo, kodwa hhayi kubona bobabili

Table 1: Average±SD percentage of learners selecting each option in TIMSS 1995, 1999 and 2003 in selected countries, and in the present study (n = 36 children). Columns are arranged in order of popularity, from most popular to least popular in all tables.

	C	D	A	B
TIMSS South Africa	**50.1±1.6**	**21.0±1.3**	**12.9±2.1**	**11.8±1.0**
Australia, New Zealand & England	77.9±8.4	10.9±3.9	8.4±3.6	2.1±1.1
Singapore	73.0±5.7	13.9±2.5	10.1±3.3	2.4±0.7
Intl. Ave.	78.4±2.1	13.7±1.0	4.9±0.8	1.7±0.3
Test sample English	64	22	8	6
Test sample isiZulu	47	25	25	3

Table 1 shows that answer C was the most popular in all countries, followed by D, A and finally B. South African children differed from children in other countries in that only 50 per cent chose the correct answer, and answers B and D were more popular than in other countries. The consistency of the pattern of preference is illustrated by the low standard deviations for each average.

In the isiZulu version of the test, fewer children answered correctly and answer A was more attractive than in English (Table 1). Despite the fact that teachers had not taught reproduction and heredity before the test, some learners indicated some knowledge of the principles of heredity in the interviews, e.g. "*I think the answer is C because the child is made by both the father and the mother and then it can inherit the traits from both of them*", and *"I think the answer is C because sometimes there are children who resemble both their parents.*" One learner articulated the reason for the popularity of answer D "*I will say it's D, because he cannot inherit the traits from both his parents, it's better to inherit from either his father or his mother, but not from both*." Three children who chose answer B did not give a reason for choosing that answer. One learner indicated the anticipated lack of understanding of the word 'traits': "*I did not understand the question, this word 'trait' gave a problem, it made it harder to understand what the question requires and then I ended up guessing the answer.*" However, it should be noted that the question can be answered by understanding the word 'inherit', but not the word 'traits'. The isiZulu word "ufuzo" carries the connotation of genetic inheritance, and here learners were led away from the correct answer in favour of particularly answer A (sons inherit from their fathers only). As already indicated, one child explained that it was easier to understand the question in the English form than the isiZulu form.

Whether children understand the question in terms of genetic inheritance or some other form of inheritance, the majority deem it most plausible that a son inherits from both father and mother, with the next most plausible answer being either father or mother, but not both. With answers involving only one parent, inheritance from the father was more plausible than inheritance from the mother. Translation into isiZulu decreased the selection of the correct answer, and increased the selection of inheritance from the father only.

Example 2

English version	isiZulu translation
What is the main function of red blood cells? A To fight diseases in the body B To carry oxygen to all parts of the body C To remove carbon monoxide from all parts of the body D To produce materials which cause the blood to clot.	Yimuphi umsebenzi omkhulu owenziwa ama-red blood cell? A ukulwa nezifo emzimbeni B ukuphatha i-oxygen iyiyise kuzozonke izicubu zomzimba C ukususa i-carbon monoxide ephuma kuzozonke izicubu zomzimba D ukukhiqiza izakhi ezenza ukuba igazi lome

Table 2: Average±SD percentage of learners selecting each option in TIMSS 1995, 1999 and 2003 in selected countries, and in the present study (n = 36 children).

Country	B	A	D	C
South Africa	**34.2±0.5**	**27.3±1.0**	**22.9±2.5**	**11.8±0.1**
Australia, England, New Zealand	75.0±5.9	15.5±3.1	5.5±2.3	3.4±1.1
Singapore	88.7±1.6	7.0±1.6	3.1±0.4	1.0±0.5
Intl. Ave.	61.6±1.7	18.0±1.0	14.0±0.4	4.4±0.6
Test sample English	22	25	33	19
Test sample isiZulu	31	33	22	14

Table 2 shows that in previous TIMSS studies in other countries and internationally, the correct answer was consistently the most popular choice, followed by answer A, and then D and C. South African children followed the same pattern, but with much less differentiation among alternative answers. The relative popularity of answer D among South African children can be explained by the fact that it contained the word 'blood', which is also in the stem, as confirmed one of the children interviewed.

