

One Teacher's Problem Solving Beliefs and Practices: Influences and Coherence

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This study explores the sources of influence on and the level of coherence of one teacher's beliefs and practices in relation to mathematical problem solving. Rose regularly uses problem solving approaches in her Year 2 class as she believes that this makes mathematics learning meaningful. Her beliefs and practices have been strongly influenced by her own experiences as a learner of mathematics as well as by advice received in postgraduate education and in curriculum documentation. Her beliefs are coherent when explored using a variety of data collection methods.

It is widely recognised that many factors influence teachers' beliefs about mathematics and how mathematics should be taught. Teachers' beliefs about the role of problem solving in the learning of mathematics are similarly influenced by a variety of factors. It is possible that teachers' classroom practices may reflect the latest trend or fad in education or they may be based on a coherent set of beliefs. Information on the sources of influence on beliefs and practices and the level of coherence of those beliefs would inform preservice and inservice education. Encouraging teachers to reflect on their experiences as learners of mathematics and to discuss their beliefs and practices may better prepare them to embrace new approaches.

This study attempts to identify factors that influence beliefs and the impact of these on classroom practices. Possible contributing factors of influence might include: early learning experiences in mathematics; experiences as a teacher of mathematics; advice about teaching mathematics from preservice and inservice education; and advice from curriculum documentation. In this paper, the sources of influence and level of coherence of problem solving beliefs and practices are investigated for one teacher, Rose. Data were collected using a questionnaire, interviews and classroom observations.

Overall Research

The research reported in this study is part of a larger investigation that aims to explore a range of beliefs about problem solving that primary school teachers hold as well as to describe their reported practices. In the first stage of the overall research, data were collected from 174 classroom teachers in New South Wales (NSW) using survey research methods. Teachers were identified as holding a wide variety of beliefs ranging from a more traditional perspective to a more contemporary perspective (Anderson, 1996). Teachers' espoused beliefs were ascertained by their level of agreement with particular statements that were presented to them in the questionnaire. These statements were constructed on the basis of reference to other studies on teacher beliefs by Van Zoest, Jones and Thornton (1994), and Perry, Howard and Conroy (1996). The questionnaire also asked teachers to identify the frequency of use of a variety of teaching strategies and problem types (Anderson, 1997).

The second stage of the overall research involved interviews and classroom observations. Nine teachers were chosen from the questionnaire responses so that a variety of beliefs were represented. These teachers were interviewed to gather more in depth information about espoused beliefs and reported practices. In each interview, teachers were presented with their completed questionnaires and discussion focused on their responses. This process also helped to confirm interpretation of items. From the interviews, two teachers were selected to participate in classroom observations. The combination of information collected from the questionnaires, interviews and observations provides a rich picture of the factors that have influenced beliefs and practices of these two

observations provides a rich picture of the factors that have influenced beliefs and practices of these two teachers. The variety of data collection methods also provided an indication of the level of coherence of their beliefs and practices.

Many factors influence teachers' problem solving beliefs and practices. Teachers' espoused beliefs are influenced by their actual beliefs (Thompson, 1992), by their knowledge and interpretation of advice about teaching problem solving (Fennema, Carpenter & Peterson, 1989), by their use and understanding of curriculum documents, and by their own experiences as learners of mathematics as well as by their experiences in classrooms. Reported classroom practices are influenced by espoused beliefs, by actions in classrooms as well as by constraints such as parent' and student' beliefs and school culture. A proposed model of the relationship between these factors is presented in Figure 1. The usefulness of this model to describe the influences on espoused beliefs and reported practices will be examined for one of the teachers in the overall research. Indeed one of the purposes of this investigation is to explore the validity of this model.

