DG 7: Dilemmas and controversies in the education of mathematics teachers

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Aims, focus and organisation of the DG

In mathematics education the critical role of the teacher is becoming increasingly recognised and has attained much research interest. This has put high demands on the institutions that organise the formal preparation and the professional development of mathematics teachers. Research has pointed to the complexity of this enterprise and a number of dilemmas and controversies involved. The aim of the discussion group was to provide a forum for researchers and practitioners to further investigate these issues. The following general questions were initially set up by the organising team to structure the work in the DG:

- *Organisation*: How can we attain an appropriate balance and connection between the main components of teacher education, for example, the mathematical, educational, and didactical components for different educational levels?
- *Mathematical knowledge*: What kind and what level of mathematical knowledge do teachers need and how could it be fostered in educational activities?
- *Professional development*: Seeing the development of teacher knowledge as a lifelong process, how can this process be initiated in pre-service teacher education programmes, and what ways of promoting in-service mathematics teachers' professional development are effective?
- *Theory and practice*: To what extent should teacher education be research or experience based, and what do we mean by that, for example, when relating teaching practice and theoretical courses?
- *Policy issues*: What roles do teacher preparation programmes play in relation to tradition and renewal within mathematics education?

With those critical issues as a background the organising team invited experts in the field to write position papers and announced a call for papers by prospective participants in the DG. Authors were also invited to set up specific questions for discussion. Contributions from both researchers and practitioners were foreseen and submissions from all countries with different economic contexts and cultural backgrounds were encouraged. Colleagues wishing to participate in the DG were encouraged to e-mail potential areas of discussion to the group co-chairs for inclusion in the draft programme even if not supported by a discussion paper. The papers were reviewed in a two-step procedure, based first on abstracts and then on the full papers. Thirteen submitted papers were accepted and made available on the DG 7 web page prior to the congress.

The work of the DG was organised in three sessions. The first session opened up in a plenary format with welcome and introduction by the organising team, followed by three invited panel presentations (Christer Bergsten, Ruhama Even and Konrad Krainer) in order to set up the agenda and stimulate the discussions in the group. After this introduction a split into three subgroups was made. Group 1: Professional development programmes (chair Yang); Group 2: Initial teacher education (chair Senk); Group 3: Knowledge of mathematics teachers (chair Bergsten). The subgroup discussions drew on the submitted and invited papers, with other questions suggested by the organising team. In the second session the discussion in the subgroups continued. The outcome from the subgroup discussions were reported and discussed in the final plenary session, followed by a concluding discussion on the main topics raised.

Summary of the plenary introduction

Bergsten pointed in his presentation *The didactic divide in initial teacher training: Can it be avoided?* to a relevance problem: an analysis of the different actors involved in mathematics teacher education and their activities in different arenas displays an educational game that takes place in a more or less autonomous world of mathematics for learning and teaching isolated from the world of applied mathematics and use of mathematical models in science and society in general, as well as in the world of mathematical research. Some of the problems in teacher education observed in literature relate to the fact that teaching traditions are 'stronger' than teacher education, recruitment, theory/practice relationships, and the didactic divide between content knowledge (knowing mathematics), pedagogical knowledge (knowing teaching) and didactical knowledge (knowing how to teach mathematics). In relation to the latter categories, Bergsten highlighted some constraints in pre-service teacher education where student teachers have their main experience only from learning (not from teaching) as well as a weakly developed mathematical knowledge base (implying a focus on ways of working with pupils rather than on how to organise mathematical content). He also pointed to constraints in in-service teacher education due to teachers' established teaching practices and their shaped beliefs of school mathematics and students, as well as institutional alignment and the effects of didactical transpositions. Along with observed tensions in teacher education programmes, that is, between tradition and renewal, experience-based and research-based knowledge, and practical and theoretical components of teacher education, Bergsten asked the question *What is possible in teacher education?* Answers to this question relate to what is critical knowledge for a mathematics teacher (training competencies or becoming knowledgeable), the form and content of teacher education practices, and issues of progression.

