

Teaching Mathematics in Primary schools: Different types of teachers.

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Abstract

Recent research into teacher effectiveness has identified marked differences in the effects different teachers can have on their students' achievement in mathematics. This paper investigates the relationship between primary school teachers' affective and cognitive factors with respect to their mathematics teaching and learning and examines the differences between teachers. Quantitative data was collected from 100 primary school teachers in Melbourne and qualitative data in the form of mathematical life histories was collected from five of these teachers in follow up case studies. The larger scale quantitative data was used to develop a profile of eight different types of teachers, taking into account their cognitive and affective characteristics. The life histories were used to provide rich information about some of the teacher types.

Introduction

Recent research into teacher effectiveness in mathematics has suggested that there are significant differences between teachers. Sullivan and McDonough (2002) found evidence that children from similar backgrounds had markedly different experiences at school. The different experiences could only be attributed to differences between teachers. Similar results were reported by Siemon, Virgona, and Corneille (2001, p. 99) in a Victorian study of middle schools in which they found that there was as much difference within schools, that is from class to class, as there was between schools, in student achievement.

The increasing focus on developing teachers' abilities to deliver high quality student outcomes means that attention must be devoted to the issue of what constitutes effective professional development when considering the differences between teachers. We are becoming much more aware of what effective teachers of mathematics do in their classrooms (Askew, Brown, Rhodes, Wiliam, and Johnson, 1997; Reynolds and Muijs, 2000) and the debate over what teachers should know to be effective mathematic teachers continues (Fennema, Carpenter, Franke, Levi, Jacobs and Empson, 1996, p. 403; Carpenter, Fennema, Franke, Levi, and Empson, 2000; Lowery, 2002).

The research reported on here has been designed to investigate how teachers rated their knowledge of mathematics and mathematics pedagogy and how they feel about their levels of understanding of these things. The study also investigated how teachers' views about themselves changed during their careers and the factors contributing to changes. The study has been designed so as not to miss out on the perspectives of teachers who would not usually attend professional development in mathematics. This was achieved by including all of the teachers in a number of Melbourne primary schools in the sample.

One of the constructs at issue in this research was what is the relationship between cognitive and affective factors in the teaching and learning of mathematics for primary teachers. Relevant literature (McLeod, 1992) and the research reported in this paper

suggest that cognitive and affective studies remain incomplete and theoretically reductive if the interaction of the two is not acknowledged.

The Study

The initial phase of this research was quantitative and the results were presented in the form of a teacher type table (Table 1) that shows tendencies in primary teachers' perceptions of their ongoing professional learning and their feelings about teaching mathematics. To understand the actual experiences referenced by the teacher type table, a number of personal life stories were collected which, when read in conjunction with the teacher type table, gave a very human face to the teacher type table.

It is the process of seeing the human face behind the research that I wish to illustrate in this paper. To do this I will: briefly outline a methodological rationale for taking life histories, describe the collection of the data, give the thematic analysis of the life histories, present the teacher type table, and then give a reading of the table in terms of the themes uncovered in the life histories.

Life Histories

The stories that we tell ourselves about our experiences are a large part of what we take to be our identity. There are a great many problems for a researcher in finding useful and controllable ways of accessing these stories. No person's full story is going to be exhausted in an interview sessions or indeed in the fullest written autobiography. In approaching the problem of collecting this data I made use of the methodology offered by Van Manen (1990). The method of data collection I chose was what Van Manen called "protocol writing". He defined protocol writing as " the generating of original texts on which the researcher can work" (1990, p.63). These "original texts" are ideally descriptions of experience without causal explanations, generalisations or abstract interpretations. They are not meant to be works of literature. How adequate the data is will depend on how well the researcher has conveyed her intentions for the piece to the participant and how able the participant is to respond.

Five teachers who worked at suburban Melbourne primary schools expressed willingness to participate in this study. They were asked to write mathematical life histories (Chapman, 1993) and given the following instructions:

I would like you to write about your mathematical life history. Could you please describe you experiences and feelings as you were learning maths at school and college or uni, and you feelings about teaching mathematics to children over the years. I am interested particularly in the times when you felt you feelings or understandings changed (either for the better or worse) and what or who you attributed the changes to. If you can remember any events that seem significant to you, please describe them in as much detail as you can. The mathematical life history is like a story of you recollections about maths and maths teaching. You should make it as long or as short as you feel is suitable.

