Chapter 1.1.4
Learning to Teach Mathematics: Expanding the Role of Practicum as an Integrated Part of a Teacher Education Programme

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1. Introduction

Teacher education programmes at tertiary educational institutions traditionally comprise three key strands—disciplinary studies, educational studies, and teaching practice (Comiti & Ball, 1996). The aim of these strands is to develop an integrated competence in student teachers and is often referred to as teacher knowledge. Winsløw and Durrand-Guerrier (2007) name the respective target knowledge components as content knowledge, pedagogical knowledge, and didactical knowledge, noting that each component "may occur with different emphases on theory and practice" (p. 7) and are viewed, in terms of weight and organisation, differently within different cultural traditions. In teaching practice, as an activity within a teacher education programme, all these components come into play in the very contextual setting where they are supposed to be functional. This is where student teachers can experience a test of the viability of the level of their own teacher knowledge. It is often witnessed by student teachers that during teaching practice, working along with an experienced practising teacher, is when you really learn something about teaching (Bergsten & Grevholm, 2004; see also Johnsen Høines & Lode, 2007); another quality is added compared to the theoretical courses on theories of education or teaching methods. The relevance of teaching practice, especially when student teachers are given the opportunity to pilot new didactic proposals they have contributed to develop, has been shown to be very high in different national teacher education contexts, even when the differences are significant in terms of structure, organization, and curriculum (Favilli, 2006).

The term "teacher training" reflects an apprenticeship paradigm for the development of teacher knowledge. Historically, for primary education the main part of

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the preparation of teachers has also consisted of teaching practice. The apprenticeship model has been criticized for supporting a continuation of existing practices (Lanier & Little, 1986; see also Mewborn & Johnson, 2005). With a modern view of a scientifically based higher education a wider spectrum of academic courses makes up, along with teaching practice, what is now normally called teacher education rather than teacher training (this shift in terminology is also discussed in Bednarz & Proulx, 2005). The change of discourse is also reflected in a change in the view of the role of teaching practice and, as a consequence, its organisation within teacher education programmes.

When talking about teaching practice within an institutionalised teacher education programme, we will use the term "practicum", defined by Wikipedia as "a college course, often in a specialized field of study, that is designed to give students supervised practical application of a previously studied theory". This definition emphasizes the connection of practice to theory, excluding a "blind" practice for its own sake, but does not give full credit to the "silent" knowledge of the community of practicing teachers earned by experience of teaching, and reflections on this experience, from which the student teacher can profit. The definition does not exclude the use of practicum as an empirical field of study for the student teacher, making it possible to make observations and data collection in relation to tasks provided in theoretical academic courses, thus also providing feedback from practice to theory. Thus, in addition to the general definition given previously, by practicum we mean the work of a student, enrolled in a teacher education programme, as a practising teacher. This work takes place in a school under the supervision of an experienced mathematics teacher, the mentor. The work is organised as a result of cooperation between an institution that offers teacher education and a school. The mentor who supports the student has been given this task as a formal part of her or his work in the school. There is an explicit agreed aim with the practicum, which may also include assigned tasks of an investigative character.

As mentioned previously, teacher education normally has as one part of the programme a practicum. Historically the education of teachers has been organised in many different ways depending on the intended school level and educational traditions as well as societal and cultural constraints (see, for example, Bergsten & Grevholm, 2004; Winsløw & Durrand-Guerrier, 2007). In the papers presented at the 15th ICMI Study we did not find much about how to organise the practicum, although we are aware of the fact that the collaboration between schools and teachers on one side and the teacher education institution on the other is not at all unproblematic but demands careful work if it is going to function well for the students. Teachers in schools are in a situation requiring hard work and are often not so eager to take on another burden, such as being a mentor for a student teacher. In addition, the extra work is often not paid by the school, although the institution has to pay the school for the collaboration. Normally this part of teacher education is the most expensive part, as it is a resource for the individual and not a whole group. This financial commitment points to the fact that a practicum is considered necessary in teacher education. What aspects, then, of the teacher profession can one not be expected to learn only through theoretical studies?