In the present study, the pattern of choice was not significantly different from random in both English and isiZulu versions of the test (χ^2 contingency test, $p>0.05$).

Six children told the interviewer that they did not know what "*red blood cells are. . . have never heard of them before"* and therefore they guessed the

answer. This key term in the stem was not translated into isiZulu, since teachers would normally use the English term when teaching blood. A misconception was clearly evident in interviews with the children. Children from two of the schools were convinced that red blood cells fight diseases in the body. One child said s/he had "*learnt about red blood cells in Grade 8,. . . and so I know that these cells fight diseases in the body*". All the children interviewed from the third school said they had never heard of red blood cells before, and they all guessed the answer. Children who attempted to translate 'red blood cells' into isiZulu gave '*amasosha omzimba*' (soldiers of the body) as the translation. This is indicative of a misconception about the functions of red and white blood cells, which may account for 33 per cent of children choosing answer A in the isiZulu version, and 25 per cent in the English version of the test (Table 2).

The results confirmed that the misconception that red blood cells play a role in fighting disease is widespread, and could account for about 18 per cent of children internationally selecting answer A. The selection for answer D can be explained by a strategy of matching words in the stem and alternative answers. Very few children chose answer C, which involved the transport of carbon monoxide by red blood cells.

Questions where South African children displayed a different pattern of answering from other countries

Example 1

English version	isiZulu translation
A girl has an idea that green plants need sand in the soil for healthy growth. In order to test her idea she uses two pots of plants. She sets up one pot of plants as shown below. Diagram Which ONE of the following should she use for the second pot of plants? Five diagrams	Intombazane inesu lokuthi izitshalo eziluhlaza zidinga isihlabathi emhlabathini ukuze zikhule kahle. Ukuze ihlole isu layo isebenzisa izitshalo ezisemabhodweni ezimbili. Yazilungiselela eyodwa yalezizitshalo njengoba kukhonjiswe ngezansi. Yikuphi OKUKODWA kwalokhu okulandelayo okumele ikusebenzise njengesitshalo sesibili?

Table 3: Average±SD percentage of learners selecting each option in TIMSS 1995, 1999 and 2003 in selected countries, and in the present study (n = 36 children).

Country	E	B	A	D	C
South Africa	**34.1±0.4**	**27.5±4.6**	**11.9±2.4**	**6.7±0.6**	**8.2±1.0**
Australia, England, New Zealand	66.2±3.7	18.0±2.4	5.2±1.6	5.8±1.7	3.8±1.1
Singapore	74.0±3.0	12.1±5.4	7.6±2.5	4.2±0.0	1.9±0.1
Intl. Ave.	58.9±1.2	16.6±0.3	8.7±0.4	8.7±0.4	4.2±0.0
Test sample English	31	36	17	8	8
Test sample isiZulu	25	31	22	11	11

Although the correct answer E was consistently the most popular choice in other countries, it was only slightly more popular than answer B in South Africa. The strong visual image of the sun in the accompanying diagrams may explain the fact that answer B was the second-favourite choice in all countries reported here. Answer C was universally rejected as the least plausible answer, except in South Africa, where C was more popular than D. The fact that less than 60 per cent of children internationally were able to select the correct answer points to difficulties with the visual representation, but it could equally be explained by difficulties that many children may have with conceptualizing a fair test with several controlled variables and only one variable different in an experimental setup. Children from Singapore were markedly ahead of children from other countries in this item.

In the present study, children favoured the incorrect answer B, followed closely by the correct answer E. The isiZulu translation confused rather than assisted children to select the correct answer. This item relied on visual literacy as well as ability to read the text, and interviews revealed that children made a concerted effort to understand the concepts and experimental design. Children said they first read the question and then looked at the pictures at the bottom. An example of correct reasoning is shown here: ". . .*in this plant she used sand, soil and water; so for the other plant that she wants to test – most of the plants come from soil and water – so, I chose E which has soil and water*" A learner who chose answer A said "*I chose A because plants need water and sand for healthy growth*." One group of four learners interviewed had each chosen a different answer, and three said they guessed, while one,

who chose B, said it was "*because the girl uses sand, soil and water*". One learner revealed how the matching words strategy led him to choose answer D, *"because here in the question it states soil and I saw that the picture, with the soil, to choose was in the option D*".

