Beginning teachers problems with fundamental mathematics

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A Ministerial Report has questioned again whether beginning teachers are adequately prepared at universities. The Report proposes measures to ensure this does happen such as a testing regime in mathematics and literacy at the completion of courses. This paper provides data that indicates some beginning teachers do not show competence in the mathematics they will soon be teaching. Hence there is a basis for concerns raised in the Ministerial Report. However it is argued that the solutions in the Report are somewhat naive and an inadequate response to this problem.

'Tough new test plan for teachers' (Jones, 1998, p.1) was the front heading on page one of The Age, Melbourne's broadsheet. The article was commenting on a Victoria government Ministerial Report which examined teacher training. Two of the recommendations of this report are, to raise the quality of students entering teacher preservice courses, and the need for a demonstration of minimum literacy and numeracy skills for graduating preservice teachers. Clearly there is ongoing concern in the community as to whether teachers can demonstrate a comprehensive command of the material that they are expected to teach.

This concern of entry and exit standards for preservice teacher courses is not new. It has been expressed by the community before, and indeed has been an ongoing concern within the profession. In the late 1980s the mathematics and science components of preservice teacher courses were examined and resulted in the Speedy Report (1989). This Report recommended that entry students should have completed years 11/12 mathematics (their interpretation was years 11 and 12, not as a number of institutions interpreted the recommendation as year 11 or 12), and that all primary preservice students should complete one unit of tertiary mathematics to ensure a good grounding in the subject.

An examination of past Mathematics Education Lecturers Association conference books show that there has been a concern within our profession, not only with our students' affective responses to mathematics, but with their mathematical achievement. So Southwell and Khamis (1987) noted that;

> It is reasonable to assume that teachers in Years K-6 have a sound grasp of the concepts and skills related to elementary mathematics in order to provide their students with the kinds of experiences in mathematics which will enable them in turn to develop strong mathematical skills. Consequently, some measure of the performance of pre-service teachers is desirable. (p.120)

In a number of other papers and reports lecturers report on various approaches to deal with students who were at risk because of their lack of skill and understanding (e.g. Bell, 1989; Perry, 1993; Redden & Clark, 1991).

The starting point of this paper was my ongoing concern with my students in the preservice course I help teach who seem to have difficulty with fundamental ideas of mathematics. These students complete a compulsory semester unit in mathematics, which I believe is innovative and excellent (for a description of the unit see Clarke & Clarke, 1996). Then follows two semester units in mathematics education. The teaching of spatial, measurement, and number curriculum ideas, among other topics, are dealt with as part of the first of the two mathematics education units by lecture, tutorial and workshop activities. No claim is made that these units are exemplary. They are, I understand, rather typical of comparable units in other university courses.

Part of the assessment for this unit is an examination. A number of items on the examination deal with the mathematical concepts covered in the unit. Clearly this group of items do not of themselves constitute a reliable 'test', in the normally accepted sense. This paper reports on how some students performed on these items. It is rather an audit of the pattern of results that occurred, but this I think is of interest for what it suggests.

The report is broken into two sections. The first deals with number and some measurement items, and the second with spatial items.

Number and Measurement Items

The results from one cohort of 63 students taught in 1997 were available. The vast majority of these students were either in their second year of a combined BA/BT program. Some six students were in their first year of a BT degree, open only to students who had previous tertiary qualifications. As is typical of this group of students, 90% were female. Many were from non English speaking backgrounds. This group of students did not appear to the author to be any different to groups who had been taught over the years.

The students' responses are shown in Table 1 for the number items, and Table 2 shows their responses to the measurement items. The students were not permitted to use calculators for these items on the basis that as teachers, although in their teaching we will want them to encourage the appropriate use of calculators, they should still be able to process such skill items without a machine.

Table 1
Number Items and Facility for 63 Students

Items	Facility
368 + 229 + 43.45	92
5000 - 225.8	76
435 x 59	74
680.3 ÷ 7 (correct to one dec. place)	31
258 + 56 x 3	53

Table 2
Measurement Items and Facility for 63 Students.