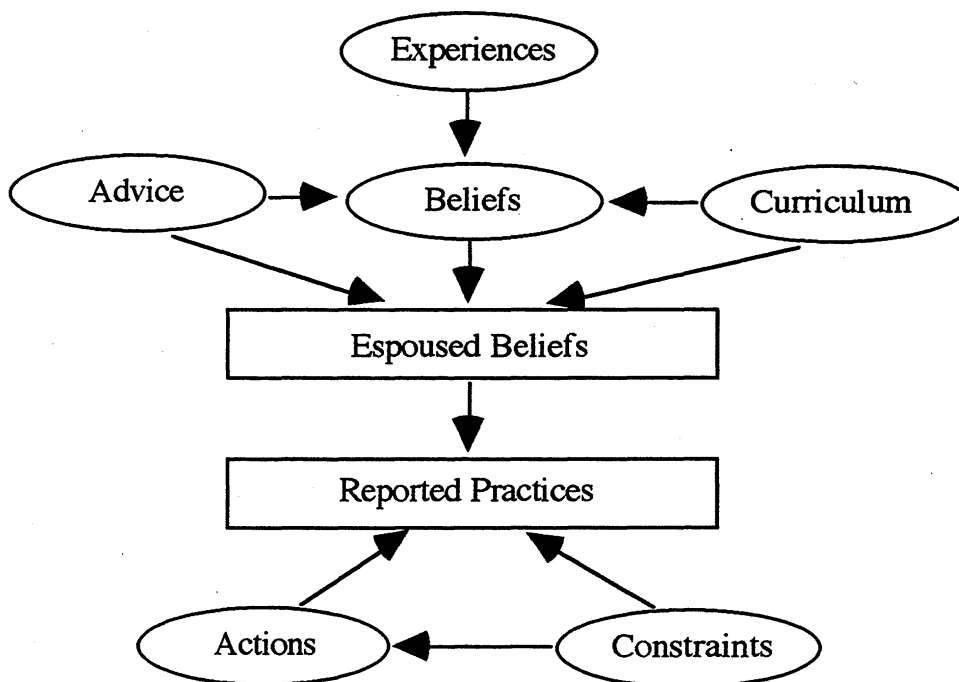


Figure 1. Factors that impact on espoused beliefs and reported practices.

Survey Responses

To facilitate a discussion about problem solving beliefs and practices, an artificial dichotomy about teaching and learning, described here as perspectives about the role of problem solving, is used. One end of this dichotomy is the belief that mathematics is a fixed body of facts to be delivered by teachers and internalised by students. This belief is often associated with classroom practices involving individual student work with rehearsal of routine questions and reliance on textbooks or worksheets. This view may be accompanied by a belief that problem solving is an 'end' (Wright, 1992) and that problems should be presented to students after they have mastered basic facts and skills. This perspective was described by Ernest (1989) and is referred to in this paper as a *traditional* teaching approach.

Another perspective, referred to as a *contemporary* teaching approach, has been described as representing a reformed classroom (Clarke, 1995). Such teachers believe that mathematics is a dynamic subject to be explored and investigated. Classroom practices associated with this perspective usually involve more group work and the use of non-

routine questions that promote mathematical thinking and the development of problem solving skills. This view may be accompanied by a belief that problem solving is a 'means' (Wright, 1992) and that problems can be the focus of learning in mathematics lessons. These two perspectives represent end-points of beliefs about mathematical problem solving with many teachers holding beliefs that are situated somewhere between. These perspectives were used as the basis of the construction of the questionnaire.

Rose's questionnaire responses indicated that she supports a contemporary perspective as she agreed with all of the statements relating to this position. She disagreed with all of the traditional statements except for an item on language difficulty that stated "some students find problem solving difficult because of the language involved in the problems". In the interview, Rose was asked to comment on her responses to the traditional statements. The first statement was "students should learn basic number facts before they do *application* and *unfamiliar problems*". Rose read this and said:

Well I think that's the wrong way around because I think the understanding of basic number facts comes from actually doing things ... That if you do things and if you've actually had a lot of hands on practice then the basic number facts are going to come so that's why I disagree with that.

