Section 3
Key Issues for Research in the Education and Professional Development of Teachers of Mathematics

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Section 3

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Chapter 3.1
Some Reflections on Education, Mathematics, and Mathematics Education

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I believe the key problems in the preparation of teachers of mathematics are related to inadequate visions of the purposes of education and of the role of mathematics teachers as educators. Prospective and in-service teachers of mathematics should be always reflecting on changes in education, which result from profound changes in society particularly those in the demographic scenario, in production, in information, and in communication. I will elaborate on the purposes of education and on the role of mathematics teachers as educators.

1. The Goals of Education

I identify a double purpose as to why societies establish educational systems:

- to promote citizenship (which prepares the individual to be integrated and productive in society), which is achieved by transmitting values and showing rights and responsibilities in society; and
- to promote creativity (which leads to progress), which is achieved by helping people to fulfill their potentials and rise to the highest of their capability.

The practice of education is in the present. The major challenge to educators is to manage, in this process, the encounter of the past and of the future, that is, the transmission of values rooted in the past, which leads to citizenship, and the promotion of the new, for an uncertain future, which means creativity. However, in this process, we must be careful. We do not want:

- to transmit docile citizenship—we do not want our students to accept rules and codes which violate human dignity, to be permanently frightened—instead, we want them to assume a critical attitude towards obedience;
- to promote irresponsible creativity—we do not want our students to become bright scientists creating new instruments to increase inequity, arrogance, and bigotry; we want them to be conscious of their acts and of the consequences of their creations.

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These are the goals that I hold important in education, hence in mathematics education.

The transmission of values is intrinsic to cultural encounters. The moment of cultural encounters has a very complex dynamic. This encounter occurs between people, as occurred in the conquest and colonization, and between groups. It also occurs in the encounter between the young man or woman who have his or her own culture and the culture of the school with which he or she identifies. The so-called civilizing process, which was carried on by the colonizers—and, we could say, by the school process—is essentially the management of this dynamic.

The promotion of the new must also be part of the school dynamic. Positive results of schooling manifest themselves in the creation of the new. However, regrettably it is frequent to see negative and perverse results which manifest themselves in the exercise of power and the elimination or exclusion of the most creative. This is the essence of the reflections that follow.

Education in this era of science and technology challenges the established approaches "validated" by results in standardized tests. The goals of education go much beyond merely preparing for professional success. Education has a responsibility in building up saner attitudes towards the self, towards society, and towards nature. Indeed, education has the responsibility of furthering creativity.

2. The Role of Mathematics Education

An important component of mathematics education is to reaffirm and, in many cases, to restore the cultural dignity of children. Much of the content of current programs is supported by a tradition alien to the children. On the other hand, children live in a civilization dominated by mathematically based technology and by unprecedented means of information and communication, but schools present an obsolete worldview.

It is equally important to recognize that improving the opportunities for employment is a real expectation that students and parents have of schools. However, preparation for the job market is indeed preparation for dealing with new challenges. There is no point in preparing children for jobs that will probably be extinct when they reach adulthood.[1] To meet the challenges of the new, self-esteem is essential. Self-esteem goes along with cultural dignity.

To acquire cultural dignity and to be prepared for full participation in society requires more than what is offered in traditional curricula. Particularly serious is the situation of mathematics, which is largely obsolete at the present in programs.

[1] For a discussion of labor in the future, see Robert B. Reich, *The work of nations: Preparing ourselves for 21st century capitalism*, Vintage Books, New York, 1992. Harsh views of the future of employment, revealing the inadequacy of current educational systems, can be read in Viviane Forrester, *The economic horror*, Routledge, New York, 1999.

Classroom mathematics has practically nothing to do with the world children are experiencing. To be literate nowadays means much more than reading and writing. Other codes are essential in daily life. Also, proficiency in mathematics means much more than counting, measuring, sorting, comparing, and solving typical problems, aimed at drilling. Even conceding that problem solving, modeling, and projects can be seen in some mathematics classrooms, the main importance is usually given to numeracy, or the manipulation of numbers and operations. Problems and situations, which are present in daily life, are new and unexpected.

