

Identifying Testable Teacher Beliefs Through Teacher-Led Professional Development

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The purpose of this study was to identify the testable beliefs of three secondary mathematics teachers, though for reasons of space only two are reported here. The teachers were involved in a collaborative teacher-led professional development program. The aims of this program were to enable the teachers to reflect on their practice, investigate issues of concern and by collaboration alter their instructional practice. The teachers' beliefs were identified and several inconsistencies highlighted. This study was able to identify testable beliefs for each teacher and a further study intends to investigate whether these inconsistencies once recognised by the teachers can be tested through teacher-led professional development.

Teachers' beliefs about the nature of mathematics influence the ways they teach mathematics. This study is situated in the many calls for the reform of mathematics education both here in Australia (Curriculum Corporation, 1994; Australian Education Council, 1990; Board of Studies, 1995; Board of Studies, 2000) and in other western countries overseas (for example the USA Research Advisory Committee of the NCTM, 1990; The National Council of Teachers of Mathematics, 2000). These reform movements are focusing not so much on what is being taught but on how mathematics is being taught (Curriculum Corporation, 1994; Australian Education Council, 1990; Board of Studies, 1995; Board of Studies, 2000). For secondary teachers in particular, there has been an emphasis to change both their instructional practices and their underlying pedagogical beliefs. Mathematics teachers are being encouraged to be more progressive (Curriculum Corporation, 1994; Australian Education Council, 1990; Board of Studies, 1995; Board of Studies, 2000).

Teacher collaborative research and teacher-led professional development (PD) are two ways that teachers can investigate their own practice (Loughran, 1999; Lytle & Cochran-Smith, 1992). These investigations can assist teachers to develop and articulate their pedagogy as they explore their practice (Loughran, 1999). The important difference from imposed PD is that teacher-led PD is tightly linked to understandings of pedagogy. One successful model of such PD is the Project for Enhancing Effective Learning (PEEL) (Baird & Northfield, 1995) which began in Melbourne, Australia.

This paper reports on the analysis of interviews conducted with two teachers who participated in the study. While three teachers were involved in the study, space restrictions limit the discussion here to two of the teachers. This study was a pilot study for further research, and as such, focused on identifying teachers' beliefs, building case studies of the teachers, and testing the methodology and instruments to be used in the later study.

Theoretical Framework

Teachers' Beliefs

Ernest (1989) proposes three beliefs that teachers have about the nature of mathematics: the *Problem Solving* view of mathematics, the *Platonist* view of mathematics

and the *Instrumentalist* view of mathematics. However, Ernest (1989) also contends that teachers are unlikely to hold one view for all situations or contexts and that they might readily adopt aspects from more than one of the above beliefs. Using this model in a study of junior high school teachers Thompson (1984) found a Problem-solving view, a Platonist view and an inconsistent but mostly Instrumentalist view in three teachers she studied. Further, Thompson (1992) proposed that for the majority of classroom teachers their beliefs about the nature of mathematics were defined mostly by the school curriculum. She further proposed that this tends to give a static view of mathematics and may explain in part why the majority of teachers can be classified as having Instrumentalist and Platonist views.

Green (1971) proposed 3 dimensions of teachers' belief systems. Firstly, he suggested they have a quasi-logical structure where some beliefs are held as *primary* beliefs and others as *derivative* beliefs. Secondly, beliefs within the system can be viewed as either *central* or *peripheral* where the central ones are the most strongly held and the peripheral ones most likely to change. Thirdly, beliefs are often held in clusters, more or less in isolation from other clusters and protected from any relationship with other clusters. Not only are teacher beliefs varied for different contexts but they also appear to be contradictory (Sosniak, Ethington, & Varelas, 1991). Sosniak et al., (1991) proposed that the teachers they investigated taught without a coherent point of view of mathematics.