After reading more of the statements, she commented that the traditional approach did not work when she herself was learning mathematics and so she does not believe that it is the best way to teach.

The teaching strategies Rose reported using "almost always" included group work, whole class discussion at the end of lessons, and concrete materials. The strategies that were "often" used included presenting problems with little indication of how they are to be completed, encouraging individual student recording of methods to problems, modelling problem solving processes, and using problems to show the usefulness of mathematics. Students working alone and full explanations of how problems were to be solved were less frequently used strategies. Rose reported that she only "sometimes" used calculators in her classroom. When asked about this she said that she would "love to have a set in the room but I don't have one". She said she would use them more frequently if they were readily available as calculators are "another learning tool".

Rose indicated on the questionnaire that she uses all four of the question types that were described. This included exercises, application problems, open-ended problems and unfamiliar problems. She believes that the best problems engage students in searching for appropriate strategies and provide hands-on experiences. Rose stated that children should be "exposed to a variety of questions. In this way I hope to appeal to each child's preferred learning method". The only qualifying comment was that when using unfamiliar questions, it is important "to be aware of the kids because you can't have too big a gap between what you're asking of them and what ... they can do".

In response to the request to record a recent problem that she had used in the classroom, Rose wrote:

I gave each child a number between 5 and 19. They had to write as many questions as they could with that answer.

This example was a favourite open-ended task that supported Rose's belief that these questions were good teaching and learning vehicles. She indicated that open-ended tasks allow the more able students to be challenged while less able students can still attempt the question at their own level.

Interview Analysis

Interviews were conducted so that questionnaire responses could be elaborated, interpretation of questionnaire items could be clarified and additional information could be collected about Rose's beliefs and practices. These interviews were conducted before and

after the classroom observations and involved conversations based on the questionnaire responses and classroom observations. Because of limited space, data from the first interview is summarised and will not be fully reported in this paper.

To analyse the transcript of Rose's first interview, points were made under key ideas that arose in the discussion and a diagram was used to represent these ideas (figure 2). Rose's interview indicated that there were several issues that she believes have had a profound influence on her beliefs and practices. These issues can be summarised under three broad categories of Rose as a "learner", a "teacher" and a "change agent". Rose's experiences as a teacher and her own learning of mathematics have influenced her teaching practices and reactions to students. She believes in life-long learning and continues to study. She has strong views about children experiencing success while learning but also that they must be taught how to think. Approaches to teaching mathematics include hands-on, meaningful experiences that can be achieved by using a problem solving focus. She also believes that the children enjoy this approach. As a change agent, Rose believes that she can influence other teachers, parents and the future development of the curriculum.

