TEACHING & LEARNING
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Teachers developing as researchers: teachers investigate their use of questions in mathematics

I had the impression research was often done by a researcher to you, however, this has shown that it can be embedded in your practice and the research can be for you.

Natalie, final questionnaire

Until relatively recently, the creation of a knowledge base for teaching has been largely perceived as belonging in the domain of the universities' academic researchers, synthesised from data gathered by observers in classrooms. Existing research reflects a "looking from the outside in" perspective, and few investigations have looked from the "inside out" to represent the teachers' perspective. There have been "prevailing concepts of the teacher as technician, consumer, receiver, transmitter, and implementor of other people's knowledge" (Cochran-Smith & Lytle, 1999, p. 16) that have contributed to the gap between research and practice.

In this research project, a group of teachers investigated their use of questioning to facilitate student learning in mathematics. Teacher-researchers were encouraged to act as reflective practitioners (Schön, 1995) and contribute to formulating their own interpretive frames (Cochran-Smith & Lytle, 1990), using methodologies established in the field of action research (Carr & Kemmis, 1986). Data-gathering methods were chosen to enable teachers to have maximum control over the process, and that were responsive to the direction of the project as it evolved with input from the teacher-researchers over the year, reflecting a grounded theory approach, such as that described by Strauss and Corbin (1998).

Eight primary school teachers worked in partnership with two research team leaders to analyse two of their numeracy lessons in order to investigate aspects of questioning practice. The project was conducted over the 2006 school year in five primary schools in the Wellington area. The teacher-researchers and research team leaders shared responsibility for determining the shape and direction of the research.

Project aim and objectives

The principal aim of this project was for a group of teacher-researchers to collaborate with the research team leaders to investigate their use of questioning in mathematics. The objectives originated from the research team leaders' shared interest in numeracy teaching as observed in their roles as teachers and numeracy advisers, where questions clearly dominated the teacher–student interactions.

The project had two strands that were closely interwoven by the involvement of teachers as partners in the research team. One strand focused on building research capability of teachers, and was designed to:

- create opportunities through which experienced teachers can develop a greater capacity and capability for engaging in and undertaking quality research
- conduct research in the context of schools and classrooms in order to "look from the inside out"
- demonstrate methodological capacities that arise from teachers' existing skills, strategies, and thinking, through which the knowledge base of teaching embedded in teachers' everyday work can be made explicit.

The second strand was focused explicitly on teachers' views of their practice. It was intended that the outcomes would increase potential for improving student achievement.

The objectives were to:

- identify the various kinds of questions teachers use in mathematics
- explicate teachers' thinking about the use of questioning during lessons
- describe patterns of teachers' questioning within mathematics lessons
- identify barriers which inhibit the use of questioning
- examine conditions that support effective use of questioning.

Research design and methodology

Over the course of the project, two sets of data were collected. The teacher-researchers gathered data that was to inform the examination of questioning, while the research team leaders collected data relating to the teacher-researchers' involvement in the research process. Sources of data included: annotated lesson transcripts, transcript analyses, categorised questions, interview summaries and audiotapes, notes from team meetings and interviews, teacher-researcher questionnaires, and a reflection journal.

The structure of the initial research design was key in developing the teacher-researchers' research capabilities as it scaffolded the data-gathering and analysis process. This structure allowed the teacher-researchers maximum control over the selection of the primary level of data to be analysed, and opportunities for in-depth reflection. Important features that contributed to the success of this process were:

- the use of accessible technology which the teacher-researchers controlled
- the lesson transcript being made available to them within a short time frame
- the interaction between the printed transcript and the videotape
- the inductive categorising process used
- having immediate and concentrated time for analysis
- discussing their findings with a research team leader in a reflective interview.

Findings

The research process was seen as providing significant relevance and immediate effect on the teacher-researchers' own classroom practice, as indicated by the quotations below:

> *[The research process has] made me reflect more deeply on my daily practice and the types of questions I ask. It has made me consider more carefully the purpose of questions.* Ursula, final questionnaire

> *Having the opportunity to micro-analyse within a subject area has heightened my awareness of the strengths and weaknesses of my own classroom practice. This in turn has challenged me to either strengthen those practices that are valuable and to adjust/improve those practices that are weak.* Erin, final questionnaire

As the teacher-researchers examined their questioning practice, they developed their research skills. Initially, they were faced with deciding what counted as a question, then with exploring and finding language to articulate their purposes and motivations during mathematics lessons. The process of categorisation caused them to question the nature and purpose of categories in organising their thinking, and challenged assumptions about types of questions, the balance of categorised questions within lessons, how interventions in the learning process are prioritised, and expectations held about students. Synthesising the variety of individually identified themes to form a cohesive and shared interpretive framework enabled the teacher-researchers to further test and describe emerging ideas about their questioning practices. The ability to reflect on and articulate their practice was also developed:

> *Classroom research helps you to reflect on what you do and can only benefit student and teacher learning.* Ingrid, final questionnaire

The developing capability of the teachers as researchers was reflected in their changing views about the nature of research. At the end of the project, the teacher-researchers described research as a vehicle for sharing, challenging, or confirming existing ideas and introducing new ones. One aspect noted by the teacher-researchers was the complexity and scale of the research process:

> *Research is fascinating when you are involved in it!! It is really difficult to do. [There are] heaps of factors to consider. It doesn't always give us answers.*
> Ursula, final questionnaire

> *[Research] involves many facets and ideas ... the sharing of thoughts with other researchers…*
> Quentin, final questionnaire

Many diverse factors that influenced the formulation, selection, and delivery of their questions within a mathematics classroom were identified by the teacher-researchers. These included such considerations as: the purpose of a question, the perceived needs of students, the type of scaffolding required, the need to target particular students for a variety of purposes, timing within a lesson, and predicted student responses.

