

Teacher Beliefs: Probing the Complexities

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This paper describes a part of a study of the beliefs about mathematics, its teaching and its learning, held by secondary mathematics teachers. The case of one particular teacher is used to illustrate the difficulties inherent in the study of beliefs, and to highlight both the importance of data triangulation and the caution required in making inferences about a teacher's beliefs.

The importance of teacher beliefs has been acknowledged for some time and recently given prominence in policy documents and various numeracy projects. For example the Commonwealth Numeracy Policies for Australian Schools (DETYA, 2000) states that, "Teachers beliefs, knowledge, understandings and skills are critical factors in students' numeracy development." (p. 23), and highlights the importance attached to teachers' beliefs in both the Early Literacy Research Project, in Australia, and the Effective Teachers of Numeracy project in the U.K.

Difficulties in Researching Beliefs

Despite their importance, discerning an individual's beliefs is fundamentally difficult (Munby, 1982). Studies of secondary mathematics teachers' beliefs have tended to be either large-scale survey based comparative studies of the beliefs of various groups of teachers (e.g., Howard, Perry, & Lindsay, 1997; Tracey, Perry, & Howard, 1998) or case studies involving necessarily small numbers of teachers (e.g., Munby, 1982; Thompson, 1984). While most case studies have used at least two data collection techniques, principally interviews and observations, these have tended to be used in a circular fashion with one informing and guiding the other (e.g., Thompson, 1984). This has the advantage of allowing pertinent issues to emerge and to be explored at greater depth, but it also diminishes triangulation and hence reduces the internal validity of the findings (Cohen, Manion, & Morrison, 2000).

Conflicting Beliefs of Secondary Mathematics Teachers?

The relationship between teachers' beliefs and their classroom practice is controversial with many researchers reporting inconsistencies between the professed beliefs of teachers and their observed classroom practices (Cooney, 1985; Shaw, 1989, & Thompson, 1982 both cited in Thompson, 1992). Others such as Grant (1984, cited in Thompson 1992) and Thompson (1984) have reported a high degree of consistency. While Ernest (1989) and McLeod (1992) stress the relevance of contextual variables on the translation of beliefs into practice, Munby (1982) goes further, attributing apparent inconsistencies to an incomplete understanding of the belief system of the subject. Pajares (1992) also stresses that beliefs must be considered in terms of their connections with other beliefs rather than as isolated entities. In spite of this, studies to date seem not to have identified any specific beliefs that may be of particular relevance to teachers' practice.

Implications for this Study

This study was designed to explore the beliefs held by secondary mathematics teachers regarding mathematics, its teaching and its learning using a methodology that would maximise the validity of the findings. Specifically it employed not only multiple data collection techniques but also multiple informants, and was designed to identify beliefs that were centrally held by the subjects and hence most relevant to their practice. Crucially, classroom observations were not simply used to check the extent to which the teacher translated their beliefs into practice but were regarded as an additional data source that could contribute to a fuller understanding of the teacher's beliefs.

The Study

Subjects

The subjects of the study were 25 experienced secondary mathematics teachers teaching in rural 7-10 high schools in Tasmania. Eighty percent of the teachers were male.

Instruments

Beliefs survey. This required teachers to respond, on a five-point Likert scale, to twenty six items relating to their beliefs about mathematics, its teaching and its learning. The items were taken from similar instruments devised by Howard, Perry, and Lindsay (1997) and Van Zoest, Jones, and Thornton (1994) and were originally part of a forty-item survey that was shortened after use in a pilot study.

Constructivist Learning Environment Survey (CLES). Teacher and student versions of this instrument described in Taylor, Fraser, and Fisher (1993) required respondents to indicate on a five-point Likert scale, the frequency of various teaching/learning practices in their mathematics classroom.

Interviews and observations. Semi-structured interviews lasting from 45-60 minutes required subjects to: reflect upon their own experiences of learning mathematics; describe an ideal mathematics classroom and compare this with the reality of their own mathematics classes; respond to 12 statements about the nature of mathematics based upon the findings of Thompson's (1984) case studies of secondary mathematics teachers; and respond to a further 12 statements about the teaching and learning of mathematics derived from the same source. The 12 statements regarding the nature of mathematics consisted of 4 each that represented Problem Solving, Platonic, and Instrumentalist views of mathematics as defined by Ernest (1989), and the 12 statements relating to the teaching and learning of mathematics were similarly representative of three corresponding views of mathematics teaching and learning. Interviews were audio-taped. Classroom observations of approximately 12 lessons per teacher and further informal interviews were conducted over a period of several weeks.