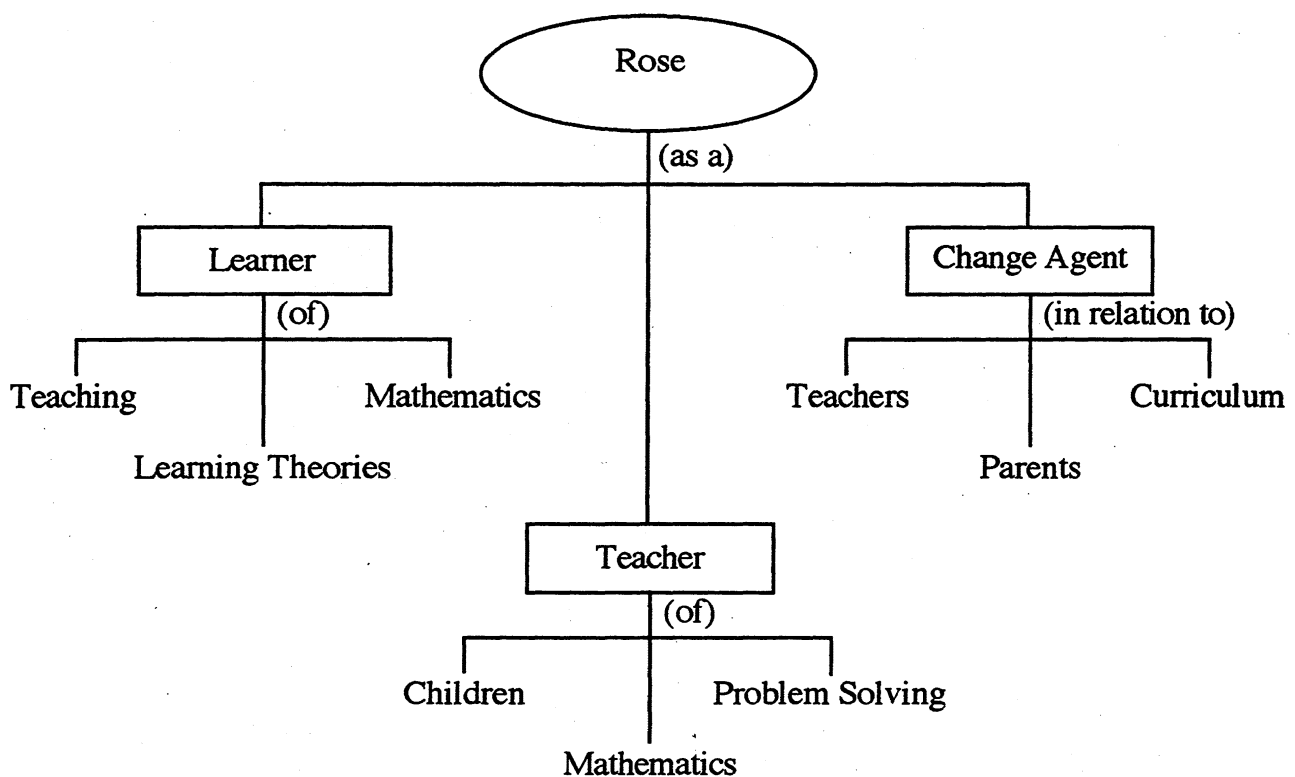


Figure 2. A summary of the key ideas from Rose's interview

Rose as a Learner

Rose's teaching career has spanned thirty years although she has only taught for sixteen of those years. She began teaching in the mid-sixties and taught for seven years before a long break for child rearing. In describing her history as a teacher, she spoke at length about the level of change she experienced when she returned to teaching as well as the amount of change that continues in education. A new *Mathematics Syllabus K-6* (NSW Department of Education, 1989) was about to be introduced when she re-entered the teaching profession. This document included Number from the previous syllabus but introduced Space and Measurement as two additional strands of study; two strands Rose

described as “only ever incidental before”. She also mentioned change in other curriculum areas including the “process writing approach” to teaching English.

Rose reflected on the level of change she had confronted and described herself as feeling like “a beginning teacher”. Not only did she have to cope with new content and new teaching approaches but she also had to cope with teaching in difficult schools. She described this period as “an enormous learning curve” although it was apparent that she is still concerned about her knowledge of teaching. She stated “I always worry about my own knowledge and confidence and understanding”.

Since returning to teaching, Rose has completed two degrees at university. Further study, and in particular, her knowledge of learning theories has offered Rose supporting reasons for her classroom efforts. She mentioned Vygotsky’s notions of scaffolding and the zone of proximal development. In discussing her belief of challenging the children to think about new ideas she suggested that it was important to extend them but cautioned that the challenge must not be beyond their reach.

Rose’s own learning of mathematics has played an important role in her views about teaching mathematics. She described herself as “a person who failed maths” and that because of this she is a different kind of teacher of mathematics than those she had experienced. She stated:

Maths is a bogey in my life and, but I maintain that actually because of that I’m probably a more sensitive teacher in the area because I remember we had a teacher who couldn’t understand why we had problems when I went to school and I hated maths and she used to just dismiss our problems as being stupid therefore you know I had a problem and I do think that maths is taught fairly poorly so, in the school system.

