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DG 6: The education of mathematics teachers

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Introduction

This discussion group was commissioned to consider issues such as:

- What mathematics should teachers in training and teachers already in service study?
- To what extent should mathematics teacher education be focused on pedagogical skills or didactical knowledge or mathematical considerations?
- What roles do mathematics teachers play and what roles should they play?
- What should teachers know about student learning?
- What practices seem to hold the best hope of reforming the teaching of mathematics and how are those practices best presented in teacher education programs?

A set of indicative questions was made available on the website under each of these themes. This was not to define the areas of discussion – that was to be done by the participants in their groups – but to attract papers from participants to support the work of the groups. The group was timetabled to meet three times, the sessions were either plenary or group sessions.

Since a discussion group is designed to discuss among a large variety of participants, we felt it important in this contribution to stress the questions that have arisen in our sessions, even if these questions have not received definitive answers. In fact, it would have been preposterous to think that a 6 hour session would have led to articulated answers to very important questions. Participants did find the questions in themselves stimulating: Sometimes it emphasised the fact that the question was not a personal or local one, but one of worldwide interest, and at other times the questions that seemed crucial for some participant was completely new for another.

The initial plenary element was used to introduce the team and to introduce the contributory papers which had been placed on the website after being approved by the organising team. Although there was no scope for participants to present their papers during the discussion group their contribution was acknowledged when they were introduced individually to the, whole group and an abstract of their paper was displayed for information. In all seventeen papers (from twelve different countries) had been posted on the ICME website (www.icme10.dk).

These papers generated four main areas for discussion in the group sessions which followed the plenary meeting.

- A. Specific ‘problem’ areas for which time may or may not be prioritised (e.g. geometry, history) or topics in which trainee teachers often had problems (e.g. fractions and proportionality).
- B. Maintaining the complexity of the teaching task whilst initiating beginners.
- C. The nature and depth of trainee teacher’s knowledge and attitudes.
- D. Effective practices and structures which help to underwrite them.

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The second element of the introductory plenary was an outline of the training systems from France; Taiwan; Finland; Serbia and Montenegro; Brazil. These were intended to raise issues for discussions in the groups, each containing participants from a wide range of countries and each led by a team member. During this first session these groups continued to explore the outlines of training systems with participants giving brief descriptions of their training systems leading them to discuss the variations and to present the three most significant issues relating to their system.

The training institutions for primary or secondary school teachers varied for different countries. In some countries, such as United States, prospective teachers are trained by universities, whilst in others such as Malaysia, Denmark and Taiwan they are trained in separate pedagogic institutions such as teachers colleges. In most countries the training lasts for a total of about four years after the conclusion of secondary schooling so that newly qualified teachers are usually at least 22 or 23 years of age, though in Iran, for example, the training is for two years and a new teacher may be just 20 years of age.

In primary school teacher programs, there are two different systems. One is where pre-service teachers need to take 3-4 year courses in an Education Faculty. The other is where the pre-service teachers study for their first degree in any subject matter and take one more extra year following a course in pedagogy institute. In secondary school teacher preparation programs, there is an assumption that pre-service secondary school teachers are required to have more mathematics content knowledge than those of primary school. There were again two training systems in the participating countries, the pre-service secondary school teachers in some of the countries need to accomplish a mathematics degree in university followed by a teacher training program, while those in some other countries mathematics and education are combined in their degree studies.

After the course preparation, there is some similarity in the teaching experiences required in most countries. Trainee teachers need to have at least half year equivalent of teaching practice before being certified as a qualified teacher. During the practice teaching, the trainee teachers are usually mentored by both school teachers and a supervisor from the training institution but there is often only limited interaction between mentors and supervisors. Sweden had developed a particular initiative in developing mentorship amongst teachers. Assessment practices varied, and whilst all have end of course assessment the French system requires trainee teachers to pass a pedagogic examination before acceptance onto a training course (requiring some pre-course study); whilst in England trainees have to pass centrally managed computer based tests of skills in literacy, numeracy and information technology.

General discussion about the recruitment and education of teachers

Most countries do not have great problems in recruiting primary teacher-trainees, but nearly all have some difficulty in recruiting secondary mathematics teachers, one exception being Korea which recruits secondary mathematics trainees well with only 10% of those completing the training course actually obtaining posts.

Difficulties with students which were identified by participants included poor knowledge of mathematical and pedagogical content knowledge together with poor mathematical vocabulary and poor communication skills. Trainee teachers frequently had low confidence and a negative attitude toward mathematics. Problems in the teacher education system included too little time to address mathematical knowledge, especially for primary teachers, and there was a perceived problem in the USA of primary teachers avoiding being seen as specialist teachers of mathematics.