Participants discovered the most useful way to categorise their questions was to reflect on the purpose for which they were asked. As the study progressed, it became obvious to all the participants that such a process was a personal activity driven by knowledge of the students, personal experience, and context. How a question looks is not always indicative of its underlying purpose. The observation and classification of questions by an outside observer seems to be an unreliable method to uncover the purpose of a teacher's questions.

During the project, the teacher-researchers condensed their question categories from an initial 17 to five general categories that encompassed all the questions asked within their mathematics lessons. Categorising a question as open or closed did not prove helpful, as these categories were too broad and did not relate to the purposes of asking questions. Neither did other pre-existing matrices of question types match what the teacher-researchers developed as a meaningful set of categories. The refined set of categories gave the teacher-researchers a common language for discussing the role of questioning in their practice and, for some, helped to sharpen the focus on their purposes for questioning.

Much of the research that examines questioning in classrooms highlights the high quantity within a lesson as an issue. The teacher-researchers in this study identified at least 158 questions in their hour-long mathematics session, and seemed to equate the high rate of questioning with effective practice. This perception was still evident at the conclusion of the project, although some teacher-researchers queried this. Also of interest was that the teacher-researchers asked close to 50 percent more questions of students who were operating at more advanced strategy stages.[1]

While the possible effect of particular combinations of question types was identified, the teacher-researchers did not identify any strong patterns of questioning within their lessons. More time may have been needed for the teacher-researchers to work with the final question categories in order to confidently classify their questions and to recognise significant patterns, if indeed any exist. Due to the complexity of questioning that became apparent during the project, and the fact that the teachers' decisions are so context bound, it appears there are no formulae for effective questioning in mathematics.

The teacher-researchers found it difficult to be specific about exactly how the research findings relating to questioning might be useful to teachers in general. The categories were seen as useful to the teachers involved in the project, as they had created them and "owned" them.

Conclusions

> *Research doesn't always provide you with answers. It often provides more questions. There isn't always a neat, tidy conclusion that can be drawn.*
> Natalie, final questionnaire

Participation in this project had an effect on the teacher-researchers' views of the relationship between research and practice, and provided opportunities to reduce the gap between them. Throughout the project, the teacher-researchers encountered authentic research problems regarding methodology, analysis, and interpretation of data as they sought to make meaning from data gathered. The process of researching their own teaching practices served to transform the apparent simplicity of the task of identifying and categorisation of questions, to a complex undertaking which confronted the teacher-researchers with some of the essential elements implicit in their everyday teaching.

The unique perspectives of these teacher-researchers about questioning provide a valuable contribution to the knowledge base about teaching in this area. Their detailed examination of the thinking that underlies the formulation of questions enabled the teacher-researchers to examine their metacognitive processes, highlighting the complexities of questioning as a synergy of interrelated factors that interact to determine the direction of teaching and learning within a lesson. Explaining their thinking to others compelled the teacher-researchers to articulate their practice more precisely, and to discuss and debate related issues.

The process of close analysis and discussion of their teaching practice was an outcome valued by the teacher-researchers, which they saw as useful for other teachers. However, it was difficult for them to assess the value of

their observations about the questions they asked and the categorisations they devised; they seemed unsure of the validity of their findings, perhaps because of a lack of sufficient time to fully explore patterns and commonalities which may have been present in their questioning practices.

Further research is needed to establish the interrelationships between the types of questions used, the patterns of questions within a lesson, the number of questions asked, and their relationships to learning.

Implications

Support for further research that includes the teacher's perspective in the analysis of teaching practice is vital. To allow teachers to develop the research skills necessary to contribute their perspective in a meaningful and rigorous manner, teacher-researchers must be provided with:

- sufficient release time to examine their practice in depth, and to attend research meetings
- access to experienced researchers to give guidance, direction, and encouragement
- research forums for discussing ideas with other teacher-researchers
- interest and encouragement from management and colleagues within their schools.

For research to be more closely aligned with practice, research questions need to originate from teachers themselves. To enable them to be involved from the earliest stages of a research project such as this one, and to have authentic ownership, they need to be involved in the development stage of an expression of interest, and then the full proposal. Teacher initiation of such proposals could be encouraged by the inclusion of a research component into teachers' job descriptions.

> *I think research is essential. Teachers are frequently overloaded with professional development, changing curriculum, and general workload and just don't have the time to look at things in as much depth as we did on this research project. Research within the real context of the classroom has a higher degree of validity and acceptability to other teachers.*
>
> Erin, final questionnaire

Note

1. The overview of strategy stages, detailed in *The Number Framework* (Ministry of Education, 2006), describes a progression of strategies that students use to solve number problems as their thinking becomes more advanced.

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The full reports of all TLRI projects are published on the TLRI website (www.tlri.org.nz).

Researchers

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