For this study testable beliefs are defined as those beliefs that teachers hold in isolation from other beliefs. Testable beliefs are contradictory in nature when compared to each other. The testable beliefs are testable in the sense that, once identified, teachers can explore within their classrooms the impact of different beliefs on their practice. This study investigated whether it was possible to identify such beliefs that could then be tested by the teachers themselves. If we can help teachers identify testable beliefs can PD be used to change or challenge those beliefs? This will comprise the next stage of the project.

Teacher-Led PD

The model of PD investigated here is one of teacher-led collaborative research. The PEEL model (Baird & Mitchell 1987) has been developed over the past sixteen years, though it began as a two-year program based in a single outer suburban school in Melbourne (for a detailed comment of the original project see Baird & Mitchell, 1987). PEEL has since spread to over a hundred schools in Melbourne and several other countries including Sweden, Canada and Belgium (for a detailed analysis of the continuing project see Loughran, 1999). The main focus of the program was to improve the quality of the students' classroom learning (Loughran, 1999). The teachers' work across faculties in what Loughran and Gunstone (1997) call a professional group, meeting regularly to share their ideas and experiences, support each other, discuss their concerns and plan teaching approaches to counter these concerns. The structure of PEEL groups with the attendance of the teachers at regular meetings to discuss issues of teaching and learning has encouraged them to develop and articulate a pedagogy of teaching for understanding (Loughran, 1999).

The role of the tertiary academics in this program has been one of support rather than investigation of teachers. This support includes administrative responsibility and offers the teachers different theoretical frames and lenses in which to view their practice. Such theoretical involvement assists the teachers develop, articulate and explain their pedagogy.

Methodology

Following Pehkonen (1999) and Munby (1984) qualitative methods appear appropriate when trying to identify teachers' beliefs for this study. Munby (1984) asserts that qualitative research allows the researcher insights into teachers' beliefs within their own unique context. Such insights when derived from qualitative research are often rich and vivid, ingrained in the examples of critical incidents that are meshed in the demanding hustle and bustle of the classroom and school environment.

In this study, the focus was on the teachers and their beliefs as they interacted with one another in a PEEL group. The importance of understanding the teachers' interactions and their changes in beliefs, if any, lends itself to a qualitative approach. One is more likely, through qualitative methods to identify the reasons, such as changes in beliefs, for the changes in the teachers' practice. Once it is established that a qualitative approach is required Munby asks "...special attention needs to be given to how one can provide an individual teacher with opportunities to talk about fundamental beliefs and principles..." (Munby, 1984, p 29). It was decided for this study to use a structured interview approach focusing on successful teaching and learning as perceived by the teacher. A structured interview protocol was developed using the teachers' ideas of successful teaching and learning as a frame of reference. An example of the structure follows where the focus is on understanding what the teachers' value as success in the mathematics classroom.

1. What do you think is a successful mathematics class?
 - (a) What defines success for you in your classroom?
 - (b) What are the things that you think are most likely to produce that success?
 - (c) What help or assistance, if any, do you think would help you further explore such success?

Most teachers articulate their teaching practice well, but research has found that they have difficulties or have not structured their beliefs of mathematics (Sosniak et al., 1991). Case profiles of each teacher were constructed from the interviews using belief maps. These were maps of the teachers' beliefs that attempted to identify the primary beliefs from the derivative beliefs and the central beliefs from the peripheral beliefs. These were then analysed for similarities and differences.

Results and Discussion

Case Study 1: Viv

Viv believes that a successful class is one where effective learning takes place, the students own the learning process, and there are high levels of student engagement. Unsuccessful classes are those consisting predominantly of chalk and talk and using the textbook as the only resource with very little variation. An apparent conflict in Viv's beliefs arose when she was considering her preferred teaching methods and what was an example of her typical class. From the list of teaching strategies discussed, Viv used chalk and talk often and describes this approach as part of her typical class. Though she has concerns about the passive learning of her senior students her teaching methods to these students are more traditional than with her junior classes. She relies heavily on the textbook and on the lecture format with the senior students. Viv resolves this by saying the examination at the end of the year forces her to do this.

