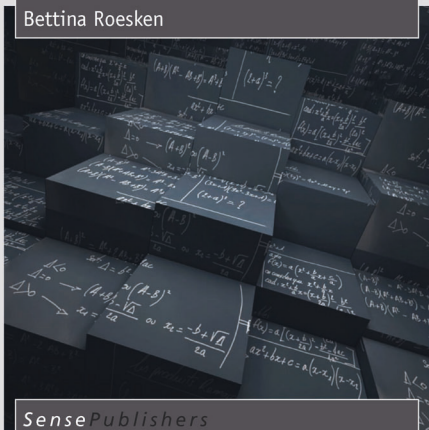


Hidden Dimensions in the Professional Development of Mathematics Teachers

In-Service Education for and with Teachers

Bettina Roesken



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INTRODUCTION

The professional development of teachers is a highly relevant topic at this time, when calls for school improvement are on the daily agenda. Since mathematics has been assigned a key role for future innovation, moreover building the basis subject for many other disciplines, professional development of mathematics teachers is implicitly in the focus of any reform endeavor (Sowder, 2007; Lerman, 2001).

International comparisons like TIMSS and PISA have led to interventions aiming at teachers, designed with the implicit goal to enhance students' achievement. However, while the knowledge base about learning and teaching mathematics as well as *effective* professional development is growing, conditions that hinder successful progress are still prevalent (Loucks-Horsley, Love, Stiles, Mundry and Hewson, 2003).

Much research has been conducted in the area of teacher education. Nevertheless, as a discrete research field, its roots are slowly emerging (cf. Adler, Ball, Krainer, Lin & Jowotna, 2005). The first *International Handbook of Mathematics Education* (Bishop, Clements, Keitel, Kilpatrick & Laborde, 1996) was published in two volumes in 1996, the Second *International Handbook of Mathematics Education* (Bishop, Clements, Keitel, Kilpatrick & Leung, 2003) followed in 2003 and the first separate *Journal of Mathematics Teacher Education*¹ was launched in 1998. Finally, the first *International Handbook of Mathematics Teacher Education* (Wood, Jaworski, Krainer, Sullivan & Tirosch, 2008), solely dedicated to mathematics teacher education, appeared in 2008. However, issues regarding teacher education have also been discussed in rather general handbooks concerning research on mathematics teaching and learning (cf. Grouws, 1992; Gutiérrez & Boero, 2006; Lester, 2007).

Research in the area of teacher professional development has focused on different issues and analyzed the topic from various perspectives. Certainly, the most important person is the teacher him- or herself. In his book *Teacher Man*, Frank McCourt (2006) describes his experiences as a high school teacher for 30 years in New York City. By the following saying, McCourt raises an interesting but relatively neglected issue, i.e., the dualism of teaching and learning:

Instead of teaching, I told stories. Anything to keep them quiet and in their seats.

They thought I was teaching, I thought I was teaching. I was learning. (p. 19)

With every passing year of their career, teachers become increasingly experienced. In doing so, aspects of teaching are inextricably connected with learning (Llinares & Krainer, 2006). In this work, this aspect will be deeply reflected and thus professional development considered as “job-embedded and practice-based learning” (Loucks-Horsley et al., 2003, p. xiv). A comparable view is given by Tenorth (2006, 2007), but also Jaworski (2006), who in particular explicates that “teaching develops through a learning process in which teachers and others grow into the practices in which they engage” (p. 187).

Nevertheless, educational reforms and developments constitute demands that teachers are supposed to meet. In most countries, changes in education have taken place like implementing learning standards for students and professional standards for teachers, assessment reform, as well as the use of new media in mathematics

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teaching (cf. Sowder, 2007). These trends and corresponding demands raise another level of professional development, which is more concerned with setting output orientations, derived from reform in education, politics and research (Grouws & Schultz, 1996; Cooney, 2001; Day & Sachs, 2004). Since teaching is regarded as a “core profession, the key agent of change in today’s knowledge society” (Goodson & Hargreaves, 2003, p. ix), it is inevitably in the focus of intervention from outside.

Balancing the efforts to meet the *needs of the system* and the *needs of teachers* within it (Day, 1997; Krainer, 2001) is one of the biggest challenges. The consequences that follow if this balance is not obtained can be anticipated when a teacher in an interview reflects new movements in mathematics education as follows: “Set theory came, set theory went”. He explained that his elderly colleagues have always used this phrase, drawing on their experiences with the *new math*-movement in Germany in the Seventies, to describe what happens to issues that are on the agenda for policy makers but not for teachers. Implicitly included in this statement is that despite of all these more or less prescribed trends and changes, the teachers remain the same, and possibly for good reason.

This work is concerned with the field of mathematics teacher professional development. Related issues will be addressed from perspectives of theory and practice, particularly by taking a wide-angle lens. One specific professional development initiative in Germany called *Mathematics Done Differently* will be presented, in whose context the data of the empirical study was gathered. What is guiding this work is to consider teachers themselves as primarily responsible for their professional development. The statement made by Krainer (2005a) that teachers have to work all the time for what constitutes good mathematics teaching, is also crucial for the approach in this book. That is to say, the teacher him or herself decides what constitutes appropriate professional development.

However, likewise to other teacher educators, the people involved in implementing the project *Mathematics Done Differently* do have clear goals underlying the design of the initiative as well as an elaborated understanding what, at least from a teacher educator’s view, constitutes good mathematics teaching. Nevertheless, all we can do is to provide opportunities for professional development, ultimately it is in the hand of the teacher to choose what is suitable to him or her. This perspective touches an issue that has already been raised in a comparable context, i.e., critically discussing the notion of *teacher change* has led to a similar understanding (cf. Hannula, Liljedahl, Kaasila & Roesken, 2007). Ultimately, this view or attitude draws on a philosophy of professional development that is evidently distinguishable from traditional deficit orientations. Putting it into the words of Day (1997), what is definitely being touched is an ethical nature of research, which requires regarding the “teacher as client not object” (p. 47).

What is striking in the field of mathematics teacher education, particularly in Germany, is a lack of empirical research. Regarding the evaluation of professional development programs, quality and effectiveness can be regarded as uncharted territory (Terhart, 2003).

One assumption guiding the conception of the initiative *Mathematics Done Differently*, that will be presented, is a postulated interdependency between effectiveness

on the one hand, and teachers' attitudes towards professional development on the other hand. The focus of the empirical approach is hence to get insight into what makes teacher professional development successful from their very own perspective. Consequently, intensely elaborating on the corresponding view of teachers, i.e., their beliefs and subjective theories, their experiences and needs regarding their professional development in mathematics is subject of this work.

The leading assumption is, following the famous paper by Bauersfeld (1980), which moreover led to the title of this work, that there are *hidden dimensions* in the *reality of professional development* that are not yet covered by research in this area. To look into this subject encompasses a theoretical and an empirical approximation, which will be presented in eight chapters, shortly outlined in the following:

In *chapter one*, numerous theoretical perspectives are discussed that range from rather general ones, contributed by research in education, to specific findings in mathematics education, in order to illuminate the relevant variables. At first, professional development and growth are discussed on a terminological level while at second different philosophies are presented on a conceptual level. At third, the notion of *teacher change* is reflected in relation to the one of teacher growth, thereby focusing on both a teacher's knowledge and beliefs. At fourth, issues of a teacher's identity are discussed and their role in the context of professional development.

Chapter two is dedicated to theoretical models, which serve to identify the relevant processes. A crucial point is to explicitly model teacher learning; different approaches in terms of practical models will hence be presented. The specific focus of this part of the theoretical discussion is on teacher in-service education and training. In particular, the corresponding effects are subject of some debate while finally teachers' needs and expectations are especially valued.

In *chapter three*, some information is given about the specific situation of mathematics teacher professional development in Germany. Again, the explicit focus is on in-service education and training since practicing teachers are the target group of this work and particularly the empirical study. The last comprehensive overview was provided by Peter (1996), this chapter hence also serves for partly up-dating the discussion. At first, the educational debate is outlined while at second the national situation of in-service education and training is presented in terms of both theoretical and practical advices. Finally, two specific and well-known professional development interventions that were launched in Germany and Austria will be outlined and reflected with regard to their significance for and contribution to the educational discourse.

In *chapter four*, the initiative *Mathematics Done Differently* for fostering mathematics teachers' professional development in Germany will be introduced. In brief, one aim of the initiative is to spread and broaden existing local or regional professional development programs to different thematic fields in Germany. Another concern is to design new courses according to teachers' needs. Presenting the initiative encompasses thoroughly reflecting the design against the theoretical background on teacher professional development and the national context in which it was launched. Hence, the chapter provides a detailed discussion on the initiative's constitutive parameters seen through different lenses. Since the author has largely been engaged in the development and organization of the initiative, the aim of the chapter is

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twofold. Besides scientifically debating on the project design, presenting the initiative contributes to framing the context of the empirical study that will be presented in chapters five, six and seven. All data was gathered in the course of *Mathematics Done Differently*, the project that started in 2007. First in-service courses were provided in April 2007. Meanwhile, more than 300 courses have been performed or at least been scheduled.

Chapter five is concerned with providing a synthesis of what has been explicated so far, outlining the empirical approach and in particular, elaborating on the methodological choices. That is, it brings together elaborating on the theoretical perspectives and models, the specific situation in Germany, and the initiative *Mathematics Done Differently*. Finally, this review leads to formulating the research questions guiding the empirical study. With regard to theoretically exploring the concept of professional development, the author is in line with Malara and Zan (2002) who found most studies in mathematics education to be more *about* teachers instead of being the type *with* or *for* them. A crucial attitude of the author in empirically focusing the topic is hence to stress the *with* and *for*. Subject of the empirical study is thus the personal domain by valuing the individual teacher as part of a professional world of practice. The purpose is to illuminate issues of teachers' professional learning and their corresponding needs, and factors that they consider as necessary for *effective* professional development. While various theoretical perspectives on mathematics teacher professional development serve as a conceptual frame of this work, theoretical and methodological triangulation was chosen in order to include different views. Methodological justification will be given while drawing on different research paradigms. Teachers from all over Germany engaged in the initiative *Mathematics Done Differently* participated in the study and contributed rich and informative data.

Chapter 6 presents the quantitative results of the empirical study while *chapter seven* the qualitative ones. The quantitative data was collected by a questionnaire, which led to five dimensions structuring teachers' needs and expectations regarding their professional development. The dimensions were further explored by interviews with teachers who contributed their view on professional development. Remarkably, teachers reported about some relevant subcategories within these dimensions that have not been explored in the research literature so far. The qualitative findings hence shed light on issues especially relevant for teachers and provide insight in what needs to be done to provide successful professional development.

Finally, in *chapter seven*, some conclusions are provided while resuming the lessons learnt from teachers and presenting an overarching research model for framing professional development practices. Last but not least, the chapter is concerned with discussing some implications in terms of future prospects.

NOTES

¹ Journal of Mathematics Teacher Education, <http://www.springerlink.com/content/102941/>

CHAPTER 1

MATHEMATICS TEACHER PROFESSIONAL DEVELOPMENT

Theoretical Perspectives

OVERVIEW

The first two chapters are concerned with theoretical positioning of this work, at first regarding theoretical perspectives and at second moving on to theoretical models. While the former aims at identifying the relevant variables in the context of professional development, the latter aims at capturing the relevant processes. An overview of the main theoretical areas in the context of teachers' professional development and a comprehensive state of the field is given while taking both a static and a procedural perspective.

With respect to the theoretical perspectives, the goals of this chapter are to outline and substantiate the relevant constructs concerning teacher professional development and growth, to explicate different philosophies of professional development, to contrast the notion of *teacher change* with the one of teacher growth, and to elaborate on the notion of teacher identity.

GENERAL REMARKS

The starting point of this chapter is a collection of some general comments on research in the field of mathematics education, in order to allude to the relevance of the theoretical background and to provide a framework for identifying parameters relevant for the review of research.

Regarding research paradigms, the field of mathematics education research is quite different to the one it is related to, namely mathematics. Unfortunately, the quintessence drawn by Pollak that “there are no theorems in mathematics education” (c.f. Schoenfeld, 2000, p. 641) indicates that the work of a researcher in mathematics education is not adequately guided like that of a mathematician.

In this context, Schoenfeld (2007) raises an interesting issue by adopting the distinction between pure and applied in mathematics to the field of education. In his talk at the Annual Meeting¹ of the German Mathematical Association (DMV)² and the Gesellschaft fuer Didaktik der Mathematik (GDM)³ in 2007, he gave some answers to the question, *What does it mean to do rigorous research in mathematics education?* Along the lines of mathematics, he defined the purposes of research in mathematics education as pure (basic sciences) and applied (engineering), whereas the former is to understand the nature of mathematical thinking and learning, and the latter is to use such understandings to improve mathematics instruction.

