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# TWG19: Mathematics teachers and classroom practices

## **Introduction to the papers of TWG19: Mathematics teachers and classroom practices**

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### **Introduction**

TWG19 is one of three TWGs at CERME10 dealing with issues related to teaching and teacher education (the others being TWG18 and TWG20). The group is particularly interested in studies that aim to understand the development of classroom practices and teachers' contributions to them. This includes the roles of other factors such as the available teaching-learning materials, modes of teacher collaboration at and beyond the school(s) in question, and school cultures as they relate to, for instance, teacher-student relationships, teachers' individual and communal responsibilities, and the role of curricular materials and testing. Finally, studies concerned with how micro-level interactions are informed by macro-level structures (society, culture and the political) are also of TWG19's interest.

A total of 27 contributions were initially submitted (26 papers and 1 poster), involving authors from at least 14 different countries, primarily in southern or northern Europe. The papers were grouped in five thematic areas, each assigned to one of the five team leaders for overseeing the reviewing process. Each proposal was reviewed by a team leader and two authors, and 24 contributions (22 papers and 2 posters) were accepted for presentation at the conference. Participants were expected to read the papers before the conference sessions. In the time slot allocated to each group of papers, the authors each gave a short presentation (5–7 minutes), sketching the key ideas of the work reported. This was followed by a reflection by the group leader on common themes and cross-cutting issues (15 minutes), which were subsequently discussed by the participants in small groups. Ultimately, 22 papers and 1 poster are included in the conference proceedings.

The five thematic areas according to which the TWG19 contributions were grouped are: (a) problem solving and general issues related to teaching practice, (b) lesson planning, lesson study and curriculum, (c) instructional quality and assessment, (d) in-the-moment teaching actions and decision making and reflection and (e) instructional practices. In the next two sections, we discuss the contributions first within and then across these thematic areas.

## Substantive issues

In this section we present research considerations and concerns in the papers in each group, including the range of theoretical perspectives and methodologies employed.

### (a) Problem solving and general issues related to teaching practice

Dominant perspectives on the teachers' knowledge have changed and now focus on content knowledge closely connected to the profession. This is fueled by current reform initiatives that emphasise processes of mathematics, for instance in terms of problem solving.

Three of the four papers in this section deal with problem solving. The paper by Kleve and Ånestad concerns a Norwegian teacher, who seems inspired by a process view of mathematics. The class works with subtraction and initially uses informal mental strategies. The authors argue that there is a need to link such methods to a standard algorithm, that the flexible use of both methods is needed, and that it should become socio-mathematical norm that both are acceptable. However, the teacher's mathematical knowledge for teaching seems too weak for her to support the students in the transition from informal strategies to standard procedures. This makes it impossible for her to support socio-mathematical norms in line with the reform.

Odindo's study from Kenya is based on the expectation that problem-solving approaches may alleviate secondary students' difficulties with their final exams. He uses Learning Study (LS) to support teachers in using problem solving when teaching algebra. The paper to some extent focuses on the students, but mainly asks what the learning opportunities are for the teachers. Odindo argues that the LS format allows teachers to consider general issues of, for instance, time management, but also to focus on patterns of task variation closely related to the contents. At least implicitly, then, the paper is concerned with how LS may support mathematical knowledge for teaching.

The study by Villalonga and Andrews is also on problem solving, but less on mathematical knowledge for teaching. In fact, the teacher is conspicuously absent, as the paper deals with how Catalan students may self-scaffold when engaged in problem solving. The students use a resource, an Orientation Base (OB), which is to help them monitor their problem solving. The teacher is almost obsolete, and the OB may be read as a response to the problem that many teachers find it difficult to support their students' problem solving. OB may be seen as an attempt to circumvent this difficulty and transfer responsibility to the students.

The last paper in this group, by Mosvold and Hoover, report on a literature review of studies on mathematical knowledge for teaching. The 12 studies in the review address questions of what, how and why such knowledge plays a part for the quality of instruction. The studies argue that mathematical knowledge for teaching is important for instance for teachers' selection and adaptation of tasks, for their planning of instruction, and for how they listen to students and pursue student thinking. Based on the review, however, Mosvold and Hoover argue that the results are mixed and that there is a need to shift the emphasis towards more dynamic understandings of the relationship between mathematical knowledge for teaching and teaching.

The discussions of these papers focus on what it may mean to adopt a dynamic perspective on the knowledge-teaching relationship. How, then, we may change the emphasis from teacher characteristics (e.g., their knowledge or beliefs) to the acts of teaching? The latter perspective

requires greater attention to issues of context, to what we mean by practice, and possibly to alternative frameworks that allow us to reconsider what we mean by knowledge.