Items	Facility
What metric units would you use to measure:	
a large area of land (answer: hectare or Km^2)	36
a very small capacity of water (answer: *ml*, cm^3)	87
Using metric units estimate the:	
height of the door (answer: 1.76 - 2.25 *m*)	56
temperature of air in room (answer: 16° - 20°)	48
253 *gm* = ... *kg*	59
2 *l* =...*ml*	75
31 *mm* =...*m*	34
round off to nearest centimeter: 3.568127 *m*	33

Clearly these results are not the source of great joy to me as the lecturer concerned. It can be reasonably claimed that none of these items appear to be very hard and all could be found in the primary curriculum. Indeed all items should be completed correctly by many grade 6 pupils. These results are little different to scores on a similar set of items reported in the 1980s from students completing the equivalent unit in that pre service education course (Clarkson, 1987/88). Anecdotal data from some colleagues suggests that such results would not be atypical for their students.

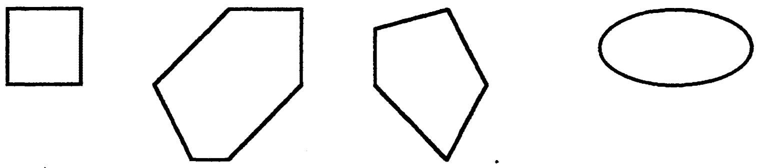
Spatial Items

The other group of items dealt with spatial relations. It was interesting to note when scanning through past papers that very few comments or test items sampled this vital area of the curriculum at all. Hence in reporting the students' responses below, a number of incorrect answers are also listed, and some more extended discussion is included.

Results were available from two cohorts of students. The first cohort were a group of 67 students in their second or third year of a combined BA/BT four year course taught five years ago. The responses for these students are shown below each of the following items in the first column. The second group of students were the 63 taught in 1997 and their responses are shown in the second column below each item. There was little difference in the gender or ethnicity make up of these two cohorts.

The spatial items are listed below with the percentage or students who chose the shown alternative. Normally only the correct response is listed. When more than one response is presented, the starred one is correct.

Item 1: Give the following shapes their correct mathematical name.



A B C D

A. Square 97 87

Other students suggested a cube.

B. Hexagon 46 51

Other answers given were rhombus, pentagon, polygon, trapezium, sextagon, rectangle, heptagon, oblong, octagon and irregular.

C. Pentagon 40 33

Students also chose hexagon, rhombus, diamond, trapezium, polygon, quintexagon and irregular

D. Ellipse 16 5

Oval 73 84

Other names given were sphere, polygon, spirolateral and oblong.

Comment: It would have been hoped that tertiary students would be able to name common mathematical shapes. Leaving aside whether 'polygon' and 'oval' are acceptable, the responses are worrying.

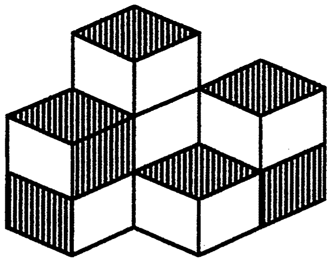
Item 2.

Imagine you were helping a child build a pile of blocks using this diagram.

(i) The parts of the blocks which are shaded are all .... of the blocks.

(ii) Indicate on the diagram an edge of a block.

(iii) If there are no blocks hidden behind this pile, how many blocks will you need?



(i)	Sides/faces/surfaces/ends	64	83

Other answers given were edge, tops, square, widths and dimensions.

(ii)	Edge	78	80

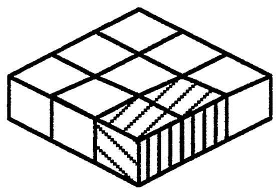
Other answers given were a corner indicated, a side indicated and some gave no answer.

(iii)	8	67	77

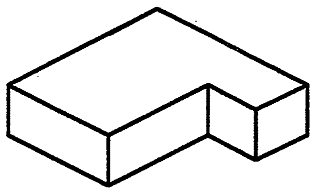
Most other students gave 7 as the answer, the number of blocks in view.

Comment: The first two parts of this item again involve naming, but in a different way to item 1.

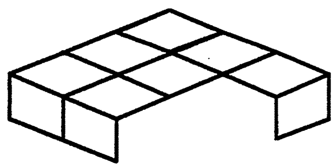
Item 3: This building has been made from cubes. The two shaded cubes are taken away. Draw what remains. (The drawing had an isometric dotted background. The position for completing the drawing was on isometric dotted background.)



Original drawing



Answer - Outline correct



Answer - Missing edges

Correct	88	84
Outline correct	0	0
Missing edges	10	10

Comment: This item required more than naming or counting. Again leaving aside whether drawing the outline is sufficient, students who left out edges in their response appear not to have grasped the notion of a diagram.