I am aware of the fact that these remarks, mainly those in support of ethnomathematics, are interpreted by many as suggesting a reduction of the importance of mathematical contents. This is a grossly mistaken interpretation. We need more and better mathematical contents. Indeed, this means that much of the traditional contents which exhaust current programs should be drastically changed in their presentation. It is a big mistake to consider current mathematics contents in the curricula as something final, essential, and subordinated to criteria of rigor, which are also considered final and essential. Sameness in defining contents redirects innovation to new methodologies aimed at teaching the same, mostly inappropriate, contents. Energy in methodology should be addressed to making advanced mathematics attractive and teachable.

Compromising rigor to the benefit of generating interest and motivation cannot be interpreted as conceptual errors nor as relaxing the importance of serious, advanced mathematical contents in schools.

3. Why Teach Mathematics?

Mathematics is fascinating as a cultural endeavor. It is seen as the imprint of rationality and, indeed, it is the dorsal spine of modern civilization. All the spectacular achievements of science and technology have their basis in mathematics. In addition, the institutions of modern civilization, mainly economics, politics, management, and social order, are rooted in mathematics. It is no surprise that accomplished mathematicians are devoted to mathematics and that the many who tasted mathematics, even without accomplishment, sometimes even with failure, act as fiduciary of mathematics. Administrators, teachers, parents, students, and the population in general see mathematics as the principal subject in schools. Society regards those who do well in mathematics as geniuses. Those who fail are stigmatized.

When looking at mathematics education, we identify two positions: to use education as a strategy for teaching mathematics, defended by those described in the end of the previous paragraph, and to teach mathematics as a strategy for good education.

I like to use a metaphor. Position 1 sees mathematics as the center of the universe. This is the Ptolemaic version of education. Mathematics appears as the absolute goal. The energy, the Sun (i.e., the children), revolves around the cold and austere focus, the Earth, (i.e., mathematics)![2]

I fully identify with Position 2. As educators, the focus of our mission is on children, young adults, elderly adults, that is, people, who are the source of energy. In this Copernican view, the disciplines, cold and austere, revolve around people, the source of energy.

Is it a good strategy for a good education to have the disciplines, particularly mathematics, revolve around people? I believe so. However, what kind of mathematics?

Bertrand Russell and Albert Einstein said, in the *Pugwash Manifesto* (1955), that a new thinking is needed to achieve equilibrium and safety in a world menaced by war and fear. Is a similar plea to envision a new thinking in mathematics and mathematics education feasible?

4. Mathematics and Mathematics Education in a Changing Civilization

It is widely recognized that mathematics is the most universal mode of thought and that survival with dignity is the most universal problem facing humanity.

We have to look at history and epistemology with a broader view. The denial and exclusion of the cultures of the periphery, so common in the colonial process, still prevail in modern society. The denial of knowledge that affects populations is of the same nature as the denial of knowledge to individuals, particularly children. To propose directions to counteract ingrained practices is the major challenge of educators, particularly mathematics educators. Large sectors of the population do not have access to full citizenship. Some do not have access to the basic needs for survival. This is the situation in most of the world and occurs even in the most developed and richest nations. A new world order is urgently needed. Our hopes for the future depend on learning—critically—the lessons of the past.

When we look at the history of mathematics since the early mathematical manifestations of man, the attempts to compare, classify and organize, measure and count, and infer and conclude much before mathematics was formalized, we recognize mathematical ideas in the confluence of various modes of understanding, such as religion, the arts, the techniques, the sciences, that is, we must assume a transdisciplinarian posture, and we also need to look at all this in different cultural environments, in different traditions, that is, we must assume a transcultural posture.

With respect to cognition, history shows us that the emergence of modern science is closely associated with the recognition of an exclusive rational dimension of thinking. Recently, there has been acknowledgement of other dimensions in the capacity of reasoning and understanding. Multiple intelligences, emotional

[2] According to Bertrand Russell, "Mathematics possesses not only truth, but supreme beauty—a beauty cold and austere, like that of sculpture".

intelligence, spiritual intelligence, and numerous approaches to rationality have important consequences for education. Also, mental tasks performed by individual human beings are better understood thanks to the advances of artificial intelligence. For mathematics education, these advances strongly challenge the concepts of skill and drilling.