In her presentation *Educating practicing mathematics teachers: What is missing in the literature?* Even pointed to three problematic aspects in current literature on mathematics teacher education: *The ill-defined nature of the field*, including both the scholarly field and the practice itself regarding the terminology; for example, the name 'facilitator' refers to encouraging teachers to find their own solutions to problems or tasks, while the name 'professional development provider' infers less participation in the process of defining and achieving the goals of the participating teachers; who counts as a teacher educator; unsystematic educational opportunities for teachers; *Missing research on the practice of mathematics teacher educators*; a focus on teacher learning and not on the practice of offering professional education; self-reports of teacher educators who publish in scholarly publications; work in English speaking countries; *A lack of information on the education of mathematics teacher educators*: a focus in literature on teacher education; the need for adequate preparation for mathematics teacher educators is often neglected; until recent years, there were essentially no formal programmes that prepared teacher educators. Even concludes that we need more information about people who might be regarded as educators of practising teachers, characteristics of different professional development systems, what mathematics educators who work with practising teachers do, and the nature of productive practice of educating practising teachers.

In his contribution *What do we know about the sustainability of professional developmental programmes?* Krainer focused on what ways of promoting in-service mathematics teachers' professional development are effective. The word 'promoting' points to a critique from outside teachers' practice as well as the issue about who promotes, that is, what ways of professional development (PD) there are. The term 'effective' regards both the goals and kinds of impact of the PD that are aimed at and its sustainability. As goals indicate what outcomes are expected, these must be regarded as interconnected dimensions of PD. As relevant goals Krainer points to teachers', students', and teacher educators' learning of attitudes/beliefs/interests, knowledge and practice, as well as that of other relevant environments, for example, principles, schools and education systems, with the expected satisfaction (about process and outcomes) not only by commissioners and teacher educators but

also by teachers and students, as well as other relevant environments. The analysis points to a variety of potential factors promoting the sustainability of PD programmes, where three dimensions seem to be of major importance: Content (high level and balance of subject-related action and reflection); Community (high level and balance of individual and social activities, in particular fostering community-building within and outside the professional development programme); and Context (high level and balance of internal and external support). The analysis of sustainability of PD needs to take into account intensively mathematical actions and reflections, the individual and the social dimensions of learning (autonomy and networking) and the influence of the context. The latter two aspects imply that sustainable PD programmes are not only influenced by the community and by the context outside the PD programme, they also shape it.

Group discussions and conclusions

Group 1: Professional development models used in different countries were discussed, looking for similarities and generalities between them. The discussion raised a question about the culture of mathematics teachers and how it seems to be different than the cultures of other academic subjects. It was discussed how working in isolation hinder mathematics and that it seems that mathematics teachers have almost a "fear" of working with teachers from other disciplines, possibly due to the fact that mathematics is seen as a tool and not as its own entity. Some similarities in the PD models that were discussed and some general factors for success observed were: a need for PD in both mathematical content and instructional practices in the classroom; an element of a focussed reflection on the PD asking teachers to think about not only the content but the way the content was being delivered, a reflection that acts as a motivator as it indicates a personal involvement; ties to a university for the content and pedagogical pieces; the PD seemed to be more successful if teachers volunteered, being more committed to the learning; a nonthreatening environment to enhance learning; the need for a sense of community with and from all involved, including the teachers, administration, and university.

Group 2: The first question discussed was *What are some models of effective initial teacher education programs?* It was pointed out that researchers and policy makers have not always agreed on what outcome measures to use to determine this but that the final goal of an initial teacher preparation program is to prepare life-long learners who will provoke learning and a love for learning in their pupils. Programs in Korea and Taiwan seem to be the most effective among those studied. Mathematics courses, courses in practical pedagogy, and courses in theoretical pedagogy all seem to contribute to greater knowledge. By ICME-12 the group wanted to see more about how studies define successful outcomes, for example, mathematical knowledge for teaching; more about the nature of various opportunities to learn in different countries; studies that take into account differences in entering knowledge of students; studies that examine relations between teacher preparation programmes and achievement of pupils in schools; studies about the nature of the mathematics and pedagogy courses (both content and form) for future teachers. Responses to the question *What has been added or deleted to initial teacher preparation programs in your university/country during the past 5-10 years?* showed that teacher preparation programmes in all countries are evolving over time and are profoundly influenced by policies put in place by national or state governments. Increased knowledge is needed about the status of initial teacher preparation programmes and the causes and effects of the constant changes of teacher education programmes. Concerning questions about beliefs and attitudes about the nature and learning and teaching of mathematics it was discussed whether 'beliefs' is a useful construct, whether all beliefs are of equal importance, and whether expectations are perhaps are more important than beliefs.

