PRE-SERVICE PRIMARY TEACHERS' ASSESSMENT OF AND PERFORMANCE ON MULTIPLICATIVE NUMERACY ITEMS

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Three groups of pre-service primary (elementary) teacher students responded to a questionnaire involving items on multiplication and division. Their responses to these items were analysed to compare the performance of the groups. In addition, students were asked to indicate the extent to which they felt that the items tested "numeracy" understanding. Students exhibited some difficulties on certain items, with ratio proving particularly difficult, but on average students indicated that they agreed that each question was related to numeracy. The variations in perception may be due to the content of the item, the context, or the background of the students.

INTRODUCTION

In recent years many countries have made explicit a concern for "numeracy standards" in the general populace, among students, and among teachers of mathematics. The fact that "numeracy" is gaining currency as a word somehow parallel to "literacy" has, perhaps, influenced the efforts taken to recognise, test for, and remedy perceived problems. One difficulty with the term "numeracy", however, is that it has a number of definitions. In Australia, one definition states that "To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life" (Australian Association of Mathematics Teachers, 1997, p.15), and numeracy is stated explicitly to include numerical, spatial, graphical, statistical, and algebraic skills. In the United Kingdom, in contrast, the definition of numeracy emphasises mainly numerical aspects of mathematics (Department for Education and Employment, 1998, p.11).

There is now a growing number of government programs being developed in Australia intended to improve the levels of students' numeracy (e.g., Department of Education, Employment and Training, 2001), and testing of numeracy performance now occurs in some states (e.g., at Grade 3, 5, and 7 levels in Victoria). Bearing in mind that it is known that teachers' beliefs affect their teaching practices (see, e.g., Thompson, 1992), there is a possibility that teachers' emphasis in mathematics may focus on things that they perceive to be more "numeracy related". It is thus of interest to determine how teachers perceive the numeracy content of different types of mathematical problems. It is presumed that they will make such judgements based on the mathematical content required and other aspects such as, perhaps, the context of the problem.

This study, therefore, reports on some pre-service teachers' assessment of the "numeracy value" of some questions involving multiplication and division, one of the key areas of subject matter knowledge for primary (elementary) teachers. There has been a long-standing concern about the levels of subject matter content knowledge of pre-service teachers (see, e.g., Clarkson, 1998). It is well-known that multiplication and division questions cause difficulties for learners, including pre-service teachers. Rowland, Martyn, Barber and Heal (2001), for example, report on the low competence exhibited by prospective primary teachers on problems involving scale factors and percentage increase. Klemer and Peled (1998) also point out a difficulty with ratio and proportion. This report, therefore, will also examine pre-service primary teachers' actual performance on the items for which they assessed "numeracy".

At the university where this study was conducted, pre-service primary teachers gain their teaching qualifications by one of two routes: either through a four-year Bachelor of Education (BEd) degree or by first completing a degree in some non-education discipline before doing a two-year Bachelor of Teaching (BTeach) course. Students in the BEd program complete six semesters of mathematics (content, curriculum, and teaching methodology), and BTeach students complete three semesters. Suitably qualified BEd students may elect to do an advanced mathematics subject in each of their final three years, which involves additional tutorial time and content. This study investigates whether or not there are any differences between the groups of students in (a) performance on items requiring multiplication or division, and (b) the extent to which they perceive such items as concerned with "numeracy". Any differences may be due to the students' backgrounds and differences in content covered in their courses.

METHODOLOGY

Three groups of students participated in this study: two groups—from the advanced class (N=19), and from the mainstream class (N=51)—from the fourth year of the BEd course, and a group of students from the second year of the BTeach course (N=89). All students were thus in their final year of teacher training.

During a 45-minute tutorial, near the beginning of the year, students were given a "numeracy questionnaire", which comprised 23 questions, some with sub-parts, covering a range of basic mathematical topics. The content was chosen to correspond with that of the primary and early secondary years of schooling. In what follows, "item" means a question or part thereof. Students were required to answer the items and, for each item, indicate on a 5-point Likert scale the extent to which they agreed that the item was a "numeracy question". The questionnaire included the following definition of numeracy, adapted partly from the Australian Association of Mathematics Teachers (1997) definition, to use as a basis for this judgement: "Mathematical knowledge and understanding that adults need and should be able to use in everyday life without specific revision".

