SOME LANGUAGE ISSUES IN THE ASSESSMENT OF SECONDARY MATHEMATICS

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Many students have difficulty with the language used in both the learning and assessment of mathematics. This paper investigates the use of English in the assessment of senior secondary mathematics in New South Wales. Using input from students, along with a linguistic perspective, it analyses a question from a recent NSW Higher School Certificate examination and suggests how the language of the assessment might be changed in order to make the mathematics in it more accessible to the students.

BACKGROUND

Part of the rationale underpinning the NSW Higher School Certificate Mathematics courses, *Mathematics in Society* and *Mathematics in Practice*[1], is that they are studied "... by beginning with situations which involve mathematics rather than by beginning with the mathematics itself." ..." (NSW Board of Studies, 1989, p.2). These courses attempt to make the mathematics studied more relevant, more accessible and less abstract than other mathematics courses offered at Higher School Certificate level. This is reflected in topics such as consumerism, transport, accommodation, chance and gambling and measuring which students might expect to encounter in their everyday lives. However, these contexts need to be examined in the light of the language that is used to make them meaningful.

While, over recent years, there has been a great deal of attention paid to the role of language in mathematics learning and teaching, much of this has concentrated on the discourse in mathematics classrooms, either between learners or between teachers and learners (Bickmore-Brand, 1990; Chapman, 1997; Ellerton & Clements, 1991; Mousley & Marks, 1991; Mousley & Sullivan, 1996) and very little on written language which might be used in texts or assessment items (Love & Pimm, 1996; Newman, 1983; Veel, 1995). Using student voices as a data source, this paper considers a linguistic analysis of a *Mathematics in Society* question, and leads to some suggestions for making the mathematics more accessible to the students.

METHOD

In the 1996 *Mathematics in Society* Higher School Certificate examination (NSW Board of Studies, 1996), Question 21(c) is presented as an advertisement for a clothing store-a real life situation to which students are assumed to be able to relate. The text of this question is presented in Figure 1. An illustration accompanied the text in the examination paper but it has been omitted here, following the advice of the students involved in this study who suggested strongly that they ignored the illustration while reading and trying to solve the question.

Student Voices

Input to the analysis of questions from the 1996 Higher School Certificate *Mathematics in Society* examination paper was obtained from a small group of five Year 11 students who attended school in the South West of Sydney. The students (3 male, 2 female from a variety of ethnic backgrounds) were asked to analyse this question, among others, by :

1) attempting to solve the question individually;
2) in gender groups and then as one group, discussing the question in terms of how they feel about it, what it is asking them to do, how they would go about doing that, what words they focus on, whether the description of the situation and the illustrations are helpful, whether they have to read all of the information and what the phrases *greatest percentage discount* and *uppermost numbers* mean to them.
3) in gender groups, rewrite the question so that the mathematics is more accessible.

While no claims can be made about the generalisability of the results from this preliminary study, they do point to some concerns which need to be addressed by mathematics educators, both in secondary schools and beyond.

Figure 1
1996 Higher School Certificate, Mathematics in Society, Question 21 (c)

Jo's Clothes is having a sale. To find the percentage discount on an item, a customer rolls three dice and adds the uppermost numbers.

(i) What is the greatest percentage discount that could be received?
(ii) For an item marked $100, how much would be paid if the smallest possible discount is rolled?
(iii) In how many ways can three dice be rolled to obtain a total of 5?
(iv) Calculate the probability of rolling a 5% discount.
(v) What is the probability of paying $95 or more for an item marked $100?

RESULTS

The students were fairly relaxed about the actual question although one did suggest that he "hated probability". Others suggested that the way in which the question was written and the perceived difficulty of the words used could influence how they felt about it. The word *uppermost* in Question 21 (c) was mentioned as being unnecessarily complicated while one student asked about the noun group *greatest percentage discount*, "Is it like a hundred or the highest you can get in that question?" This suggests a level of confusion which may make it impossible for the student to deal with the rest of the question.

When the students were asked about how they go about doing questions like these, they suggested that they: read the question thoroughly; made sure they understood it and underlined the important words.

The students focussed on the words *how much*, *what is the greatest percentage discount*, *calculate* and *what is*. They were of the opinion that if the questions started off with what you had to do - *calculate, multiply, find*, for example - then that would make it easier to get to the mathematics because "it tells you straight away that you have to do this. It's not you have to read the whole thing then at the end it tells you what to do and you have to go back to the beginning of the question then go straight through it again and then you work out the answer. This way it will tell you at the beginning and you can work it out straight away." The need for an active voice in the language used can be critical for some speakers of English as a second language whose original language may not deal with passivity of voice in the same way as English.