Procedure

Teachers completed and returned the beliefs survey during the first few weeks of the school year. After a gap of several weeks they completed the teacher version of the CLES. They then gave the student version of the survey to students in at least two of their

mathematics classes. Several teachers, including the subject of this paper, felt that their classrooms were different for different classes that they taught and so opted to complete two of the teacher version of this survey; one in relation to each of the two classes to which they gave the student version.

Preliminary analysis of the data from the surveys was conducted during the winter school term. Eight teachers were selected from those who had indicated their willingness, to be interviewed and possibly observed. The teachers chosen represented a range of positions with respect to their espoused beliefs as reported in the surveys.

Interviews were conducted in early October and observations of mathematics lessons of six of the interviewed teachers occurred throughout November and December. While the interviews included responses to sets of statements that represented particular perspectives with respect to mathematics, its teaching and its learning that have been described in the literature, it was not the aim in presenting these to classify the teachers, but rather to provide prompts to which they could respond freely in the hope of obtaining an authentic understanding of their beliefs. To this end also, the researcher did not consult the survey data of the interviewees either prior to or during the interview and observation phases of the study. Further informal interviews were conducted throughout the observation period.

Following completion of the data gathering process interviews were transcribed and analysed, at first independently of the survey data. Issues that emerged as important to each respondent were listed and beliefs about mathematics, its teaching and learning inferred from these. The transcripts were then analysed again in order to find statements supporting, contradicting or clarifying subjects' belief survey responses. Detailed notes made during and immediately following each observation period and the teacher and student CLES data were similarly analysed.

Results and Discussion

The results for one teacher, Nick, are presented and discussed here. Nick had been teaching secondary mathematics and science for 14 years, in two high schools. He had been in his present school for 5 years and was teaching 4 mathematics classes and 2 science classes. He had studied mathematics at tertiary level for 2 years as part of his B.Ed.

Beliefs Survey

Nick's survey score indicated that he, more than any other of the teachers surveyed, had a view of mathematics characterized by Ernest (1989) as problem solving, and held beliefs about mathematics teaching that could broadly be described as learner-focussed (Van Zoest et.al., 1994). His beliefs about mathematics learning were inclined towards constructivism. Consistent with this, he indicated strong agreement or agreement with statements such as:

1. Ignoring the mathematical ideas that children generate themselves can seriously limit their learning;
2. A vital task of the teacher is motivating children to resolve their own mathematical problems;
3. Providing children with interesting problems to investigate in small groups is an effective way to teach mathematics;
4. Mathematics is a beautiful, creative and useful human endeavour that is both a way of knowing and a way of thinking;

5. It is important for children to be given opportunities to reflect on and evaluate their own mathematical understanding;
6. Knowing how to solve a mathematics problem is as important as getting the correct answer;

And he disagreed, or strongly disagreed, with statements such as:

7. It is not necessary for teachers to understand the source of children's errors; follow-up instruction will correct their difficulties;
8. Listening carefully to the teacher explain a mathematics lesson is the most effective way to learn mathematics;

However, he also indicated agreement with:

9. Telling children the answer is an efficient way of facilitating their mathematics learning;
10. It is the teacher's responsibility to provide children with clear and concise solution methods for mathematical problems;
11. It is important that mathematics content be presented to children in the correct sequence.

And agreed strongly with:

12. It is important for teachers to understand the structured way in which mathematics concepts and skills relate to each other.

It is possible that with respect to item 9, above, that Nick focussed on the time aspect of efficiency but did not believe this strategy to be particularly effective. Items 11 and 12 suggest Platonist leanings and, along with item 10, which contradicts item 2, would place him closer to this perspective regarding the nature of mathematics than would be the case had he disagreed with these items. It is also possible that his agreement with both item 2 and item 10 indicates some tension between the way in which Nick would like to teach and the way in which he believes he should, or is expected to, teach. This hypothesis is also supported by the fact that he was undecided about the following items:

13. There is an established amount of mathematics content that should be covered at each grade level;
14. Mathematics material is best presented in an expository style: demonstrating, explaining and describing concepts and skills;

The survey, of course, provides no way of knowing if, or to what extent, Nick is aware of these potential inconsistencies.