As pre-service teachers often revert to "teaching styles similar to those their own teachers used" (Brown, Cooney, & Jones, 1990, p. 649), Lerman (2001, p. 48) notes that "courses do not provoke students to confront their naive notions of teaching mathematics" and sets out the student teacher's development of an identity as a mathematics teacher as the critical issue. Such development may be supported by critical reflections on experiences from practicum of existing practices in schools and from promoted practices displayed at the teacher education institution. However, the student teacher must then co-exist within different discourses that are sometimes conflicting and value laden as well as subject to social power issues, which also influence "modes of operating, knowledge, and positionings" in the school practice context (Walshaw, 2004, p. 68).

At a very concrete level, what student teachers sometimes worry about in the beginning of their studies is how they will be able to work with pupils. They cannot easily imagine what to expect from pupils concerning earlier knowledge in mathematics, their thinking and reasoning, and their behaviour in a mathematics class. It is therefore often a relief for them when they find out, during the first practicum, that they are able to communicate with pupils and explain to them in ways that are well received (Bergsten & Grevholm, 2004).

One key aspect of a teacher's work is the practice of classroom management. In this we include the student teacher's ability to establish communication with the pupils individually and as a group, to talk to pupils about the mathematics content, to listen to pupils' ideas and reasoning and try to understand it on the spot, to be able to respond in a way that the pupils find helpful and meaningful, and to use a professional language that is functional in the communication with pupils (Grevholm & Bergsten, 2005). The ability to listen, to hear pupils, is rarely dealt with explicitly in teacher education, although it is highly important and often critical as informal assessment of pupils' knowledge during normal class work (Wallach & Even, 2005). The student teachers' beliefs about mathematical knowledge and teaching, as well as attitudes towards the pupils, come into play here, thus providing a basis for further reflection and elaboration in courses linked to the practicum. All these aspects of classroom management are difficult to learn how to handle by theoretical studies only and thus constitute some of the obvious aims for the practicum.

Another aspect that teacher educators would investigate when visiting a student teacher during practicum in school would be if the lesson resulted in learning. It is possible to organise a class that seems to be running well and smoothly and where pupils seem to be pleased but where little learning actually takes place (Goodchild, 2007). The question is if the student teacher is able to care for the important, relevant issues in class and not only for superficial aspects that do not really matter when it comes to pupils' mathematical learning.

One critical issue is the weight given to the practicum in teacher education programmes in terms of volume as well as how it is being evaluated or assessed. As an example, what kinds of criteria are used to evaluate the student teacher's work during practicum, and who is doing this evaluation? What is lacking in a student's abilities and competencies when not given a pass in the practicum, and how does this relate to when during the education the practicum takes place? As these issues

highlight what aspects of teacher knowledge are valued by the different programmes, they deserve serious attention in discussions about mathematics teacher education.

In the following sections some interesting examples presented at the study conference of ways of working with and through practicum will be discussed. Some of these concern how the educational and motivational payoff of practicum can be increased by the choice of structure of the programme. In addition, theoretical tools related to practicum activities have been developed and integrated in the education. Examples of more specific practices are also presented, and some questions are raised concerning issues of cultural differences in relation to practicum. Finally, some conclusions are drawn pointing to the expanding role of practicum as an integrated part of a mathematics teacher education programme.

2. Structural Ways of Using Practicum

The term "structure" in connection to a teacher education programme can apply to several dimensions, such as the balance of different components of the programme and their order and integration in terms of courses and practicum, combinations of teaching subjects, and target age levels of students to teach, as well as more fine-grained structural elements of formats of tutoring in lectures, classes, or small activity groups. Another dimension refers to who is teaching pre-service student teachers—what is the role of mathematicians, general educators, mathematics educators (didacticians), experienced teachers (mentors), or others? Yet another dimension is the issue of research—what is the balance of research-based and experience-based aspects of the education, including the role and character of the diploma thesis and teaching practice (practicum)?

Due to organisational and institutional factors, including traditions and values, a complex professional education such as that of future teachers is likely to result in compartmentalised knowledge, where for example mathematical content knowledge, didactical knowledge, and experiences that form practicum have no or only weak connections. Such a compartmentalisation of teacher knowledge, which may exist both on the organisational level and as personal knowledge within the student, has been termed a didactic divide (Bergsten & Grevholm, 2004). A programme to develop a unified organisation of an educational knowledge in mathematics needs to merge the divide between content and didactical knowledge, as defined previously (Bergsten & Grevholm, 2005). One component of a teacher education programme with a potential to bridge this didactic divide is practicum, including not only its professional content, but also its structural organisation. One key issue is then the integration of practicum with other course components; another is the kind and level of responsibility given to the student teachers.