Viv believes students can learn differently and she tries to present material for different learning styles. She doesn't remember when she was introduced to this paradigm but uses it regularly. The learning styles she identified in her teaching were aimed at the auditory learner, the visual learner and the kinaesthetic learner. She liked to use chalk and talk or the lecture format for auditory learners, concrete materials for visual learners and hands on activities for the kinaesthetic learners.

Viv places a high value on teacher knowledge in the classroom and sees this as the main cause for most of her poor lessons. Fresh in her mind after many years is a critical incident in her first year of teaching when she felt she was caught out by students on an issue of content. Since then she has viewed content knowledge and her own knowledge as very important.

Viv believes in a recipe format for her classes: start with an introduction, students work on an activity or exercises and she concludes before they leave. Viv views herself as very traditional with an emphasis on students practicing the skills through many repetitions. She believes maths learning comes from lots of skills practice and lots of repetition, an Instrumentalist or Platonist approach to mathematics. She recognises that she loses some students along the way with this approach but believes the benefits for the other students are important and worth the cost. Informal class interviews are used as an anecdotal measure of knowledge but, she believes, the test shows the real understanding. She states she is rarely surprised by the test results of her students. Good learning can also be measured, she thought, by the level of student engagement.

To improve her own teaching Viv would like to learn more about monitoring learning and try new and innovative teaching strategies. Viv experiences many pressures from the school management in respect of her classes and does not feel confident to try some of the strategies she has been introduced to. She fears losing control of her class. She is also concerned with how she will be viewed by management and other staff when trying new tasks, particularly if they are unsuccessful.

In identifying what has influenced these changes in her teaching, Viv reported an awareness of effective learning, and a desire to move away from poor teaching habits towards positive teaching to promote the best learning. PEEL just struck a chord with her at a meeting.

OK just being aware that there are people like Ian Mitchell (university academic who coordinates PEEL) who come out to schools and that's how I first came across him, he came out to the school I was at. He started talking about what the PEEL program was and it was really striking a chord with me, like this terrific this is fantastic why don't we all just do it? You know we've got to do it, this is the only way, we've got to do something about our classes or we can't just go in there and do very ordinary stuff, it's just not professional it's not satisfactory.

Viv recognised that discovery learning and problem solving are areas that she needed to and wanted to use in her teaching more often. However, she believed she had legitimate reasons for not using such strategies in her classrooms. Viv was concerned with control of the class and issues of discipline.

I suppose where you get to a point in some classes particularly the junior ones where you are trying to establish control and routine and discipline and the thought of rocking the boat or making a little bit open ended there is sort of uncertainty creeps in and you worry about perhaps loss of discipline etc in the room.

Viv considered using open-ended problems or learning strategies, but dismisses them on the grounds of allowing the students too much freedom. Her over-riding concern is the control and discipline in the classroom. She doesn't want to let go of the control she has in

the learning of her students. To this end she does not allow them to work in open-ended situations and discover knowledge for themselves in case they get out of control. In the interviews Viv often grappled with the issue of letting students discover concepts for themselves versus spoon-feeding through transmissive methods and being in control.

If anything I prefer to throw them in the deep end and let them struggle for a bit and then say hey guys I've got the goods. Over the years if there is one thing I've changed drastically it is from spoon-feeding to not spoon-feeding, I'm conscious of that because I know how bad spoon-feeding is. And so I really try to watch myself that I don't just go in there and blurt it all out. So I've got to keep some back for dessert you know I've got to keep them just waiting there, let them perhaps prompt you just a little bit before you give them that final bit. So as a consequence of that, of throwing them in the deep end a bit, the kids who aren't comfortable with that start feeling insecure which leads to complaining to parents which leads to management and so it can be very difficult to work on what you believe in a system where um well... As long as you can explain yourself you are OK. But if you don't there can be problems at the management end. That's all I'll say on that.