I analysed the data using a thematic approach. The notion of what a theme is and how one actually identifies it is not at all straightforward. Indeed themes, as used here, are as musky as lived experience itself. Uncovering themes in a piece of protocol writing requires empathetic understanding on the part of the researcher. To understand why two humans can understand each other is to enter into the very heart of the debate about the validity of human science research. An interpretation of text may in fact say more about the interpreter than the text or its author. Thankfully there is a practical solution to these

concerns: if the meaning I see in a text, and you also see in the text, then we will take it to be there. What I'll mean by a theme is a phrase or word that seems to capture the point of a sentence or group of sentences as they are found in a number of stories.

Van Manen gave three practical approaches to discovering themes: the holistic or sententious approach, the selective or highlighting approach and the detailed or line-by-line approach (Van Manen, 1990, pp 92-93). The approach adopted here was what he called the highlighted approach. Each of the stories was read quietly and key phrases were highlighted, that is, the phrases which seemed particularly apt in expressing the experience being described.

The questionnaire

Before presenting the analysis of this data, the results of the questionnaire, the Mathematics Attitude and Knowledge Scale (MAKS), from which the teacher type table was constructed, will be summarised. The MAKS was designed to probe the interrelationships between a teacher's cognitive and affective factors related to the teaching and learning of mathematics. (For a detailed account and analysis of the use of this instrument refer to Carroll, 1998). In the study reported here the instrument was administered to 100 Melbourne primary schools teachers, 88 females and 12 males.

Factor analysis of the MAKS data led to a four factor solution (using oblimin rotation on the pattern matrix of the factor analysis) which provided information about how the teachers felt about teaching mathematics (labelled Factor F); how they viewed their knowledge of and feelings about mathematics (labelled Factor M); how they perceived their knowledge of mathematics pedagogy (labelled Factor K) and how they conceived of mathematics and mathematics teaching (labelled Factor C). The teachers' scores on each of these factors were used to develop a teacher type table which identified different types of teachers and described tendencies related to mathematics teaching and learning. Only the first three factors, factors F, M and K, were considered in developing the teacher types because these three contributed to the underlying construct; knowledge and feelings about mathematics and mathematics teaching. Factor C, relating to teachers' conceptions of mathematics and mathematics teaching was not included in the analysis of teacher types, since the items included in it showed little correlation with the principal construct.

Table 1: Positive and negative factor characteristics

NEGATIVE FACTORS	POSITIVE FACTORS
F- Negative feelings about teaching mathematics including lack of confidence, lack of enjoyment and finding it threatening.	F+ Positive feelings about teaching mathematics including confidence, enjoyment, excitement, challenging and find it non-threatening.
M- Knowledge and feelings about doing or studying mathematics are negative; have not done well at maths, maths is not the best subject and find doing maths problems frustrating.	M+ Knowledge and feelings about doing or studying mathematics are positive; have done well at maths, better in maths than other subjects and find maths problems interesting and challenging
K- Lacking in knowledge about the methods and approaches for teaching mathematics to primary school children	K+ Knowledgeable about the methods and approaches for teaching mathematics to primary school children.

The teachers' scores for each factor were said to be positive if they were above the mean factor score and negative if they were below the mean. The characteristics represented by the positive and negative factors scores are summarised in Table 1. These statistics were used to allocate teachers to one of eight teacher types which are shown in Table 2. The percentages indicate the proportion of the surveyed teachers in each type.

Table 2: Teacher types and percentages of each type

F-M-K- 23%	F+M-K- 3%
F-M+K- 13%	F+M+K- 8%
F-M-K+ 11%	F+M-K+ 6%
F-M+K+ 5%	F+M+K+ 31%

Life histories were collected from five teachers; Ann, Betty, Cathy, Dot, and Ellen, who represented the teacher types F-M-K-, F-M+K-, F-M-K+, F+M+K- and F+M+K+ respectively. These were the largest categories. The small size of the other categories made selection of teachers willing to participate in case studies, difficult. The five teachers were female, as none of the male teachers volunteered to take part in this aspect of the study.

Thematic Analysis of the Life Histories

To report on the data contained in the life histories is a verbose procedure. To accommodate this in the present space constraints, the themes found in the data will be briefly illustrated. The key dispositions expressed in each life history are summarised in Table 3.

Experiences as students

Each of the teachers wrote of significant experiences which occurred during their own schools years in which their remembered perceptions of the events had seemingly influenced their self-concept. For example, Ann (F-M-K) wrote, "I remember reciting tables, however, to my father, and I know I knew them well ... My father said I knew them well, but only because I had a good memory – he was right! – and I really didn't have a mathematical mind, as he did". Betty (F-M+K-) spoke about her school experiences, "My early years at the local technical school gave me memories of challenging and enjoyable maths sessions and I seemed to breeze through. I think in about year 9, I undertook Maths A and B and did very well in both.