CLES

There was considerable agreement between both of the surveys completed by Nick and those completed by his grade 10 class and grade 8 class. In fact Nick's two responses to each item and the average responses for each of the two classes vary by only 1 point on the Likert scale for every item except one. This exception was in regard to the statement "I don't pay attention to other students' ideas". The average grade 10 response was "Often", while the average grade 8 response was "Seldom". Nick agreed with the grade 8 class, but chose "Sometimes" in relation to the grade 10 class.

The consistency of this data suggests that Nick's perceptions of what is taking place in his classes are relatively reliable and that, in spite of his initial assumption that his grade 8 and grade 10 classes were significantly different (which led him to complete two surveys rather than one), they were in fact quite similar even in his own assessment.

Interview

In reflecting on his own experiences of learning mathematics Nick claimed to have found mathematics, at least up to grade 8, challenging but enjoyable. Beyond this it became more difficult and less enjoyable. Nick attributed his reduced enjoyment to the increasing irrelevance of the content. In relation to his secondary school experience he said:

... obviously most of the stuff that we learned past grade 8 was theoretical stuff... so I probably didn't tie it up as being really relevant, um, because I mean most of the maths that we do past grade 8 isn't that relevant, ...

In relation to his studies of mathematics at university he said:

... particularly the number theory, just showed how irrelevant that kind of stuff is to real life, talking about imaginary numbers and those sorts of things, just doesn't have any use at all, so, it just drove home to me that people learn all this stuff for no real point, ...

Interestingly, Nick did not attribute his earlier enjoyment of mathematics to its greater relevance at that time, but rather to the sense of achievement he felt at being able to reach a final definite answer.

Nick made many other references to the irrelevance of most of mathematics, often mentioning grade 8 as a pivotal year, and linking it to the problems he experienced in motivating classes in higher grades, and his frustration at the lack of progress many of his students appeared to make in mathematics. He also made further references to mathematics being an exact discipline with definite answers, describing mathematicians as narrow-minded in trying to "always get a particular answer, or try and zone it down."

However, when responding to the statement, "The content of mathematics is 'cut and dried': Mathematics offers few opportunities for creative work." Nick disagreed, saying:

... obviously maths is involved with many other ... disciplines, so for example music, so music can be seen as a form of maths, so therefore it is creative, and it's involved with all sorts of other things that aren't strictly maths but they use mathematical ideas ...

In discussing his teaching Nick referred to difficulties in motivating students, particularly those in higher grades and those he described as lower ability. He seemed to accept that such students would not like mathematics or see it as in any way relevant, and described attempts to motivate them by telling them that good marks in mathematics are important for finding jobs or accessing future courses or that it "trains your mind to think logically" as "a bit of a con" that the students could readily see through. In the course of this discussion he described his own perception of his job as a teacher as developing relationships with students that would result in them staying on task in order to please the teacher. He felt that this particularly applied to lower ability students.

Nick described an ideal mathematics classroom as one in which the students could see the relevance of the work they were doing and hence were motivated and on task. Time would be unlimited so the teacher would rarely need to intervene and the students could learn from their mistakes rather than being told the answer. He spoke at length about the need for very large classrooms, at least three times the size of a standard classroom, so that students had space to spread out resulting in a lower noise level, and there would be room

to store materials like cardboard and scissors. He also attached importance to the room being a place where students wanted to be and could feel a sense of ownership.

Although Nick attributed many of the differences between the actual and ideal situations to physical factors, he saw the most significant obstacle as the intellectual limitations of the students and related this to their lack of motivation, again referring to grade 8 as a pivotal year:

... the huge problem of kids having reached grade eight and, and probably having reached the cognitive level that they're going to be for the rest of their life and still force feeding them maths for two years, even though they'd much rather be outside doing ... and you know, it's much more inviting, so you've basically got a huge problem in terms of trying to motivate kids that just don't want to be there and probably aren't going to be able to learn that much more than they already have ... that would be the biggest problem, for maths.

Nick also attributed many of the difficulties he experienced to societal factors including the relative economic depression of the region; the high proportion of aboriginal students enrolled in the school; poverty; alcohol and drug abuse; and the devaluing of education in many families and the community generally. Having spoken at considerable length about these issues and what he believed to be their increasing prevalence, Nick offered the following, unprompted, perhaps indicating a degree of tension or even guilt in locating the source of all the problems outside of himself and his own practice:

... because, I mean, I don't necessarily not blame myself. I think as you get older you see things definitely differently, but I definitely think that it, it's mostly to do with kids changing, social things changing rather than myself.