The interviews confirmed that children had difficulty understanding the question, and guessing probably accounted for some of the pattern of answering.

Example 2

English version

A person sorted some animals into the two groups listed on the table Which characteristic of animals was used for the sorting?

Group 1	Group 2
Humans	Snakes
Dogs	Worms
Flies	Fish

A. legs
B. eyes
C. nervous system
D. skin

isiZulu translation

Umuntu wehlukanisa ezinye zezilwane ngamaqoqo amabili abhalwe kuleli-***table***. Yisiphi isici salezizilwane esasetshenziswa ekuzahlukaniseni?

Iqoqo 1	Iqoqo 2
Abantu	Izinyoka
Izinja	Ama-***worms***
Izimpukane	Izinhlanzi

A. imilenze
B. amehlo
C. i-*nervous system*
D. isikhumba

Table 4: Average±SD percentage of learners selecting each option in TIMSS 1995, 1999 and 2003 in selected countries, and in the present study (n = 36 children).

	A	C	D	B
South Africa	**20.2±1.2**	**24.0±2.7**	**26.8±1.7**	**21.5±0.6**
Australia, England, New Zealand	66.8±2.8	15.7±1.5	9.6±1.9	6.2±0.9
Singapore	61.7±2.8	21.0±2.1	13.6±0.7	3.4±0.2
Intl. Ave.	50.8±3.3	23.7±2.3	12.9±0.6	9.3±0.7
Test sample English	17	28	39	17
Test sample isiZulu	31	17	36	17

In the TIMSS studies, South African children showed little evidence of preference among the answers, although the answer D was slightly more popular than other answers. The order of popularity in other countries was answer A first, C second, D third and B the least-favoured answer. The percentage correct for Singapore and the international average was considerably lower than for the three Anglophone countries included here, indicating that this question favoured home-language English speakers.

The correct answer (A) attracted more children in the isiZulu version than the English version of the test, but in both versions, the incorrect answer D was the most popular. In the interviews, children said they did not know how to answer this question. They did not know whether to tick the box or select an answer from A, B, C or D. One learner offered the following translation "*Yisiphi isilwane esingafani kulezi?*" while another added "*umuntu unhlanganisa izilwane kulama-group womabili, u-A no B"*. This translation helped this particular learner to understand what to do, but s/he chose answer B, because s/he said they all had different eyes. Several learners explained the popularity of answer D, saying that human skin is different from the skin of all other animals shown in the table. They clearly did not see that the organisms listed under one group shared a characteristic that separated them from all the organisms in the other group.

Some learners who chose the correct answer reasoned as follows: "*I did not understand the question in English and so I tried it in isiZulu* (meaning translating it) *then I understood what was happening and chose the answer A. . .*", "*I chose A because all the animals in Group 1 have legs. . .", "Ja, it's A because the animals in Group 2 have no legs while those in Group 1 have the legs."* These comments support the improvement in performance when the test was translated into isiZulu.

This question is based on the principle of classification, which is particularly important in Biology, since it underpins the Linnean classification system. It appears that worldwide, and in South Africa particularly, many children had not grasped the principle of a grouping characteristic. Translation into isiZulu provided clarity to some South African learners in this question.

Example 3

English version	isiZulu translation
Why would male insects be treated to prevent sperm production? A to increase the number of female insects B to reduce the total population of insects C to produce new species of insects D to prevent insects from mating	Kungenziwa yini ukuba izinambuzane zesilisa zelashwe ukuze kuvikelwe ukuba zikhiqise amasperm? A ukuze kwandiswe inani lezinambuzane zesifazane B ukuze kuncishiswe isamba se-population yezinambuzane C ukuze kukhiqizwe i-species esisha sezinambuzane D ukuze kuvikelwe ukwandisana kwezinambuzane

Table 5: Average±SD percentage of learners selecting each option in TIMSS 1999 and 2003 in selected countries, and in the present study (n = 36 children).