The enormous changes in society, particularly due to demographic dynamics, raise to unbearable levels the exclusion of large sectors of the population, both in developed and undeveloped nations. The same among nations which as a consequence of globalization are facing a tendency toward federation. The exclusion of countries of the benefits of progress and advancement is unsustainable. An explanation for the current perverse concept of civilization asks for a deep reflection on colonialism. This is not to place blame on one or another; this is not an attempt to redo the past. Rather, it is the moment to understand the past as a step to move into the future. To accept inequity, arrogance, and bigotry is irrational and may lead to disaster.

Since mathematics has everything to do with this state of the world, its autonomy in the curriculum and its central role as the dominating discipline and as an educational sphere in itself should be reconsidered. To paraphrase Mikhael Gromov (1998), we shall need for this the creation of a new breed of mathematical teachers able to mediate between mathematics and the other disciplines. However, current curricula, in all levels of education, look like a selection of non-overlapping sets. As a result, there is a lack of equilibrium between mathematical competence and a broader vision of the world and of society among teachers.

Curriculum is the strategy for educational action. An answer to my criticism of the lack of equilibrium is my proposal of literacy, matheracy, and technoracy (1999). It is a proposal for a curriculum based on developing a broad perception of the complexity of the world and of society and providing the instruments to deal with such a complexity. Literacy is the capability of processing information, such as the use of written and spoken language, signs and gestures, and codes and numbers. Nowadays, reading includes the competency of numeracy, the interpretation of graphs and tables, and other ways of informing the individual. Reading even includes the understanding of the condensed language of codes. These competencies have much more to do with screens and buttons than with pencil and paper. Matheracy is the capability of inferring, proposing hypotheses, and drawing conclusions from data. It is a first step towards an intellectual posture, which is almost completely absent in our school systems. Matheracy is closer to the way mathematics was present both in classical Greece and in indigenous cultures. The concern goes far beyond counting and measuring. Matheracy proposes a deep reflection about man and society. This is the central idea behind the origins of mathematics. It should not be restricted to an elite, as it has been in the past, but should be conveyed by education. Technoracy is the critical familiarity with technology. Of course, the operative aspects of it are, in most cases, inaccessible to the lay individual. However, the basic ideas behind technological devices, their possibilities and dangers, and the morality supporting the use of technology are essential issues to be raised among children at a very early age. History shows us that ethics and values are intimately related to technological progress.

The three constitute what is essential for citizenship in a world moving swiftly towards a planetary civilization.

Reference

D'Ambrosio, U. (1999). Literacy, matheracy, and technoracy: A trivium for today. *Mathematical Thinking and Learning*, 1, 2, 131–153.
Gromov, M. (1998). Possible trends in mathematics in the coming decades. *Notices of the AMS* (p. 847).

Chapter 3.2
Toward a More Complete Understanding of Practice-Based Professional Development for Mathematics Teachers

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Teacher educators, professional developers, and researchers have recently shown great interest in the design and facilitation of an approach to mathematics teacher education that is commonly called practice-based professional development (PBPD). At the conceptual and operational heart of PBPD one finds professional learning tasks (PLTs)—activities that are situated in and organized around components and artifacts of instructional practice that replicate or resemble the work of teaching. PLTs are often built around artifacts of practice such as curriculum materials, video or narrative records of classroom teaching episodes, and samples of student work. In particular, video and narrative cases (e.g., Smith, Silver, & Stein, 2005) have been extensively used in PBPD.

PLTs provide stimuli and opportunities for teachers to develop and refine the knowledge needed in pedagogical practice (Ball & Cohen, 1999). PLTs make the work of teaching (e.g., designing, preparing to teach, or enacting classroom lessons or larger units of instruction; analyzing evidence of student thinking from verbal statements or written products) available for investigation and inquiry. A common underlying characteristic of PLTs is that they provoke teachers to treat a particular situation as problematic. Helping teachers discern the problematic component of the task and consequently own it and see it as meaningful is a critical aspect of the work that goes in the design and facilitation of PLTs. The highly contextualized nature of these tasks is intended to allow teachers to propose, debate, and consider solutions to pedagogical dilemmas and explore pedagogical possibilities as they move back and forth between past and current teaching experiences and the activity space of the professional development experience (see **Fig. 3.2.1**).