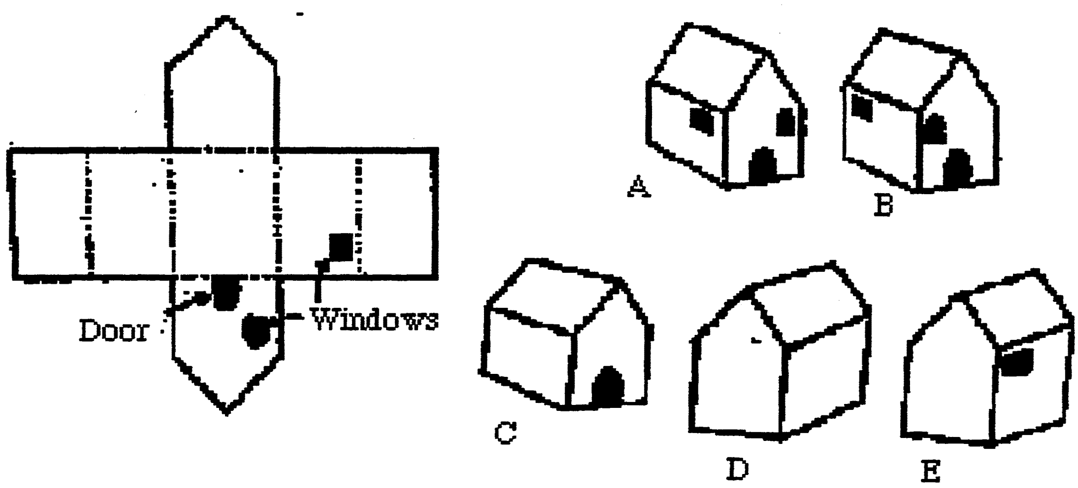
Item 4: These two foot prints were seen on the sand. Circle the correct answer. They were made by:

A. a left foot and a right foot, or B. two left feet, or C. two right feet.

B	93	97

Comment: The wrong answers were spread evenly between the other alternatives.

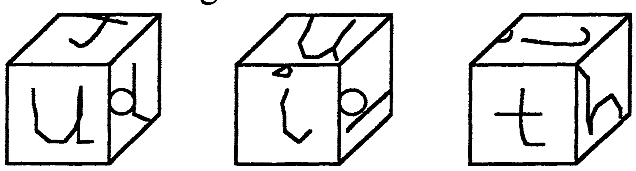
Item 5: The plan of a house which has only one door and two windows is shown below. Which of A, B, C, D, E could be the house?



D	67	67

Comment: This item proved to be hard.

Item 6: Judith wrote the letters of here name on the six faces of a cube. Three different views of the cube are given.



Which letter is on the face opposite the u?

A J   C t

B d   D h

t	40	38
* h	54	53

Comment: This was perhaps the most difficult of all items. Apart from 'u', all other incorrect responses had their supporters with 't' being by far the most popular.

Item 7: Draw the possible two dimensional shapes which are constructed using four squares where each square shares at least one side with another square.

* 5 Correct	25	36
4 Correct	13	13
3 Correct	4	8
2 Correct	15	18
1 Correct	19	8
Totals- One or more correct	*76*	*83*

Comment: This item clearly relies on respondents being aware that a number of correct shapes are possible to fulfill the criteria. 25% in the first cohort and 20% in the second drew 3D diagrams. This implies that a number were not familiar with the term 'two dimensional'.

Item 8: There is a pile of 27 cubes stuck together in such a way to make one large cube which contains no holes or empty spaces. The surface of this large cube is painted. How many of the small cubes have;
only 1 side painted? .., 2 sides painted .., 3 sides painted .., no sides painted ..?

Totally Correct	37	34
1 side painter (6)	52	51
2 sides painted (12)	43	43
3 sides painted (8)	58	64
no sides painted (1)	43	53
Total no. of blocks (27)	51	48

Comment: This item proved to be difficult for all respondents. There were comparatively a large percentages who did not check to see whether they only had 27 small cubes in total, most of these having more than 27.

The first three items were based around diagrams, but to answer the question correctly the diagram could remain static. The first item and parts 1 and 2 of the second simply required naming of shapes and parts of diagrams. The knowledge of such terms is fundamental if teachers are going to adequately communicate with pupils. Later in item 7, respondents needed to understand the technical term 'two dimensional'. The responses to these items taken together give some signs of cause for concern. The last part of item 2 required that a block not shown be counted. Item 3 required that blocks be removed and the remainder drawn. There is cause for concern here given the percentages of errors made by the students.