For Ann, who had been teaching for over 30 years, the experience of learning tables with her father seems to have left her feeling that even though she could do her tables she couldn't do maths. On the other hand Betty's report gives the impressions of thinking herself capable mathematically.

Personal philosophy

Personal philosophy is considered here to be the expression of positions that convey a sense of coherence in self-understanding regarding teaching practice and personal history. For example Betty says, "In conclusion, I think that it wasn't until I was teaching maths myself that I realised that there were better ways to teach/learn maths. As a student myself I don't think I knew any different ... Maths skills are essential to our everyday lives so we have to ensure that students want to participate and learn the

concepts involved”. Betty’s belief that mathematics should be personally relevant appears to stem from the lack of relevance of her experiences as a learner.

Table 3: Key Dispositions in Life Histories

Teacher	Ann	Betty	Cathy	Dot	Ellen
Type	F-M-K-	F- M+K-	F-M-K+	F+M+K-	F+M+K+
Training	2 years	4 years	2 years	3 years	2 years
Experience	31 years	7 years	17 years	10 years	30 years
Maths level	Year 10	Year 12	Year 11	Year 12	Year 12
School experiences	Negative episode recalled vividly. Firmly held belief that she is not mathematically minded	Positive, did well	Felt that she did not understand mathematics, all rote learning, vivid recollection of upsetting experience, managed to pass.	Positive experiences at school left feeling confident of her knowledge	Loved maths and did well although she didn’t always understand
Teacher training	Not important	Unexciting, boring, disappointing	Began to understand the mathematical concepts as she learnt how to teach them	Encouraged her to reflect on her own learning to develop approaches	Shocked by lack of mathematical knowledge of other students
Personal philosophy	Not evident	Has ideas about how maths should be taught but finds them difficult to implement	Clearly developed based on own negative experiences a learner.	Reflection of lecturer’s philosophy	Evident, well developed
Significant influences	Colleagues, team teaching, inspiring EMIC tutor, gifted tactful coordinator, the experience of teaching	In-services, team teaching, publications, own experiences as a learner	Teachers’ college, experience as a teacher, experiences as a learner, curriculum documents	Lecturer at teachers’ college, own experiences as a learner EMIC program	Loved maths at school, very involved in professional development, her role of maths coordinator
Maths Teaching	At times avoided teaching, especially using materials. Knowledge developed through experience	Believed she was not teaching appropriately, knowledge still developing.	Has worked out what works for her, always trying new ideas and approaches	Teaching mathematic is challenging and demanding and rewarding.	Very confident
Maths Knowledge	Rote learning, pointless sums, no global view at school	She did well in year 12 maths, but doesn’t mention her knowledge of maths otherwise	Lacking in confidence about her knowledge	Adequate	Very confident

Ellen (F+M+K+), in discussing the student teachers who work with her said, “Comments from student teachers are interesting. ‘I never knew why you did that until being here’ is a common one and applies to basic concepts such as subtraction

(decomposition). People still don't know why they do things! Rote still goes on!" Ellen does not approve of rote learning and is continually surprised that student teachers unquestioningly accept their own rote learning, until being shown the reason for procedures they have learned. Each of these quotations expresses a position on mathematics teaching and learning and provides a rationale. The statements of position are taken to indicate personal philosophies.

Significant influences

Significant influences are taken here to mean the descriptions of experiences that the writer interprets as having informed an on-going change in her teaching practice and consequent self-understanding. For example, from Dot (F+M+K-), "Lecturers during my teacher training were quite influential in helping me to develop, in my teaching of maths, the qualities and approaches which had lacked in my own maths teachers". Ann commented on notable events that had improved her teaching. "really getting into the team teaching area, guided by a very gifted and tactful coordinator. We did this for terms at a time, and although he took the maths measurement component ... he explained his operation in detail, and gave us such useful notes, that we were able to follow a similar model in future years, when he had gone to admin."

