Chapter 1.2.1
Studying Student Teachers' Voices and Their Beliefs and Attitudes

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1. Introduction

Learning to teach mathematics is a complex undertaking, and in the last twenty years there has been a great deal of research looking at aspects of the process. There are many ways one might structure an analysis of research on learning to teach mathematics. It is clear, though, from all the research on learners in all kinds of situations that what student teachers bring to their teacher education courses in terms of prior knowledge, experience, attitudes, beliefs, goals, fears, hopes, and expectations has to be a key factor in preparing for and teaching those courses and hence for research. This particular focus for research in our field is not new; my own doctoral studies, completed in 1986, looks at connections between student teachers' beliefs about the nature of mathematics and their perceptions of teaching mathematics (Lerman, 1990).[1] It remains, however, of great importance, and there are new insights drawing on a range of theoretical frameworks emerging in the field.

Central to research in the study of student teachers' attitudes and beliefs and any changes in those beliefs during pre-service teacher education courses are issues of methodology. Access to student teachers' beliefs and experiences is inevitably through their voices, expressed in interviews, conversations, and their writing, but the interaction of beliefs and practice is a necessary consideration too. First, regarding students' voices, what must concern us is how to read across a number of stories in order to be able to say something about how these voices are produced (Arnot & Reay, 2004). Without that focus we produce a spiral of more and more detailed stories with no possibility of making sense of the data (see Brown & McNamara, 2005, for an excellent example of the struggle for an appropriate theoretical framework for analysing student teachers' voices). Second, there is always a gap between what people say about what they do and what they actually do in their practice (Lerman, 2002). Research needs, therefore, to be aware of that gap

[1] All references are to papers presented at the ICMI 15 study conference unless otherwise indicated by date. A list of papers appears in the reference section of the chapter.

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and find ways to bring descriptions of practice as close to that practice as possible. Video-recording lessons and interviewing the (student) teacher using those videos for stimulated recall immediately after is one way that has been used (Clarke, 2001). Third, choosing to observe teachers' practice as a way of bringing together these two domains draws the researcher into interpretation of the observations, calling for some form of systematic procedure with explicit rules for recognition and realisation (Brown & Dowling, 1998). These are not insurmountable difficulties of course, as can be seen in the research presented at the 15th ICMI Study being reported upon in this chapter, for example. These methodological issues remain, however, as considerations when planning, carrying out, and reviewing research on student teachers' attitudes, beliefs, and practice.

As a final comment in this introduction, I want to note the challenge for teacher educators regarding the theme of this chapter. Clearly, one's task is to help the student teachers become the best mathematics teachers they can be, however one might define that—opening up a space for the play of ideology of course. Whatever position one takes, however, attitudes, beliefs, and dispositions, affected or determined by prior experiences, are likely to be obstacles or affordances to a student's achievement of that goal. This gives rise to talk of "changing student teachers' beliefs" and other, potentially coercive, objectives. At the same time, the teacher educator has a wealth of experience, informed by research, and should not shy away from drawing on that experience. Furthermore, there are likely to be regulatory constraints on what is perceived by government to be good mathematics teaching, and there may also be a wealth of cultural knowledge and practice to be acquired by students. One might best see these contradictory elements as a tension which needs to be constantly engaged, and researched, in the practice of mathematics teacher education.

In what follows, I will examine each of these methodological issues in turn, drawing on the papers presented at the 15th ICMI Study, namely, interpreting students' voices, relations between attitudes and beliefs "in theory" and practice, systematic observations of classrooms, and challenges for teacher education.

2. Interpreting Students' Voices

As suggested previously, eliciting students' voices in a manner that informs research and teacher education requires an approach that draws across cases to reveal how the positions student teachers narrate are produced and gives indications of which actions might be relevant for the teacher educator. Questionnaires and interviews are the common source of students' voices, but there are other approaches. For example, "two of the assignments (one at the beginning and one at the end of the course) asked students to describe their view of mathematics and to discuss an appropriate metaphor for their personal experience with mathematics" (Gadanis & Namukasa, 2005). Another approach is found in engaging students in solving mathematics problems. The researchers might then observe students at work, since "the analysis of answers (to a questionnaire or an interview) can give information on

teachers' explicit conception of mathematics, while the observation of their practice can give an insight into their implicit. . .conceptions" (Morselli, 2005). Alternatively, students can engage in mathematical activities, reflecting subsequently on implications of their experiences for school mathematics.