She claimed that she learnt things in mathematics but she did not understand them. She believes that this approach to teaching mathematics is poor as she believes that students up to year ten should have hands-on experiences instead of just sets of rules to learn.

Rose as a Teacher

Rose believes that her own negative experiences as a learner of mathematics has enabled her to develop a more sympathetic approach to teaching mathematics. She is more aware of how the children feel when they cannot do the work. She described her concerns about their individual needs and said “I do try to look at every child as if they are mine and say well now what do you need, what is it that I can give to you to solve this problem for you”. The Year Two class that Rose currently teaches has been described as a challenge because of the diverse needs of the pupils. Her class is a middle set in a streamed year two with 20 boys and five girls. Five are quite bright and about five need much extra support and individual help. She spends considerable time with these students who experience difficulties although she expressed frustration because she feels that other children are being ignored while this is occurring.

Rose is concerned about providing children with meaningful yet challenging experiences and believes that problem solving is a good way to do this. She likes to teach the children how to think. Rose described a recent lesson and felt that it represented a good problem-solving lesson because the children were “buzzing” and helping each other. She said “they got really enthusiastic about it and they loved it”. Not all children found the number patterns involved in the lesson easy to find. She observed that some of the children found the patterns difficult to work out and she suggested that this would help to inform the focus of future lessons. She would provide a “scaffold of some counters and things” in the next lesson for the students she identified as needing this support.

Rose does not like to “tell” the children how to do problems but describes her approach as “the guide on the side” rather than “the sage on the stage”. She described another problem solving lesson she had embarked upon recently. The children were required to consider how they might construct three-dimensional shapes. She gave no instructions but left them to think about the idea. She reported that some children tried to work this out whereas others did not bother. She listened to their suggestions and guided their ideas over the next ten lessons until all of them had constructed reasonable solids. She commented that this was a good lesson because she did not tell them how to do the task. In the survey, Rose indicated that she “hardly ever” explains “in detail what the students have to do to solve problems”.

Rose was concerned about the level of understanding of teachers in relation to problem solving. When asked about her overall views on problem solving and the professional development needs of teachers at her school, Rose wrote in the questionnaire “the teachers - me included - need a lot of PD re problem solving. We are all still locked into old style concepts of maths”. When this was discussed in the interview, she said “I still think as teachers we’re really only at the beginning of this I don’t think we have enough, um understanding of it”.

Rose as a Change Agent

Rose also saw herself as a change agent and wanted to support other teachers in their efforts to confront change. Her view of herself as still being a learner was not viewed as a bad thing. She suggested that “because I feel I’m still learning ... I can show other teachers that learning continues”. She revealed that she has ambitions to be a principal so that she can have a greater influence on teachers and their approach to change. She believes that teachers can be afraid of change and so they often use excuses of being stressed or too busy.

Further evidence of Rose’s beliefs about change was identified in the questionnaire. One of the open-ended questions stated:

The following statement was made recently at a teacher inservice course:

“People who push problem solving in mathematics obviously don’t work in classrooms. It is a waste of time.”

What is your reaction to this statement?

In response to this Rose wrote:

My reaction is that this teacher is afraid of change, afraid that his/her knowledge of mathematics learning will be exposed - and he/she is expressing and reflecting community views about maths. He/she is probably into control in the classroom.

When questioned about this response, Rose indicated that she believes that many teachers in the local area are older and use community views as an excuse not to change. She acknowledged that other teachers are not confident about teaching mathematics as well.

There were many signs displayed around the school in prominent positions. The one facing the teachers’ car park was “change is a conscious choice”. These signs were organised by Rose and she explained that teachers, parents and students had voted on the twenty best signs to display. She said:

And the one right in the back paddock I actually fudged and I had that put up even though it wasn’t in the top 20 signs that went up and that is “change is a conscious choice” and I deliberately put it so that every teacher who walks into this school every morning has to see “change is a conscious choice”.