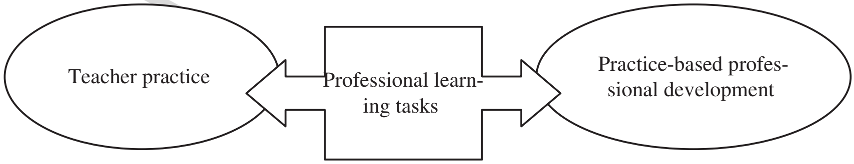

Fig. 3.2.1 The role of professional learning tasks

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Many scholars have pointed to the potential benefits of having teachers learn in and through professional practice (e.g., Ball & Bass, 2003; Ball & Cohen, 1999; Lampert, 2001; Smith, 2001; Stein, Smith, Henningsen, & Silver, 2000). At this time the theoretical development of ideas related to PBPD and PLTs has far outstripped the empirical evidence base. The time is ripe for empirical investigations of practice-based professional development that can contribute to the currently impoverished evidence base.

Two distinctive features of PBPD lie at the core of claims regarding its anticipated efficacy:

1. Unlike conventional approaches to professional development, PBPD treats mathematics content, mathematics pedagogy, and student thinking in an integrated manner. Advocates argue that this treatment of knowledge domains is similar to the way that they appear in the actual work of mathematics teaching, thereby increasing the likelihood that teachers will acquire knowledge that is useful and usable in their practice (Smith, 2001).
2. PBPD learning experiences are highly connected to and contextualized in professional practice settings, and advocates for this approach argue that this results in useful and usable knowledge that builds mathematics teachers' capacity for the kinds of complex, nuanced judgments required in mathematics teaching (Ball & Bass, 2003).

One can generate a number of questions that could stimulate productive research inquiry by considering critically each of these distinctive features of PBPD.

When teachers engage in PLTs that deliberately entangle aspects of mathematics content, pedagogy, and student learning, we can ask, "What are they learning?" and "How do we know?" Despite the general appeal and hypothesized benefits of learning in and from practice through engagement with PLTs, little is known about if and how teachers actually learn mathematics or pedagogy in such settings. How does PBPD provide opportunities for teachers to acquire mathematics knowledge for teaching? How does PBPD provide opportunities for teachers to become more pedagogically proficient? What characteristics of PLTs (e.g., task design), and associated features of professional development (e.g., facilitation), appear to support or inhibit teachers' learning of mathematics or pedagogy? What forms of evidence are adequate to make claims about such learning?

Consider, for example, the matter of teachers learning mathematics through PBPD. Ball and Bass (2003) argue persuasively that "...mathematical knowledge for teaching has features that are rooted in the mathematical demands of teaching itself" (p. 4). Thus, we can hypothesize that PBPD using PLTs can develop the mathematical knowledge that teachers need in their instructional practice. Because professional learning tasks simulate and emulate the demands of teaching practice, the strong potential benefits of knowledge gained in this way are clear. Thus, PLTs may be particularly well suited to serve as tools to assist teachers to learn to use mathematics in the ways they will do so in practice—such as interpreting, making mathematical and pedagogical judgments about, and formulating useful responses to students' questions, solutions, difficulties and insights—as well as to serve as activities that strengthen and deepen their understanding of important mathematical ideas. The theoretical basis for such claims is clear, but empirical evidence is lacking to support, refute. or modify the claims.

Turning to the second distinctive feature of PBPD—its highly contextualized nature—we can identify additional questions for research. How do teachers move from the particularities associated with specific PLTs to more general ideas, understandings, or principles that can be applied to instructional settings or demands that differ from those in the PLTs? What characteristics of PLTs, and associated features of professional development (e.g., facilitation), appear to support or inhibit teachers' application of knowledge from PBPD settings to their own instructional practice? What forms of evidence are adequate to make claims about the usefulness and usability of knowledge gained by teachers in PBPD settings? Investigations provoked by these and similar questions should help the field make progress—not only allowing refinement of the theoretical basis for PBPD but also stimulating practical improvements in this very promising approach to teacher education.

Reference

Ball, D. L., & Bass, H. (2003). Toward a practice-based theory of mathematics knowledge for teaching. In B. Davis, & E. Simmt (Eds.), *Proceedings of the 2002 annual meeting of the Canadian Mathematics Education Study Group (CMESG)*. Edmonton, AB: CMESG.