### **(b) Lesson planning, development and curriculum**

This group of papers focuses on planning for teaching, utilizing lessons learned in other contexts, and dealing with curricula and textbooks. Four papers approached these issues.

In her case study of a Swedish mathematics teacher, Grundén targets the practice of planning. Reflecting on her own planning, the teacher conceptualizes planning as making informed decisions regarding the teaching of the mathematical content in different contexts, and she relates planning to other practices of the teacher as well as practices of other teachers. Relating to the practice of other teachers is also an issue in the study of Runesson Kempe, Lövström and Hellqvist, who investigate how experiences from a Learning study can be shared and used by teachers in other contexts. Applying the results from a previous Learning study in new classrooms, the authors investigate some necessary conditions for learning about negative numbers and indicate possibilities for cultivating more effective professional practice in mathematics classrooms.

Although development and change in mathematics teaching might be teacher-driven, it is sometimes prescribed by curriculum reforms. Klothou and Sakonidis investigate the implementation of a new curriculum reform among primary mathematics teachers in Greece. They argue that contradictions in teachers' own discourses can be explained by recontextualization procedures that appear when teachers attempt to implement the reform, and inconsistencies may abide in the very discourses that teachers draw upon. Whereas some countries have official textbooks that everyone must use, French teachers are free to decide if they want to use a textbook and how – if they adhere to the national curriculum. In their study on how two experienced French teachers use and adapt the content of mathematics textbooks and teacher manuals, Priolet and Mounier analyze how the teachers use the same textbook when teaching the same mathematical content. None of them follow the recommendations from the textbook completely in their lesson, and the adjustments they make tend to reduce the difficulty of textbook tasks.

These four papers provide compelling glimpses into the complex work of teaching mathematics. They discuss how authorities, schools and other teachers may provide resources that are intended to support the work of teaching, and how adapting and using such resources introduces mathematical, didactical and social demands on teachers' work. Mathematical knowledge for teaching can be described as knowledge required to deal with such demands (Ball et al., 2008), and these four papers thus indirectly contribute to investigating more dynamic relationships between knowledge and teaching.

### **(c) Instructional quality and assessment**

The five papers in this thematic group describe qualities of teaching. Three papers concern instrument development for assessing qualities. One such instrument is the Realization Tree Assessment tool (Weingarden, Heyd-Metzuyanım & Nachlieli). This tool is particularly interesting in the way it reduces the complexity of the lesson into a picture of the mathematical concepts discussed in order to describe qualities of the lessons. This picture organizes mathematical ideas related to what Sfard (2008) calls saming and objectification. A second instrument presented is an innovative tool to observe, describe and evaluate metacognitive practices in mathematics

(Nowinska & Praetorius). Six out of the seven dimensions developed had highly reliable ratings. A third instrument developed by Jentsch and Schlesinger starts from three established dimensions (classroom management, personal learning support, cognitive activation) and aims at adding a subject-specific dimension. This dimension includes nine characteristics – such as teachers' mathematical correctness, explanations and mathematical depth – and produces results with good interrater agreement and satisfying reliability measures.

In addition, two papers study qualities of teaching using observation and interviews. Tuset investigates pre-service teachers trying ambitious teaching, allowing students to exercise authority while staying accountable to the discipline. The study finds that the pre-service teachers are able to create opportunities to engage in explorative discourses, but that their talk moves seem to be ritualized and therefore constrain students' participation. Kaldrimidou, Sakonidis and Tzekaki attempt to identify crucial elements shaping classroom mathematical meaning construction. To achieve this, they study three highly motivated and professionally active teachers' instructional practices and reflections. Findings reveal that the teachers' choices restrict the mathematical meaning because they desire to provide an easy, safe and pleasant learning environment.

These five papers illustrate two main issues for further research. The first issue regards the challenges of low and high inference observations. Low inference observations, like talk moves, explain little in themselves. On the other hand, high inference observations require extensive rater training that might result in simplification and even ritualization of the rating. What could we lose then? The second issue is that these articles illustrate the need for an instrument review. Which instruments are available for assessing qualities of teaching, what do they intend to measure, what theories do they build on, how reliable are they, and how much data and extent of rater training is needed to make them reliable?

#### **(d) In-the-moment teaching actions and decision making and reflection**

The studies in this group address mathematics instruction in a variety of ways: as teachers' management of actions and moments determining students' learning (Ferreira & da Ponte); as an activity shaping and being shaped by teachers' professional enactment in intervention or reform settings (Stouraitis; Sterner); as a practice being intentionally problematized to support teachers to develop (Potari & Psycharis; NicMhuirí). A different approach is to distinguish between papers that look at mathematics instruction as a learning-to-teach site through scrutinizing yourself or others acting it (Ferreira & da Ponte; Potari & Psycharis), as a professional activity developed through collaborative action (Sterner; Stouraitis), or through individual reflection via literature (NicMhuirí).