The crucial point in mathematics education is that knowledge is based on empirical evidence and findings. Even though there are no theorems like there are in mathematics, there are of course theoretical aspects to consider. The preference for a specific theory of mathematics education mainly affects formulating research questions, choosing the theoretical framework (Sriraman & English, 2005) and selecting the research design and methods (Lester, 2005).

A common criticism is that much of the research in the field is *atheoretical* (Lester, 2005), an issue already raised some years ago by Kilpatrick (1992). However, the relevance of theory is colorfully accentuated by Karl Popper's saying that "theory is the net which we throw out in order to catch the world" (1935/1966, p. 26).

The following literature review brings together theoretical aspects and findings that concentrate more generally on professional development, gained in the field of education, and domain specific research by mathematics educators. Since the field is very broad and diverse, the literature review is just a selection that serves the specific purposes of this work. Much of the discussed contributions could easily fit under more than one heading. Hence, the different topics raised are not completely disjoint.

IDENTIFYING THE RELEVANT VARIABLES

The overall theoretical perspective taken in this work is primarily an international one although the situation in Germany will be explicitly focused on in chapter 3.

In 1992, Bishop had already identified "a remarkable growth in the awareness of the international dimension in mathematics education" (p. 710), documented by an increase in international conferences, collaborations and publications. Regarding teacher education, Sowder (2007) stresses that the "recognition of the need to change the way in which mathematics is taught and learned is international in scope" (p. 159).

In their review of PME⁴ research, Llinares & Krainer (2006) identify a huge cultural diversity of different professional development programs and different national characteristics. Unfortunately, this diversity has also caused various notions, which will be described later, and obviously, we do need *cultural awareness* in order to deal and cope with this variety.

Regarding empirical research, even 16 years ago, Hoyles (1992) reported a quantitative increase in research incorporating the teacher as an integral and crucial facet of learning mathematics. Adler et al. (2005) provide a broad synopsis of teacher education research published in the years 1999 to 2003, based on a literature review of international mathematics education journals, international handbooks of mathematics education and international mathematics conference proceedings.

What is concluded by Adler et al. (2005) is that research in this area is dominated by small-scale qualitative research. The authors trace this observation back to the fact that "having teachers as the focus of research leads to high complexity. This increases the tendency to keep the sample small in order to reduce complexity" (p. 369). Further, the authors conceive as natural process that particularization comes before generalization in an emerging field of research. The next interesting point

Adler et al. (2005) make is that teacher educators, studying the teachers with whom they are working, conduct most research. Thus, teacher educators are involved in a “double role of intervening and investigating” (p. 371).

Teacher education research is still on the agenda and a highly researched topic. Theoretical perspectives on teacher professional development are complex and multifaceted. In 2007, this conclusion was one of the results of a weekly workshop provided at the *Mathematisches Forschungsinstitut Oberwolfach* (MFO)⁵ in Germany, which led to partial dissatisfaction on the conceptual level. The workshop was especially dedicated to *Mathematics Teachers’ Professional Development – Research and Practice from an International Perspective* and provided substantial information where the field is currently located.

More than 40 researchers in mathematics education from all over the world, partly also engaged in mathematics, psychology and education, participated in the meeting. As announced in the title, research and practice in the field of professional development were discussed from an international perspective and the workshop provided broad conceptual and theoretical information. Many different strands were presented and gave an impression of how diverse the field is (Mathematisches Forschungsinstitut Oberwolfach, 2007).

In this context, while providing an overview on 25 years of research on teacher education contributing to teacher professional development, da Ponte (2007) concluded that the overriding image still is the deficient teacher. This view on professional development as compensating for deficits has primarily guided traditional approaches and will be contrasted with rather opposite positions in the following section.

Da Ponte (2007) also alludes to another interesting issue, namely the striking observation that although the topic has been researched since a long time very little progress has occurred. Obviously, the title of a paper by Cooney published in 1994, *Research and Teacher Education: in Search of Common Ground*, is still relevant.

PROFESSIONAL DEVELOPMENT AND GROWTH

In the introducing chapter, the dualism of teaching and learning was highlighted as a decisive aspect of professional development. That is, teachers’ professional development takes place every day, inside as well as outside the classroom, through reflecting or talking about practice or students’ work, preparing themselves for the next day, encouraging in school conferences, and in many other related instances that might not be seen as professional development at first glance. This important thought is stressed by Tenorth (2007) when saying “in-service training for me is just another name for the everyday life of the profession” (p. 2).

Likewise, Guskey (2000) points out that “if we view professional development as an ongoing, job-embedded process, every day presents a variety of learning opportunities” (p. 19). And Schoenfeld (2006) values that “some of the most interesting approaches to professional development are those that take the notion of teacher learning seriously” (p. 485). This view or perspective on professional development reminds of Watzlawick’s axiom that one cannot not communicate, which is certainly nontrivial. What remains unclear and mostly open is the direction to which professional

development then will point. Nevertheless, teacher educators should bear in mind that professional development, and even any program planned and designed with the implicit goal to initiate change, is embedded in a context of learning (Guskey, 2000; Tenorth, 2007).

The following literature review is organized around five main topics, which address professional development and growth as being (1) life-long learning, a process characterized by a (2) diversity of notions, related to a (3) diversity of teaching, dependant on changes in (4) teaching mathematics and finally, the state-of-the-art results in (5) defining the notions.

Lifelong Learning

The next important and closely related aspect is that learning lasts as long as the career. Every passing year, teachers become increasingly experienced while doing their job. Even if one acknowledges, in adoption of the aforementioned axiom that teachers cannot not develop in their profession, and consequently considers that processes occur even without any intervention from outside, there are movements and trends in teacher education that lead to demands teachers are supposed to meet (Day & Sachs, 2004; Cochran-Smith & Zeichner, 2005).

Interventions like professional development events are regarded as a classical instrument for establishing reforms in teaching in the wider purpose of accountability and performativity (Sprinthall, Reiman & Thies-Sprinthall, 1996; Sowder, 2007). In many countries, in-service training programs in particular serve as a mean of political crisis management, which allow for an immediate reaction, when, for example, educational excellence is questioned by students' outcomes in international comparisons. As a result, these programs are intentionally designed opportunities, mostly transporting ideas from outside the classroom (Cochran-Smith & Lytle, 2001), however, implemented in a context of an educational system and addressing the teacher within (Krainer, 2005b).

Hence, the challenge is balancing the needs of the different persons involved and, above all, not to lose sight of the teachers who are looking themselves for ways to improve their teaching (Day, 1997). Even on the teacher's side, the challenge is that professional development is, on the one hand, a personal journey and, on the other hand, embedded in an educational and social system (Day, 1999).

However, professional development events that are implemented top-down are easy to get started (Kohonen, 2007) but the question emerging then is, *Whose project is it, who owns it?* In contrast, innovative approaches are sensitive to teachers' needs and their conceptions, and are not of the type 'either/or' but 'both/and', as Ann Lieberman formulated at the GLANZ-conference⁶ in Germany in 2007. Taking a 'both/and' perspective would help to overcome strict views expressed in common statements like *teachers should* by people responsible in school administration, which are, despite of all reform endeavors, still on the agenda.

Interestingly, a plenary panel at ICME 11⁷ addressed the more general question whether research in mathematics education is providing information that teachers as well as policy makers most need. This aspect will partly be revisited in the

following sections, since the overview on the contributions by research in this field is guided by a focus on what teachers need for their professional development.

Diversity of Notions

In general, this chapter is concerned with a traditional literature review revealing both what we know and what we do not know about teacher professional development. Research in this area is characterized by a diversity of notions and focal issues, as well as numerous theoretical and empirical approaches. Although some authors consider the multiplicity as disadvantage in the field, Lerman (2001) recalls that this fact as well evidences “how much there is to say and how much there is still to learn” (p. 33). What is immediately striking when dealing with professional development and growth is the wide range of research conceptualizing these notions, not at least due to different cultural backgrounds. Goodson and Hargeaves (2003), for example, emphasize an “ongoing struggle to establish meaningful concepts of teacher professionalism in a fast-changing educational world” (p. x).

The diversity of notions arises not only from developmental aspects, when taking a vertical view, but also various activities, when taking a horizontal one. Accordingly, Sowder (2007) points out that “professional development is an umbrella term for many types of activities and settings” (p. 173). This aspect is also referred to by Kelchtermans (2004) when saying that professional development “seems to have become a new ‘container concept’ in the educational research discourse” (p. 217). This conceptual variance and fuzziness can be stated as well for the more general term of professionalism of teaching like Sachs (2001) stresses that “there is no singular version what constitutes professionalism or a teaching as a profession that is shared by these diverse groups” (p.150).

Diversity of Teaching

In the following, numerous conceptual approaches will be presented by drawing together their commonalities and differences. One imaginable explanation for the complexity in the field of professional development might be given in that it simply mirrors the complexity of teaching (Guskey, 2004). As Guskey further points out professional development “is not about particular forms of activity but rather about a range of activities -formal and informal- that meet the thinking, feeling, acting, context and change purposes of teachers over the span of their careers” (2004, p. xiii). What should not be forgotten is that teaching is diverse by nature as the following statement by Ball (2000a) indicates:

If a colleague and I chose and developed the same mathematical task with our students, we would likely end up with substantially different lessons. If I teach the same lesson to two different groups, even I end up with different lessons.
(p. ix)

Moreover, Davis (2004) asked his students for synonyms of the word teaching and comments the results as follows: “Everyone seemed to converge on the same,

commonsensical conclusion: Teaching is multifaceted. The teacher wears many hats” (p. 2).

Changes in Teaching Mathematics

Over the last 30 years, the perception of what it means to teach mathematics and what teachers’ related competencies should be has significantly changed. As Sullivan (2004) argues, “mathematics teaching is more challenging than it was, but it is becoming more interesting. Likewise, mathematics teacher education” (p. 298). Challenging interventions of governments to improve students’ outcome as well as teaching have been carried out. The last years are characterized by a clear shift from input to output orientation (Krainer, 2005b), which can be stated for most countries, to some extent initiated by a standards discussion ranging from learning standards for students to professional ones for teachers. Consequently, decisions about learning, teaching and assessment are not any longer the business of teachers alone even when the individual school has become increasingly responsible.

Nevertheless, teachers are assigned a key role because only they can change the way mathematics will be taught (Sowder, 2007). Quite recently, in the final report of the National Mathematics Advisory Panel (2008) it was stressed that “substantial differences in mathematics achievement of student relates are attributable to differences in teachers. Teachers are crucial to students’ opportunities to learn and to their learning of mathematics” (p. 35). More concretely, differences in teachers were found to account for 12% to 14% of total variability in students’ achievement during an elementary school year. Hence, not surprisingly, teacher development has become an increasingly important focus in the process of school reform and educational excellence. Effective school improvement is not imaginable without acknowledging the key role of teachers (Lerman, 2001) or as Stigler and Hiebert (1999) put it:

In our view, teaching is the next frontier in the continuing struggle to improve schools. Standards set the course, and assessments provide the benchmarks, but it is teaching that must be improved to push us along the path to success. (p. 2)

Based on this important role, the improvement obtainable by providing professional development for teachers has also drawn increasingly attention (Sowder, 2007).

Teachers are not only key to successfully implementing reform aspects but also their attitudes and the atmosphere they are able to generate, influence students’ engagement in class. A mathematical task is at first nothing else than “ink on the paper” (Mason, 1991, p. 16) and it is up to the teacher to create a challenging and demanding atmosphere for students. Finally, the following issue raised by Schoenfeld (2007), that the teacher also represents the mathematical community, is often neglected. Relating to the accountability discussion in general, he points out the following:

[...] there is accountability to the teacher - both in terms of the traditional authority structure, but also in that the teacher is the prime orchestrator of the classroom mathematical community, and a representative of the mathematical community in the classroom. (p. 4)

Defining the Notions

At first, professional development and growth is concerned with preparing professionals to teach effectively (Grouws & Schultz, 1996), promoting reform in the practice of school mathematics (Adler et al., 2005), and fostering teachers to teach in reform-oriented ways (National Council of Teachers of Mathematics, 1989, 1991, 2000; Cooney, 2001; Day & Sachs, 2004; Sprinthall et al., 1996). Not surprisingly, interventions aimed at fostering reform-oriented teaching, have been in the focus of school improvement endeavors, as Wilson & Berne (1999) so aptly sum it up: “Professional teachers require professional development” (p. 173).

Peter (1996) stresses that the notion of professional growth is concerned with empowering teachers while traditional views on professional development are primarily deficit models. This aspect points to quite different research agendas and is elaborated on in one of the following sections.

Some authors explicitly refer to procedural aspects of teacher education when applying the term continuing professional development (CPD) that is used “to describe all the activities in which teachers engage during the course of a career which are designed to enhance their work” (Day & Sachs, 2004, p. 3).

At second, the notion is composed of the terms professional and development, which refer, on the one hand, to professional competence in a professional role and, on the other hand, to development towards improving this personal performance and to enhancing progress in the career (Shulman, 2005).