The notion of practice is in the centre of the teacher education programme described and discussed by Bednarz and Proulx (2005), based on a principle of "learning-in-action rather than learning-about-action" (2005, p. 2). By a planned integration of practicum with other course components, a pool of observations and

experiences of teachers' and student teachers' enacted knowledge in classroom settings make possible an emphasis on actual educational situations. Such integration is further supported by a practice in which mathematics educators teach both the mathematics-content courses and the didactics courses and take part in the supervision of the student teachers during practicum. Using a principle of contextualized knowledge construing, teaching situations are placed in a cycle of "planning based on a conceptual analysis of a mathematical notion, a priori analysis of curricula and usual teaching approaches, the construction of a repertoire of chosen problems, and a classroom experimentation" (2005, p. 2). By adding tasks of reflective analyses and collective discussions, with such sequences recurring during the whole programme, the student teachers are supported to develop a personal conceptual reference framework. The functioning of this programme has been investigated in a case study by Proulx (2003), where it was observed how the five participating student teachers interpreted the programme very differently although in a coherent way. It was viewed as a source of potential teaching resources, an authoritative acceptance of principles and content, recognizing and supporting one's own implicitly used principles, as a philosophy of teaching using general principles rather than specifics, or as a model-in-action. These differences may be due to the student teachers' different backgrounds and visions, and make it necessary to "move away from an intention of control" on what kind of "good practices" to promote in a mathematics teacher education.

An important issue for student teachers is their experience, already during practicum, of contributing to the growth of their pupils' mathematical knowledge and self-esteem. To account for this, Tirosh and Tsamir (2005) describe how the evolution of their teacher education programme designed a third-year practicum at a school with a low socioeconomic population, where the programme took full responsibility for the geometry teaching in grade nine. The student teachers working in pairs in small-sized classes, supported by an experienced mentor, were highly motivated by this arrangement and put forth strong efforts in their teaching.

To support the development of the student teacher's identity as a mathematics teacher, an elaborated integration of practicum with the other parts of the programme may be efficient but not sufficient if there is not also a personal commitment and an experience of having reached out to the pupils and seeing a result of this commitment. The content and structure of practicum in a programme designed to develop a personal conceptual reference framework, as described previously, therefore seems critical.

3. Theoretical Tools to Use Practicum

One way to expand the role of practicum in teacher education is to integrate research-based theoretical tools with activities in the programme. Such tools may help the student teachers analyse and reflect upon their practicum experiences in

a more focused and systematic way and thus deepen the understanding of critical aspects of the teacher's role in the mathematics classroom. Important here is the work of the mentor as well as the student teacher's post-teaching discussions with the mentor and the teacher educator, which take place within many programmes. Since such conversations traditionally tend to have an evaluative character in terms of normative statements, rather than focus on epistemological aspects of mathematical knowledge and learning, they risk hindering the student's development of teacher identity. To avoid this, Johnsen Høines and Lode (2007) investigated didactical conditions for a subject-based discussion to support a more reflective approach. To learn, in the sense of developing a teacher identity, from imitation of the mentor as a model teacher, the student teacher also needs to understand the rationale behind the activities of the mentor (Nilssen, 2003).

A student teacher, when enrolled in a formal teacher education programme, is typically participating in at least three socially organised practices, linked to the corresponding mathematics teaching knowledge components: content knowledge; pedagogical knowledge; and didactical knowledge, as discussed above. Due to institutional traditions and different epistemological emphases, these practices have developed their own specific discourses, which may be experienced as contradictory by the student teacher, as well as contribute to the development of their professional identities (Lerman, 2001). To analyse practicum experiences, and the relation between the pedagogical models offered at school and those "taught" at the academy, Goos (2005a) suggests a theoretical framework based on Valsiner (1997), integrating Vygotsky's conception of a zone of proximal development (ZPD) with a zone of free movement (ZFM) and a zone of promoted action (ZPA). Here, the ZFM for a student teacher during practicum accounts for the environmental constraints on action and thought, such as the characteristics of his or her students, curriculum requirements, and teaching resources. What the teacher educator at the academy, as well as the mentor and other experienced teacher colleagues, promotes as desired teaching approaches make up the ZPA. For the student teacher to develop a teacher identity, it "is important that the ZPA be within the novice teacher's ZFM, and is also consistent with their ZPD" (Goos, 2005a, p. 2). As a complicating factor, this development may be influenced, during practicum, by conflicting ZPAs, as represented by the teacher education programme and the mentor at school. The strength of this framework to help students to analyse their practicum experiences and relate them to coursework at the academy, is highlighted by Goos (2005a,b) by an example from a research study in an Australian context.