Here Viv outlines two of her most fundamental conflicting beliefs, the issue of letting the students discover for themselves and the issue of control. Management in the form of the school administration are of great concern for Viv and as a consequence she teaches in a way that she prefers not to but feels compelled to. But her response also reveals parts of her belief about the students' learning of mathematics, that is, a belief that the students are empty vessels and the teacher has the knowledge to pour in. "...I really try to watch myself that I don't just go in there and blurt it all out. So I've got to keep some back for dessert you know I've got to keep them just waiting there, ..." Viv believes she has the knowledge and can pass it on to the her students all at once or hold some back for dessert. This is a Platonist view of mathematics with the teacher in possession of all the mathematics knowledge the students need. In many ways throwing them in the deep end is not the way Viv wants to teach, it would give up too much of her control, so it is almost a fantasy goal that she sets for herself.

Testable belief for Viv. A testable belief for Viv is her belief that the students should be more in control of their own learning. A fundamental principle in PEEL is to: "*Foster student's independent learning through training for enhanced metacognition.*" (Baird & Northfield, 1995, p.iii). While Viv has the belief that students need to be metacognitive, this belief is in conflict with her belief in control. Once this conflict in beliefs is identified by Viv could be it be tested by her in the classroom? Is it possible for her to relinquish some of the control in order to share the intellectual control with her students?

Case Study 2: Fran

Fran believes that a successful mathematics class is one where all the students were moving forward in their learning. By this she means learning and perfecting new skills. Fran believes successful classes are ones with high levels of student engagement and interest. To this end she uses a large number and variety of activities. Fran believes in the use of technology in mathematics. It was important because technology was important, as an end in itself, it was also important as another way to add variety to the lessons.

Fran believes the classroom should be organised in such a way that the students could work at their own skill level. To this end she pretests her students to find their level of skill and gives out a checklist of skills and associated problems for students to monitor their own learning. Fran believes mathematics is a set of skills to be learnt with exercises and problems practiced to accommodate that learning. She had quite an Instrumentalist view of mathematics. To her mathematics was predominantly a set of disconnected skills to be

learnt. Her main focus was to teach the students skills and the students were to practice those skills often.

Though she has a strongly Instrumentalist view of mathematics, Fran believes it is important to have lots of different activities for her students. She had a primary teaching background where she used a wide variety of activities for the younger students. She would spend considerable time on her preparation, she wanted well prepared activities, activities that developed or demonstrated student skill level. Fran recognised she didn't have the pedagogical content knowledge she had in her other subject, Music. Fran was a music teacher who had recently retrained as a mathematics teacher. With music she knew what activity to use to introduce a topic or teach a skill and she lacked this experience in mathematics. She believes this will improve with further experience.

Fran believes that poor teaching is when teachers do not monitor where the students are at and then moving forward when the students aren't ready, not listening to student needs, teaching predominantly at the board, using the same type of lessons and offering no variety. She believes it is important for teachers to be seen as being fair in their handling of students and student behaviour. Fairness was also defined to include the teacher's time and ensuring it was evenly shared amongst the students.

Fran believes the most important issues with poor learning relate to the behaviour of the students, that is students not completing enough problems to learn the skills, or not spending enough time on skills practice. Poor learning was attributed to students who were not monitoring their own learning and or when they didn't follow up and learn from their mistakes. Fran had concerns with students not making their mathematics work a high enough priority at school compared with all the other things they were involved in eg sport, musical production, etc. She placed the blame for the students' poor performance on the students themselves.