The students reported that the description of the situations - the contextualisation - was useful in some questions but not in others. In some cases, it only provided a distraction from the mathematics. They felt that the sort of questions in their text where the mathematics is explicit and there is little attempt to contextualise the situations were easier - "It saves time and gets to the point." "Sometimes the reading can be confusing and you can sit staring at it for too long." Similarly, diagrams and other illustrations could be useful. However, in Question 21 (c), the artwork was seen to be useless in terms of helping the students.

The students all claimed to understand the specific terms listed, although they suggested that *uppermost* could well be replaced by *top number*. There was agreement among the students that the language used in the question was not "everyday language" which might be used in real-life situations. When they were asked what their teacher did if a number of students were stuck with the language in a class exercise, they agreed that "[s]he explains that easier. She does it step by step. She doesn't use the same words as that, she tries to, like, break it down into smaller words and then probably give us an example some times."

DISCUSSION

Experiential Distance Continuum

Generally, to make meaning in 'real' situations, either in 'real life' or in the mathematics classroom, a more 'spoken-like' language mode is used because of the interpersonal nature of the transactions implicit in the text. For example, if a situation existed where a person was able to obtain a discount by rolling dice, as suggested in this question, the following language might be typical of the actual, as against the written, situation.

Figure 2
Spoken-like Language for Question 21 (c)

Customer:	So I've got to roll them to see what I get?
Proprietor:	Yeah. Just add 'em up.
Customer:	O.K. Here goes.
Proprietor:	That's 13%.
Customer:	Great.

In this verbal exchange there are social interactions occurring and the language is almost a kind of action in itself. (Eggins, 1994, p.54). For example, the language indicates turn taking, rolling the dice and adding up. In this case, the language and the actions that accompany it are virtually one in the same. On the other hand, in the written text of the question there is no social action: the "language is in fact creating and therefore constituting, the social process.... language is being used to reflect on experience rather than to enact it." (Eggins, 1994, p.54) The differences between these two texts can be represented on a continuum, which Martin (1984, p.27) calls the *experiential distance continuum*. When closer to the action, the language will be more 'spoken-like' because of the immediacy, spontaneity and dynamism of the social interaction involved. When reflecting on experience, the language will tend to the more 'written-like' because of the distance between the language and the situation.

This particular dimension of language has important implications for the two Higher School Certificate mathematics syllabuses under consideration here. While they are predicated on establishing everyday contexts for mathematics, it would appear that the language used in the Higher School Certificate examination questions may not be the language of the everyday. There is clearly a tension between the intention of some of the questions, including the example given above, and the language used in them.

Context Dependency

Spoken language is often context dependent because the understandings that people get depend on 'being there'. On the other hand, written language needs to be context independent so that the reader can understand what is going on. The writer needs to build the context for the reader so that the messages being communicated can make independent sense. The text in Figure 1 is designed to provide this information. However, the very building of this context may cause problems for the students attempting the task.

Lexical Density

The Higher School Certificate courses under discussion attempt to provide real life scenarios for the mathematics being learned or assessed. Hence, they are compelled to provide context independent examples which, in turn, result in much greater reading demands for the students. The greater reading demands are created because of the 'conceptual baggage' that formal writing can pack into relatively short text. One way to measure this is to calculate the *lexical density* of the two texts by dividing the number of content words by the number of clauses used (Eggins, 1994, p.60). Figure 3 shows the written text of part of Question 21 (c) with the content words - the main parts of verbs, the nouns, adverbs and adjectives - underlined and the clauses separated by double slashed lines, in preparation for the calculation, while Figure 4 shows the spoken-like equivalent with similar preparation.

Figure 3
Written Text and Lexical Density

" Jo's Clothes is having a sale.// To find the percentage discount on an item,// a customer rolls three dice// and adds the uppermost numbers."

In this particular text there are 14 content words and 4 clauses, giving a lexical density of 3.5.

Figure 4
Spoken-like Text and Lexical Density

Customer:	So I've got// to roll them // to see what // I get?//
Proprietor:	Yeah. Just add 'em up.//
Customer:	O.K. Here goes.//
Proprietor:	That's 13 %. //
Customer:	(That is) Great.//

In this text there are 10 content words and 8 clauses (if some of the ellipsis is replaced), giving a lexical density of 1.2.