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In one group there was considerable discussion about how the isolation that teachers so often face can be overcome and how teacher educators can help teachers develop a more thorough knowledge of the mathematics they teach and of various ways of teaching that mathematics. A number of suggestions were offered, the most prominent of which emphasized the need for teachers to work in concert with other teachers in which problems are discussed in a professional atmosphere, forming a 'community of practice'. Individuals discussed how they worked with the entire mathematics staff within a given school; others talked about the formation of networks that provided a structure for teachers from different schools to communicate with one another. The role of technology (primarily email and the Internet) was explored as a vehicle to promote this kind of communication.

Another form of isolation discussed was that between theory and practice. How could tertiary mathematics programs become more relevant for those planning on becoming mathematics teachers. There was a perceived gap between university level mathematics and the student teachers' understanding of school mathematics. How could teacher educators enable student teachers to see the more empirical side of mathematics given that mathematical formalism dominated most of their mathematical training? The view was expressed that mathematical formalism was not helpful to generating effective teaching strategies for enabling students to learn mathematics. Student teachers needed to study less mathematics but more thoroughly, 'advanced mathematics from an elementary standpoint'; we needed to create more and better connections between tertiary mathematics and school mathematics.

New questions raised by the discussion

- A. Specific problem area (e.g. the place and nature of geometry or the history of maths) or specific problem topics (fractions and proportionality).
- How far does/should the training curriculum (or the inservice programme) reflect the current state of the school curriculum?
 - How do we 'fill in the gaps' in the trainee teacher's mathematics experiences in the time which is available?
 - Problem areas have been problem areas throughout their learning – what can we change to help them improve?
 - How do we help teachers/trainee teachers to identify weaknesses/areas for development without challenging their confidence and self image?
 - If practicing teachers themselves have problems with some particular concepts (e.g. ratio and proportion) how do we enable them to support trainee teachers to teach these concepts?

It was felt important that the training curriculum must go beyond the student curriculum to help teachers to model, represent in multiple ways and prove at different levels of justification. It was clearly important to achieve an appropriate balance between pedagogy and the subject (i.e. mathematics) curriculum. Much depended on the quality of mentoring by experienced teachers supporting the trainee teachers.

- B. Teaching mathematics is complex – how do we support trainee teachers to recognise this and teach in this complex manner.
- Images which capture the complexity.



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- ‘Simplifications’ which still contain the complexity.
- Methods of analysis which retain the complexity.
- Maintaining the ‘connectedness’ of trainee teacher knowledge by providing rich networks of knowing.

This topic provoked much discussion as participants set out trying to describe the complexity. Complexity can be found both in pedagogy (for example dealing with unconventional or unexpected answers from pupils) and in the subject (connectedness, content, misconceptions). This complexity may also vary for primary and secondary teachers.

It is important that students recognise this complexity. Teacher educators must however be careful not to over-complicate (thus perhaps causing anxiety for elementary teachers) or to over-simplify (secondary teacher students need to know that their “brilliant explanations” may not be good enough to get pupils learn). It is important that students understand the depth of “simple” mathematics – echoing Klein’s call for an understanding of elementary mathematics from an advanced standpoint.

Participants also pondered how we can prepare teachers to teach successfully in such a complex environment. It is important, that in pre-service training we should seek to reduce mathematical fear, to model best practice, to provide a variety of tools and to enable the possibility to gain real/realistic experiences (e.g. video case studies, real classroom activities, “What happens if ...?” situations). It is also important that teachers continue pondering these topics through in-service training.

- C. ‘Borderlines’ of acceptability and the nature of teacher/trainees knowledge.
- Attitudes towards knowledge and the teaching act.
 - The nature of the trainee teacher’s mathematical knowledge – the struggle between technical efficiency and relational understanding in learning mathematics.
 - Assumptions about learning and the learning act – trainee teachers assumptions about pupils.
 - Mathematics as distinctive or representative in the school curriculum.

This was addressed by discussing four questions.

- What mathematics do all students/teachers need?
- Should we start the training by assuming an empty slate?
- Should our students be able to explain underpinnings?
- Are we intending to educate good apprentices or mediocre masters?

- D. Effective practices and structures in teacher training courses.

- Ways of working with trainee teachers.
- The role of in-school experiences and the contribution of teacher-mentors.
- Assessment and analysis of classroom situations which help students to access the complex classroom.

In responding to these questions it was important to recognise the need for trainee teachers to be faced with realistic situations which model good mathematics teaching. To help trainee teachers develop criteria to help analyse good teaching we must be able to

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define effective practice and provide opportunities to observe good teaching. They must feel part of a community of learners of teaching through participation in an effective “lesson study” model with immediate feedback, assessment and a chance for reflection, including the development of skills in analysis – What could I have done? What will I do next?

Feedback is of critical importance, including:

- Self-feedback (observe video).
- Mentor teacher feedback.
- Teacher educator feedback.
- Design/utilize a feedback system from schools to pedagogical institutions.