She indicated that she can understand why teachers find it difficult to change but she would like “to drag teachers kicking and screaming into this next level of understanding”.

Rose was also prepared to take a role in influencing parents' views as well as actively participating in curriculum development. She indicated that she always informs parents about her approach to teaching mathematics and that she has not experienced problems with parents views. She believes that this is partly because of her communication to parents but also because she teaches in the infants department and so hands-on experiences are acceptable. Rose recently reviewed a draft of the new *Outcome Statements* distributed to schools by the Board of Studies in NSW. She was quite concerned about the document because she believes that there is a gap between the syllabus and teachers' knowledge and understanding. She feels quite passionate about it and stated "I found myself really reacting to that".

In summary, from the questionnaire and interviews, detailed information was collected about one teacher's problem solving beliefs and practices. Rose is an experienced, dedicated teacher of a Year 2 class who believes that children need to experience challenge and success in mathematics learning. She believes that the best way to achieve this is to use a problem solving approach in the classroom. This is achieved by using a variety of problem types on a regular basis. Problems provide opportunities for students to think about mathematical ideas, to share their ideas with each other, to explore concepts using concrete materials, and to learn about mathematics in a meaningful way. Rose's espoused beliefs and reported practices were confirmed in classroom observations.

Implications

In addition to collecting information about beliefs and practices, this research explored the sources of influence on those beliefs for one teacher. Rose's beliefs about learning in general and learning mathematics in particular have been influenced by several factors. Her experiences of learning mathematics were fraught with difficulties and poor teaching. Her life-long learning has revealed alternative approaches to teaching and learning and has made her question the way she was taught. Returning to the classroom after a period of extended leave provided her with the experience of feeling like a beginning teacher and further changed her views about teaching and learning as well as the role of professional development. She has responded to advice given in curriculum documents, and in undergraduate and postgraduate courses. Her experiences as a teacher of mathematics have reinforced her belief that this is the best way for children to learn. She employs teaching strategies that support these approaches even though there are constraints operating in her school that support more traditional teaching approaches.

A model was proposed (see Figure 1) that connects espoused beliefs and reported practices with anticipated sources of influence. For the teacher in this study, the main sources of influence on beliefs and practices were her experiences, the advice from postgraduate courses and the impact of a new mathematics curriculum. Classroom observations confirmed Rose's reported practices that were adapted to accommodate constraints operating within the school context. These results clearly support the proposed model for this teacher. Raymond (1997) developed a model of relationships between mathematics beliefs and practices that included the additional factors of students' lives, teacher's life and personality traits. It is possible that extra sources of influence would need to be considered for a larger group of teachers. Even though Raymond included other factors, she reported that the strongest influences were past school experiences, teacher education, and the impact of actions and the immediate classroom situation. Further factors will be explored in the overall research.

Another purpose of this study was to explore the level of coherence of beliefs and practices across a variety of data collection methods. Rose consistently and coherently reported the same beliefs and practices on the questionnaire and during the interviews. Because she has strongly held views about mathematics teaching and learning, she has

been able to resist constraints on using this approach. Rose believes that her position as a member of the school executive as well as her increased knowledge through further study have empowered her to resist the constraints that are operating in her school. This suggests that strategies need to be considered in preservice and inservice courses that empower teachers to similarly resist constraints.

Focusing on teachers' beliefs and practices and encouraging them to reflect and describe what they believe may be the first stage in changing teachers' beliefs and practices. Identifying the sources of influence on beliefs provides a starting point for discussions in preservice and inservice education. As many teachers have not responded to advice to incorporate problem solving into their teaching approaches, it is possible that prevailing beliefs held by many of these teachers mitigate against the implementation of contemporary approaches in classrooms. Confronting these beliefs seems to be a necessary step if change is to be embraced.

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