In a comparison between French and Danish teacher education students Winsløw and Durand-Guerrier (2005) comment:

> It's quite surprising that all five French pairs insist on the importance of finding a "real-life" situation to explain the sign rule (for (–2).(–3) = 6); given their mathematical formation, one could expect them to . . . search more for a mathematical explanation of the non-arbitrary character of this convention.
>
> The Danish pairs have encountered this problem in their own formation, and the two pairs who explicitly realise that their "explanations" are false or just mnemonic rules, seem to conclude that the problem is somehow too difficult for them and hence for their pupils. As one of these four students says, ". . . I haven't yet read or heard any [explanations why minus times minus is plus] . . . not any I could totally accept, there was always some trick 'then we do like that' . . . to be totally realistic, I would get around it . . . I would simply say: that you must swallow."

The mathematics content of mathematics teacher education courses is the site of battles in many countries and, in a different domain, evidence of the beliefs about mathematics and about the teaching of mathematics.

> In most frameworks used to analyze teachers' professional knowledge—which implicitly serve as a basis for the structural organization of pre-service teacher education programs in Brazil—this knowledge is partitioned in such a way that content knowledge, usually identified with academic mathematics, assumes the status of fundamental component. Other components (didactical, pedagogical, curricular, pedagogical content knowledge, etc.), though important, are viewed essentially in relation to activities aiming for the "transmission" of the fundamental knowledge. It follows that subject-matter preparation for the mathematics schoolteacher has been conceived as an autonomous process, aiming basically to promote an internalization of the values, techniques, methods, conceptions and ways of thinking proper to academic mathematics. Thus, academic mathematics tends to occupy the center of gravity of the teacher education process, subtly pushing the discussion of issues related to teaching practice to the margins of the content courses (Moreira & David, 2005).

In terms of analysis of the responses of students to these various forms of data collection, Gadanis & Namukasa (2005) offer the following:

The analysis of the data from the 2004 elective Mathematics Course revealed a number of themes. These themes are briefly discussed below.

Frustration: "I'm still frustrated by my inability to see the conclusion or the point. I can't seem to push my thinking beyond the exercise to the solution, on my own."

Attention and insight: "I had a lot of moments where things just popped!"

Collaboration: "I felt really comfortable working in my group. It is easy to experiment with different things, and more ideas seem to come out."

Time: "I liked that we were asked what other methods can we come up with to test right-handedness/left etc. Then we were given time in class to go through and actually try ideas—it's been so long since I've had an experience like that in school. It was relaxing."

The complexity of mathematics: Most elementary mathematics teachers view mathematics as a subject of procedures for getting correct answers. As the Math Therapy course progressed, many pre-service teachers started expressing more elaborate views of mathematics.

Mathematics as a human activity: "Math has started to consume my thoughts."

Teaching mathematics: "I faced my 'math demons' and actually grew to enjoy a subject I thought would be my nemesis forever."

Beliefs and practice: "This class has completely shattered my understanding of math and how to teach math. It makes me feel that teaching math is going to be difficult—or at least more challenging than I previously thought. There are so many ideas—I feel overwhelmed" (Gadanis & Namukasa, 2005).

These categories, amongst others that researchers have produced, can provide a framework for research and development of teacher education programmes. Clearly the beliefs and experiences of student teachers who will be teachers of young children are quite different, in general, from those who will be secondary/high school teachers. The former are more likely to express the kinds of views captured in the Gadanis & Namukasa (2005) research quoted previously; other analyses of student teachers with a more secure knowledge of mathematics are provided by researchers. For example, on the basis of interviews, Proulx (2005) characterises five teachers as follows:

Future teacher's name	Perception and usage of the program
Albert, "The technician"	The program is seen as a source of potential teaching resources. It offered him, in his terms, some interesting and possible "tools" (activities, problems, good questions to ask) to use in his teaching.
Bertrand, "The mimic"	The principles/content brought forth in the program are considered optimal and ultimate: he does not question them and takes them for granted. The educators have an authoritative status for him and he "blindly" follows what was suggested.

