MATHEMATICS EDUCATION IN FIRST YEAR PRE-SERVICE PRIMARY TEACHERS

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What are these students' approaches to mathematics education and, in particular, what are the differences in approach, between passing and failing students? The term "approach" is used to suggest a broad underpinning of a student's thinking about knowledge, a relatively persistent characteristic, changing only gradually, and, as proposed here, plays a powerful part in a student's learning behaviour.

THE INVESTIGATIONS

Students' views of mathematical knowledge were investigated to determine to what extent mathematics was integrated into their ways of thinking about the world, to what extent they appeared to value knowledge for its intrinsic interest and its usefulness to them. Did the students failing the First Year Mathematics unit regard mathematics as a series of compartmentalised rules and processes, and separate from their informal ways of quantifying? Were there successful students with these views?

Finding evidence of these views was investigated in three ways; A and B with 92 students, 15 of whom failed, 77 of whom passed, the First Year mathematics competence and methodology unit; and C with these groups and two case studies.

A **Error analysis of working and modelling division problems**
This was done to assess procedural skills and instrumental understanding, and whether students could use models to show how and where an operation might be used.

B **Connection-making**
Which students were making connections in mathematics? Success in a concrete version of the problem and lack of success in an abstract one was taken to mean that connection-making had not happened and that the student's view of mathematical knowledge was likely to be compartmentalised. Relational understanding was less likely (Skemp, 1976). Evidence of successfully completed operations on division and ratio in different contexts was assumed to mean that connection-making could have taken place.

C **Learning behaviours**
In this part, how students said they learned, the language they used to describe their learning and mathematics, and their associations with mathematics were compared for two attributes, their quality of learning and their orientation on mathematics and learning generally.

i) *Quality of learning*
Saljo's concept of Quality of Learning Scale (Figure 1) was used here to gauge learning behaviours that the case studies described. This is a scale

produced for assessment of how students learn; to distinguish between a quantitative change and a qualitative change, the acquiring of principles and control over knowledge, rather than just the amassing of facts.

Saljo describes behaviours, such as remembering a few terms from a lesson, or simply rote learning information, at levels 1 and 2. Here, where there was evidence of faulty, rule-bound behaviour, a lower quality of learning was assumed.

Level	Type of learning
1	A quantitative increase in knowledge
2	Memorising
3	The acquisition of facts, methods etc which can be retained and used when necessary
4	The abstraction of meaning
5	An interpretive process aimed at understanding reality.

Figure 1: Saljo's Quality of Learning Scale (1984)

The quality of learning above Level 2, is of a more interactive nature. At the middle level, one indicator is a student's tendency to select and manage a number of mathematical procedures appropriately. It was assumed that many of the students just passing the First Year Unit would be learning in this way.

At the upper levels, students would understand the effects of operations, make sense of procedures, ask why these work, connect them with earlier experiences, and apply them.

ii) *Orientations on mathematics and learning*

What are barriers to these more interactive learning behaviours? Are they attributable to students' orientations on knowledge? Current research indicates that a student's knowledge definition and the ways he or she acquires knowledge, are interrelated (Wilkinson, 1989; Copes, 1985; and Buerk, 1985).

The schemes of Perry (1968) and Belenky, Clinchy, Goldberger and Tarule, (1986), were used as a guide to views typically held about knowledge. These are developmental schemes, devised as a result of making longitudinal studies of undergraduates of Humanities at Harvard, and women returning to tertiary education, respectively. In this study of pre-service primary teachers, their orientations on mathematics were grouped into three broad brackets, I, II, and III (see Figures 2, 3, 4).

Where students' viewed mathematical knowledge as discrete rules and procedures, necessary to pass examinations, perhaps made more acceptable by being seen as a part of the primary school curriculum, but nevertheless, as separate from themselves, this orientation was placed in Bracket I. The quality of learning associated with this, is likely to be restricted. According to Belenky et al., student with this orientation, were less likely to value their own thinking, their "subjective" knowledge and relate it to the "objective" knowledge being taught.

THE CASE STUDIES

Two students who had failed the mid-year examination in their First Year, were interviewed, to discover to what extent they held such views. Alison had one of the lowest marks in this examination, and Adam had only just failed. Alison was interested in learning what she understood or found relevant:

Alison — I've always liked learning - new things - but then there are just some things that I find irrelevant or boring.

(Maths) just - it's never been my forte.

Even at primary school I never liked it, and like, fractions I hated, and decimals up till now, which .. It's because I understand them now, that I like them - so that if I understand something, I like it in maths."

This sounds as though she is ready to learn, as though the opportunity is there to improve this relationship with mathematics, but her preparation for examinations involves a heavy load of rote learning, and apparently little of the making sense behaviours.