As an alternative to the prevailing apprenticeship model for teacher education, Mewborn and Johnson (2005) argue for the use of the notion-assisted performance (Feiman-Nemser, 2001) to engage student teachers in central tasks for their preservice education. In line with the Vygotskyan conception of ZPD, such assisted performance provides opportunities to enable them to "learn with help what they are not ready to do on their own" (ibid., p. 1016) rather than a mere practice of what they will do as in-service teachers. This may prevent the commonly observed alignment to own experiences after the apprenticeship period, that is, to "teach as you were taught". Examples of assisted-performance tasks provided by Mewborn and

Johnson include "reading and discussing an article, . . . working one-on-one with a child for eight weeks, and observing an experienced teacher" (2005, p. 2).

Recognising that post-observation meetings during practicum between student teacher, mentor, and teacher educator often tend to focus on classroom management rather than on aspects of how mathematical knowledge per se has been handled during the lesson (Brown, McNamara, Hanley, & Jones, 1999), Rowland, Thwaites, and Huckstep (2005a) suggest an empirically based framework called the "Knowledge Quartet", aimed at giving structure to such discussions of teachers' mathematical knowledge in the classroom. The first dimension of foundation refers to subject-matter knowledge as well as beliefs and understandings related to the teaching and learning of mathematics developed during academic coursework. During lesson planning and actual teaching, teachers' "knowledge-in-action" defines the second dimension, transformation. Of interest here is, for example, how examples are chosen and used to support student learning. How the teacher provides links and handles different cognitive demands of separate parts of mathematical content constitutes the third dimension of the quartet, connection. Finally, to account for the unexpected, for decisions impossible to plan for about developments of classroom activity, the dimension of contingency completes the quartet. Elements of mathematical knowledge in lesson episodes can be captured and understood in discussions at post-observation meetings during practicum, when structured by the four dimensions of the Knowledge Quartet (Rowland, Thwaites, & Huckstep, 2005b).

All these examples highlight the strength of using different theoretical tools for designing and framing activities with a potential to integrate formal courses and practicum to a functional basis for developing teacher knowledge and identity.

4. Specific Ways of Using Practicum to Develop Teacher Knowledge

Within different organisations of practicum and theoretical frameworks for analysing teaching practice, more specific activities have also been developed which may contribute to the expansion of the role of practicum. Examples reported here deal with gaps between planned and actual classroom activities, the use of stories of practice, questioning as a tool in teaching practice, and establishing communities of interpretation of classroom interaction.

Recognising that a common experience in practice is gaps between the (student) teacher's planned and actual activity in classroom episodes, DeBlois and Maheux (2005) focus on how student teachers during practicum explain and what they learn from such gaps. A discussion team, comprised by the student teacher, the mentor, the school's special education teacher, and a researcher, met regularly before and after the testing of planned activities. The meetings were structured by phases of narration, analysis, and synthesis. From these meetings it could be noted that the student teachers used four types of adaptations to handle such gaps. Using a projective adaptation, the student teacher grabbed an utterance or a question from

a student to put questions or pursue further discussion. When the students were expected to manage difficulties by themselves, a withdrawal adaptation was sometimes practiced, observing students doing their mistakes. By prompting students to adjust to specific ways of proceeding, a normative adaptation to an experienced gap was used. Lowering expectations on students, simplifying tasks, or not requiring explanations are examples of avoidance adaptations. The team-meetings format also triggered discussions about what factors cause these different ways of gap adaptation, and the student teachers were "able to recognize the devolution of the teaching situation . . . the 'taking charge' of classroom activities, and the student teacher's projection into his/her professional practice" (DeBlois & Maheux, 2005, p. 5).