As the literature review reveals, the following constructs are used simultaneously but not consistently in the international discussion to describe the field of providing help for practicing teachers: professional development, professional growth, teacher education, teacher development, staff development, and also teacher ‘change’.

Some authors restrict the notion of teacher education to pre-service teacher preparation (Lerman, 2001; Ponte, 2001) and use the term professional development exclusively for in-service teachers whereas the National Science Foundation uses the term “to refer both to teacher preparation and to the development of practicing teachers” (Sowder, 2007, p. 158). However, in most cases, teacher education is more connected with pre-service education whereas teacher development and teacher ‘change’ with in-service programs. In the following, professional development is not restricted to but rather used in the context of in-service teacher education since the practicing teachers are the target persons of the research that will be presented in detail.

The next challenge, due to the conceptual variance, is defining the relevant notions. As Kelchtermans (2004) argues, the concept of professional development obviously “has a strong ‘face validity’”. Almost anyone can imagine something when hearing it” (p. 217). He further points out that professional development is, on the one hand, this “commonly known phenomenon”, equipped with a powerful self-evident meaning and, on the other hand, it is characterized by an “absence of a shared understanding by researchers” (p. 217). As the discussion in the beginning of the section has shown, a prevalent conception of professional development as job-embedded process, taking place every day, is rather unusual. Likewise unusual is conceiving teachers

as learners, or as Lerman (2001) puts it, “we fight shy of using learning in relation to adults” (p. 34). These restraints are also reflected in most commonly shared definitions of professional development, simply equaling it to special events at some days during the school year as provided by traditional in-service training programs (cf. Guskey, 2004; Loucks-Horsley et al., 2003; Sowder, 2007).

Clarke (1990) gives a concise definition of professional development while referring to “any activity or process intended to change any combination of the following: teachers’ beliefs and attitudes, teachers’ knowledge and teachers’ classroom practice” (p. 1). Accordingly, Sowder (2007) identifies professional growth as “marked by change in teachers’ knowledge, beliefs, and instructional strategies” (p. 161). Slightly different, Guskey (2000) defines professional development as “those processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might in turn, improve the learning of students” (p. 16). Schoenfeld (2000) approaches the field in another way by emphasizing the following aspect:

Teacher knowledge leads naturally to the issue of growth and change of teacher knowledge - and hence to issues of teacher learning and professional development. (p. 20)

Since the aforementioned definitions focus on knowledge, beliefs and practices of individual teachers, Sparks and Hirsh (1997) stress that a comprehensive understanding of professional development needs to take into account context factors like the cultures and organizations in which the teachers work. An encompassing definition, considering such contextual aspects and specifically elaborating on the procedural character of lifelong learning, is given by Day (1999):

Professional development consists of all natural learning experiences and those conscious and planned activities which are intended to be of direct or indirect benefit to the individual, group or school and which contribute, through these, to the quality of education in the classroom. It is the process by which, alone and with others, teachers review, renew and extend their commitment as change agents to the moral purposes of teaching; and by which they acquire and develop critically the knowledge, skills and emotional intelligence essential to good professional thinking, planning and practice with children, young people and colleagues through each phase of their teaching lives. (p. 4)

Further, Guskey (2000, p. 16) tries to clarify the concept of professional development by considering, in addition to the definition presented above, three defining characteristics:

- It is an intentional process.
- It is an ongoing process.
- It is a systemic process.

First, it is stressed that professional development is an intentional and purposeful process. Consequently, any events planned or designed should have a well-structured outline as well as clearly defined goals of what is intended to be accomplished. Establishing these goals and keeping them in mind helps to explicitly distinguishing these events from approaches that conceive professional development as “a set of

random, unrelated activities having no clear direction or intent” (Guskey, 2000, p. 17). Second, professional development is an ongoing process since our general knowledge is expanding every day. New results, for example in mathematics education research, provide new insight in topics, or different teaching approaches. Also, a teacher is confronted with learning every day, and the challenge then is to reflect upon issues in order to take advantage and use new understanding in the future. Third, professional development should be more than providing a single learning opportunity for a single teacher, “true professional development is a systematic process that considers change over an extended period of time and takes into account all levels of organization” (Guskey, 2000, p. 20). To sum up, these characteristics add many aspects to the first attempts of simply defining the concept, as conducted earlier in this paragraph, and in particular, the systemic aspect is dealt with in more detail later. Moreover, these characteristics point to another crucial aspect in this research field, that is the effectiveness of all events, designed with the explicit goal to provide professional development opportunities.

In order to conclude this section, the question is raised whether we explicitly need a sharp definition of professional development. In this regard, Day (1997) takes the view that a clear conception is needed for determining a path of professional development. Likewise, Cochran-Smith and Zeichner (2005) point out that among other issues “identifying terms and concepts that require clarification and consistent usage” (p. 1) is an important issue on the research agenda for teacher education. Moreover, Kelchtermans (2004) stresses that the conceptual fuzziness makes it difficult to obtain an overarching research-based theory. Beyond these issues, which are of course significant, another possibility might be to acknowledge the diversity as an opportunity to take different positions. The following sections, therefore, will capture multiple perspectives in order to result in implications for constructing practices of professional development that are grounded in what teachers really do need.

PHILOSOPHIES OF PROFESSIONAL DEVELOPMENT

Before presenting different philosophies on teachers’ professional development and how they influence any conception of initiatives, the following episode sheds some light on how, for instance, the aforementioned reluctance to consider teachers as learners can have effect on providing adequate events. Loucks-Horsley et al. (2003) report about a study in which they asked teachers what makes learning powerful in mathematics and science. They received answers like the following: “learning has to be active”, “you need to connect what you are learning to what you already think and know” and “learners have to want to learn - it has to be meaningful and relevant to them” (p. 32). Hence, most of the teachers hold a primarily constructivist view on learning but as they were asked how many of them have had analogous professional development opportunities, the response was none or few. Loucks-Horsley et al. (2003) conclude that “the field of education is living in a paradox of knowing one thing and doing another” (p. 32).

Most professional development events, or at least those which are conceived as traditional ones, do not provide appropriate learning opportunities in the above mentioned sense. That is, findings from cognitive research on learning play a marginal

role when teachers' personal learning is on the agenda. Likewise, Lerman (2001) stresses that "we have well known ways of theorizing children's learning, but we are not so well served when thinking about adults' learning, especially learning about their work" (p. 34).

Views on and attitudes towards professional development, for both teacher educators and teachers, shape how it is perceived and valued. The overall image builds on an underlying philosophy that ranges from deficit compensation to a more constructivist view by valuing the teacher (Peter, 1996). Professional development events that focus on compensating for deficits in knowledge and competencies are typical for hasty policy interventions implemented in order to immediately aim at enhancement. But there is one problem occurring then, which is metaphorically described by Posch (1998) who compares the evolving situation to the medical one of organ transplantation, taking the risk of transplant rejection, when the recipient's body turns against the new organ. An analogous situation can be reported for professional development events, that are carefully and thoroughly planned, theory-driven designed and conducted in a well composed way, but ultimately it is up to the teacher to decide whether a program is suitable or not. This decision also includes testing the imparted issues in practice to find out whether there are feasible or not. Maybe, the following conclusion drawn by Heidegger (1968) that "teaching is more difficult than learning because what teaching calls for is this: to let learn (p. 15)" is particularly provoking when learning is provided by teacher educators for teachers.

How different conceptions of teacher learning implicate and justify different attitudes and approaches to promote professional development is in the center of Cochran-Smith and Lytle's (2001) work on the relationship between theory and practice and will be outlined in the next section. Fortunately, the current view on professional development "comes not from acknowledgment of deficiencies, but instead from growing cognition of education as a professional field" (Guskey, p. 16). Professional development is therefore seen as empowering teachers, considering them as actively involved and allowing them to develop a sense of ownership of their personal growth.

Elliot (1993) identifies three different philosophies relevant in the context of teacher education and describes how they enable "a context of free and open discussion of its basic ideas and principles" (p. 15):

- the platonic or rationalist view of teacher education
- the 'social-market' view of teacher education as a production/consumption system
- the hermeneutic view of teacher education as a practical science

In the platonic or rationalist view, the teacher is seen as a "rational-autonomous professional" and a highly individualistic image of the teacher is favored as someone who can "be left to self-direct future professional learning" (p. 16). That is, the initial teacher education phase is concerned with the development of theoretical understanding and background essential for practice. The teacher "can then be left to self-direct future professional learning" (p. 16). For the role of professional development, Elliot (1993, p. 16) points out that consequently "rationalism in professional education implies a volunteristic pattern of in-service provision" since any prescription would

run counter to the transported image of the rational-autonomous teacher. However, Elliot (1993) remains rather vague when explaining the labeling as platonic view as follows:

The platonic perspective gives little significance to an induction phase in teacher education, which is perhaps why, given the dominance of this perspective in the past, it has been neglected. (p. 16)

The idea of a platonic view on teacher education will be revisited later in this section after presenting the other perspectives.

In the '*social-market*' philosophy of teacher education, the view of a teacher differs from an autonomous acting individual since accountability is primarily given into the hands of the school. Elliot (1993) puts it like follows, "from a '*social market*' perspective, schools conceived as individual consumers of the products of teacher education are the market" (p. 17). Interestingly, although teacher education is seen as dealing with products, hence considering that these imply markets and consumers, the autonomous role of the teacher is strongly limited by the emphasis on school authority:

The continuing education phase is concerned with progressively developing higher skills, and this of course may be a more prolonged process. It is certainly not viewed as a volunteristic process. An individual's training needs are identified by the school which also controls the provision for them. There is not much room for the rationally-autonomous professional in this scenario. (Elliot, 1993, p. 17)

In the hermeneutic view, teacher education is thought of as a practical science, a perspective that "has become increasingly adopted by in-service teacher educators in higher education as an alternative to the Platonic view" (Elliot, 1993, p. 18). Particularly, in the field of in-service teacher training this view led to action-research approaches focusing on practical situations and classroom research, and on a more individualized level, to valuing issues of reflective practice (Schoen, 1983). Elliot (1993) explicates that "the basic principle which underpins the hermeneutic perspective is that of situational understanding" (p. 18). He further stresses that "this principle implies that practice is grounded in interpretations of particular situations as a whole and cannot be improved without improving these interpretations" (p. 18). Particularly, the latter aspect is a crucial one since it definitely questions the relevance of theoretical input or the significance of a theoretical orientation with respect to providing teachers an elaborated framework for reflection and interpretation.

Moreover, the different philosophical perspectives each favor different relationships between research and practice, an issue that will also be discussed in other sections of this work. From the rationalist perspective, a one-way street from theory to practice is assumed while from the hermeneutic perspective, practice is assigned a key role since "bias is a condition of situational understanding because all interpretation is shaped by a practical culture i.e. a system of value and belief which is conditioned by practical concerns" (p. 18). Hence, in the hermeneutic view, teacher education is primarily considered as enhancing teachers' situational understanding. In the '*social-market*' perspective, schools are assigned a moderating function

concerning conflicting aspects in the relationship of theory and practice that appear in terms of educational reform and school issues.

Remarkably, Elliot (1993) discusses teacher education in terms of philosophical issues, a tradition that has been on the agenda in mathematics teacher education as well, mostly drawing on “teacher’s conception of the nature of mathematics in his or her beliefs system concerning the nature of mathematics as a whole” (Ernest, 1989, p. 99). In this context a Platonist view of mathematics is construed as viewing of “mathematics as a static but unified body of certain knowledge. Mathematics is discovered, not created” (Ernest, 1989, p. 100). At least, the platonic or rationalist view mentioned by Elliot (1993) bears a slight resemblance to what has been discussed under the headline of a Platonist view in mathematics, where theory is considered as rather given and static, contrarily to putting the emphasis on creatively improving practice as in the hermeneutic view. But interestingly, the platonic or rationalist view does not hesitate to consider teachers as autonomous.

The three perspectives will be seized on later, when discussing different professional development initiatives and perhaps, the impression pressing now is that maybe a humanistic view, explicitly valuing the persons involved, is missing.

Underlying philosophies in the field of teachers’ professional development are crucial and play a central role on different levels. Fundamental importance is attached to how teachers’ education is conceived in general, teachers’ learning is viewed in particular, and what relevance is given to theory and practice. Besides distinguishing traditional approaches in terms of deficit compensation or innovative approaches in terms of empowering teachers, Kelchtermans (2004) refers to two different research perspectives when emphasizing the descriptive and the prescriptive agenda. The former is concerned with simply describing a “learner’s experiences and aims to understand its meaning and determinants” (p. 219) and the latter with aspects of providing effective professional development, as Kelchtermans (2004) further concretizes:

The second agenda aims to move beyond description in order to answer the question: how can CDP [Continuing Professional Development] be organized most effectively? This is the prescriptive agenda of the school consultant, the in-service trainer, the induction supervisor ... of all those people who are concerned with intentionally creating and supporting opportunities for professional learning. Their first interest is not so much a final, encompassing understanding of the phenomenon, but rather lies with the ‘pedagogy’ for effectively influencing professional development. (p. 219)

Kelchtermans (2004) adds an appealing issue to the discussion while pointing out that the interests of teacher educators might be rather local than final or encompassing. He additionally points out that although the focus is different both perspectives are intertwined in any research related to professional development.