Carl, "The self-assured teacher"	He recognized himself, as a teacher, in the principles brought forth in the program—involved implicitly in his practice. This program confirmed his practice and helped him to explicate (give a name to) the very practices he was enacting.
Donna, "The reflective practitioner"	The enunciated principles were seen as a philosophy of teaching, in which general ideas on education and mathematics teaching were the center. She did not focus on specifics for particular subjects, she aimed at themes like encouraging students to argue, working on diverse solutions, contextualizing mathematics, and so on.
Enrico, "The teacher in-action"	The program gave him a model in-action of teaching—not by the concepts brought forth in the program but from the way the educator was teaching. The educators were seen as teaching-in-action models.

3. Relations Between Attitudes and Beliefs "In Theory" and Practice

Much research has treated beliefs revealed in interviews and questionnaires, called "espoused beliefs", and beliefs as interpreted by observing teachers' actions, called "enacted beliefs", with the expectation that when teachers are consistent these will match. Researchers then try and explain why they are frequently very different. This approach is demonstrated by the assumption that using interviews and questionnaires reveals the presence of an identifiable object called a belief, or a system of beliefs, that is, the main determinant of a teacher's actions in the classroom. There are both theoretical and methodological problems here. Different contexts elicit different actions. Responses to interviews on the one hand and decisions one takes in a classroom on the other will certainly have significant overlaps, but they will not be the same, and to interpret the difference as a gap is to underestimate the nature of context in human activity and to perpetuate the mind—body distinction, that theories in the mind drive what one does in practice. On the contrary one could argue that those research techniques are productive of the findings. Further, there is circularity about the assumption of beliefs driving actions. Since beliefs are private and therefore hidden from the gaze of the researcher one can only infer a teacher's beliefs from her or his actions, including answering questionnaires or responding in interviews. One then claims that the actions are determined by the beliefs. Methodologically, then, one learns the most from research that succeeds in drawing together the teachers' practice and the teachers' views about that practice as close as possible, whether about mathematics itself or about mathematics education, if one can usefully make that distinction.

Based on three lessons for each of the five future teachers, I construed individual semi-structured interviews to delve into the intentions and background influences that framed these future teachers' classroom practices. The purpose of construing the interview on the basis of the future teachers' lessons was to ground and situate interview questions in the practices of the teacher.

Such an effort was useful to better understand the future teachers' practices and rationales and to create interview questions that were contextualized and linked to those same practices—and not external to them (Proulx, 2005).

4. Systematic Observations of Classrooms

Theoretical frameworks to describe and categorise mathematics teaching are frequently developed from classroom observations, and there is clearly a need for the explication of the procedures used for developing those frameworks. That procedure may be developed from appropriate theories (e.g., Adler & Davis, 2006) or from a grounded approach.

The purpose of the research reported in this paper was to develop an empirically-based conceptual framework for the discussion of the role of trainees' mathematics SMK [subject-matter knowledge] and PCK [pedagogical-content knowledge], in the context of lessons taught on the school-based placements. Such a framework would need to capture a number of important ideas and factors about content knowledge within a small number of conceptual categories, with a set of easily-remembered labels for those categories.

This inductive process generated a set of 18 codes.

We anticipate, however, that 18 codes is too many to be useful for a one-off observation. Our resolution of this dilemma was to group them into four broad, super-ordinate categories, or "units", which we term "the knowledge quartet".

The first, foundation, consists of teachers' knowledge, beliefs and understanding acquired "in the academy", in preparation (intentionally or otherwise) for their role in the classroom. The key components of this theoretical background are: knowledge and understanding of mathematics per se and knowledge of significant tracts of the literature on the teaching and learning of mathematics, together with beliefs concerning the nature of mathematical knowledge, the purposes of mathematics education, and the conditions under which pupils will best learn mathematics (Rowland, Huckstep, & Thwaites, 2005).

The researchers exemplify the use of their tool for analysing teaching by examining one lesson of one teacher from their extensive data.