As a means for analysing practicum and provide one's own lived experiences as cases for reflection in theoretical didactic courses, Chapman (2005) suggests an approach of using stories of practice in pre-service teacher education. Rather than judgements about good or bad teaching, the focus is on sense making. As the first stage of a sequence of four, student teachers are asked to write one story each of "good", "bad", and "memorable" teaching from their own teaching during practicum or from their own observations of teaching. The story is to include a complete mathematics lesson with as much detail as possible, including what teachers and pupils have said, but should be descriptive rather than normative. Details not remembered are to be filled in with what makes sense, not to leave gaps. The second stage is one of initial self-reflection, where the student teachers write journals on why they think their stories represent good or bad teaching, which they share and discuss with their peers, providing readings for what stories they like or don't like. During the third stage the stories are used during the semester to interpret theory and for the analysis of actual practice during practicum with a focus on making sense of mathematical content and discourse in the classroom as well as alternative approaches. The fourth and final stage, at the end of the course/semester, aims at a final self-reflection by rewriting the previous story "in the way he/she would want it to unfold", in order to "provide an alternative way of conducting it in term of engaging students in the content to facilitate deep understanding of it" (Chapman, 2005, p. 4). The student teachers then write journals to compare their two stories, to share and discuss with their peers. Data from an observed sequence with 26 student teachers showed that this approach of writing stories of practice provided a constructive means to articulate their thinking of mathematical teaching and learning in a holistic way, with self-reflections prompting conflicting beliefs and shifts of thinking. The analysis of practicum initiated an increased awareness of critical aspects of teaching not previously noted, leading to a more inquiry-oriented approach and recognition of the need of a deep understanding of mathematics to be able to support their students' learning.

Since questioning is one key tool in teachers' practice to promote and reveal student learning, its place in teacher education needs illumination. Rosu and Arvold (2005) report on a study of questioning that took place in a secondary mathematics teacher education programme. After an initial sequence of investigations into questioning, the student teachers studied questioning in practice during their second semester practicum, including meetings and discussions. Whether the focus

in these discussions were on learning for or in practice, these studies "generated a milieu of learning appropriate for the multiple meanings and contexts of teaching experiences" (ibid., p. 4). It was observed that an inquiry approach was supported by the study of questioning, which helped student teachers develop knowledge on students' mathematical understanding. However, this focus on questioning also created a milieu in teacher education where questioning as practice and questioning as theory do not come into conflict. To develop and maintain an inquiry stance in teachers, the study reported supports a practice of questioning as a learning milieu.

Based on the two assumptions that a lesson in mathematics is "exactly what those involved see in it" and that classroom interaction is very complex, depending on the mathematical content under discussion, lines of arguments used, interaction patterns, and how students participate, Gellert and Krummheuer argue that a focus on a "collaborative interpretation of classroom interaction" (2005, p. 2) may be productive for learning from teaching practice. To be able to "uncover" what was behind the development, or flow, of a lesson, a group of teachers and student teachers, along with the researchers, met to analyse a chosen videotape of a fifteen-minute lesson sequence. To give structure to the interpretations produced, three techniques developed in mathematics education research were adopted, that is, interaction analysis, argumentation analysis, and participation analysis. Seen as members of a "community of interpretation" (2005, p. 3), this group also involved in different communities of practice moved during the meetings from peripheral to full participation in this community as they become more competent in classroom-interaction interpretation. By using a heterogeneous community of interpretation it was possible to make different interpretations of classroom interaction visible and as a consequence open up for change and development of teaching approaches. The rationale behind this outcome relates to differences and changes of perspective, contrasting the "centred stance of teaching practitioners" and "de-centred stance of observers" in the "re-centring stance of legitimate self-regulation of a community of interpretation" (2005, p. 5).

The didactical power of practicum rests on experiencing oneself as an agent inside the classroom taking part in and affecting its flow. By reflecting jointly, within this context, on one's own adaptations, stories, questioning, and interpretation of classroom interaction, an increased awareness of the complex processes of teaching and learning can emerge and contribute to shaping one's identity as a mathematics teacher.