Items 4, 5 and 6 were also based around diagrams, but for a correct answer to be obtained this had to be manipulated in some way. Item 4 required the rotation of part of the diagram. Responses of the students hint at concern. However the next two items which are clearly more complex in the manipulations needed, led to even higher error rates.

The last two items proved to be challenging. The multiple nature of the responses clearly contributed to this, but did not explain all errors. Images needed to be formed and dealt with in different ways for correct solutions to be obtained. It is outside the scope of this short paper to speculate for example on why in item 8 the edge blocks with the two sides painted proved to be the most difficult.

This brief analysis indicates that the beginning teachers were not handling the items at all well. It should be remembered that these items need skills which many would assume all entry tertiary students would process. Indeed many would assume such skills would be available to many exit primary school pupils. It may be that the spatial errors that are observed with school students (e.g. Clarkson, 1994) are in part related to teacher abilities in this area.

The other obvious point to note is that there was little difference in the results for these two groups of students. Hence changes to entry conditions to this course may have had little effect, a point taken up below.

Discussion

One could criticize these set of results on the basis that they only come from one university, and for half of the results presented, from only one group of students. However it seems to me that they are worth reporting because of what they suggest. They suggest that these students have not shown they are wholly in charge of what would appear to be reasonably straight forward mathematics that they certainly will be expected to teach within two years time.

It will be noted that these students have already completed an innovative semester unit of mathematics at university. To the author these students do not seem to be as worried by the subject matter as students who presented in the mid 1980s. This suggests that the preliminary unit is certainly helping overcome some of their fears for mathematics. But the teaching of that unit does not seem to have allowed students to come to grips with fairly fundamental mathematical skill notions. Hence there is some reason to think that the reasoning behind one recommendation of the Speedy report has not come to full fruition. In that Report it was implied that an extra unit of mathematics would bring all students up to an acceptable achievement level. These results suggest that this is not so. It is probably the case that a number of students who have not studied this mathematics for some years are helped to remember and refine their ideas while completing the first mathematics unit. However it also appears there are a number of students who have such deep misunderstandings that the completion of one such unit, although in some ways very helpful, is simply not sufficient to help them come to grips sufficiently with their long term problems.

The other recommendation from Speedy noted earlier in this paper, that is that entry students should have completed year 11 and 12 mathematics, was never fully implemented for my university. The 1993 students whose results on spatial items were shown above would have been able to claim a bonus percentage for their university entry score if they had have completed some mathematics in year 12. However, by the time the 1997 students applied for entry to this university that bonus had been discontinued because of administrative ease, and because we were battling for students. But, as noted above, there seems to be little difference between these students, at least on the scores on the spatial items. Here then is some indication that manipulation of entry criteria to the course in this way has little direct benefit as had been hoped. This suggestion is in line with an earlier study which in part looked at students' secondary school studies in mathematics and their performance at tertiary level. There were a number of students in that study who were not performing well at tertiary level, even when they came with year 12 mathematics (Clarkson, 1987/88).

What then are we to do? What obligations do universities have in this area, given that many of my students will exit their course and make fine primary school teachers? It should be noted that virtually all of them will gain employment within six months of graduation. Principals of the schools that they go to will also report for most of them that they 'are an asset to my school'. We know this for a fact from survey work completed by the Faculty.

Should we as a profession continue to be concerned about these issues of lacking in particular areas, in this instance mathematics although the same argument could be run for art, or science, or physical education, since students do graduate and get jobs? Are we caught up too much with just one small facet of their preparation, given the extensive matrix of parameters in which primary teachers, on the whole, should have some expertise?

Clearly the Ministerial Report is based on information that to some degree matches the data reported here. Are the concerns expressed in that Report 'for real', or is it just political expediency and another opportunity to kick the profession? Will the macro lines of action that the Report suggests be more beneficial than what Speedy put forward?

It seems to me that students who have long term problems with mathematics still make fine teachers, but they can cause their pupils harm if their mathematical insights are not grown. But in these days of downsizing in universities, and my own in particular, we are no longer in a position to help with long term solutions for these mathematically at risk beginning teachers. Hence the problem must be addressed at the entry point of the course. However the use of macro tools working with data readily available, such as the level of mathematics studied at secondary school, is not sufficient. Other assessment strategies need to be developed and implemented. If governments are really serious about this matter, then one could expect to see tenders which seek expressions of interest to address these issues being advertised. I for one am not holding my breath.

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