Ball, D., & Cohen, D. (1999). Developing practice, developing practitioners. In L. Darling-Hammond, & G. Sykes (Eds.), *Teaching as the learning profession* (pp. 3–32). San Francisco: Jossey-Bass Publishers.

Ball, D. L., Hill, H. C, & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*, 14–46. AQ1

Lampert, M. (2001). Teaching problems and the problems in teaching. New Haven, CT: Yale University Press.

Smith, M. S. (2001). *Practice-based professional development for teachers of mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Smith, M. S., Silver, E. A., & Stein, M. K. (2005). *Improving instruction in algebra: Using cases to transform mathematics teaching and learning* (Vol. 2). New York: Teachers College Press.

Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. A. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development*. New York: Teachers College Press.

Chapter 3.2

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Chapter 3.3
Public Writing in the Field of Mathematics Teacher Education

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Mathematics teacher education can be seen as directly related to activity in mathematics classrooms and the success (or other) of students learning mathematics worldwide. In what ways does what is published in the field of mathematics teacher education inform us about key question and issues, about programmes for educating teachers, and about research findings? We refer specifically to an International Congress on Mathematical Education (ICME) survey (with Adler as chair) and to the *Journal of Mathematics Teacher Education* (JMTE), the leading journal in the field (with Jaworski as editor in chief).

1. Defining the Scope and Nature of the Field: an Icme 10 Survey

In July 2004, an international team of five mathematics educators and researchers presented the results of their survey of research in mathematics teacher education from 1999 to 2003, during a plenary session at ICME 10, in Copenhagen. The details of the survey have since been published in *Educational Studies in Mathematics* (November 2005), and the authors conclude that the survey provides a vantage point from which to reflect on the current state of the field of mathematics teacher education research.

Briefly, the survey included published research in international mathematics education journals, international handbooks of mathematics education, and international mathematics education conference proceedings. Some regional sources from various parts of the world were also included. The investigation focused on who was writing, from and in what settings, with what theoretical frameworks, and with what sorts of study designs for what core questions. The range of findings and conclusions produced in these studies were also examined. Four themes stood out from the initial investigation of almost 300 published papers. These themes were then systematically elaborated through a focused study of a 160 papers across two key journals in the field (*JMTE* and the *Journal for Research in Mathematics Education* [JRME]) and a key set of conference proceedings (*Psychology of Mathematics Education* [PME]). Four substantive claims were made, evidenced, and commented on from different perspectives. Here we summarise rather than debate these claims.

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Claim #1: Small-scale qualitative research predominates. The authors clarify that by small-scale qualitative research they include research that focuses on a single teacher or on small groups of teachers ($n<20$) within individual programmes or courses. They explain that the systematic analysis of the 160 papers referred previously revealed that there were fewer than 20 teachers in close to 70% of the studies reported. In short, a significant percentage of papers surveyed were small case studies.

Claim #2: Most teacher education research is conducted by teacher educators studying the teachers with whom they are working. In addition to most studies being small case studies, the survey also revealed the phenomenon of what some would call "insider" research—where researchers have some direct involvement and thus some interest in the case being studied. Of articles representing research that focuses on teacher education between 1999 and 2003, 90% of *JMTE*, 82% of *PME*, and 72% of *JRME* articles were of this type.[1]

Claim #3: Research in countries where English is the national language dominates the literature surveyed. The following figures were presented to substantiate this claim. In *JMTE* between 1998 and 2003, 80% of the articles are from such countries. In *JRME* this figure is 71%. It is less stark, but nevertheless prevalent, in *PME* between 1999 and 2003, when the percentage is 43%. One effect posited was that questions that come to constitute the research field are driven by concerns in particular contexts and thus might not reflect the diversity of problems in teacher education that exist globally. This was a controversial and contested claim, both at the ICME 10 Congress after the presentation, as well as during discussion after our presentation at the 15th ICMI study conference. The objection was that this is self-evidently skewed by the journals and conference proceedings focused upon, as these were English-language journals. We will not take the debate further here but rather ask: are the questions that drive mathematics teacher education research appropriate across diverse cultural contexts and conditions?