There was no discussion in the interviews about links between the skills or topics. The curriculum was viewed as the skills needed to solve the problems, broken down into its constituent pieces of chapter, exercise, problem and skill. Learning mathematics is emphasised by the practice of skills without reference to understanding, deep or surface learning. Hence, in Fran's teaching there is a strong emphasis on the textbook for problems. She believes good and poor learning relate also to the way the textbook is used, for example poor learning is indicated when the student turns to the back for the answers before completing the problem.

Fran believes that learning mathematics is about learning new skills. Here is how she described a successful class in Year 8.

So we did a pretest, ... And that was good because they all got to see the sort of material they were going to be going through. It also enabled me to line up who needed what concepts. So then I had small groups of people who were dealing with different concepts and I would then take them in those small groups... And the whole unit of work for six or seven weeks was moving around that, where different groups would come with me and work on a task and then go and do follow up exercises and they had a checklist of things that they had to be able to do. And they all found that that worked very well. And by the end of the unit most of them had for example those who couldn't change an improper fraction to a mixed number could then do it and could find percentage and so they had those specific skills and then they could tick them off whether or not they could do them. So that seemed to work well.

It seemed that the purpose for Fran of the pretest was to identify what skills the students had and subsequently what skills they needed to work on. It was very skills based and identified her as teacher with an Instrumentalist view of mathematics.

And as I was saying before if I had more time I would be researching a lot more wonderful ideas and be able to sit down and think about really interesting ways to present things with a bit more experience again I will probably have a better resource of ideas. I know because I have been a music teacher and I had a really good repertoire of ideas of ways to introduce musical topics so with the more experience I have with maths and the more ideas I try out and use I'll know which ones work and which ones to come back to.

Fran recognised here that she lacked the pedagogical content knowledge in mathematics that she had built up in music. Her change from a music teacher to mathematics teacher had taken her out of her field of expertise and she was grappling with teaching in the ways a novice might. She knew how to teach, but not how to teach mathematics.

Testable belief for Fran. A testable belief for Fran relates to her belief about the nature of mathematics. While she uses a wide variety of teaching strategies in her classroom, the underlying purpose is to teach skills for the checklist. Using the goals of PEEL can Fran change her beliefs about mathematics and adopt a more 'teaching for understanding approach' that she acknowledged she used in her primary teaching?

Conclusion

The interview protocol used in this study allowed for the teachers' beliefs about their practice and their beliefs about mathematics to be identified. This study highlighted some minor deficiencies in the interview protocol and changes have been implemented for the larger study. In particular, the framework adopted of successful classes and lessons uncovered the classroom practices of the teachers and the beliefs that underlie such practices. However, the framework did not easily reveal the teachers' beliefs of mathematics and these had to be interpreted from their responses. A question on the teachers' beliefs about mathematics had been added to the new version of the protocol.

The case study of each teacher demonstrated that the teachers were able to articulate their teaching practices and the beliefs on which the practice was based. The case studies revealed the teachers' beliefs about mathematics, but not much was revealed about their beliefs on learning. The teachers reported here had beliefs that appeared isolated from and at times in strong conflict with each other as stated by Green (1971). As Sosniak et al., (1991) contended in their article about the teachers they investigated, the teachers here didn't appear to have conceptualised a coherent view of mathematics and its teaching. Their beliefs about teaching mathematics were in conflict with their beliefs about what mathematics was. Their immediate concerns were focused on their next class and improving their teaching there.

The effectiveness or otherwise of all PD can be the effect it has on the beliefs of those involved and the effects on their long term practice. If those reforms outlined at the beginning of this paper are to be implemented then the PD that is to be used should be such that the teachers' beliefs are challenged as much as their practice. Otherwise as Munby (1984) has noted, teachers will tend to use their beliefs as a filter to such change and implement reform proposals not as they were intended but within their current practices and beliefs. In the PEEL model teachers have control over their own PD, research their own practice, and in so doing they have the opportunity to articulate their pedagogy. The larger study will investigate in what ways this leads to a change or restructuring of teachers' beliefs about pedagogy, mathematics and mathematics teaching.

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