5. Practicum and Issues of National and Cultural Differences

National differences between teacher education programmes in terms of structure, organization, and curriculum represent a crucial issue when speaking about teacher education in general and practicum in particular. Several questions should be answered to better understand mathematics educators' and student teachers' habits, behaviours, and attitudes as far as the practicum is concerned. Is the practicum

part, for example, of a university degree programme in mathematics in a faculty of sciences or in mathematics education in a faculty of education? Or is it part of a post-graduate university programme? What is the volume of practicum in terms of time, and is it organised in longer or shorter periods? What kinds of activities are required by the student teacher during practicum, in terms of observations, own teaching in class, specific tasks such as assessing pupils' mathematical knowledge or collecting other empirical data, or reporting from practicum? During their practicum, are student teachers provided with supervisors by the institution organising the teacher education and mentors by the school? How do supervisors and mentors interact in particular and interrelate with the whole educating team in general? In several papers submitted to this ICMI study it is difficult to find explicit answers to even just a few of these questions.

Another crucial question could refer to the history of teacher education programmes at the national or local levels, as mentioned previously. These programmes hold a (sometimes very) long tradition in some countries, whereas they have been (sometimes very) recently introduced in others. These differences set different constraints to didactical developments and reflect and affect the local school, educational, and, even, societal contexts, with their cultural values and should be kept in mind because they are present in the schools and the classrooms, where the practicum takes place (e.g., Skott, 2005). Some examples from the study conference will illustrate this.

Considering the previous remarks, it is not surprising to read the following realistic and honest comment:

> Schools' attitudes towards practicum have not been pleasing recently. Cooperating teachers show indifference towards student teachers, and school administration has deemed student practicing as disrupting school schedule. Part of this problem emanates from students' unbecoming behavior. Some student teachers do not take their practicum seriously, resulting in inadequate preparations of lesson plans and scheme of work. Moreover, timetable clashes result in inadequate supervision (Garegae & Chakalisa, 2005).

Here the authors refer to Botswana. Is it a single case? Where else can similar situations be found, and why?

Another issue concerns the use of information and communication technology (ICT) in mathematics teacher education: How common is it, and how is it an integrated part of the practicum? In Kadijevich, Haapasalo, and Hvorecky (2005) this strong "official" complaint can be found: "This important issue of preparing teachers [to the ICT] has not been recognized by the ICMI Study 15. . .whose Discussion Document, to the authors' surprise, doesn't even use the words 'computer' and 'technology' ". Nevertheless, the topic is raised in several other papers (e.g., Bairral & Zanette, 2005; Miller, 2005), recognizing its power of shaping the structure of the educational environment.

Other critical issues relate to interdisciplinarity and diversity, as expressed in Carneiro Abrahão and de Carvalho Correa de Oliveira (2005). Philosophical premises of the courses as well as of the discipline of mathematics "are related to the interdisciplinary practices and the development of opportunities to consider diversity in classes" (2005, p. 1). Centred around research activities in a real context

the education is aiming to learning to select "priority objectives, and appropriating resources and strategies in teaching mathematics in an interdisciplinary approach" (2005, p. 3), and the knowledge increase "includes an evolution in the connection among the disciplines" (2005, p. 5). In this paper, interdisciplinarity is thus strongly emphasized and rooted in a pedagogic philosophical idea. What do the different teacher education programmes in mathematics provide to the student teachers under this aspect? Which obstacles, if any, are faced in the implementation of an interdisciplinary education, namely, when practicum is concerned? How can they be removed? Is it just a matter of tradition or of educational culture? For instance, in Italy, despite lower secondary-school mathematics teachers having to teach experimental science as well, the two subjects tend to be rigidly separated in the pre-service training programmes (Favilli, 2006) and, as a consequence, in the class practices. However, as reported by Novotná and Hofmannová (2005) for the Czech Republic, mathematics and language student teachers are being trained to cooperate in view of teaching mathematics through the medium of the English language, using the Content and Language Integrated Learning approach.

One aspect of diversity in classrooms concerns intercultural education in mathematics, raised in Favilli (2005): "Policy makers and educators are increasingly concerned with the inclusion of minority culture pupils in the classrooms. Mathematics teachers have started to consider the ways of dealing with multiculturalism in the class. In several countries, such as Italy, they complain about the lack of refresher courses and didactic materials." How are initial teacher education programmes in mathematics dealing with this issue? As the classroom is the place where the actual cultural commonalities and differences can be seen, the practicum is even more crucial for this kind of training. In a multi-cultural classroom the passage from the theory (even when supported by a good introduction to the intercultural education issues) to the practice can be even harder than in an "ordinary" classroom.