Claim #4: Some questions have been studied extensively, while other important questions remain unexamined. The survey noted that much of the research, particularly in the United States, was concerned with reform and involved efforts to show that particular programmes of teacher education "work". As a field, we are more informed about teachers learning or relearning mathematics, teachers learning about students' thinking, their language, their orientations, and pedagogical practices. As a consequence of the focus on reform, however, we know much less than we should about teachers' learning from experience: what they learn, whether they learn, and what supports learning from experience. We also know too little about teachers' learning to directly address inequality and diversity within their teaching of mathematics, and we lack comparisons in the field of different opportunities to learn. Finally, we have done much less studying of what it means to scale up a programme or extend a programme that has worked in one setting to another setting.

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[1] As there were only seven *JRME* papers between 1999 and 2003 that fit our survey, this percentage can only be regarded as a very rough measure.

2. The Journal of Mathematics Teacher Education

It seems clear from reports from the survey that *JMTE* is an important publishing resource in our area. Its mission statement reads as follows:

> The Journal of Mathematics Teacher Education is devoted to research into the education of mathematics teachers and development of teaching that promotes students' successful learning of mathematics.
>
> JMTE focuses on all stages of professional development of mathematics teachers and teacher educators and serves as a forum for considering institutional, societal and cultural influences that impact on teachers' learning, and ultimately that of their students.
>
> Critical analyses of particular programmes, development initiatives, technology, assessment, teaching diverse populations and policy matters, as these topics relate to the main focuses of the journal, are welcome.

JMTE is a young journal: at the time of this writing, the tenth volume had just been completed. The journal has an acceptance rate of 18% for research articles. The contents of *JMTE* are compiled mainly from submitted articles in two categories: accounts of relevant research and accounts of teacher education programmes around the world. The latter has been established to encourage publication from a wide range of countries. However, papers come mainly from the developed world, with a high proportion (>50%) from North America. Nevertheless, the journal invites papers from all countries and works hard to help non-English-speaking authors complete a paper in English. In addition, *JMTE* publishes special issues, either compiled from submitted papers that centre around one important topic area (an example was "community" in *JMTE* 6, 3) or a topic area proposed by a prospective guest editor and accepted by the editorial team (e.g., "Relations between theory and practice", *JMTE* 9, 2). Most recently, a special triple issue (*JMTE* 10, 4–6) was completed, focusing on the nature and role of tasks in mathematics teacher education.

In accordance with the survey, most research articles report small-scale qualitative research that comes largely from teacher educators researching their own practice. From the volumes so far we see evidence of a developing field from papers in which research provides evidence of individual teacher or small teacher group development within a particular programme;

- that a learning community exists or is developed;
- that teachers engage in critical inquiry, reflective practice, or action research;
- that a teacher education programme links closely with the practice field;
- of teachers and teacher educators working side by side in and out of school; and
- that teachers or student teachers learn from engagement in research.

In all cases there is evidence of deep learning and changes to practice. It is clear that such research both documents learning in practice and, in many cases, contributes to that learning. Editors and reviewers look for a suitably critical stance from authors reporting research into their own practices or programmes. Nevertheless, we should ask what endures and grows from these published accounts. What can take the field beyond the local and special-case nature of such research? How is it possible to generalise from such studies? What methodologies will provide larger-scale evidence of teacher learning and developmental approaches that result in better teaching and learning? What theory can we see emerging from research in the field? There is a wide range of theoretical models or frameworks for developmental practice or to explain or analyse teacher and teaching development. However, there are, as yet, no "grand" theories to compare, for example, with theories of learning, such as constructivism or sociocultural theories. Indeed, attempts to distil guidelines for practice from learning theory have resulted in pseudo-theoretical appellations ("constructivist teaching" is one common example), which have no substance or credibility in the practical world.

Rightly, the world of practice expects more from research than can be seen currently; however, the nature and prevailing conditions of and for research militate against fulfilment of such expectations. Political short-termism, local and national, perpetuates the status quo: teacher educators are required to publish; large research teams are difficult to convene and fund; longitudinal studies are both expensive and, crossing different administrations, not always politically compatible. Developmental sustainability beyond the end of a project is accordingly difficult to enable. However, there are deeper issues in the field that we have to consider before changes in policy can be expected to change the developmental landscape.

3. Research Programmes

In response to the previous discussion, we end with a focus on two areas of research that are starting to address some of the key issues raised.