Six of the questions and their parts involved some aspect of multiplicative thinking, and students' responses to these were analysed for this paper. Question 1 asked students to express $28 \div 3$ as (a) a whole number with remainder, (b) a mixed number (whole number with fraction), and (c) a decimal. Question 2 told of Amy who worked from 8.45am to 5.30pm and asked (a) how long she worked, and (b) what she earns if she is paid $10 an hour. Question 3 asked which is the better deal: a 375g can of beans for $2 or an 810g can for $5. Question 4 asked how much flour will be left over if there are 11 cups of flour, each batch requires 3/4 of a cup, and as many batches as possible are made. Question 5 gave the exchange rate of $1 Australian for 50 kemmits and asked (a) how many kemmits will you get for $3.50, and (b) how much is 210 kemmits worth in Australian dollars. Finally, Question 6 asked how much concentrate is used to make 200ml of cordial, if cordial is made by mixing concentrate and water in the ratio 1:4. These questions corresponded to questions 1, 5, 9, 11, 14, and 23 on the questionnaire respectively.

Each item was marked right or wrong; if students answered Question 2a incorrectly but carried out a correct calculation in Question 2b based on their incorrect data, then Question 2b was marked right. The numeracy rating, ranging from strongly agree through neutral to strongly disagree, was assigned a number between 1 and 5, with 1 signifying "strongly disagree", and 5 "strongly agree", with "neutral" given the value 3. Students who did not respond to an item or who did not give a numeracy rating for an item were excluded from the data set when calculating overall success rates or numeracy judgements for that item. This inflates the percentage of correct answers for each item, but all items except Question 6—the last on the questionnaire—were attempted by 90% or more of the students. Question 6 was omitted by 21 of the 89 BTeach students and 3 of the 51 BEd students, perhaps because of its placement at the end.

RESULTS AND DISCUSSION

Students' Performance on the Items

Figure 1 shows the percentage of students responding correctly to each of the items. As can be seen the most problematic item was Question 6, concerning the ratio 1:4, with only a quarter of those attempting it getting the correct answer of 40ml. Nearly half of the students (47%) responded with 50ml, presumably working with the fraction 1/4 instead of 1/5. A probability item on the questionnaire reported elsewhere (Chick & Hunt, 2001) also revealed that students often confuse ratios and fractions. An additional 20% of the students gave the answer 800mls to Question 6, perhaps because they misunderstood the difference between the cordial mixture and the concentrate.

Items 1b and 1c (requiring 28÷3 to be written as a mixed number and as a decimal respectively) also caused difficulty for students. A lack of understanding of how to treat the remainder when determining a fraction or decimal seemed to be the cause of most errors. In Question 1b, 12 of the 157 students wrote 9 1/28, confusing which of the divisor or dividend is the denominator of the fractional part. Of the 147 students who responded to Question 1c, 14 gave the answer 9.1, suggesting that the remainder of 1 obtained from the division was used as the number after the decimal point. A large number of students gave answers closer to the correct value but did not show that the decimal expansion of 1/3 involves recurrence, with 21 giving the answer 9.3, 19 giving 9.33, and a further four giving 9.333 or 9.3333.