6. Conclusions

The examples presented here reflect only some of the ongoing developments of practicum in mathematics teacher education taking place in different parts of the world. However, they all reflect a move away from a teacher training paradigm of teaching pre-defined teaching skills and a fixed body of content knowledge towards a teacher education paradigm of developing educational knowledge in mathematics. This accounts for a shift both in the target knowledge of mathematics teacher education and how to achieve it. Within this shift, the main features of the picture that emerges of the role and practice of the practicum are both its complexity and its educational potentials. The latter explain why teacher education programmes continue to offer a practicum although it is expensive and difficult to organise in ways that fulfil the demands from students and the institution.

It is obvious that there is a general agreement that some parts of the teacher profession are better learned in a classroom. There is also the question of how to

balance theoretical studies and time spent in the classroom. This has varied over time and also between teacher education programmes in different countries. Student teachers often claim that this part of their education is the most important, and the study conference papers discussed here explicate the rationales hiding behind these beliefs. Other professions also include practice, such as nurses, medical doctors, lawyers, priests, and police officers. What kinds of issues concerning practice are relevant for all these professions and their practicum? What can mathematics teacher education learn from research about practicum in these other professions as well as from the education of teachers in other disciplines?

Issues of differences in cultures and school systems between countries, which may set critical constraints or open up possibilities with regard to the structure and kinds of activities that are viable in a teacher education programme, have only been raised briefly in the discussion here but with an emphasis on their importance. The focus has rather been on the kind of teacher knowledge needed for teaching mathematics in schools today and how to support the development of such knowledge in student teachers within an institutionalised educational programme. A critical issue concerns how to organise an education that supports the development of a teacher identity. This sets demands on the student teacher to navigate between constraints, free movements, and promoted action, for which practicum is the key arena. An elaborated integration of practicum to other parts of the teacher education programme is needed to base this development in a personal conceptual-reference framework. Practice-based reflecting conversations with participants in their education need a theoretical basis and a focus on the diffusion of mathematical knowledge to contribute to personal and viable teacher knowledge.

The contributions at the study conference presented in this chapter all witness how the role of practicum can be expanded as an integrated part of a mathematics teacher education programme, as well as the need of this educational development to accomplish the aims of the complex enterprise of preparing students for the teaching profession. Structure, formats, and activities that merge didactic divides between different components of the education seem to be at the core of these examples, with a common aim to foster the development of a personally based teacher identity in future teachers of mathematics.

References

Bairral, M., & Zanette, L. (2005). *Geometric learning and interaction in a virtual community of practice*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Bednarz, N., & Proulx, J. (2005). *Practices in mathematics teacher education programs and classroom practices of future teachers: From the teacher educator's perspectives and rationales to the interpretation of them by the future teachers*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Bergsten, C., & Grevholm, B. (2004). The didactic divide and the education of teachers of mathematics in Sweden. *Nordic Studies in Mathematics Education, 9*(2), 123–144.

Bergsten, C., & Grevholm, B. (2005). *The didactic divide and educational change*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Brown, C., Cooney, T., & Jones, D. (1990). Mathematics teacher education. In W. R. Houston (Ed.), *Handbook of research on teacher education* (pp. 639–656). New York: Macmillan.

Brown, T., McNamara, O., Hanley, U., & Jones, L. (1999). Primary student teachers' understanding of mathematics and its teaching. *British Educational Research Journal, 25*(3), 299–322.

Carneiro Abrahão, A. M., & de Carvalho Correa de Oliveira, A. T. (2005). *The initial education of primary teachers of mathematics: The Superior Institute of Education of Rio de Janeiro, Brazil*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Chapman, O. (2005). *Stories of practice: A tool in pre-service secondary mathematics teacher education*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Comiti, C., & Ball, D. (1996). Preparing teachers to teach mathematics: A comparative perspective. In A. Bishop et al. (Eds.), *International handbook of mathematics education, part 2* (pp. 1123–1153). Dordrecht: Kluwer.

DeBlois, L., & Maheux, J.-F. (2005). *When things don't go exactly as planned: Leveraging from student teachers' insights to adapted interventions and professional practice*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Favilli, F. (2005). *Italian math teachers in multicultural classrooms*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Favilli, F. (Ed.) (2006). *LOSSTT-IN-MATH—Lower secondary school teacher training in mathematics. Comparison and best practices*. Pisa: PLUS—Pisa University Press.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*, 1013–1055.