Country	B	D	C	A
South Africa	**20.5±0.3**	**25.3±1.5**	**21.2±1.6**	**26.8±3.4**
Australia, New Zealand, England	66.2±3.1	18.0±1.0	8.8±2.5	6.0±1.7
Singapore	68.5±0.0	21.7±0.1	5.7±0.1	3.8±0.2
Intl. Ave.	46.1±0.5	27.2±0.3	13.7±0.1	10.8±0.4
Test sample English	33	25	19	22
Test sample isiZulu	44	36	6	14

In previous TIMSS, the selected countries consistently preferred B, followed by D, then C and A. South African children's pattern of choice shows that the least favourite answer in other countries (A) was the most popular, although there is little clear pattern of preference among South African children. The international average showed a clear trend towards D as a second favourite after B, supporting a misconception as the main reason for the popularity of D. The misconception used in choosing answer D is that preventing sperm production automatically prevents mating.

In the translation test, more children chose the correct answer in the isiZulu version than the English version of the test. Answer D was the second-favourite answer, especially in isiZulu, followed by A and then C. One learner explained that he translated the English question in order to understand it. His translation was: "*Yinindaba izinambuzana zitreated ukupreventa i-sperm*

production. . ." It is noticeable here that *insects* is translated (*izinambuzana*), together with *why* (*yinindaba*), but other key words remain in English with Zulu prefixes. Several children confirmed that they did not understand the word 'treated', and consequently they guessed the answer. One child argued that answer was C, "*because they want to prevent the old ones and produce the new species of insects*". A reason given for choosing answer B was "*because many people do not like insects, so they can treat them so as to reduce the total population of those insects*". The phrase "*to prevent sperm production*" was not used in selecting an answer to this question. This is supported by the pattern of answering in isiZulu (Table 5), since more children selected answers A and D, indicating that translation enhanced children's understanding of this question.

Some learners reported a strategy of selecting an answer by matching words in an answer with a word in the stem question: "*the question has the word 'production' and this answer here* (pointing to C) *has the word 'produce'".* Although not indicated by the learner, similar reasoning could lead learners to select answer D, since the words '*to prevent'* appear in the question and in answer D. The choice of D as second favourite is explained by faulty reasoning and/or the use of textual cues.

As was shown in the interviews, omitting the information about preventing sperm production makes answer A more attractive. Children who read and understand the whole question may actually be disadvantaged in this item. The reason for the popularity of answer A among South African children and in both languages was not articulated by children interviewed.

Example 4

English version	**isiZulu translation**
Which of the following organs is NOT situated in the abdomen? A liver B kidney C stomach D bladder E heart	Iyiphi kulama-organ alandelayo ENGATHOLAKALI kwi-abdomen? A isibindi B inso C isisu D isinye E inhliziyo

Table 6: Results for learners in present study, and average±SD percentage of learners selecting each option in 1995, 1999 and 2003

Country	E	D	B	C	A
South Africa	**29.0±2.8**	**16.0±1.6**	**13.8±0.8**	**17.3±1.6**	**19.0±2.1**
Australia, New Zealand, England	69.9±3.7	16.4±3.4	4.8±0.8	5.1±1.6	2.2±0.5
Singapore	72.7±6.0	18.9±4.4	3.0±0.4	2.9±0.8	2.0±0.8
Intl. Ave.	66.1±3.7	19.5±2.4	5.6±0.3	3.7±0.4	2.8±0.8
Test sample English (n=36)	36	25	14	11	14
Test sample isiZulu (n=36)	28	25	25	8	14

Table 6 shows that the heart was the favourite answer in other countries, followed by bladder and then liver, kidney or stomach by a small percentage of the children. This indicates that children in these countries were certain about the location of the liver, kidney and stomach in the abdomen, but less clear about the location of the bladder.

South African children differed from other countries in that less than one-third selected the heart, and order of popularity after the correct answer was liver, stomach, bladder and then kidney. South African children were less clear than children in other countries about the location of liver, kidney and stomach in the abdomen. In the test sample, the order of popularity after the correct answer was consistent with other countries, in that the bladder was the second-favourite answer after the heart.

In the English version of the test, more children chose the heart than the isiZulu version. The kidney was more plausible in isiZulu than in English, and more so than any other country. Several children reported that they translated the question into isiZulu: "*Iyiphi i-organ ebhalwe la ngezansi engekho situated kwi-abdomen*?" Three key words were not translated, and the translation lacks the precision of the expert translation. Many learners said they did not know the word 'abdomen', and they did not know where it is situated in the body. As a result, most children resorted to guessing. Guessing procedures include the following reported strategies: ". . .*look at all the words given in the alternatives and know that some of these words will not fit in with the question* (do not match the question), *so do not look at those words any further but consider the other three possible ones, then guess from there*".