Until so far, philosophical aspects have been discussed on a rather meta-level, keeping the whole system in mind. On the teacher level, beliefs about professional development, build over a period, shape and influence how they conceive and respond to any offer made regarding their professional development.

TEACHER 'CHANGE' VERSUS TEACHER GROWTH

The last decades, the nature of teaching has undergone significant transformation processes since the landscape of teacher professionalism is changing fast (Goodson & Hargreaves, 2003). The challenge for teacher education in this context of progress and development has already been explored by Jerome Bruner (1996), an elder statesman in educational psychology, when stating that “it is a complex pursuit of fitting a culture to the needs of its members, and their ways of knowing to the needs of the culture” (p. 43). Indeed, as explicated so far, the professional development of mathematics teachers is a lifelong learning endeavor and takes place every day. Furthermore, when used in a psychological meaning, learning is a post-hoc construct, i.e., learning takes place when an individual undergoes a process of change (Swann, 1999). Hence, explicitly connected with the notions of development and growth are issues of change (Day, 1999; Sullivan, 2007).

Unfortunately, as pointed out by Clarke and Hollingsworth (2002), from a historical viewpoint “teacher change has been directly linked with planned professional development” (p. 948). However, talking about teacher ‘change’ has become a critical issue in recent years. For good reasons, the question, *Who has the agency?* has been addressed in the discussion about change processes (Hannula et al., 2007; Sullivan, 2007). As already mentioned in the introduction, the perspective taken in this thesis is that we cannot change another person. Likewise, Day (1999) puts it, “teachers cannot be developed (passively). They develop (actively)” (p. 2). All we can do is to provide opportunities for teachers to change; the teachers themselves hold the “ownership of change” (Sullivan, 2007, p. 152). Nonetheless, teacher educators do have clear goals for how they want to influence this change process.

When discussing this issue in our contribution to the Research Forum at the 2006 Psychology of Mathematics Education’s (PME)⁸ annual meeting in Prague we chose the following solution for the obvious dilemma in the context of pre-service education:

We can talk about *empowering* students, or *occasioning change* within those who suffer mathematics anxiety. A stance of either empowerment or occasioning allows the agency of change to remain with the student teacher while the agency of treatment – through research methodology – to remain with the instructor/researcher. (Hannula et al., 2007, p. 156)

Another interesting issue in the context of *teacher change* is the one raised by Cooney (2001), when asking, “*Change from what to what?*” or further, “*What compass defines change?*” (p. 10). Possible changes or directions of change, relevant for professional development, might be, so Cooney (2001), to “conceive of teacher change as moving from the traditional mode to the reform mode” (p. 11). Nevertheless, teachers tend to perceive their own teaching as mostly adequate regarding the positions promoted, for instance, by the standards movement.

What becomes obvious and makes the situation rather challenging is that the teacher’s view thus substantially differs from the observer’s one and the crucial question is, *How can any change be initiated when there is no need to change perceived by the recipients?*

Change literature also deals with how teachers actively cope with educational change and discusses possible constraints like a teacher's prior knowledge as it serves as assimilatory scheme (Simon, 2007). Simon (2007) further points to the limits of teachers' learning on a day-to-day basis since they "do not necessarily see what researchers and mathematics educators see" (p. 141) and concludes that "significant change (paradigm shift) is unlikely to happen solely as a result of a teacher learning from her own teaching" (p. 141).

Day (1999) deems *teacher change* as a necessary outcome of effective professional development and describes this process as "complex, unpredictable, and dependent upon past experience (life and career history), willingness, ability, social conditions and institutional support" (p. 15). Many variables are thus involved when talking about change processes but more concretely, Day (1999) sums up in the following what levels need to be touched in order to make any change happen:

Change which is not internalized is likely to be cosmetic, 'token' and temporary.

Change at deeper sustained levels involves the modification or transformation of values, attitudes, emotions and perceptions which inform practice, and these are unlikely to occur unless there is participation in and a sense of ownership of the decision-making change processes. (pp. 97/98)

These statements add some important aspects to the already discussed issue of ownership in change processes and elucidate how important it is to enter the field with a broad conception of teachers being responsible for themselves, in particular regarding their professional development.

But there are also different facets involved when talking about change processes, which primarily depend on the chosen viewpoint. In this regard, Clarke and Hollingsworth (2002) describe six perspectives on *teacher change* that allow for integrating different views of professional development while leaving the individual level of a teacher:

Change as training – change is something that is done to teachers; that is, teachers are "changed".

Change as adaptation – teachers "change" in response to something; they adapt their practices to changed conditions.

Change as personal development – teachers "seek to change" in an attempt to improve their performance or develop additional skills or strategies.

Change as local reform – teachers "change something" for reasons of personal growth.

Change as systematic restructuring – teachers enact the "change policies" of the system.

Change as growth or learning – teachers "change inevitably through professional activity"; teachers are themselves learners who work in a learning community. (p. 948)

These different perceptions or views of *teacher change* gather most of the issues discussed earlier under the headlines of professional development and growth as well as philosophies of professional development and indicate once more the complexity within the field.

As already mentioned, the first point of view is a quite optimistic one since a change process is ultimately beyond control from outside, whilst the other ones outline important aspects. Clarke and Hollingworth (2002) identify the last perspective of “change as growth or learning” (p. 948) as primarily align with current professional development efforts, a quite optimistic estimation, although this conception certainly is on a good way to permeate the field.

Likewise, Sowder (2007) emphasizes that change is a “process rather than an event, it must be considered in terms of continuous growth over time” (p. 97). Pehkonen and Toerner (1999) add that these processes are dependent on personal factors, that is, any development may vary in pace according to a teacher’s personality:

Everybody who has worked in teacher in-service training has surely recognized the following odd situation: there are some teachers who have reached the pedagogical goal of the in-service course already in the very beginning. And on the other hand, there might be some teachers who have difficulties adapting to the first ideas. (p. 261)

The movement of action research, which is primarily concerned with change in teacher’s professional practice, is particularly based on the idea that development and innovation are essential parts of professionalism (Altrichter, Feldman, Posch & Somekh, 2008). Moreover, Altrichter et al. (2008) put it as follows:

Action research rejects the idea that changes or “improvements” are needed because there is some deficit or failure on the part of practitioners, and sees change instead as inevitable and important part of being a professional. (p. 269)

Emphasizing more on the notion of growth over time and development than on *change* of mathematics teachers allows for a paradigm shift that has already been on the agenda in the field of education while the discussion in mathematics education concentrated a lot on the notion of change. That is, *change* of mathematics teachers has been elaborated on widely but regarding different strands. Some authors consider any change of teachers as inextricably connected to change in their mathematical beliefs (Pehkonen & Toerner, 1999; Wilson & Cooney, 2002; Pehkonen, 2006; Sowder, 2007) whereas others accent the role of the affective component as an influential factor (Hannula, 2004; Goldin, 2002). Pehkonen and Toerner (1999) identify some key change factors regarding mathematics teacher professional development, which promote substantial change instead of just surface one. Out of the statements they received in interviews, they yielded 15 change factors that were categorized into four groups:

The change factors were classified by us into four groups: experiences (1) ‘as a teacher with individuals’, and (2) ‘as a teacher with institutions’, as well as experiences (3) ‘as a learner with individuals’, and (4) ‘as a learner with institutions’. (p. 270)

Interestingly, Pehkonen and Toerner (1999) report that out of all given statements, the participants “referred to themselves as a teacher in 72% of the responses, and as a learner in 28% of the responses” (p. 270). Obviously, the reluctance to regard teachers as learners, as mentioned earlier, can also be observed in teachers’ estimations.

However, knowledge and beliefs are crucial parameters in any process of learning, or as Peter Sullivan explicated in his talk at the 2008 American Educational Research Association’s (AERA)⁹ annual meeting in New York, they address the *what* in mathematics teacher education and is therefore elaborated on in the following. That is, the next section is concerned with teachers’ professional knowledge, competencies and actions while the section after that elaborates on teachers’ beliefs and epistemological views.

Professional Teacher Knowledge, Competencies and Actions

Knowledge is regarded as key construct in teachers’ professional development. Hence, interventions in mathematics education are often designed along the leading questions, “*But what is it that mathematics teachers need to know, and know how to do [...]?*” (Adler et al., 2005, p. 361) or “*What mathematical knowledge is needed for teaching?*” (Wood, 2005, p. 193). Wilson and Berne’s (1999) focus is slightly different, when asking, “*What do we know about teacher learning? Specifically, what do we know about the professional knowledge teachers acquire in such experiences?*” (p. 176). Interestingly, in the last position, the focus is on teachers as learners and how they obtain their professional knowledge, while in the first one, it is deduced from mathematical knowledge what teachers should know. Hence, within the domain-specific discussion, the question where teachers *have to go* in spite of *how to get there* is much more significant than on the general level. In what follows, the literature review is organized to shed light on both positions in order to illuminate what knowledge teachers need to be *effective* and what experiences teachers need to acquire this knowledge.

However, within the discussion of teachers’ professional knowledge, Shulman’s venerable paper *Those who understand: Knowledge growth in teaching* (1986) remains central, and his notions of *subject matter knowledge* and particularly *pedagogical content knowledge* initiated the discourse significantly, and much subsequent research has followed. By this basic work, Shulman (1986, 1987) developed both a topology as well as a typology of professional knowledge of teachers (Baumert & Kunter, 2006). The construct of *pedagogical content knowledge* allows for a description-oriented reconstruction of teaching practice not any longer through a detailed portrayal of observable teacher actions but in terms of a teacher’s competence (Bromme, 1995).

Some authors further developed the notion of *pedagogical content knowledge* by a refinement (c.f. Grossman, 1990; Bromme, 1994). In this regard, Bromme’s (1995) criticism addresses the lack of a clear distinction between didactical concepts on the one hand, and subjective representation on the other hand. Moreover, in the domain of mathematics education, the concept does not differentiate between mathematics as a science and a school subject, an important issue, since the transformation of mathematics to a school subject leaves its mark on the content. In this respect,

Shulman's work was extended by Bromme (1994, 1995, 1997), who reformulated the topology of teachers' professional knowledge attending to the discipline of mathematics, a modification that received much attention, in particular in German speaking countries.

Over the last two decades, essential research in mathematics teacher education has focused on different accounts of teacher knowledge (cf. Sherin, Sherin & Madanes, 2000), particularly maintaining the decisive role of substantial mathematical skills for teaching (Ball, 1988; Ball, 2000a,b; Ball, 2002; Ball & Bass, 2000; Ma, 1999). Since most studies focusing on teacher knowledge are situated in teacher education in general or cognitive psychology, Ball and colleagues give a domain-specific conceptualization when elaborating on the mathematical knowledge needed for teaching. Teachers' knowledge of mathematics is regarded as decisive parameter for improving their instructional quality. Accordingly, effects of professional development are measured in terms of improvement of teachers' content knowledge. In particular, Ball (1988) considers as critical dimension knowledge *about* mathematics:

This includes understandings about the nature of knowledge in the discipline – where it comes from, how it changes, and how truth is established. Knowledge about mathematics also includes what it means to “know” and “do” mathematics, the relative centrality of different ideas, as well as what is arbitrary or conventional versus what is necessary or logical, and a sense of the philosophical debates within the discipline. (p. 58)

More recently, Ball and Bass (2000) coined the term *mathematics knowledge for teaching* (MKT) to refer to the complex relationship between mathematics content knowledge and teaching. Furthermore, they differentiate *subject matter knowledge* between common knowledge of mathematics that any well-educated adult should possess and specialized mathematical knowledge that teachers require (Ball, Hill & Bass, 2005). At the 2008 American Educational Research Association's (AERA) annual meeting in New York, Ball and colleagues gave an overview of their program of research. They stressed that teachers and teaching are key because teacher effects in any educational situation are large. A teacher's instructional resources depend on his or her capacity in terms of more subject matter knowledge as basis for profound mathematical knowledge for teaching.

Close to the work of Ball and colleagues is the one of the COACTIV¹⁰-group in Germany, a study embedded in the PISA 2003 assessment. The challenge within this study has been to capture the construct of professional teacher knowledge in the domain of mathematics education theoretically in order to provide empirical access (Baumert, Blum & Neubrand, 2004; Krauss et al., 2004). The model is based on Shulman's work since facets of professional knowledge are initially distinguished into *subject matter knowledge*, *pedagogical content knowledge* and *general pedagogical classroom knowledge*. The construct of *pedagogical content knowledge* is then further divided into declarative expert knowledge and procedural expert knowledge; additionally a scale concerning beliefs and attitudes is comprised. This theoretical conceptualization of teacher knowledge is derived from central goals of teaching mathematics, i.e., instructional processes and practice enhancing cognitive activation of students (Baumert, Blum & Neubrand, 2004; Kunter et al., 2007).