It is clearly important that universities and schools should work more collaboratively. Supervisors can help or impede trainee teacher’s experience in a particular context and it is valuable to enable school teachers contribute to the pre-service program and for university staff to work in schools. Some schools hire ‘coaches’ – specialist support personnel - to work in this context betwixt and between theory and practice. The issue of providing quality mentoring was raised through asking the following question: ‘How can a university mathematics teacher with no school experience have knowledge of the pedagogy of primary or secondary mathematics?’ One answer to this rests upon the existence of a body of knowledge provided by research in mathematics education. Where this knowledge exists, a university educator can make him/herself aware of this knowledge and of its significance. What (s)he can then give to the trainee teachers is not a personal knowledge but – as is often the case for other professions – a useful cultural knowledge. Furthermore, this question can be reversed to ask ‘what kind of knowledge can an experienced primary or secondary teacher transmit to trainee teachers?’ To reflect upon one’s own practice is a very difficult exercise, and to know how to transmit the major element of a successful practice is even more difficult. Sometimes the experienced teacher can only present his/her own personal solution to a trainee teacher’s search for how best to teach a particular piece of mathematical knowledge. But how then can this particular professional solution be compared to another solution? To what extent is this solution really related to an outmoded traditional curricula or ways of teaching embedded in the experienced teacher’s history? The group agreed on the importance of having a variety of educators interacting with trainee teachers to avoid the sense that there is one particular approach or solution to a problem.

It must also be recognised that assessment influences classroom practices and assessment practices should be ones which support and are sympathetic to developing the analytical skills and self awareness of trainee teachers.

E. To what extent is mathematics teacher education about enculturation or about reform?

- What is the priority for mathematics teacher education?

Some raised the question whether enculturation and reform are really polar opposites. The point was made that teacher education is about facilitating student teachers’ entrance into the profession of mathematics teaching but it is also about educating student teachers on the use of technology, problem-solving strategies, open-ended assessment



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techniques, and various instructional methods other than the traditional lecture method. Much of this discussion focused on how teacher educators could help beginning teachers incorporate these methods into their teaching in a successful way. The creation of communities of professional teachers was one of the primary means for enabling young teachers to be mentored as they entered the profession and to provide a support system for “reforming” the teaching of mathematics.

F. Inducting trainee teachers into the profession.

- How can we promote “communities of professional teachers”?
- How can we help teachers develop a better understanding of school mathematics?
- More generally, How do we prepare trainee teachers to work with colleagues?

Again a theme emerged regarding the need to provide a context for beginning teachers to feel a part of the teaching profession. The Japanese approach that places considerable emphasis on mentoring beginning teachers was mentioned as one example of what was needed. Part of the discussion dealt with the need for beginning teachers to appreciate the complexity of teaching and dealing with students’ thinking about mathematics, yet enable them to develop confidence in their teaching ability. It was agreed that the beginning teacher is a rather fragile entity that needs nurturing and support.

Appendix: The papers

- Primary school teachers’ perceptions about their needs concerning mathematics teacher education. *Solange Amorim Amato – Brazil*
- Training elementary teachers of mathematics: What are the essential components? *Mark Arvidson – USA*
- History of mathematics and didactics: Reflections on teachers education. *Giorgio T. Bagni – Italy*
- Synthetic Euclidean geometry as a didactic basis for primary and secondary school geometry. *Marita Barabash, – Israel*
- Transposition of didactical knowledge: The case of mathematics teachers’ education. *Isabelle Bloch – France*
- What is the role of the university in influencing the behaviour of trainee teachers in the classroom? Theory and practice in teacher education. *Paul Dickinson et al – UK*
- Reflections on mathematics teacher education. *M. García and V. Sánchez – Spain*
- Constraints, coins and combinations: Working with teachers in South Africa. *Faaiiz Gierdien – South Africa*
- Integration of didactical knowledge and mathematical content knowledge in pre-service teacher training. *Pedro Gómez and Luis Rico – Spain*
- An exploration into the mathematics subject knowledge of primary trainees. *Tony Harrie and Ruth Barrington – UK*
- On the mathematical and didactical content knowledge of prospective teachers: the case of the division of fractions and proportional reasoning. *Tapio Keranto – Finland*
- Didactical Analysis – A Plan For Consideration. *Milosav Marjanovi ć- Serbia and Montenegro*
- Teaching mathematics student teachers in challenging contexts. *C.E.F. Monteiro and M.M.F.Pinto – Brazil*
- What mathematical and educational competencies should be developed on elementary prospective teachers? *Cecília Monteiro and Lurdes Serrazina – Portugal*
- Toward a Model for Teacher Professional Development in China. *Huang Rongjin and Bao Jiansheng – P.R.China*
- A study of middle school teachers’ understanding and use of mathematical representation in relationship to teachers’ zone of proximal development. *Zhonge Wu and Gerald Kulm – USA*
- Teacher Education in Iran. *A. Shahvaraniran – Iran*

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They are happy to be contacted at for further information on the work of this DG.