Interviewer — Could you tell me generally about your learning, not necessarily in connection with maths?

Alison — Um - I can learn, like in P.E. for example last year I would learn my notes word for word off by heart, and write word for word in the exam.

That's how I would learn things whereas I was told it would be much easier if I summarized notes and then learnt the basic things about - even English and things like that, if I summarized notes and then just basically learnt what they were saying it would be much easier, but I found it easier to learn the text word for word.

Interviewer — This year...?

Alison — This year I've done it again. This year in P.E. I've learnt word for word definitions and things. And if I don't ... If they're not on the exam I think, Oh, it was a waste of time, learning all that but ... For exams I learn everything I have done

Alison has been given advice to make notes but is not relating to the subjects well, and has not done this, perhaps because of her orientation, rather than lack of motivation.

The quality of her learning is clearly at Levels 1 and 2 of Saljo's Scale, in Bracket I.

Adam, on the other hand, has procedural skills, characteristic of Level 3, ("...in my Skills Test, I got 100%"). His discussion of several calculations that he made, suggested that he worked well at a rule-driven level, but was not concerned with understanding the effects of division, Bracket II. So that in spite of his competence, his quality of learning was not what one would expect of learning at Levels 4 and 5.

Alison in the classroom:

Her approach to learning for examinations / assessment appears to play a large part in her learning behaviour in class.

Interviewer	Does that mean you work very hard?
Alison	Yes. for exams and assignments I'll do very hard work whereas in the classroom I mightn't feel like learning anything and I'll do it in my own time.
Interviewer	Does that mean you don't have a lot of confidence about what's going on in the classroom?
Alison	Oh, no! No, I just - some things I find irrelevant, like Base Five. I learnt to do it. But then I knew I wouldn't have to do it when I taught. It's not in the school curriculum.

The base five topic was intended to provide an opportunity to look at the four operations, and algorithms, in an unfamiliar base, from the perspective of a beginner, and in order to focus on the structure of our decimal base system. Her response, like many others', to this, is not positive. Her reasons, very much those associated with a "received knowledge", Dualist perspective, for neglecting it are reasonable, considering her view of the primary curriculum and mathematics. They are not helpful in developing her understanding of the number system and how children learn about it. Her view is a limiting factor in the development of her learning.

THE SCHEMES OF INTELLECTUAL AND PERSONAL DEVELOPMENT

The first three major subdivisions of Perry's scheme are set into the three brackets.

BRACKET I: THE DUALIST

1 Basic Dualism: World viewed in polarities of right and wrong, passive learners, dependent on authority to teach right from wrong.

BRACKET II: THE MULTIPLIST

2 Multiplicity: Awareness of diversity of opinion and multiplicity of perspectives. Authorities may not have the right answers at least in humanities; also everyone has a right to his own opinion.

BRACKET III: THE RELATIVIST

3 Relativism Subordinate: Cultivation of an evaluative, analytical approach to knowledge in an academic area.

4 Relativism: Full shift to relativism where student comprehends that truth is relative, that meaning of an event depends on context and on the framework used. Relativism pervades all aspects of life not just the academic. Students understand that knowledge is:

constructed	not absolute,
mutable	not fixed.

5 Affirmation of Identity and Commitment: These follow with the belief that until the framework changes the student will act in the current light.

Figure 2: Perry's Scheme: Intellectual and Ethical Views of Knowledge

Adam shows several characteristics of Perry's Dualist and Multiplist categories. Adam is more assertive than Alison, and the way he makes decisions indicate a muscular view of "Authority" that Perry describes.

Adam's approach to C & M Mathematics half way through First Year

Interviewer ... in the months that you have been here, is there anything that you have found significant to you as a learner?

Adam There are several other ways of doing questions and tackling questions.

For example ... I've always thought right before the course ... I'm going to teach it this way, because it's done this way.

I've always learnt that way and it always will be done that way, but there are other ways - like subtraction - there's decomposition, equal additions.

Adam's new found interest in mathematics education was in the possibility of showing more than one way to do an algorithm. During this interview he mentioned "different ways" sixteen times, an indication of the delight and relief he felt at finding these alternative algorithms. This is the expression a Multiplist, Bracket II, willing to cope with diversity, in certain areas of thinking.

Adam Look, if I'm teaching a grade I'd do it both ways. Now I'd do it this way _ equal additions _ now we can always do it another way, and I've done the decomposition and whatever feels right to them they could do. I mean I'm not going to force them like we were forced to do equal additions.