This implies that a process of elimination is applied first, before random guessing is applied.

One learner described a mixed strategy of eliminating the most familiar words, and then looking further at the unfamiliar words. "*I have left out the words* ***stomach*** *and* ***heart*** *because they will not fit in with this question and also I know these words, then look at the other three words:* ***liver****,* ***kidney*** *and* ***bladder****, but also I do not know the words* ***liver*** *and* ***bladder*** *and so I did not select them but I selected the word* ***kidney*** *because it sounded familiar.*"

isiZulu names exist for all the organs named in this item, and the translator used the correct terms for these organs, but learners performed worse in the isiZulu version than in the English version of the test. The key word *abdomen*, which could not be translated, proved to be the barrier in this item. Interviews thus confirm that South African children were uncertain about the location of organs in the body, and uncertain about the isiZulu names for the organs.

Free response items

Free response items are scored according to very specific assessment criteria provided with TIMSS documentation. The results obtained in other countries are of little relevance. In the translation test, children answered the English version in English, and the isiZulu version in isiZulu.

Example 1

English version	isiZulu translation
What is the advantage of having two ears to hear with rather than one ear?	Buyini ubuhle bokuba nezindlebe ezimbili ukuze uzwe kunokuba nendlebe eyodwa?

Credit for the correct response was given when learners made reference to locating the source of sound, hearing sounds from both sides, and retaining hearing if one ear does not function. Of the 36 children writing the tests, 14 per cent and 28 per cent answered correctly in the English and isiZulu versions respectively. When answering this question in English, learners said they translated it into isiZulu to understand it correctly, for example "*Yibuphi ubuhle bokuba nezindlebe ezimbili kunokuba neyodwa ukuze uzwe kahle*?" This translation is very close to the expert translation given in the isiZulu version of the test, with some changes in the word order. Children also used visualization techniques, as in the following example:

"I thought of a person, I have never seen a person with only one ear, so I thought that maybe someone with one ear only cannot hear very well."
"I pictured a person with one ear and I thought it could be abnormal and that person cannot hear very well."

During the test sessions, it was interesting to see learners putting a hand over an ear as if simulating the experience of having one ear.

The answers written in isiZulu were better than those written in English, in that more learners located the position, direction and/or distance of the source of sound, and that if hearing is lost in one ear, the other may still function. Nevertheless, only 10 out of 36 learners were able to answer the question correctly in isiZulu, compared with 5 in English. Language interfered with learners' ability to answer this question, but that was compounded by lack of knowledge.

Example 2

English version	isiZulu translation
What processes take place in the human body that prevent it from overheating during exercise?	Yimaphi ama-process enzakalayo emzimbeni womuntu awuvikela ekubeni ungashisi ngokweqile lapho ezilolonga?

In order to get credit for this question, learners had to meet specific requirements with respect to combinations of cooling mechanisms and physiological processes that effect the cooling mechanism. Only 14 per cent of learners in the English version and 17 per cent in the isiZulu version of the test obtained credit for this question. Most learners did not refer to the cooling effect of evaporation, and many misconceptions and off-task answers were given.

Learners said they translated the English question into isiZulu to make sense of the question, and then visualized a person exercising. Several learners mentioned that *". . .he sweats, loses weight and gain more energy"*. One child said s/he understood the question better in the English test than in the isiZulu test. The emphasis on exercise in many answers indicates that the phrase 'that prevent it from overheating' was ignored, and learners answered in terms of the beneficial effects of exercise, e.g. "*exercising is good for you, you feel good"*. There is also some indication that 'overheating' was understood as 'overeating', as indicated by these written answers: "*eat healthy food, e.g. food with starch more vegetables and more water. . .need water . . .muscles get bigger. . . must have energy first and get proteins of the body*".

Some learners said they did not understand the question in English or in isiZulu, and they had never met this at school before. They "*did not understand how you can prevent overheating in the body when exercising*".