Interaction of themes

In any particular piece of writing the themes are often woven very closely together and it would be a mistake to see them tied to particular sentences or paragraphs. The nature of a life history as a present expression of a complex past is illustrated well in this longer quote from Cathy (F-M-K+),

I also remember very clearly being very frightened in my maths in grade 4 because the teacher would come around with a ruler and the ruler was on its side and if you got things incorrect he would take the ruler and smash it against your knuckles so what I tended to do was be very quiet, and try not to participate too much so that he would forget I was there, because I was very very scared of making a mistake. So of course, there was no push to have a go at it. Like, making mistakes are a part of life and I think that is something that I have learnt through my own experiences and it's something I'm very conscious of in my own class. To actually encourage the kids to be risk takers and they get rewarded for the tries that they have, even if they're nowhere near correct, because otherwise they're going to do what I did and just go into the background and that's the end of that ... I feel that the way that I was taught has helped me now in teaching maths because I do exactly the opposite where I won't just teach a method. I make sure that the kids really understand everything that they're doing, they realise that there are many methods to achieve a certain answer, plus I try to do a lot more open ended work than I had ever done. I think that this is a direct result of my school history.

In this quote we see woven together her experiences as a student (grade 4) her personal philosophy (making mistakes is part of life) and the results of her experiences in her own classroom.

Discussion

The data collected in the life histories (summarised in Table 2), allow us a view of the complex procedure of identity formation, which is reflected in the snapshot of dispositions represented in the teacher type table (Table 1). Connecting the themes with

the types means that the teacher type table is of use as an instrument in instigating change for teachers. The life histories give a human underpinning to the scales expressed in the teacher type table.

The life history data suggests that school experiences were important determinants of teachers' current attitudes towards mathematics and their views of their mathematical knowledge. Ann and Cathy, whose scores were negative on Factor M (knowledge and feelings about doing or studying mathematics), described negative experiences of learning mathematics at school and spoke of themselves as lacking in confidence in their knowledge of mathematics. They recalled mathematics learning as a predominantly negative experience involving memorising procedures of which they had little understanding. The frustration and the lack of enjoyment that stemmed from these experiences was evident in their histories, which were written years later. Betty, Dot and Ellen, who were positive on Factor M, recalled school mathematics as involving more enjoyable experiences and rated their mathematical knowledge more highly. They also inferred that their knowledge of mathematics today is adequate or better.

Schuck (1997) identified different voices when teachers speak. She discussed "self as student" and "self as teacher" as two of the voices that teachers use. It is evident from the life histories and teacher type table that the "self as student" continues to speak many years after the teachers have ceased to be students. The feelings about "self as student" appear to have been relatively unaffected by subsequent experiences of "self as teacher". Professional development for teachers like Ann and Cathy may need to allow them to acknowledge and understand this voice which continues to influence their views so strongly.

The views of mathematical knowledge and associated feelings described by the teachers reinforce the notion that affective and cognitive factors are interwoven in the learning of mathematics. The interaction of cognitive and affective factors were also apparent in the factor analysis when items loading on factor M consisted of those concerning feelings about learning and doing mathematics as well as items related to knowledge of mathematics.

In discussing the influences contributing to changes in their teaching over the years, the five teachers described situations in which significant relationships were established between themselves and a knowledgeable other. These histories suggest that professional development occurs in the context of personal interaction. The interactions described were with lecturers, tutors, presenters, coordinators, peers, principals and other colleagues. Many of these relationships were ongoing, ranging from several months, in the case of lecturers and presenters, to several years for relationships with colleagues and principals. These relationships were important when they valued the teacher's experience, included a climate of respect and enabled learning to be collaborative.

The development of a personal philosophy appeared to be linked to the development of the teachers' confidence in their knowledge of the approaches for teaching and learning mathematics. The life histories of Cathy and Ellen contain clearly outlined personal philosophies of teaching and learning and they are both positive on factor K (knowledge of the approaches for teaching mathematics). The other three teachers had less well-developed views and were negative on factor K, indicating that they lacked confidence in their knowledge of mathematic pedagogy, suggesting that this is a limiting factor in the development of a personal philosophy.

The teacher type table was constructed from a statistical analysis of the teachers' responses to the questionnaire. As pure research it could have been left as a complete entity. This paper was designed to show that reading the teacher type table in terms of the lived experience of some of the teachers involved provides a human face for the statistics and creates a meaning beyond the abstract. This has the power to make the teacher types personal for other teachers and to provide information for those interested in professional development. Personal stories bring understanding beyond the cognitive and their affective dimension often gives access to changed practice where purely cognitive understanding does not.

The differences between teachers are significant and go far to explain the differences in student outcomes in different classrooms. Professional development programs for teachers of mathematics in primary schools, which take into account the different teacher type is suggested by this research.

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Biography

Jean Carroll is a lecturer in education at Victoria University. Her work focuses on teacher training and professional development, with a particular interest in mathematics education