Sherin, Sherin and Mandanes (2000) report on two other representative research programs elaborating on teacher knowledge besides the one conducted by Shulman. Leinhardt and Greeno (1986) focus on describing the mental structures of skilled teachers in terms of routines, agenda, and curriculum scripts while Schoenfeld (1998, 2000) aims at modeling the teaching process in terms of knowledge, goals and beliefs. The approaches have in common that they extend merely theorizing about knowledge to additionally considering knowledge that is relevant in practice, i.e., when teaching in the classroom. In this context, Baumert and Kunter (2006) explicitly refer to the dualism of knowledge and know-how, which is considered by some authors as knowledge-in-practice, routines, or knowledge-in-action (Ball & Bass, 2000; Cochran-Smith & Lytle, 1999; Leinhardt & Greeno, 1986; Voigt, 1984). Further, Terhart (2002) deems this aspect of knowledge as a developmental goal that becomes particularly salient in practice. Ball and Bass (2000), moreover, refer to the crucial role of mathematical knowledge needed in practice:

Furthermore, the use of mathematical knowledge in teaching is often taken for granted. The mathematical problems teachers confront in their daily work - such as the simple case at the beginning of this chapter - are left unexplored, the occasions that require mathematical sensitivity and insight unprobed. Hence, the content and nature of the mathematical knowledge needed in practice is insufficiently understood. Moreover, the role played by such knowledge is also left unexamined. (pp. 86, 87)

More recently, Shulman (2005) argues that it is signature pedagogies, which connect thought and action in the profession:

The signature pedagogies of professions are designed to transform knowledge attained to knowledge-in-use, and to create the basis for new kinds of understanding that can only be realized experientially and reflectively.[...] A professional has to be prepared to act, to perform, to practice, whether they have enough information or not.

Finally, Tenorth (2006) claims that professional routines are the decisive characteristic of professionalism in teaching. Routines were studied in the nineteen-eighties in connection with patterns of interaction by the school of Bauersfeld (cf. Voigt, 1984) and others (cf. Leinhardt & Greeno, 1986), and interestingly, they tend to be relegated to the status of mechanical skills or technical trappings. However, professional routines play a crucial role since they encapsulate the essential wisdom of teaching practice (Shulman, 1987), thereby showing professionalism as resulting from well-established and experienced action schemes. In the context of ongoing professional development, Gellert (2008) stresses the role of routines as one focal point of teachers' collective reflections. Nevertheless, what should not be neglected is the issue raised by Ball (2000b), that our tendency to focus either on the cognitive domain, e.g. knowledge, or teachers' action "is yet one more recent form of fragmentation in teacher education, and in particular, in our efforts to help teachers acquire usable content knowledge" (p. 246).

While the starting point of this section has been to describe research on teachers' professional knowledge in mathematics, in the following, the focus is on theorizing

teacher learning as a framework for professional development, primarily in relation to practice. In respect to this, Messner and Reusser (2000) stress that what is considered as fruitful professional knowledge depends on the relationship between discipline and profession, on the one hand, and knowledge and practice, on the other hand. Cochran-Smith and Lytle (1999) provide an interesting analytical model while maintaining that “three different conceptions of teacher learning drive many of the most prominent and widespread initiatives intended to promote teacher learning” (p. 251):

Knowledge-for-practice: formal knowledge generated by research outside the school.

Knowledge-in-practice: knowledge generated by teachers studying their classroom and practices.

Knowledge-of-practice: practical knowledge by teachers generated by their own systematic inquiry.

The three conceptions are derived from different conceptualizations of teaching, learning and the relation between them. Moreover, they serve for structuring different approaches of providing professional development opportunities (Sowder, 2007). Cochran-Smith and Lytle (1999) make an interesting point when concluding that “the salient differences among the three conceptions of teacher learning reside not in the methods used to foster teacher learning but [...] in the assumptions that underlie these methods - in the images of knowledge, practice and teachers’ role that animate them” (p. 252). That is, currently highly valued approaches like, for instance, *inquiry groups* and *communities of practice* might be designed very differently regarding their purposes and goals so that the methods themselves carry different views of teachers and their learning. Consequently, one should be aware of the fact that a new method is not innovative by itself.

Cochran-Smith and Lytle (1999) consider these conceptions of teacher learning as significantly different:

Although competing in fundamental ways, these three conceptions coexist in the world of educational policy, research, and practice and are invoked by differently positioned people in order to explain and justify quite different ideas and approaches to improving teaching and learning. (p. 251)

The differences between the categories manifest themselves in the underlying assumptions regarding the images of knowledge, practice and teachers’ role, as mentioned above, which they convey. In the category knowledge-for-practice, it is assumed that, simply speaking, the more a teacher knows, whether it is subject matter or pedagogical content knowledge, the more effective he or she is, i.e., a simple linear relation is taken up:

The idea here is that competent practice reflects the state of the art; that is, highly skilled teachers have deep knowledge of their content areas and of the most effective teaching strategies that provide access to the knowledge base. (p. 255)

According to Cochran-Smith and Lytle (1999, 2001), most current professional development programs are grounded in a conception related to knowledge-for-practice, transporting ideas of best practice that are identified by research, and the role of the teacher educator is to provide the knowledge. In this regard, Messner and Reusser (2000), while discussing the analytical model by Cochran-Smith and Lytle, point to the limited scope of the ideas reflected in this construct since research has already confirmed that it is a long way from knowing to acting. Merely theoretical knowledge imparted to teachers always involves the risk of getting inert knowledge. That is, the process of understanding does not take place to that extent where the knowledge can be used for teaching.

In the next category of knowledge-in-practice is emphasized what knowledge teachers derive from their practice, based on daily experiences. As corresponding image, the authors argue that teaching is a “wise action in the midst of uncertain and changing situations” (p. 266), developing in the case that the teacher is able to reflect upon his actions and decisions. Initiatives designed along the knowledge-in-practice view center on “the teacher as valid knower of practical knowledge” (p. 269). Accordingly, teacher educators act as facilitators and guide the teachers’ collaborative work on practical arguments:

In teacher learning initiatives that derive from knowledge-in-practice, the point of using cases or reflections or inquiries is to provide the social and intellectual contexts in which prospective and experienced teachers can probe the knowledge embedded in the wise teaching decisions of others and/or can deepen their own knowledge and their own abilities to make wise decisions in the classroom. (Cochran-Smith and Lytle, 1999, p. 272)

Clearly, the focus is on situative learning while the role of research is rather neglected.

The last conception of knowledge-of-practice has a mediating function. While the first construct stresses formal knowledge and the second one practical knowledge, in the third conception the universe of knowledge is not regarded in likewise discrete entities. As Cochran-Smith and Lytle (1999) emphasize, knowledge-of-practice also addresses the process of teaching and reflecting but further alludes to a broader context than the single microcosm of teaching. In the beginning of chapter one, it was stressed that professional development actually takes place every day. However, one crucial point is making these mostly implicit processes transparent and hence leaving these issues accessible. Developmental processes certainly need a theoretical impetus since situating professional learning in a theoretical frame opens new or different windows for teachers (c.f. Borko, 2004), an issue already discussed in the section before, in relation to *teacher change*. In that context as well, the role of prior knowledge as assimilatory scheme has been emphasized (Simon, 2007), i.e., how teachers’ learning from their own practice is restricted, an issue Simon aptly describes by the catchy phrase “we see what we understand” (as cited in Proulx, 2008, p. 145).

The conception of knowledge-of-practice considers theory as interpretative framework for teachers to reflect their practice, offering new opportunities as the

teacher's and the researcher's views mostly differ. Cochran-Smith and Lytle (2001) describe their idea of knowledge-of-practice as follows:

From this perspective, knowledge making is understood as pedagogic act – constructed in the context of use, intimately connected to the knower, and although relevant to immediate situations, also inevitably a process of theorizing. [...] The idea behind knowledge-of-practice is not that practitioners' research provides all the knowledge necessary to improve practice, or that the knowledge generated by university-based researchers is of no use to teachers. (p. 48/49)

The three categories are not domain-specific and therefore do not differentiate between subject related and pedagogical knowledge. Further, these different conceptions also influence how professional development initiatives are composed (Messner & Reusser, 2000). In the knowledge-of-practice conception, for instance, professional development is regarded as encompassing a teacher's experiences in practice while at the same time involving expertise from outside. What is particularly stressed is that teachers learn collaboratively but also within an educational system, and hence, even though implicitly, they influence the culture of teaching on a broader basis.

One might tend, so Cochran-Smith and Lytle (1999), to subsume currently highly valued approaches like teacher research, action research, or communities of inquiry under the conception of knowledge-of-practice although they actually would fit under each of the three conceptions. That is, the authors stress that "historical roots notwithstanding, however, the fact is that terms like action research and teacher research have been widely appropriated and have come to mean many things as they are attached to various teacher learning initiatives and various educational purposes" (p. 282).

Day and Sachs (2004) add an interesting and often neglected aspect to the model created by Cochran-Smith and Lytle while emphasizing the role of a teacher's identity:

Knowledge of self: generated by teachers engaging regularly in reflection in, on and about their values, purposes, emotions and relationships. (p. 9)

As already mentioned in the NCTM Professional Standards for Teaching Mathematics (1991), "being a teacher of mathematics means developing a sense of self as a teacher. Such an identity grows over time" (p. 16). Issues of personality and identity of teachers, also embracing the concept of self-efficacy, as well as emotions, which are found to be "at the heart of teaching" by Hargreaves (1998, p. 834), are essential and will be discussed deeper in the following section.

However, what makes professional development arguably challenging is that "teacher-learners bring increasingly diverse mathematical histories" (Adler et al., 2005, p. 361) and hence diverse amounts of knowledge, a parameter, which is decisive when learning, is understood in a constructivist view. Nevertheless, Day and Sachs (2004) give an interesting conclusion, when reflecting on the conceptions provided by Cochran-Smith and Lytle (1999):

While these conceptions are important, they represent only a partial framework for conceptualizing, planning and analyzing CPD [Continuing Professional

Development], for they are entirely concerned with cognitive knowledge. Research continues to show that the best teaching involves a combination of cognition and emotion. (p. 9)

Indeed, most research related to professional development is constrained to cognitive aspects while focusing on teacher knowledge, but besides this some authors also acknowledge the affective domain. Borko and Putnam (1995), for instance, explicitly provide a discussion on professional development under the headline of a cognitive psychological perspective, but in addition, they stress the dual role of a teacher's knowledge and beliefs acting both as filters through which he or she reflects practice and receives "various messages about changing their teaching. It is through their existing knowledge and beliefs that teachers come to understand recommended new practices and activities" (p. 59).

Teacher Beliefs and Epistemological Views

As the section above shows, most emphasis has been on enhancing teachers' knowledge base while another thread of research highlighted the influence of the affective domain (Thompson, 1992). Human learning in general can be described by the three components cognition, motivation, and emotion (Meyer & Turner, 2002). Most of research addressing these psychological categories of the mind has been carried out separately by elaborating on one of those (Hannula, 2004). However, the cognitive domain is not entirely restricted to a teacher's knowledge. One crucial parameter influencing actions in the classroom, located at the borderline of the aforementioned categories of cognition, motivation, and emotion, are a teacher's beliefs about the nature of mathematics as well as its teaching and learning. By most who study teacher beliefs, they are defined as primarily cognitive statements to which the holder attributes truth or applicability whereas researchers in the affective field consider them as component of affect (Philipp, 2007).

The focus of this work, however, is not to reopen this discussion but at least to provide some answers to the important question, *What are beliefs and what role do they play regarding issues of teacher learning?* In his beliefs-alphabet, Mason (2004) creatively lists related concepts and alludes to the different strands concerned when talking about beliefs. Nevertheless, since beliefs have been described as a messy construct with different meanings and accentuations (Pajares, 1992), moreover lacking a clear and distinctive definition (Furinghetti & Pehkonen, 2002), there is some consensus that mathematical beliefs are considered as personal philosophies or conceptions about the nature of mathematics and its teaching and learning (Thompson, 1992). Beliefs do play a crucial role in teacher professional development, so Ernest (1989), because "knowledge is important, but it alone is not enough to account for the differences between mathematics teachers" (p. 99). He further stresses that "recognizing, understanding, and challenging our personal theories of mathematics education holds the real key to effective and meaningful change" (Ernest, 1989, p. 98).

For more than 25 years now, mathematics educators have dealt with beliefs about mathematics and analyzed these for different groups (students, teachers) under diverse

conditions. The early papers by Thompson (1992) and Pajares (1992), already mentioned above, are cited again and again. The more recent work by Leder, Pehkonen and Toerner (2002) tries to update the discussion and to bring together the results of different domains of research.

When comparing the two aforementioned papers by Thompson and Pajares, which both appeared almost at the same time, one becomes aware of the different fields the researchers are involved in, which are, on the one hand, mathematics education and, on the other hand, psychology. In his work, Pajares emphasizes the epistemological character of beliefs whereas in the work of Thompson the word epistemology is not even mentioned. Nevertheless, it is apparent that quite similar constructs have been discussed against a different background, and therefore different classifications were made.