Group 3: The first issue discussed concerned the three main components in mathematics teacher education, that is, mathematics, pedagogy, and teaching practice. In one paper it was claimed that, among these, mathematics is the key component. What does such a claim mean and how is it substantiated? And what "mathematics"? Are most pedagogical questions content-specific

rather than general, with mathematics the key to resolving them? These questions led to a general discussion about mathematicians and educators, and details about specific teacher education programmes (the separation of mathematics and pedagogy, problems with diversity of student background). It was suggested that productive collaboration can result from an examination of examples with attention to specific mathematical and pedagogical details, which can lead each group to see what is key about the other's contribution. It was also discussed whether the notion, raised in one paper, of the mathematical depth of a piece of classroom discourse is a well-defined construct, and whether it can be measured. This issue presented some difficulties of interpretation and lent itself to consideration of many complexities: mathematical depth includes making connections; the variety of mathematical behaviours; professional judgment; a focus on teacher knowledge and teacher moves. The third issue discussed concerned the question: *Is the division into different kinds of knowledge (as presented in one paper, technological pedagogical content knowledge) psychologically valid?* Is it useful in designing teacher preparation programs? Represented symbolically by Venn diagrams, it was suggested that such circles represent different cultures and that overlaps are areas of interaction between these cultures. Differences in kind between the circles relate to constancy versus changeability. Such divisions response to, and challenge, the idea of specialised mathematical knowledge for teaching: whether mathematical knowledge is universal; how different professions unpack different pieces of knowledge; whether, within a common domain, there are different social practices. Discussion of the usefulness of this model in guiding teacher preparation programmes helps break down barriers between content and pedagogy courses. Our difficulty with these notions must imply a similar difficulty for teachers.

In the final discussion, in relation to the 'sequence' *Teacher educator – Teacher education – Student teachers/Teachers – Teaching – Students*, two questions were raised: What do we 'know'? What do we not 'know'? Concerning the first question: there is a lot of should, need, and so on in discussions about mathematical knowledge for teachers, often based on our own experience and ideals rather than on existing research; on initial teacher training, many questions raised rested on teacher education practices, that is, on how-issues; does all this reflect the complex relation between theory and practice that is deeply rooted in education generally or is it because of the complexity of mathematics teacher education, with its many dimensions of knowledge and actors in this educational game? Concerning the second question: revisiting the problems/questions discussed in the three subgroups, is there something in common, some core issues concerning what is most critical to becoming, being, and developing as a mathematics teacher?; in initial teacher training, how to merge the didactic divide ("educational knowledge of mathematics"); in professional development, how to put knowledge to relevant practice ("knowtice").

Appendix: The papers

Hatice Akkoç, Fatih Ozmantar, Erhan Bingolbali (Turkey) – Exploring the technological pedagogical content knowledge.

Elisabeth Belfort, Luiz Carlos Guimaraes (Brazil) – Pró-letramento matemathics: Improving mathematical knowledge and practices of primary teachers in Brazil.

Christer Bergsten (Sweden) - The didactic divide in initial teacher training: Can it be avoided?

Ana Paula Canavarro, Isabel Rocha (Portugal) – Professional development of mathematics teachers: Challenges from a national in-service teacher education program in Portugal.

Ruhama Even (Israel) - Educating practicing mathematics teachers: What is missing in the literature?

Tony Gardiner (UK) – The key component?

Konrad Krainer, Stefan Zehetmeier (Austria) - What do we know about the sustainability of professional developmental programmes?

Sebastian Kuntze (Germany), Frank Lipowsky (Germany), Kathrin Krammer (Switzerland), Kristina Reiss (Germany) – What is "best practice" for video-based in-service teacher trainings? Views and experiences of secondary mathematics teachers and findings from evaluation research.

Hea-Jin Lee (USA) – Developing professional knowledge, implementing professional learning, and sustaining professional growth.

Ana Lúcia Manrique (Brazil) – Changes in expectations of students doing a mathematics teacher training program about the teaching profession

William McCallum (USA) – Seeing the mathematical knowledge of teachers: A mathematician's perspective

Bernard Murphy (UK) – The 'Teaching Advanced Mathematics' programme of professional development

Ana Maria Redolfi Gandulfo (Brazil) – The education of mathematics teachers and a learning environment

Allan Tarp (Denmark) – Concealing choices to teachers

Jian Wang (USA) – *Chinese elementary teachers' understanding and representation of mathematics concepts in classroom: Relationship between pedagogical content knowledge, instructional practice, and mandated curriculum materials*

Fan Zhongxiong (China) – *The development of mathematics higher education for Tibetan learners in China*

This report was compiled by Christer Bergsten (christer.bergsten@liu.se), based on the contributions of the participants. You are welcome to contact him for further information about the work of the discussion group. Full papers are available at <mai.liu.se/~chber>