A range of theoretical or conceptual frameworks – mostly of sociocultural origin – are at work in the studies reported, and reflection (on teaching practice) and collaboration are at heart of these frameworks. In particular, NicMhuirí employs a reflective practitioner's perspective in combination with a model allowing for levels of teachers' reflection to be identified. Reflection is also of concern in Potari and Psycharis' work operationalized through the construct of 'critical incidents' within a community of inquiry framework. The theoretical underpinnings of the community of practice approach are adopted by Steiner, with reflection being seen this time as a professional learning enterprise developing collaboratively. Drawing on a CHAT perspective, Stouraitis views reflection as an aspect of teachers' decision making which interacts with teaching activity. Finally,

the study by Ferreira and Ponte employs features related to tasks assigned to the students and the communication established in the classroom to evaluate teaching actions.

Most papers in the group report on small, qualitative studies. Empirical data include observations of teaching, meetings and/or interviews audio-taped and transcribed. These data are predominately analyzed based on categories indicated by the literature (content analysis) or by the data themselves (grounded theory like analysis). One study uses no data, but analyzes two empirically tested constructs to exemplify the tool indicated (NicMhuirí). The results of the studies highlight various levels of mathematics teaching interacting with teachers' professional activity.

Overall, the studies in the group seek to understand how mathematics classroom teaching feeds teachers' professional practice, focusing on teachers inquiring into specific aspects of it. The relevant discussions carried out during the conference sessions raised concerns about the clarity of the terms and constructs used, the appropriateness and the functionality of the theoretical frameworks employed, and the boundaries between teaching action/practice and teacher practice.

### **(e) Instructional practices**

The four papers in this thematic group approach instructional practices from different sociocultural perspectives. Two papers investigate teacher change during professional development programs. In particular, Venkat and Askew employ variation theory and example spaces to understand how teachers mediate primary mathematics, mainly how they generate and validate solutions as well as build mathematical connections. Şeker and Ader, on the other hand, focus on maintaining the cognitive demand of mathematical tasks, teachers' attention to students' mathematical ideas and intellectual authority in the classroom. Using the aforementioned frameworks makes it possible to illuminate different aspects of teacher practices that seem to improve based on research recommendations. Future research concerning both papers may entail a close look into the nature of professional development that influences instructional practices.

The paper by Baldry focuses on the development and viability of an analytical framework aiming to understand a 'typical' mathematical classroom in the United Kingdom. The analytical framework *Orchestration of Mathematics* portrays the quality of mathematics orchestration combining several theoretical constructs including cognitive demand of mathematical tasks, sociomathematical norms, hypothetical learning trajectories and professional noticing. The framework thus seems closely related to the scheme of analysis adopted by Şeker and Ader. A common theme of the two studies is teachers' difficulty in noticing and building on student thinking as well as maintaining cognitive demand of the tasks.

The importance of discourse in understanding instructional practices is evident across all papers. Drageset and Allern use drama as an innovative tool, allowing students to gain mathematical authority and engage in productive discourse patterns in making sense of mathematics. Instructional practices shaped and were shaped by student participation and responses. Future consideration for this work is to explore how teachers might implement such drama-based interaction patterns in their classrooms with the help of teacher educators.

A general trend identified in this group is using interviews together with observational data to understand teacher instructional practices, including teacher decisions and professional noticing abilities, closely connected with student participation and sociocultural norms. It would be

productive to define boundaries of instructional practices and how to incorporate pre- and post-observation interviews with teachers in analysing relevant data.

## **Trends and developments**

The studies in TWG19 address a wide range of features and factors that regulate the quality and development of classroom mathematics teaching as well as its relation to teachers' professional growth. A systematic attempt to understand, assess and trace contributions to teacher and classroom practices can be identified across the papers. Issues pursued along each of these three directions are discussed below. The section concludes with some critical considerations related to the studies hosted by TWG19.

In trying to understand teachers and classroom practices, some of the studies look at mathematics teaching in challenging circumstances (e.g., Kaldrimidou et al.; Kleve & Ånestad; Priolet & Mounier). Their results suggest that adapting teaching to effectively respond to such occasions is a difficult endeavor often leading to poor and even contradictory teaching practices. Teaching is also seen in relation to teachers' professional knowledge and practices/perspectives, with the relevant studies indicating a complex but dynamic and fertile relationship (e.g., Mosvold & Hoover; Grundén; Stouraitis). Finally, some studies consider the influence of contextual factors upon teaching practices (e.g., Baldry; Venkat & Askew). The findings reveal teachers' difficulties in administering the mediational role of these factors in order to develop effective teaching practices.