Although there are only a few papers addressing epistemology in mathematics education, these issues are implicitly central in many discussions with roots going back to philosophical positions on mathematics (Hersh, 1991; Hersh, 1997; Sierpinska & Lerman, 1996). This focus is legitimated by the fact that epistemology, hence beliefs about the origin and acquisition of knowledge, affects teachers' and students' learning of mathematics. Not at least, epistemological views held by university professors, shape and influence prospective teachers' actions in class (e.g. Carter & Norwood, 1997; Schraw & Olafson, 2002), and this again might explain the various beliefs of their students. Roesken and Toerner (2007), in this regard, yielded seven dimensions structuring university professors' beliefs about mathematics. Among them there are factors like characteristics of mathematics, main features of mathematical learning, philosophical aspects and sophisticated views on mathematics, which allude to the relevance and spectrum of epistemology and beliefs in mathematics education on the tertiary level.

More generally, it was René Thom, a famous mathematician and Fields medalist, who postulated this link in 1973: "In fact, whether one wishes it or not, all mathematical pedagogy even if scarcely coherent, rests on a philosophy of mathematic" (p. 204). His paper was in particular aimed at the New Math-movement, which by that time had already turned out to be a failure, and Thom argued that this should be traced back to some fundamental misunderstanding of epistemological mathematical positions. Toerner and Sriraman (2007) comment on his statement as follows: "Simply put, philosophy of mathematics is the important framework for teaching (and learning) mathematics" (p. 155). Likewise, the corresponding importance of beliefs has already been stressed in the classical book by Schoenfeld (1985) who stated that one reason for the failure of introducing Problem Solving in curricula in the United States lay in inappropriate world views of teachers.

Furthermore, Toerner and Sriraman (2007) stress that elaborating on "the question: what is mathematics? for teaching and learning considerations brings into relevance the need to develop a philosophy of mathematics compatible with mathematics education" (p. 156). Quite recently, in his book review of Byers' *How Mathematicians Think*, Hersh (2007) points out that one commonly shared and prevalent belief, not at least among teachers, is to perceive mathematics as precise while Byers elucidates that ambiguity is always present when dealing with mathematics. Even as elaborating

on the notion of ambiguity, Byers (2007) stresses how strongly held and non-reflected beliefs permeate and influence our knowledge base; an observation also rather relevant in the context of professional development.

Some years ago, the issue has already been touched by Hersh (1991), but in terms of backstage and front mathematics, as he identifies the former as being mainly characterized by intuitivism, primarily accompanied by uncertainty:

Compared to “backstage” mathematics, “front” mathematics is formal, precise, ordered and abstract. It is separated clearly into definitions, theorems, and remarks. To every question there is an answer or at least, a conspicuous label: “open question”. The goal is stated at the beginning of each chapter, and attained at the end. Compared to “front” mathematics, mathematics “in back” is fragmentary, informal, intuitive, tentative. We try this or that, we say “maybe” or “it looks like”. (p. 128)

Lerman (2001) identifies two major strands of research concerning beliefs: the analysis and classification of beliefs, and monitoring changes in beliefs over time. In this regard, Cooney (2001) refers to an essential aspect when he underlines that much literature is concerned with beliefs but not with their structure. Further, he considers the structure as crucial since from information about how beliefs are formed can arguably be derived how they change.

A few studies use well-established categorizations of beliefs in order to document change in a person’s beliefs about the nature of mathematics and its teaching and learning (cf. Liljedahl, Rolka & Roesken, 2007b). However, recently conducted research draws on the fundamental work by Green (1971) and identifies structural feature in beliefs research in terms of dimensions (Pehkonen, 1995; De Corte, Op’t Eynde & Verschaffel, 2002; Roesken, Hannula, Pehkonen, Kaasila & Laine, 2007). More recently, issues of changes in beliefs have been discussed in terms of conceptual change (Murphy & Mason, 2006; Pehkonen, 2006; Liljedahl, Rolka & Roesken, 2007a), extending a mostly cognitive-based theory to the concept of beliefs.

However, beliefs are often robust and therefore difficult to change or as Sowder (2007) puts it “many of teachers’ core beliefs need to be challenged before change can occur” (p. 160). Schommer-Aikins (2004) gives an interesting metaphor in order to capture the process of change in beliefs:

Beliefs are like possessions. They are like old clothes; once acquired and worn for a while, they become comfortable. It does not make any difference if the clothes are out of style or ragged. Letting go is painful and new clothes require adjustment. (p. 22)

What this quotation stresses is that any change or development in a teacher’s beliefs is a long-term process. Nevertheless, Pehkonen (2006) lists studies reporting about quick changes in beliefs while teachers participated in a professional development program. This is striking at first glance, but obviously, besides questioning issues of sustaining effects, the personality variable is a decisive and influential parameter. That variable refers to aspects of identity as a mathematics teacher, an issue that will be elaborated on in the subsequent section.

In order to conclude the last two sections it has to be emphasized that teachers' existing knowledge and beliefs extraordinary influence any vision of change they encounter (Cohen & Ball, 1990). Moreover, following Borko and Putnam (1995), teachers' "knowledge systems are simultaneously the objects of change and factors that support or constrain the change process" (p. 38). This interesting dualism might give some explanation on the conceptual level why changes are difficult to obtain. For that reason, Borko and Putnam (1995) call for powerful professional development programs in order to overcome the emerging obstacles. Perhaps one effective idea might be to integrate teachers very early in planning and implementing their needs and choices.

TEACHER IDENTITY

However, it is true that the most complete command of the relevant knowledge, paired with a perfect mastery of the required know-how and appropriate beliefs about mathematics and its learning, might still result in a lackluster performance that fails to hold the student's attention. Hence, one should not lose sight of the teacher's personality as a relevant variable in the classroom, or like Shulman (2005) emphasizes:

And we all know that you could have the most skilled classroom teacher who understand their subject matter deeply. But if they are not a person of character, there's something deeply deficient here.

Professional development is closely affiliated with personal development; therefore, the focus in the following will be on a teacher's identity and self as a mathematics teacher. In the preceding sections, aspects of knowledge and beliefs have been treated mostly independent from a holder's perspective. Nevertheless, closely related to these ideas of professionalism are issues of identity in a rather autonomous professional role. As Sachs (2001) notices, there is considerable conflict between issues of autonomy and outside pressure. She further enunciates that "the teaching profession is being exhorted to be autonomous while at the same time it is under increasing pressure from politicians and the community to be more accountable and to maintain standards" (p. 150). Regarding these paradoxes, teacher professionalism in terms of a teacher's professional identity should be explored more closely.

An identity as a teacher, particularly a self as a mathematics teacher, is formed over time, developed through a process of identity formation, as it is labeled by Wenger (1998), who has provided essential work in this area. This identity formation includes a wide range of facets relevant for teaching while "a sense of self as a mathematics teacher not only will differ among teachers but also will change for individual teachers while they progress in their profession" (Sowder, 2007, p. 168).

Nevertheless, Wenger (1998) does not talk about identity formation in simple individual terms, but explicitly refers to the relevance of communities among teachers:

Identity formation is a lifelong process whose phases and rhythms change as the world changes. From this perspective, we need to think about education not merely in terms of an initial period of socialization into a culture, but

more fundamentally in terms of rhythms by which communities and individuals continually renew themselves. (p. 263)

Hence, from their very nature identity processes of teachers are socially imbedded, though they mostly act individually in the classrooms. Wenger (1998) identifies five categories relevant in the context of professional identity, which are characterized by “a profound connection between identity and practice” (p. 149):

1. Identity as *negotiated experiences* where we define who we are by the ways we experience ourselves through participation as well as the way we and others reify our selves.
2. Identity as *community membership* where we define who we are by the familiar and the unfamiliar.
3. Identity as *learning trajectory* where we define who we are by where we have been and where we are going.
4. Identity as *nexus of multi membership* where we define who we are by the ways we reconcile our various forms of identity into one identity.
5. Identity as *a relation between the local and the global* where we define who we are by negotiating local ways of belonging to broader constellations and manifesting broader styles and discourses. (p. 149)

Wenger (1998) sees these categories as “modes of belonging” in which practice and identity are closely interweaved. Sachs (2001) puts it in even stronger words by saying that “identity and practice mirror each other” (p. 154). She further points to the wide scope of the provided dimensions as they “have application in developing a revised view of professional identity of teachers as they address the social, cultural and political (macro and micro, individual and group) aspects of identity formation” (Sachs, 2001, p. 154).

Hence, professional identity is seen in a bigger frame even when at first the individual teacher is addressed. The latter focus is legitimate, too, so Day (2000), because “professional development must be concerned with the whole teacher as a person, since it is the teachers’ whole self that brings significance to the meaning of the teaching act” (p. 108).

For sure, the challenge for a mathematics teacher is rather complex, as Adler et al. (2005) put it, in that “an enduring problem in mathematics education is its task to build both mathematics and teaching identities” (p. 378). Hence, especially building a mathematics identity, as indicated in the beliefs section, is a non-trivial endeavor. As could be shown by referring to Byers’ (2007) work on ambiguity, very easily views on mathematics obtain normative character that do not necessarily meet the complex work of a mathematician. While analyzing the structure of university professors’ beliefs about mathematics and its teaching and learning, Roesken and Toerner (2007) could show that, for instance, sophisticated views on doing mathematics correlate negatively with viewing students’ learning and the prerequisites they need in order to do mathematics. Too many teachers, probably, leave the

university with mostly non-reconciled views on mathematics (G. Toerner, personal communication, August 13, 2008), sometimes resulting in a general fear of being able to teach mathematics or at least in unstable self-efficacy beliefs.

The role and power of these aspects have already been mentioned by Cooney (2004), when stressing that “teachers’ beliefs and dispositions toward mathematics and its teaching influence the shape of implementing reform measure” (p. 505). One goal of professional development is therefore to develop a sense of self as a teacher of mathematics, as Sowder (2007) explicates, which “can be a byproduct of sound, ongoing professional development” (p. 167).

A very interesting point, addressing the prevalent focus on a teachers’ knowledge as dominating most of research related to professional development, is raised by Laursen (2005), who states that “not only emotional but also the cognitive aspects of teachers’ knowledge as the pedagogical content knowledge (Shulman, 1987) are personal” (p. 202). In this regard, Day (2000) underlines the following: “My vision for the twenty-first century is that good teaching will be recognized as work that involves both the head and the heart” (p. 108). In order to provide an overarching conception of teachers’ personal variables Laursen (2005) elaborates on the notion of a teacher’s authenticity:

The personal quality of a teacher in the classroom is experienced as a unified whole by students and not as several ‘sub-competences’ or aspects and therefore it is useful to have a single concept to denote this quality. (p. 203)

He identifies seven competencies relevant for authenticity, among them that authentic teachers are able to take care of their personal and professional development. Another important category is that authentic teachers cooperate intensively with colleagues. Hence, developing professional knowledge is primarily considered as an interactive process that responds to a teacher’s needs for growth.

Teachers are responsible for their professional growth, their personal goals and associated reflective processes. While some authors consider professional development as a linear continuum and identify different stages in the career development of a teacher (cf. Day and Sachs, 2004), others like Sachs (2001), refer to the process of identity formation as not necessarily being a straightforward one.

Sachs (2001) also stresses, and this is remarkable, that “clearly teachers inhabit multiple professional identities” (p. 155). Astonishing at first glance, the situation becomes clearer when considering Wenger’s (1998) explanation that “teachers’ professional identities are rich and complex because they are produced in a rich and complex set of relations of practice” (p. 162). However, developing a strong professional identity is part of a teacher’s expertise, makes him or her unique but also, through the way by which it is conceived, connected to a community of teachers (cf. Sfard & Prusak, 2005).

NOTES

¹ <http://www.dmv-gdm-2007.math.hu-berlin.de/>

² <http://dmv.mathematik.de/>

CHAPTER 1

³ <http://didaktik-der-mathematik.de/home.shtml>

⁴ International Group for the Psychology of Mathematics Education, <http://igpme.org/>

⁵ <http://www.mfo.de/>

⁶ International Conference, 24.-26.9.2007, University of Bamberg, 'Is teacher training effective? Answers from empirical research', <http://www.glanz-tagung.de/>

⁷ The 11th International Conference on Mathematics Education was held in Monterrey, Mexico, July 6–13, 2008.

⁸ <http://class.pedf.cuni.cz/pme30/>

⁹ http://www.acra.net/meetings/Default.aspx?menu_id=342&id=2936

¹⁰ COACTIV: Cognitive Activation in the Classroom, <http://www.mpib-berlin.mpg.de/coactiv/index.htm>.