3a. Mathematics for Teaching

An interesting observation from the survey and an overview of *JMTE* is that in the current foci in mathematics teacher education research, the specificities of mathematics recede. Here we bring mathematics back into focus through a discussion of what elements of a research programme will take forward the field of mathematics teacher education research.

What mathematics is selected into mathematics teacher education courses and programmes, be these mathematic courses, or mathematics methods courses? How is this mathematics taught and evaluated and with what effects on teachers' (both prospective and practising) learning mathematics and mathematical know-how pertinent to the demands of teaching? Generally referred to as mathematics for teaching, there is now a growing interest in describing the specificity of the ways teachers need to know and be able to use mathematics effectively in their teaching and the opportunities teachers are provided for learning this situated or professional knowledge. There is a growing appreciation that this kind of mathematical focus and learning is left to the vicissitudes of practice. Just as we know that in school there are gaps between curriculum intentions, implementation, and attainment, we need to acknowledge that even in programmes where there is a focus on what is becoming valued as mathematics for teaching, we need empirical studies on such, what comes to be learned, by whom, and with what effects. One such study (the QUANTUM research project), in South Africa, for example, has revealed a range of pedagogic modalities at work through a cross-case analysis of different sites of formalised in-service programmes. The ways in which mathematics and pedagogy are integrated differ across courses and provide different (and potentially inequitable) opportunities for learning mathematics for teaching (Davis, Adler, & Parker, 2007). Moreover, through a focus on assessment that mathematics courses specifically designed for formalised in-service teachers in these programmes rarely required teachers in these courses to demonstrate competence in reasoning mathematically neither in relation to a particular mathematical idea or concept nor in relation to how this might be done and so responded to by the teacher (Adler & Davis, 2006). We need to know a great deal more about the kinds of mathematical learning opportunities afforded in both formal and informal sites of teacher education so as to be able to improve the quality of teacher education, particularly in relation to what and how mathematics is selected, taught, and assessed.

3b. Research Partnerships Between Teachers and Educators

The survey and *JMTE* experience show the scarcity of long-term research programmes in which development can be studied. Setting this alongside a scarcity of research linking teacher education to the learning of mathematics in classrooms, a study in Norway, currently in its fifth year, offers potential significance. Here, teachers and educators (didacticians) work together to study development of mathematical learning activity in classrooms through the creation of inquiry communities. Both groups bring important knowledge and experience to the research interface that forms the basis of community; both engage in inquiry to introduce and explore innovative practices and challenge traditional classroom approaches. Original funding for four years from the Research Council of Norway has been extended to four more years, and the original team in one city and university has extended to five locations in Norway. At the end of the first four years, findings show significant development for individual teachers or groups of teachers in project schools and clear evidence of pupils' engagement in practices that motivate students and foster mathematical understanding. The locus of power in the early years has rested with didacticians, teachers taking time to find a voice and influence the directions of activity. Institutional and sociocultural factors also have dominated practices for teachers, often working against preferred practices within the project. More recently, schools have sought and attracted their own funding, and school leaders, together with didacticians, design activities and take responsibility for their operationalisation in institutional settings. In each of the five locations we see substantial teams of didacticians and a range of participating schools. Funding from the research council is matched by local funding from a range of sources. The scale of this research and the potential it creates for development is a result of ambitious design, adequate (although not generous) funding, a sincere will to develop partnerships with shared power and responsibility and a long-term vision. In these respects the Norwegian research is addressing several of the concerns reported previously (Jaworski et al. 2007).

There seems to be a necessity for seeking out and reporting from projects that are starting to address the issues raised, particularly those with large-scale and long-term funding, as a basis for encouraging this longer-term vision.

Reference

Adler, J., & Davis, Z. (2006). Opening another black box: Researching mathematics for teaching in mathematics teacher education. *Journal for Research in Mathematics Education*, 37, 4, 270–296

Davis, Z., Adler, J., & Parker, D. (2007) Identification with images of the teacher and teaching in formalised in-service mathematics teacher education and the constitution of mathematics for teaching. *Journal of Education*, 42, 33–60.

Jaworski, B., Fuglestad, A. B., Bjuland, R., Breiteig, T., Goodchild, S., & Grevholm, B. (2007). *Learning communities in mathematics*. Bergen, Norway: Caspar Forlag.