Garegae, K. G., & Chakalisa, P. A. (2005). *Pre-service mathematics teacher preparation programs and early years of teaching on Botswana*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Gellert, U., & Krummheuer, G. (2005). *Collaborative interpretation of classroom interaction: stimulating practice by systematic analysis of videotaped classroom episodes*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Goodchild, S. (2007). Students' goals in mathematics classroom activity. In C. Bergsten, B. Grevholm, H. Strømskag Måsøval, & F. Rønning (Eds.), *Relating practice and research in mathematics education*, *Proceedings of NORMA 05* (pp. 27–49). Trondheim: Tapir Academic Press.

Goos, M. (2005a). *Theorising the role of experience in learning to teach secondary school mathematics*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Goos, M. (2005b). A sociocultural analysis of the development of pre-service and beginning teachers' pedagogical identities as users of technology. *Journal of Mathematics Teacher Education, 8*, 35–59.

Grevholm, B., & Bergsten, C. (2005). *The development of a professional language in mathematics teacher education*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Johnsen Høines, M., & Lode, B. (2007). Meta-level mathematics discussions in practice teaching: an investigative approach. In C. Bergsten, B. Grevholm, H. Strømskag Måsøval, F. Rønning (Eds.), *Relating practice and research in mathematics education, Proceedings of NORMA 95* (pp. 311–323). Trondheim: Tapir Academic Press.

Kadijevich, D., Haapasalo, L., & Hvorecky, J. (2005). *Educational technology standards in professional development of mathematics teachers: an international study*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Lanier, J. E., & Little, J. W. (1986). Research on teacher education. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 527–569). New York: Macmillan.

Lerman, S. (2001). A review of research perspectives on mathematics teacher education. In F. Lin & T. Cooney (Eds.), *Making sense of mathematics teacher education* (pp. 33–52). Dordrecht: Kluwer.

Mewborn, D., & Johnson, P. (2005). *Mathematics teacher education as assisted performance*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Miller, D. (2005). *An ICT rich mathematical environment enhancing pre-service teacher education*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Nilssen, V. (2003). Mentoring teaching of mathematics in teacher education. In N. A. Pateman, B. J. Doherty, J. Zilliox (Eds.), *Proceedings of the 27th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 3, pp. 381–389). Honolulu: PME.

Novotná, J., & Hofmannová, M. (2005). *Teacher training for content and language integrated learning*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Proulx, J. (2003). Pratiques des futures enseignants de mathématiques au secondaire sous l'angle des explications orales: Intentions sous-jacentes et influences. Master's thesis, Université de Québec à Montréal, Montreal.

Rosu, L. M., & Arvold, B. (2005). *Questioning as a learning milieu in mathematics teacher education*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Rowland, T., Thwaites, A., & Huckstep, P. (2005a). *The knowledge quartet: A framework for reflection, discussion and professional development*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Rowland, T., Thwaites, A., & Huckstep, P. (2005b). Elementary teachers' mathematics subject knowledge: The knowledge quartet and the case of Naomi. *Journal of Mathematics Teacher Education, 8*, 255–281.

Skott, J. (2005). *Developing pre-service teacher education in times of constraints: the case of the Eritrea elementary school*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Tirosh, D., & Tsamir, P. (2005). *Formulating and developing a didactics of mathematics component in a teacher education program: Research and instruction*. Paper presented at the conference of the 15th ICMI Study on the Professional Education and Development of Teachers of Mathematics, Águas de Lindóia, Brazil.

Valsiner, J. (1997). *Culture and the development of children's action: a theory of human development* (2nd ed.). New York: John Wiley & Sons.

Wallach, T., & Even, R. (2005). Hearing students: The complexity of understanding what they are saying, showing, and doing. *Journal of Mathematics Teacher Education*, *8*, 393–417.

Walshaw, M. (2004). Pre-service mathematics teaching in the context of schools: An exploration into the constitution of identity. *Journal of Mathematics Teacher Education, 7*, 63–86.

Winsløw, C., & Durrand-Guerrier, V. (2007). Education of lower secondary mathematics teachers in Denmark and France. *Nordic Studies in Mathematics Education*, *12*(2), 5–32.