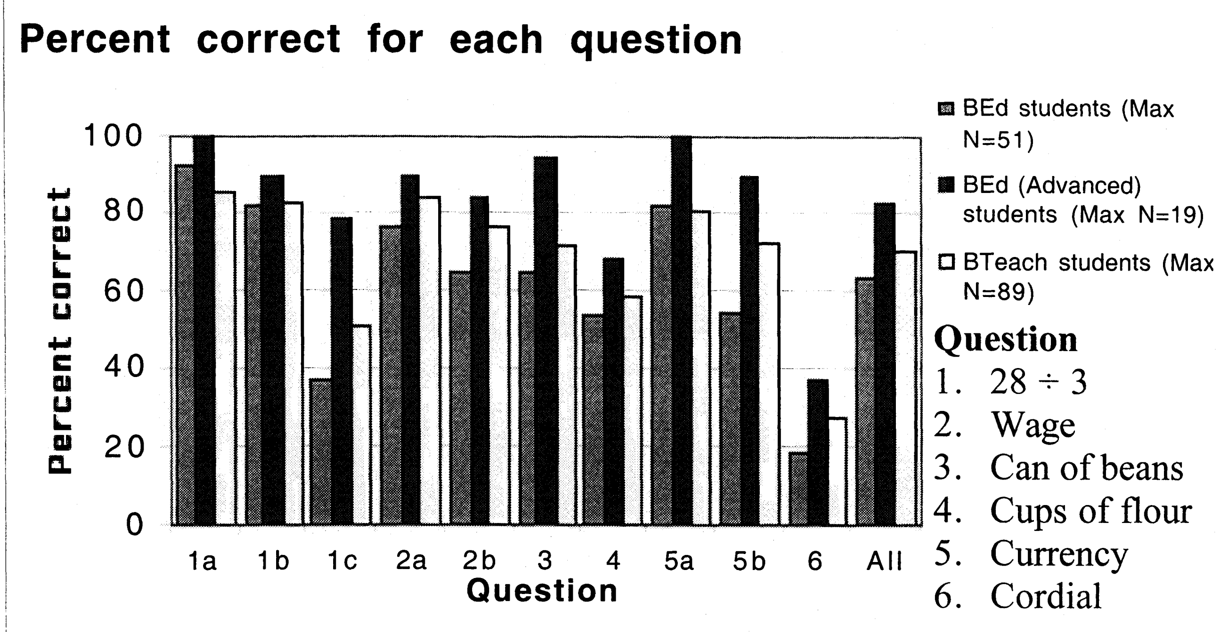

Figure 1. Percentage of students in each group answering questions correctly.

In Question 2b (working out the wage based on the number of hours worked) a common difficulty came from dealing with 45 minutes as a decimal or fractional part of an hour, with at least eight students using 0.45 to give a final answer of \$84.50. Just as Question 2b required students to operate on 8 hours and 45 minutes, Question 5b could also be answered by treating the number to be operated on as two parts. Many students treated the 210 kemmits as 200 and 10 more, and successfully converted the 200 kemmits to \$4 Australian. They then had difficulty with the remaining 10 kemmits, leading eight students to give the answer \$4.10 and another five to halve the 10 (rather than double it) to give \$4.05. This part of Question 5 was not done as well as Question 5a, suggesting that students find one direction of currency conversion easier than the other, depending on the rates.

Looking at the overall results, the BEd advanced group performed significantly better than the other two groups, with a mean score of 8.2 for the ten items compared with 6.2 for the mainstream BEd class and 6.6 for the BTeach class (one way ANOVA, $p<0.0001$). When the results of the BEd advanced class are combined with the mainstream BEd class, however, there is no significant difference in overall performance compared with the BTeach group ($p=0.67$), suggesting that the path to a teaching qualification has no effect on performance. Question 1c (decimal evaluation of 28÷3) was the only question for which the differences between the groups on individual questions approached significance (a χ^2 test with $df=2$ yielded $0.05<p<0.1$), with the BEd advanced class performing better than the other two groups. It would be expected that the advanced class perform better, as ability is the main criteria for eligibility for this class. Nevertheless students elect to participate in it, so it appears that the appropriate group is choosing to enrol.

Students' Perception of "Numeracy"

The average numeracy ranking given to the questions by each group is shown in Figure 2. Overall, the average numeracy ranking for the questions ranged from 3.5 (for the BEd students on Question 1c) to 4.8 (for the advanced class on Question 2a), suggesting that the students felt that the items came in the purview of "numeracy" to some degree. It will be interesting to compare these values with those obtained for the remaining items on the questionnaire. To illustrate the potential for differences, the three probability items on the questionnaire—requiring students to place events in order of likelihood, and then assign a word and a numerical value for the likelihood of each event—were given much lower values for numeracy by the BTeach cohort. The BTeach students gave values of 3.5 to 3.7 as the numeracy ranking for the probability items (see Chick & Hunt, 2001), whereas their values on the multiplicative questions reported here ranged from 4.0 to 4.5.