Discussion

Taking Pollitt and Ahmed's (2001) model of question answering, the learners tested in this study had clearly not encountered most of the content assessed in TIMSS before. Therefore, the first step, learning the content, was not secure as they embarked on the test. Reading the question in English posed a second problem for the children, since they did not recognize some of the words in the questions. They added another step to the process: translating the question into isiZulu to make better sense of the question. The translation was sometimes incomplete as they encountered content words that they could not translate. Visualization was used when appropriate.

Following reading and translation, Pollitt and Ahmed (2001) insert several rapid, often simultaneous processes of searching the memory, matching question to memory, and generating an answer. In our study, the children were searching their memories, relying on general knowledge and successfully activating correct responses, as in the question related to inheritance, which is not taught in the school curriculum. However, where they are unable to activate correct responses, they used alternative strategies such as eliminating answers containing unfamiliar words, or matching words in the answer with words in the question. These are widespread and robust strategies, as shown by analysis of trend items in successive TIMSS studies.

In the South African context, children have limited experience of the content assessed in TIMSS, and therefore the first step of Pollitt and Ahmed's 6-step model is not always well-established. Reading the question is difficult for many children, due to their limited understanding of the language of assessment. Zuma (2006) proposed that two additional steps were added to Pollitt and Ahmed's (2001) model, involving translating the question into their home language in order to understand it better, and then translating the answer, which they generate in their home language, into English. The performance of South African learners on the free response items in TIMSS has been much worse than their performance on the multiple choice questions, indicating a poor ability to write answers in English.

When they were able to write the answer in isiZulu, the answers were more accurate and gave more information than the answers written in English. This is consistent with results obtained by Probyn (2005) with isiXhosa-speaking children in the Eastern Cape.

Despite the improvement in understanding questions that was apparent in some items translated into isiZulu, the overall score in isiZulu was not significantly better than the score for the English version (Zuma and Dempster, 2008). This indicates that South African children suffer an additional disadvantage over the language disadvantage; one of acquiring scientific concepts, either in English or isiZulu. This paper illustrates how far behind South African learners are relative to other Anglophone countries and Singapore. It illustrates that South African learners sometimes show the same order of preference for alternatives in MCQ items, but far fewer select the correct answer than other countries. Where a distractor is a second-favourite choice in other countries, it attracts many more South African learners than is the case in other countries. In some questions, South African learners display no pattern of preference, or they favour answers that are among the least popular in other countries. The analysis presented in this paper shows that misconceptions, use of textual strategies, guessing and misunderstanding the question contribute to the way children made choices.

The results presented here support the view that South African children in Grade 8 or 9 have not acquired cognitive academic language proficiency in either English or isiZulu, and adds further evidence of the disastrous state of science education in schools. It adds support to a growing movement in South Africa that proposes either a switch to mother-tongue instruction for a longer period of time (Heugh, 1999) or throughout schooling (Kwaa Prah, 2003), or improvement in teachers' ability to teach in bilingual contexts (Probyn, 2006). Probyn (2009) refers to the widening gap between the performance of children in township and rural schools and those in urban schools, where they are likely to be taught by English home-language teachers. Code-switching is likely to continue in schools where children and their teachers have low proficiency in English, but Probyn argues that current teacher education practice gives insufficient attention to the skills of teaching content subjects in bilingual contexts. She criticizes policy that does not take into account the reality of schools in which children and their teachers rarely hear English spoken outside school, and share a common language that is not English.

Dalvit, Murray and Terzoli (2009) conclude that "English can and definitely should be used in the education of African students in South Africa" (p.49).

However, they feel that the dominant role of English should be diminished, since it retards social transformation by perpetuating a language policy "designed to disempower speakers of an African language" (p.49). They argue that it would be more cost-effective to develop appropriate vocabulary for more subjects in African languages than to continue the current inefficient language practice. They end their paper with a call for new momentum for bilingual education in South Africa, which they regard as representing the reality of post-apartheid South Africa.

The present paper provides further evidence of the language disadvantage under which many South African learners approach assessment in English, but this is compounded by poor content knowledge, which is not compensated by offering tests in the home language. Providing bilingual education may assist children to understand science, but if the content is not being taught, there will be little improvement in performance in assessment tasks in home language or in English.

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