His approach to mathematics knowledge is still, in some senses, Dualist, concerned with what "Authority" allows in this area, but he is, what Belenky et al. call invested in the knowledge of this operation.

Alison is probably better described by the concepts of Belenky et al.'s scheme, because of its focus upon "subjective" knowledge. She is very much the Recipient of Bracket I, in this area of mathematics.

Belenky, Clinchy, Golberger and Tarule's scheme of the ways women construct their experience, 1986

In this a strong element of personal development, assertiveness, and integration of public and private knowledge influences learning behaviours.

BRACKET I: (RECIPIENT)

1 Silence: Women as mindless, voiceless, subject to the whims of external authority.

2 Received Knowledge: Women capable of reproducing knowledge of their own on their own.

BRACKET II: (COMMUNICATOR)

3 Subjective Knowledge: Concept of truth and knowledge, personally or privately known or intuited.

4 Procedural Knowledge: Women are invested in learning, applying objectives and procedures for obtaining and communicating knowledge.

BRACKET III: (CONTEXTUALISER AND CREATOR OF KNOWLEDGE)

5 Constructed Knowledge: View of knowledge as contextual, women experience themselves as creators of knowledge, and value both subjective and objective strategies of knowing.

Figure 3: Scheme II: Women's Ways of Knowing

SUMMARY OF MAIN SAMPLE QUESTIONNAIRE RESULTS

Connection-Making in Mathematical Workings

The following questions were set to note what connections were being made; and to decide whether connection-makers were successful in passing the unit.

i) An abstract problem in decimal division that students typically get wrong 2 -- 0.4 =

ii) A problem that students can do, related to this, estimating how many items they can get for a sum of money.

"How many 41 cent stamps would you get for $3?"

iii) What images do they make for themselves of a decimal division problem in mathematical code?

"Write a real world problem that accurately reflects the mathematical sentence, 2 -- 0.4 "

(eg. Set in a money context:

$2, how many lots of 40 cents?)

iv Do they manage to relate decimal division to a number line model of the operation? "Show how this division problem would look modelled on a number line."

Figure 4: Assessing Competence and Connection-making

Mathematical Workings and Connection Making

Connection-making would be considered at least in Bracket II, and could indicate Bracket III orientations and quality of learning. The results here are mixed, but point to the likely compartmentalisation of mathematics by the Repeats and a number of the CM200's.

At most, a third of passing students are possible connection-makers.

Most students could do the Stamps problem (ii), with the correct change, CM200's 90% and Repeats, 80%.

40% of CM200's could dot the abstract division problem (i). None of the Repeats could do either, confirming their weakness in procedural skills in abstract contexts.

A third of CM200's could supply a real world model for the abstract problem. 20% of Repeats could do this, and yet did not relate it back to the earlier question, to get the answer to the abstract problem. Connection-making, as an indicator of orientation on mathematics, suggests here that 20% of Repeats do this on occasion. In neither group is it very evident.

Students' Associations with Mathematics

About a third of both groups associated mathematics with "Boredom". More than half of the CM200's associated it with "Rote Learning", Bracket I learning behaviour, whereas, fewer, (40%) of Repeats did this, perhaps because they knew they were not such successful rote-learners at this stage, the beginning of their Second Year in the course.

A third of CM200's associated mathematics with "Imagination" and "Creativity", (Bracket III) possibly the third here are the "Connection-makers" above. Less than 7% of the Repeats did this.

Sources of Help when Stuck

CM200 students mentioned more sources of help than Repeats. Repeats (6%) were less inclined to call upon a lecturer for help than CM200's, (22%), and more inclined to go to their families for help, (12%, as compared with 3%).

Preferred Method of Instruction in Mathematics

40% Repeats wished to be shown how to do an algorithm, and how only, (Bracket I), whereas 14% of CM200's wanted this.

Over half of both groups wished to be explore several ways to solve a problem, suggesting that not everyone who failed had such Dualist orientations.

CONCLUSION

A clear picture of orientations and the relationship between orientations and learning behaviours, came from the interview data. It was apparent that the two students had orientations in Bracket I, particularly in relation to learning for examinations. These could have played a major part in their learning difficulties.

The similarities and differences which appeared, between the passing and failing groups are informative, but suggest that the Repeats cannot be thought of, in every respect, as one Bracket below the passing students, and vice versa. The stages described explain in part the success and lack of success in their formal college assessment. A follow up survey, given nearly two years later, as students were finishing the course, should when analysed, supply information about trends in the areas surveyed.

If students do appear to progress through the stages of the schemes, further study of individual students' views of mathematical knowledge would be worthwhile, as from such a longitudinal study, results could be used to devise a more appropriate curriculum, to promote more effective orientations.

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