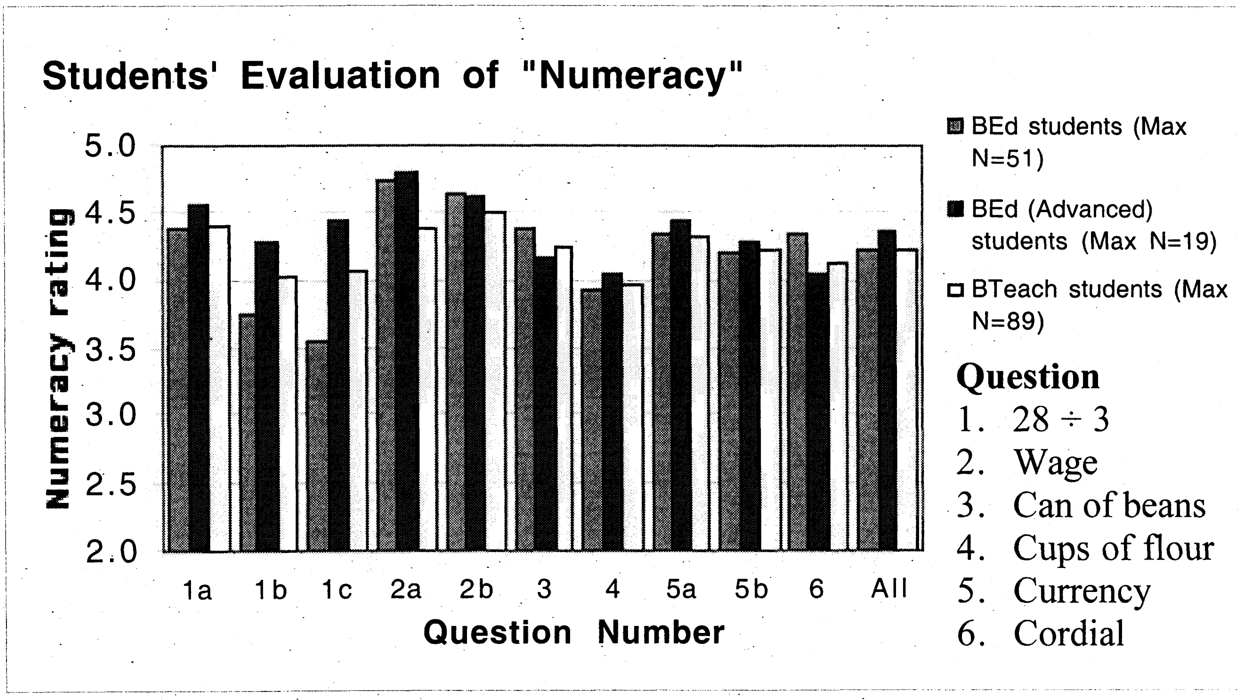

Figure 2. Average numeracy rating of the questions for each group.

When the cohorts are all combined, the questions most regarded by students as being numeracy items were Questions 2a and 2b (time and wage calculation): for both items over 60% of all the students strongly agreed that the items were numeracy-related, with at most 3 students in all disagreeing or strongly disagreeing. The items with the lowest numeracy rankings were Questions 1b, 1c, and 4. Items 1b and 1c had the greatest number of students on the disagreeing side of neutral (17 and 16 respectively), but the modal (and median) responses were still agreement in both cases. Question 4 (fractional cups of flour) had nine students disagreeing and two strongly disagreeing that the item concerned numeracy; nevertheless nearly half agreed and another 30% strongly agreed. It should be pointed out that of the 112 students who assigned numeracy rankings to *all* items, only 18 gave the same response for all questions. Six students did not give any numeracy evaluations at all.

Significantly different perceptions exist between the groups about the "numeracy content" on two of the questions. In Question 1c the BEd advanced class gave a higher numeracy ranking than the other groups (one-way ANOVA, $p<0.01$), with all but one student agreeing or strongly agreeing. All of the students who disagreed or strongly disagreed that the question concerned numeracy came from the other groups. It may be that the lack of context for this question (and also Question 1b) influenced the lower rankings, although the related and context-free Question 1a was more strongly regarded as numeracy. It is possible that students could more readily visualise a context for working out a remainder, than they could for determining fractions and decimals. In Question 2a (calculation of time difference) the BTeach class gave a lower numeracy ranking than the other groups (one-way ANOVA, $p<0.01$).

It was thought that there might be a relationship between students' success rate on questions and the numeracy ranking, perhaps because students might assign higher numeracy rankings to questions they find easier. Figure 3 plots, for each question and group, the percentage of students in the group responding correctly against the average numeracy ranking given to the question by the group. There is the suggestion of a relationship; if all the data is combined the correlation coefficient is $r = 0.45$, with the BEd group marginally more scattered than the other two. This outcome may be a reflection of students' confidence, given that other studies have established correlations between confidence and achievement (see, e.g., McLeod, 1992).