CHAPTER 2

MATHEMATICS TEACHER PROFESSIONAL DEVELOPMENT

Theoretical Models

Regarding the theoretical models, the goals of the chapter are to model teacher learning and professional development, to present major models of professional development, to elaborate on the specific model of in-service education and training, to discuss effects of in-service training, and to elaborate explicitly on teachers' needs and expectations. Finally, some implications for research on professional development will be given.

IDENTIFYING THE RELEVANT PROCESSES

While summing up issues of theory and practice in mathematics teaching development, Jaworski (2006) stresses that to theorise teaching is a problem with which most educators are struggling (p. 189). She further points out that although mathematics education has been assigned a key role in the development of theories, which were mainly promoted in other disciplines like for instance constructivism, "the position of mathematics teaching remains theoretically anomalous and underdeveloped" (p. 188). At least an overarching theory to characterize mathematics teaching as well as its development, or as Jaworski (2006, p. 188) puts it, "a big theory" for teacher learning is missing on the research agenda.

The corresponding, rather complex and demanding issue is to theorize professional development, above all when it is tackled on a meta-level, going beyond simply identifying the relevant variables. This approach is a crucial one, since most of the conducted research is restricted to merely theorizing but neglecting the significance of the processes (cf. Krainer, 2006). Since the former has been in the focus of this work so far, for instance, while dealing with the domains of knowledge and beliefs, in the following, different approaches to model how these parameters interact will be visited, hence, in terms of broader models.

MODELING TEACHER LEARNING AND PROFESSIONAL DEVELOPMENT

Although a big theory for teacher professional development is missing, there are different approaches relevant in the context that provide substantial theoretical models. Regarding the multiplicity, the following choices were based on if and how the aforementioned theoretical perspectives were seized on. That is to say, the following approaches are key with regard to the issues presented in the first part of the theory

section, since they stress procedural aspects in terms of interdependencies regarding the involved variables, moreover addressing the single teacher as well as the whole system.

At first, a general model on teaching will be outlined that draws on a teacher's knowledge, goals, and beliefs (1), secondly a more systemic approach valuing the interplay of aspects of community, context and content (2) will be presented, thirdly a model pointing to the same direction but being based on the dimensions of action, reflection, autonomy and networking (3) will be sketched and finally an interconnected model of professional growth (4) will be elaborated on:

Knowledge, Goals and Beliefs

Schoenfeld (1985, 1999) provides an interesting approach to the field of teacher education when deriving theoretical aspects concerning teacher professional development from aspects of learning and teaching mathematics in general. He enters the field by framing at first teaching as a type of problem solving with multiple goals relevant at the same time. His theory of *Teaching-In-Context*, that he also understands in a broader sense as *Teaching-In-Action*, models teaching primarily as function of a teachers' knowledge, goals and beliefs (Schoenfeld, 1998). In what follows, Schoenfeld (1999) also highlights the outcome of the approach:

On the one hand, work addressing such teaching issues is deeply theoretical; it calls for delineating a teacher's goals, beliefs, knowledge, and decision-making, and modeling how all these interact. On the other hand, such work will have significant practical payoffs. It will provide tools for identifying practices and knowledge that support desired kinds of teaching, as well as tools for examining various forms of professional development and their impact. (p. 6)

Teachers are acting in a specific moment; these actions are goal-oriented and based on a teacher's knowledge, orientations as an abstraction of beliefs, values, preferences, and decision-making. Then, as an implication for professional development, he deduces that these parameters may not only serve as tools to identify practice, but in addition provide information about how several issues interact, finally with respect to capture how the dynamic can be influenced. What is interesting in the model provided by Schoenfeld is that the parameters he considers as crucial and decisive are also referred to in many publications dealing with aspects of professional growth. However, the focus is on the individual teacher, and although contextual factors are valued, the taken perspective is primarily a cognitive one.

Community, Context and Content

Llinares and Krainer (2006) provide a different approach while pointing out that considering teacher learning as a crucial aspect of professional development involves discussing the issue on an individual, a social and an organizational level:

This perspective stresses the fact that the analysis of teachers' professional development needs to take into account a wide range of variables which include

the teachers, their relations with other teachers, and the context in which their operate, and of course the content. (p. 445)

To sum up, relevant variables for teacher learning are the ones of community, context and content, but particularly crucial is their interconnection. Krainer (2006, p. 86) explicates the concepts as follows:

Contents that are relevant for all who are involved (e.g. interesting activities for the students, challenging experiments, observations and reflections for teachers, constructive initiatives and discussions at school);

Communities (including small teams, communities of practice and loosely-coupled networks) where people collaborate with each other in order to learn autonomously but also to support others' and the whole system's content-related learning;

Contexts (within a professional development program, at teachers' schools, in their school district, etc.) have conducive general conditions (resources, structures, commitment, etc.)

Since the research focus so far has often been on content, and communities have nowadays found their way onto the research agenda, what is often neglected is the relevance of the context. The former two aspects, for instance, are addressed jointly by Lachance and Confrey (2003), who report about a successful professional development opportunity while interconnecting content and community. However, the latter has only received minor interest. That is, a decisive parameter is the organizational support by administration or the educational system as a whole, not at least regarding variables like "enough time, space and other resources" (Krainer, 2006, p. 86).

The concepts are sometimes referred to as the three C's of marketing, a naturally interesting approach to teacher in-service education, which understands providing help for practicing teachers to be dependent on the law of supply and demand. This issue is explicitly paid attention to in the project design of the professional development initiative that will be presented later.

Action, Reflection, Autonomy and Networking

Krainer (1998, 2002) further introduces a four dimensional-model of teachers' professional practice while dealing with action, reflection, autonomy, and networking, which are described as follows:

Action. The attitude towards, and competence in, experimental, constructive and goal-directed work;

Reflection. The attitude towards, and competence in, (self-)critical and one's own actions systematically reflecting work;

Autonomy. The attitude towards, and competence in, self-initiated, self-organized and self-determined work;

Networking. The attitude towards, and competence in, communicative and cooperative work with increasingly public relevance (Krainer, 2002, p. 282)

While reflecting the typical situation of a teacher at school alongside these dimensions, Krainer (2002) describes it as “mostly dominated by action and autonomy, there is a lack of reflection and networking in the sense of a critical dialogue about one’s teaching with colleagues, mathematics educators, etc.” (p. 282). As explanation, Krainer (2002) refers to the traditional pre- and in-service education, focusing primarily on the individual teacher.

The dimensions are dependent on each other since “an increased competence in reflection raises the quality of action, and the knowledge of views of others enlarges the view of one’s own situation. Summing up, more reflection and networking contribute to a higher quality of autonomous action” (Krainer, 2002, p. 283). Hence, the dimensions considerably correlate with each other and balancing the needs of an individual within this field of tension is a great challenge for teacher educators and teachers.

The model further serves to capture similarities and differences of diverse professional development programs, independent from the country in which they were launched (Krainer, 2002). That is, the focal point of initiatives can be discussed against this background. Moreover, the dimensions are crucial when considering teacher education on a theoretical level, since they bring together different perspectives, particularly valuing the influence of attitudes and beliefs. The interdependency between action and reflection, for instance, is also a central issue in action research (cf. Altrichter et al., 2008), the conception of teachers as learners, whether autonomous or collaborative is in the focus of constructivism and any relation between those views is the central topic of a systemic theory (Krainer, 2002).

Interconnected Model of Professional Growth

The last model that will be outlined is particularly aiming at teacher professional growth while elaborating on different domains of developmental processes. Clarke and Hollingsworth (2002) describe the model as offering “a powerful framework to support the analyses of those studying teacher change (or growth) and the planning of those responsible for teacher professional development” (p. 947). The model that will be discussed in detail was developed through several iterations (Clarke, Carlin & Peter, 1992; Clarke & Peter, 1993; Peter, 1995, Clarke & Hollingsworth, 2002).

As Clarke and Hollingsworth (2002) report, the empirical foundation of the model draws on three different Australian studies: the ARTISM study (Active and Reflective Teaching in Secondary Mathematics), the EMIC study (Exploring Mathematics in Classroom) and the negotiation of meaning project. What is striking is the explicit focus on understanding the processes of professional growth and the supportive conditions. At first, Clarke and Hollingsworth call to mind the “implicit purpose

of many teacher in-service programs: specifically the causal chain in which such programs are based” (p. 949):

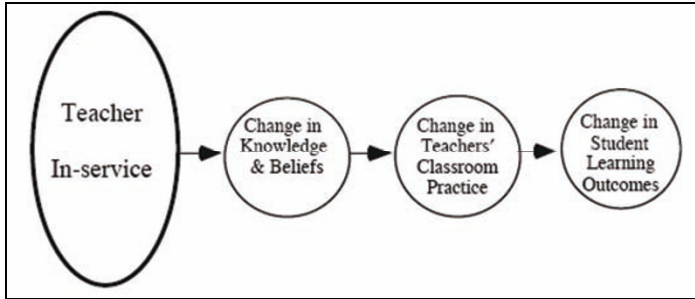


Figure 1. An implicit model of the purpose of teacher professional development (Clarke & Hollingsworth, 2002, p. 949).

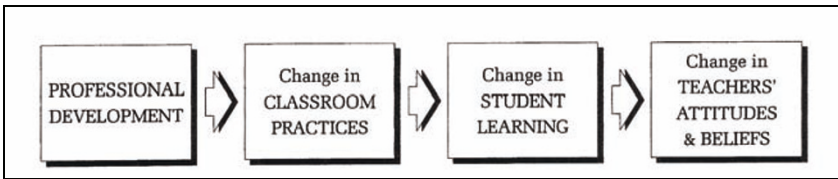


Figure 2. Guskey's (2000, p. 139) model of the process of teacher change.

The “change in attitudes comes first” approach, so Guskey (2000, p. 139), which is modeled in figure 1, drives most of the common professional development programs and draws on the classical work by Kurt Lewin who stated a likewise relationship for therapeutic settings. An alternative model is given by Guskey (2000), who emphasizes that “significant change in teachers’ attitude and beliefs occurs primarily *after* they gain evidence of improvements in student learning” (p. 139), as is indicated in figure 2.

Still the process of teacher change is defined by means of a naïve linear model and some authors rightly criticize that a highly complex process is oversimplified (Clarke & Peter, 1993; Peter, 1996). In this regard, Peter (1996) reminds of the fact that Guskey’s model is mainly derived from in-service training practice in the 70s and early 80s.

However, the model at least refers to one striking point, that is, the sequential order in the model indicates that change in a teacher’s beliefs and attitudes is a long-term goal, depending on how changes in a teacher’s classroom practice interfere with changes in student learning outcomes. That is, significant development is likely to occur, “once teachers have “field-tested” change proposals in classrooms and experienced first hand changes in student learning outcomes” (Clarke & Hollingsworth, 2002, p. 949).

Cobb, Wood and Yackel (1990), who explain that changes in beliefs can occur at any point of the developmental process, provide a consequently different approach. They draw on the well-known work by Leon Festinger and explain that teachers have to undergo feelings of cognitive dissonance. While engaged in the classroom, conflicting beliefs and thoughts need to occur in order to produce any change in behavior.

Clarke and colleagues have modified the initial linear model by Guskey fundamentally while assuming a cycle of professional development, as can be seen in figure 3:

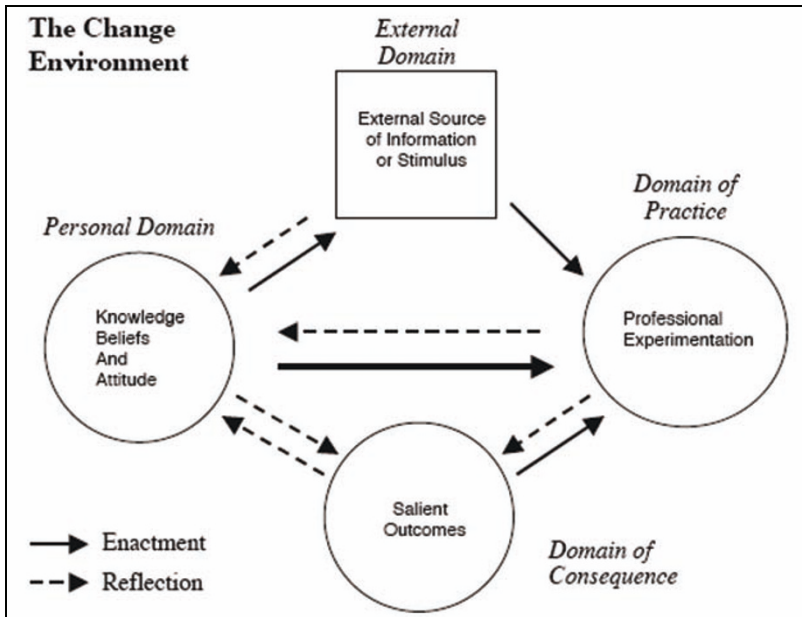


Figure 3. The Interconnected Model of professional growth (Clarke & Hollingsworth, 2002, p. 951).