Despite the negativity of much of what he said, Nick seemed quite relaxed and cheerful, and did not hesitate to agree to having his classes observed.

Observations

Nick taught all of his mathematics lessons in the same classroom. A colourful number line spanned the wall above the blackboard, and a number of cardboard polyhedra hung by strings from the ceiling. A number of student-made games including a dart board and a marble maze were either hanging or leaning against the walls at various points.

There were no formal starts or finishes to any of the observed lessons, but students simply entered the room, with their school bags, sat down and started their work as they were ready. Occasionally Nick reminded them to go on with what they were doing last time, but in most cases they began relatively promptly without instruction. Nick's grade 9 and grade 10 classes were all working from the same worksheets copied from a text, on statistics. Nick moved around the classroom assisting students individually or in pairs, often for 5 minutes or more, and largely ignoring those who were off task, provided the noise level was relatively low. He often used humour, occasionally sarcasm, to cajole students into doing the work. Occasionally he raised his voice in response to student misbehaviour and on one occasion sent a student to time out. The overall atmosphere of his lessons was friendly and very relaxed.

In the first lessons observed the grade 8 class were working in groups of two or three, designing and making games based on chance, that they would show and explain to a grade 7 class in a subsequent lesson. These were the games evident around the room. Some of the students who had finished constructing their game were trialling them and collecting data regarding the frequency of various possible outcomes. In later lessons they were working

individually or in pairs to draw floor plans of their dream home given certain constraints on size and functionality. They would then construct three-dimensional models of the houses. In one lesson, two boys whom Nick described as “very bright” were also working on planning the wiring for their house as they were studying electricity in science (also with Nick).

Nick sometimes told students the answers to their questions but at least as often attempted to help them to understand what they were doing. Several cases were observed in which Nick began by attempting to help students to solve difficulties for themselves but ended up telling them the answer when other students demanded his attention or he became frustrated with the student’s apparent disinterest in understanding the mathematics. On several occasions he asked students who had not sought help how they got the answer to a previous question. The responses of students in these situations suggested that this was a common though not necessarily welcome occurrence.

In conversations during and after lessons Nick reiterated all of the concerns and attributions that he expressed in the interview. He also revealed that both the number line and the polyhedra were produced by his grade 8 class, and that he was quite an accomplished pianist.

Nick’s Beliefs

The interview and observations provided considerable evidence that he does indeed hold the beliefs he claimed to in the initial survey, however it is clear that the survey data do not provide the complete picture. For example, it seems likely that in strongly agreeing with the statement numbered 4, above, he had in mind fields such as music. Nick also seems to hold at least two beliefs that were not tapped by the survey, but yet appear to be fundamental to his teaching, namely:

1. Students realise their cognitive potential by the end of grade eight.
2. Students do not like (school) mathematics because it is irrelevant.

Nick also showed some awareness of the tension in relation to items 2 and 10 of his beliefs survey. While one could attribute this to the difficulties of managing a class of 25 students, his lack of perseverance in relation to allowing students, particularly in higher grades, to resolve their own difficulties and in helping them to understand the work are logical consequences of the first of these fundamental beliefs. The two beliefs together also account for the contrast in teaching methodologies employed in grade 8 compared with his other classes, and the second may also have resulted in Nick’s emphasis on relating well to students as a means of motivating them in what he perceives as the absence of anything intrinsically motivating in the content of mathematics courses beyond grade 8.

While it seems that the recent reform agenda in mathematics education has impacted upon Nick’s teaching in lower grades it appears not to have significantly influenced his teaching of higher grades. Clearly unless Nick believes that older students are able to learn mathematics he will be unlikely to make efforts to improve his teaching of them. He is also unlikely to attempt to provide these children with motivating and relevant mathematics problems while he believes that they do not exist. In short, unless these fundamental beliefs are addressed, professional development activities, particularly those relating to the teaching of senior students, are likely to be ineffective.

Concluding Comments

The results reported here support Munby's (1982) assertion that apparent conflicts between teachers' beliefs and practice are evidence of the researcher's incomplete understanding of the relevant beliefs, as they illustrate that the use of data from multiple sources can reveal beliefs with which practice is in fact consistent. They also suggest that the methodology employed in this study may be able to shed light on some of the fundamental beliefs teachers hold that may account for failure of repeated attempts to reform mathematics education (Southwell, 1995). Once identified efforts to modify them can be better targeted.

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