Laura's professional knowledge underpins her recognition that there is more than one possible written algorithm for whole number multiplication. We

conceptualise this within the domain of fundamental knowledge, being the foundation that supports and significantly determines her intentions or actions.

It is perhaps not surprising that she does not question the necessity to teach the standard column format to pupils who already have an effective, meaningful algorithm at their disposal.

At this stage of her career in teaching, Laura gives the impression that she is passing on her own practices and her own forms of knowledge. Her main resource seems to be her own experience (of using this algorithm), and it seems that she does not yet have a view of mathematics didactics as a scientific enterprise. (Rowland, Huckstep, & Thwaites, 2005)

5. Tensions and Challenges for Teacher Education

The goals of mathematics teacher education courses must be to develop the teaching potential of student teachers and improve the learning of mathematics in schools. Whether this is seen in terms of changing teachers' beliefs and/or their practices, inculcating a culturally valued set of teaching practices, or enabling student teachers to meet the demands of the regulatory system depends on the particular circumstances, ideals, and philosophies in different countries and in different institutions. The tension between recognising and supporting the developing teacher's autonomy and the teacher educator conveying her or his experience is at the heart of teacher education. "We are facing future teachers who have different visions and backgrounds and are interpreting things in different ways" (Bednarz & Proulx, 2005).

Indeed the research discussed previously, in eliciting students' beliefs and attitudes and analysing teaching practices, is aimed at identifying what might best be done in teacher education programmes.

An initial knowledge base which I think it is a combination of a strong conceptual understanding of mathematics (SMK) and knowledge of a repertoire of representations (PCK) must be available to student teachers in pre-service teacher education. Otherwise their first students may well be led to think that mathematics is a complicated and unreachable form of knowledge because their teachers have not yet learned ways of communicating the subject (Amato, 2005).

Thus the direction of research on the changes student teachers experience through their pre-service teacher education courses are on their mathematics, their pedagogical practices, or both.

Improving student teachers' perception of mathematics as a subject matter involving exploration, pattern recognition, functions, problem solving, reasoning, modeling and applications, far beyond the "theorem-proof" activity typical of academic math courses.

Moreover, providing for a context in which future teachers can grasp the nature of mathematics culture, its beauty and its intellectual fulfillment so that they develop an enthusiastic attitude towards communicating these values to school children, has been a true challenge.

To meet these challenges, and similar ones in other areas of specialization, the Department of Education made it its departmental policy to include in the preparation program for high school teachers courses specially designed to bridge between the pure and applied subject-matter courses, and the psychology and methods courses taken towards a teaching certificate in any particular area.

The discussion will focus on values such as mathematical usefulness vs. mathematics as a human endeavor; motives for the development of mathematics; failure and success in mathematics; mathematics for the majority vs. mathematics for the elite—and more (Movshovitz-Hadar, 2005).

6. Concluding Remarks

These studies indicate that the research community has moved on substantially from the questionnaire as the lone tool for eliciting teachers' or student teachers' beliefs about mathematics and mathematics teaching and learning, observing in the classroom, and identifying a gap between espoused and enacted beliefs. The literature on activity theory and on social practices provides richer perspectives of identity formation and on the study of trajectories as people move into practices. Those trajectories differ from others because of prior experiences, goals, needs, and the tensions and conflicts that arise. This calls for researchers drawing on more sophisticated research tools such as those reported here. The study by Brown and McNamara (2005) has been mentioned; Ensor's (2001) analysis of mathematics student teachers' formation is another that draws on theory, in this case Bernstein's sociology, to provide principled accounts of students' voices and their identities. Looking to developing directions in the research community, one might expect, and indeed can already encounter, studies that analyse student teachers' experiences through their courses in terms of communities of practice (Kanes & Lerman, 2007) and of activity theory. The complexity is captured in the following: "In the novice teacher we see the very beginnings of a process of reconciliation of pre-existing beliefs, new 'theoretical' knowledge, 'practical' advice received from various quarters, in the context of highly-pressured, high-stakes school-based placements" (Rowland, Huckstep, & Thwaites, 2005).

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