The qualities of teachers and classroom practices are assessed by focusing quantitatively or qualitatively on subject-specific rather than generic features. Studies adopting quantitative instruments highlight the value of such approaches when able to assess high inference valuations with the necessary inter-rater agreement (e.g., Jentsch & Schlesinger; Nowinska & Praetorius). The qualitative instruments, like interviews and observations (e.g., Weingarden, Heyd-Metzuyanim & Nachlieli; Tuset), found to face the same challenges of assessing high inference valuations. To do this with trustworthiness, the qualitative research typically focuses on depth of scrutiny rather than inter-rater agreement.

Certain ways of contributing to teachers and classroom practices are identified in the papers, mainly in some form of collaboration, reflection or intervention. In particular, opportunities to collaborate with other teachers to explore various aspects of teaching mathematics seem to offer possibilities for teachers to develop their professional practice (Sterner; Runesson Kempe et al.; Odindo). Teachers' reflection on classroom practice is a central constituent of this collaboration facilitated by inquiry tools. When exercised on varied levels and at specific aspects of classroom practice, affordances and constraints of this practice become evident (NicMhúirí; Psycharis & Potari). The latter appears to be also the outcome of intervention studies supporting teachers to transfer more learning responsibilities to students (Drageset & Allern; Şeker & Ader; Villalonga & Andrews).

The research activity on teachers and classroom practices included in TWG19 reflects some interesting steps forward, but it also reveals at least five sets of issues in need of critical consideration. Firstly, issues related to the methods adopted, for instance, the issue of generalizing across contexts, the role of using multiple methods, and the (dis-)advantages of different teacher-researcher relationships. Secondly, concerns about the theoretical frameworks employed, for example, selection criteria, levels of generality targeted, issues of compatibility, questions (not)



addressed, ‘own’ frameworks. Thirdly, there is a need to carefully consider concepts and terms used. For instance, terms like ‘practice’, ‘context’ and even ‘teaching’ need clarification, whereas constructs like ‘stability of knowledge’ require further consideration. Fourthly, it is important to adopt clearly defined criteria for assessing the quality of teaching with reference to the learning of mathematics achieved as well as the wider educational goals targeted. Finally, it is necessary to consider quality criteria for research adopted, contribution to theory or practice, coherence, and sufficiency of evidence to warrant an empirical claim.

### **Concluding remarks**

The work reported in TWG19 is part of the research on mathematics teachers and classroom practices developed in recent years employing a predominately sociocultural perspective. Within this perspective, teaching is seen as a social practice in which teachers are practitioners (Jaworski, 2006). Classroom practices are viewed as regular activities and norms continually developed by teachers’ involvement in multiple simultaneous activities, “taking into consideration working contexts, meanings and intentions (...) the social structure of the context and its many layers – classroom, school, community, professional structure and educational and social system” (Ponte & Chapman, 2006, p. 483). These activities mutually structure and frame each other to constitute the practice of the classroom (Skott, 2013).

There is a range of issues addressed by the studies reported that concern teachers’ contribution to classroom practice in various contexts, mostly related to critical aspects of instruction-in-action and teachers either inquiring into their own teaching or working towards developing it. Collectively these contributions appear to suggest that it is valuable to shift the emphasis in this line of research from teachers to teaching. Several theoretical and analytical frameworks are used often in combination (rather than in coordination) providing multiple lenses through which certain constructs (rather than structures) are examined within particular contexts. Along the same line, different methodological approaches are pursued, mainly qualitative, seeking to capture the complexity and richness of the practices unfolding within mathematics classroom life shaping students’ learning of mathematics and teachers’ learning to teach mathematics alike. The findings of the studies offer some notable insights into this shaping, highlighting the importance of focusing on the micro-level of classroom practice, on the resources teachers draw on as they engage in it, and their (intentional or unintentional) professional activity.

The plurality of theoretical perspectives, constructs and analytical tools employed in the studies of teacher and classroom practice reported in TWG19 underline the dynamics of the research activity aiming at ‘unpacking’ teaching practice. It might be the time for the research community working in this area to consider what is already known, what is to be further examined and to develop on the basis of this evaluation a research agenda to fill the gaps. How different tools may be used considering different theoretical perspectives, decisions of whether to use an existing tool or to develop a new one and how to report the added value of using different tools require special attention in moving forward. To this end, the emphasis should be on teaching rather than on teachers, as suggested by the work presented and discussed in the context of the conference sessions.

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