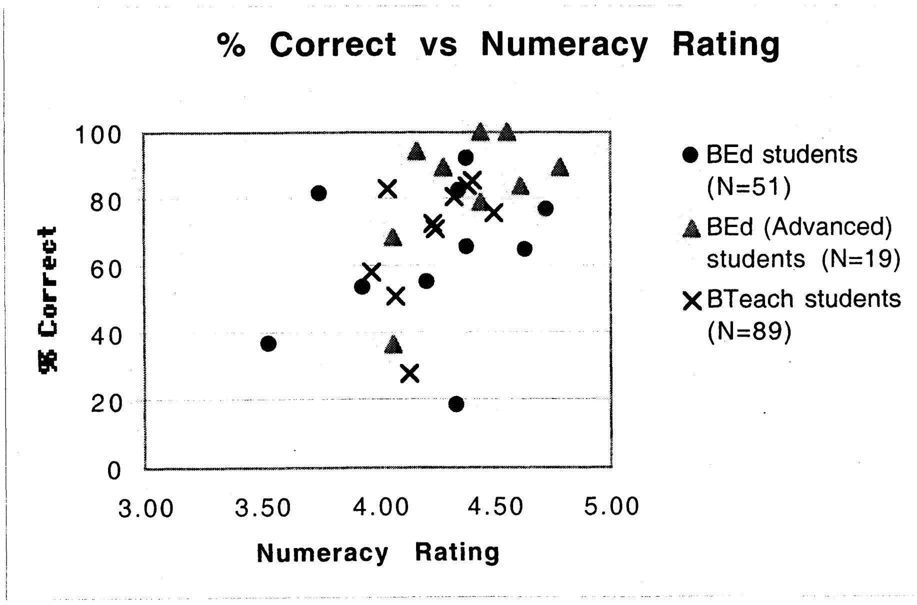

Figure 3. Relationship between numeracy rating and correctness for each of the groups.

Of interest, however, is the fact that at least one question—Question 6 about ratios of ingredients—was regarded as quite highly numeracy-related despite students' poor performance. In contrast, students performed quite well on Question 1b—which required $28 \div 3$ to be expressed as a mixed number—but regarded it as less numeracy-related than most other questions. It may be that the issue of context comes into play here, with students able to do Question 1b but not seeing it as something they "should be able to use in everyday life". Alternatively it may be the content, because Question 4 (which also involves fractions, with the cups of flour used to make batches of food) was given a reasonable context and yet students did not regard it highly as a numeracy question. The teaching and use of fractions has declined in Australia in recent years and this may have influenced students' evaluations; certainly the students found Question 4 one of the more difficult items.

CONCLUSION

Not surprisingly, given the criteria for eligibility, the BEd advanced class performed better on the questions overall, although there were no significant differences on any individual items. It seems that students' background prior to commencing a teaching degree and then the degree chosen makes little difference to the outcomes. While students do cover some mathematics content within their teacher training subjects, the content of questions used in this study was assumed to have been taught to students in their years of compulsory schooling. It would be interesting to confirm this by comparing an entering cohort with an exiting one, to determine whether or not students' performance changes in the course of a teacher training degree. Similarly, it would also be informative to study the performance of primary and secondary school students: to see what, if any, changes take place in understanding of basic mathematics once basic education has been completed.

All items were regarded by the pre-service teachers as "numeracy related" to a greater or lesser degree. There were minor differences in perceptions of the numeracy value of items, perhaps as a consequence of the background or ability of the group of students, or the topic or context involved. It will be informative to examine other, less numerical, items from the questionnaire to compare numeracy rankings.

With teachers being called upon to explicitly teach numeracy and account for students' numeracy performance, the question of what mathematical content is perceived by teachers as being numeracy is important. This is of particular concern where, as is happening already, education systems decree that a certain amount of teaching time be set aside for numeracy. With an overcrowded curriculum, it may be that some important aspects of mathematics and/or numeracy will be pushed aside if teachers do not perceive them as being strongly associated with numeracy. It is therefore of interest to continue investigating teachers' perceptions in this area.

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