The written text has nearly three times the lexical density of the spoken-like text. It incorporates many more concepts that the students have to unpack if they are going to understand what the question is asking them to do. By recreating the everyday experience through dense, context independent text, the question places much greater demands on the readers, sometimes to the extent that the meaning is hard to retrieve.

Passive Voice

In Question 21(c) (i), the students are asked, "What is the greatest percentage discount that *could be received*?" The passive voice used in this question can cloud the meaning beyond the understanding of many students. It can remove the action from the everyday. It is highly unlikely that the customer would ask the question of the shopkeeper using that exact wording. Text written in the passive voice is generally considered to be more difficult to comprehend than text written in the active. The passive voice is not the preferred method of communication among teenagers but it is used extensively in mathematics learning and assessment.

Nominalisation

In Question 21(c) (i), there is another challenge arising from the noun group, *the greatest percentage discount*. This group has three distinct concepts packed into one naming or nominal group. To unpack this complex nominal group the student would have to gloss it as:

- *the greatest:* largest number that can possibly be added from the rolled dice;
- *percentage:* the proportion of occurrences of that added number out of all possible occurrences, expressed out of one hundred;
- *discount:* the amount that can be subtracted from the full price.

The single nominal group has the effect of hiding the complexity of the concepts represented by it. Grammatically, the actions of adding, proportioning and subtracting have been changed into a single 'thing'-a noun or nominal group. This process of changing verbs (actions) into 'things' is called *nominalisation* and is a common practice in mathematics (Veel, 1995). One of the effects of nominalising parts of text can be to the text much more concise. Another effect, however, is that it makes the text much more abstract.

Nominalisation can result in abstracted concepts which, in themselves, have "no unique, unambiguous representations in the real world" (Veel, 1995, p.5). The formality of the nominalisation process is directly at odds with the professed syllabus rationale to enable students to use "mathematics successfully and appropriately in everyday situations" (NSW Board of Studies, 1989, p. 2). There is a clear contradiction between the spirit of the syllabus and the way it is assessed. The net effect of using dense, nominalised texts can be to make their meanings inaccessible to all but the experts (Collerson, 1994, p.82).

CONCLUSION

The exercise of rewriting Question 21 (c) provided confirmation of the analysis discussed above. The students removed the passive voice and introduced action and personalisation. Both nominalisation and lexical density were reduced through a simplification of the sentence structures. The students were unanimous that there was no need to include the information in the 'illustration' which was part of the original question as it did not help them understand what was asked to be done. In fact, many of the students felt that the 'illustration' really only had the potential to confuse, rather than assist them in getting to the mathematics required to answer the question. The rewritten questions are shown in Figure 5

Figure 5
1996 Higher School Certificate, Mathematics in Society, Question 21 (c) - Rewritten by students

Group 1 (Female)

(i) What is the highest percentage discount you can receive after rolling the three dice and adding them together?

(ii) Find the lowest percentage discount you can receive after rolling the three dice. For an item marked $100, use the lowest percentage discount to find the new price.

Group 2 (Male)

Jo's Clothes is giving you the chance to get a discount. All you have to do is buy something and roll three dice. The numbers facing up when added determine the percentage discount.

(i) What is the biggest percentage discount that you can receive?

(ii) If an item costs $100, what is the amount paid when the smallest discount is rolled?

(iii) How many different ways can you roll three dice to obtain a total of 5?

(iv) Calculate the probability of rolling a 5% discount.

(v) What is the probability of paying $95 or more for something which costs $100

While there are many criticisms which could be raised about the students' rewritten questions from both mathematical and linguistic points of view, the overall message is clear. The students have confirmed much of the analysis discussed earlier in this paper and have shown that, in order for them to feel part of the 'everyday and real-life mathematics' supported by the syllabuses and reflected in the examination paper, accessible language must be used. This language must be active, personalised and not so dense that it makes it difficult for the students to reach the mathematics required of them.

In many ways, what the students have done in their rewritten question is precisely what their teacher is reported to do for them: "[s]he explains that easier. She does it step by step. She doesn't use the same words as that, she tries to, like, break it down into smaller words and then probably give us an example some times." In the examination, there is no teacher to "explain that easier". The students have to do it themselves and it appears from the comments of this small sample of students that they have trouble doing so. Not only does there appear to be a mismatch between the written syllabus aims and the assessment practices but also between the teaching and assessment practices. Even though the two courses: *Mathematics in Society* and *Mathematics in Practice* have been consigned to history, the challenge still remains: how do we use language in mathematics to provide a contextual, relevant, accessible and rigorous mathematics challenge for our senior secondary students without making such a challenge incomprehensible to the students?

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