The *Interconnected Model* explains teacher professional growth in terms of analytic domains that are connected through mediating processes. The domains, provided by Clarke and Hollingsworth (2002, p. 950), are the following ones:

- *The personal domain:* teacher knowledge, beliefs and attitudes
- *The domain of practice:* professional experimentation
- *The domain of consequence:* salient outcomes
- *The external domain:* sources of information, stimulus or support

Hence, the model encompasses two different types of domains while distinguishing between external and rather internal domains, the latter representing a teacher's personal world:

In combination, the domain of practice, the personal domain and the domain of consequence constitute the individual teacher's professional world of practice, encompassing the teacher's professional actions, the inferred consequences of

those actions, and the knowledge and beliefs that prompted and responded to those actions. (Clarke & Hollingsworth, 2002, p. 951)

In the personal domain, teachers' knowledge, beliefs and attitudes, underlying any classroom practice, are considered as essential while the domain of practice is concerned with the enactment of knowledge and beliefs, explicitly considering the teaching practice as being partly experimental (Peter, 1995, 1996) but also conceiving it as "encompassing all forms of professional experimentation" (Clarke and Hollingsworth, 2002, p. 950).

The values then attached to the corresponding outcomes, so Peter (1995), "constitute the mediating domain by which classroom experimentation is translated into changed teacher knowledge and beliefs" (p. 322). Clarke and Hollingsworth (2002) further explicate, "change in the domain of consequence is firmly tied to the teacher's existing value system and to the inferences the teacher draws from the practices of the classroom" (p. 953). Furthermore, they emphasize that values do have an individual dimension, i.e., that they differ among teachers, who also estimate different issues as salient.

Referring to values is an interesting approach since teachers appear to have a very strong value system, which makes them easily resistant to any purpose of change processes. Moreover, values also exist on the administration side that might lead to conflicting positions.

The external domain encompasses any external source of information or stimulus and is not restricted to in-service sessions but includes other sources of information like publications or conversation with colleagues as well (Clarke & Hollingsworth, 2002). An important role is attached to those mediating processes that are "classified as being either enaction or reflection" as means to "translate growth in one domain into another" (Peter, 1995, p. 322). Clarke and Hollingsworth (2002) explain the labeling as follows:

The term "enaction" was chosen to distinguish the translation of a beliefs or a pedagogical model into action from simply "acting", on the grounds that acting occurs in the domain of practice, and each action represents the enactment of something a teacher knows, believes or has experienced. (p. 951)

Obviously, the authors' conception is close to Schoenfeld's approach of understanding teaching as a function of a teacher's knowledge, goals and beliefs.

The model allows for describing different aspects of change processes, serving as factors that influence a teacher's growth. The change process can begin and end at any point in the model but an ideal course would include all domains (Peter, 1996). As mentioned earlier, the model has been revised a number of times. Since most of the change processes could not adequately be described in earlier versions, for instance, because the intentionally provided in-service education was not the only stimulus for changes in the classroom or because the reciprocal interaction of the factors was firstly neglected (Peter, 1996), further modifications have been worked out. Finally, as Clarke and Hollingsworth (2002) note, "this model recognizes the complexity of professional growth through the identification of multiple growth pathways between the domains" (p. 950).

Though a teacher’s learning process is modeled in detail by including different domains, it can also be described in rather individual terms, e.g., with respect to a single teacher’s growth. Accordingly, Clarke and Hollingsworth (2002) provide an individualized version of the model, explicitly stressing the focus on a particular teacher, as can be seen in figure 4:

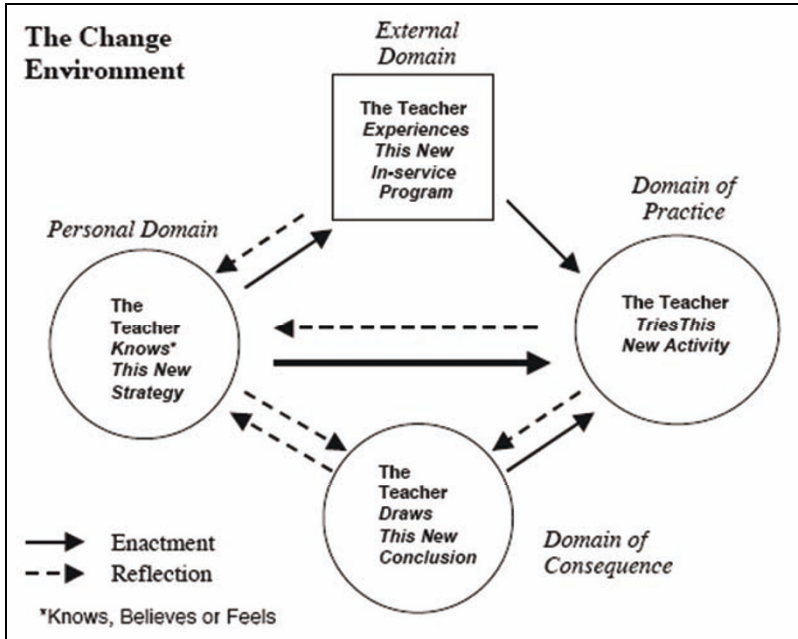


Figure 4. Operationalization of the domains regarding a single teacher (Clarke & Hollingsworth, 2002, p. 957).

All domains are now personalized, a teacher obtains new information or strategies during an in-service program, tries the new activities in the classroom, connects them to the salient outcomes which then “will inevitably reflect the teacher’s existing conception of the goals of instruction, and of acceptable classroom practice; that is, the teacher’s knowledge and beliefs” (Clarke & Hollingsworth, 2002, p. 957).

The authors are aware of the demand that their “modeling of teacher growth must conform to some coherent theory of learning” (Clarke & Hollingsworth, 2002, p. 955). With respect to the criticism expressed by Jaworski (2006), as reported earlier in this section, they mainly regard a cognitive or situative perspective on learning as crucial but they advise against the following:

The Interconnected Model can be interpreted as consistent with either the cognitive or the situative perspective, dependent upon whether we take teacher growth as being the development of knowledge or of practice. This is not a

dichotomous choice. Indeed, any dichotomization of knowledge and practice as competing objects of learning should be seen as problematic. (Clarke & Hollingsworth, 2002, p. 955)

An analogous point of criticism has been raised earlier, Ball (2000b) reflected upon the distinction between knowledge and action as a not helpful fragmentation in teacher education. In that sense, the value of the model lies not only in its interconnectedness but interrelatedness since it pays attention to both development of knowledge *and* practice in terms of possible growth networks, takes into account key change domains and highlights the mediating processes relevant for effective professional development.

MAJOR PRACTICAL MODELS OF PROFESSIONAL DEVELOPMENT

The increasing discussion on professional development has not only led to various theoretical and methodological approaches but also to new models and designs. Guskey (2000) differentiates seven major models of professional development, which are presented in [table 1](#):

Table 1. Major practical models of professional development (Guskey, 2000, p. 22).

<i>Majors models of professional development</i>
Training
Observation/assessment
Involvement in a development/improvement process
Study Groups
Inquiry/action research
Individually guided activities
Mentoring

As Guskey (2000) further points out, “these various models differ in their assumptions, expectations, and beliefs about professional growth” (p. 28). They serve different purposes since some aim at changes on a more general and systematic level whether others explicitly provide support on the individual level.

However, the most common conception of professional development is certainly related to providing training for serving teachers, which is the prevailing model in many countries (Guskey, 2000). Even though over the last 20 years, the vision of teachers as lifelong learners has permeated research in this area, in-service education and training appear “to be the most efficient and cost-effective way to reach the huge population of teachers” (Day & Sachs, 2004, p. 8). These courses have a wide range of topics, goals and methods but limited duration. The methods involved can

range from group work, use of video, learning from practice to presenter-given input. Until so far, and regarding the focus of this work, in-service education will be deeply elaborated on in the following, always keeping in mind that no method is innovative or traditional by itself (Cochran-Smith & Lytle, 1999).

The other models of professional development will not be presented in detail but sometimes referred to since they stress relevant aspects for a general debate on teacher growth; for a general conspectus on study groups, inquiry and action research the reader is referred to the work of Altrichter et al. (2008), Borko (2004), Jaworski (2006), and Lave and Wenger (1991). As more relevant is considered that these models are not discrete entities. One legitimate view on in-service training arguably might be to view this specific type of activity as partly comprising the other ones. That is, in-service training can include facets of inquiry and action research or study groups. Garet, Porter, Desimore, Birman and Yoon (2001) point to the same direction when concluding that “to improve professional development, it is more important to focus on the duration, collective participation, and the core features (i.e., content, active learning, and coherence) than type” (p. 936).

IN-SERVICE EDUCATION AND TRAINING

For good reason, the focus so far has been on teacher professional development, the broader and more elaborated concept, embracing that of in-service education and training. While providing principles concerning effective professional development, Loucks-Horsley et al. (2003) emphasize that “beliefs about professional development have changed during the past 30 years” (p. 47). Particularly, they stress that “in the early 1970s, professional development was called inservice training” (p. 47). However, the authors do not further explicate what kind of beliefs about professional development are decisive and of relevance for teachers, teacher educators and administration. Particularly, teachers’ beliefs about and attitudes towards professional development are a non-negligible parameter, as will be pointed out in the following sections.

Meanwhile, the concepts of professional development and in-service education are clearly distinguishable and much research has been conducted focusing on each of them, although with different strength and relevance concerning the specific subject education. As mentioned earlier, the model still definitely associated most with professional development is in-service teacher training (Guskey, 2000), since it ultimately presents the most common form of providing help for practicing teachers.

There has been much progress in the field, and viewing in-service education as being job-embedded and a part of professional development has permeated the agenda. Nevertheless, the following statement given by Guskey (2000) stresses that the hitherto conception of in-service education as brief and rarely sustained, deficit oriented, and radically under-resourced unfortunately is still relevant:

Many teachers and school administrators regard professional development as special events that are restricted to 3 or 4 days during the school year. Seldom have they had input into the planning of these events, and only rarely are the ideas that are offered applicable to their situation. (p. 14)

However, while acknowledging a growing recognition of conceptualizing in-service education and training and professional development in different ways, Hargreaves (1994) gives an interesting metaphor for each of the concepts:

The INSET [In-Service Education and Training] model during periods of reform treats teachers as needing occasional injections to pep them up, calm them down, or ease their pain. The professional development model requires a different metaphor: Unless teachers are offered through professional development a regular and balanced diet, they will not be effective practitioners. (p. 430)

In the past, in-service training was mainly conceived as bringing outside knowledge to the single teacher; no particular relevance was given either to collegial work or the system the teacher was working in (Day, 1999). In this regard, Day (1999) recalls that the concept of professional development “does not eschew INSET [In-service Education and Training], in the form of courses, but locates it in a wider learning context, as contributing to the repertoire of learning modes now used to promote growth of individuals and institutions, and taking place both on- and offside” (p. 131). In particular, in European countries a historically rooted reluctance to speak of professional development in terms of a systemic and life-long conception can be recognized (Day, 1999).

Further, Day (1999) reminds of the fact that a traditional concept of in-service training as taking place rather isolated from the learning life in school still hinders staff development in single schools. Practicing teachers do have learning experiences on a daily basis and the crucial point, also with regard to what makes professional development successful, is to connect any offer to a teacher’s daily and lifelong professional learning, in order to strengthen processes that are already on the way (Tenorth, 2007).

However, Day gives a straightforward definition of in-service education, the much more precise concept than the global one of professional development, when defining it as a “planned event, series of events or extended program of accredited or non-accredited learning” (p. 131). Although views on professional development differ notably from one another, they can be classified into two groups that were earlier labeled as deficit compensation and empowering teachers. Again, Day (1999) makes a very good point when regarding the underlying different philosophies as follows:

If it is accepted that teachers, schools and policy-makers outside schools have legitimate interests in improvement and redirection in contractual, moral and professional accountability contexts, then notions of ‘defect’ and ‘growth’ approaches present a false dichotomy. (p. 134)

He moreover stresses that “INSET [In-Service Education and Training] should not focus predominantly on one at the expense of the other” (p. 134), which can easily happen. Nevertheless, since so far, at least in European countries, the emphasis has been on regulating from outside, for example via curricula, a crucial shift that has to take place is the one in favor of a more a bottom-up approach by giving change into the hands of teachers or simply viewing them as involved instead of concerned people (Krainer, 2002). To sum up, beyond any dichotomy, the effects of in-service

teacher education address the whole system. Hence, professional development goes alongside with school and educational system development.

EFFECTS OF IN-SERVICE EDUCATION AND TRAINING

However, under the headline *Teachers' Professional Lives*, Schoenfeld (1999) drastically concludes, that “for the most part, they don’t have them – that is, teachers in the United States don’t have professional lives, in any sense worth speaking of” (p. 22). He criticizes that most teachers do not have opportunities for sustained and well-conceived professional development. Likewise, Day (2000) concludes that “for many teachers, the last 20 years have been years of survival, rather than development” (p. 101).

More drastically, Hargreaves and Goodson (1996) stress that “teachers deserve and demand professional lives but some of the new directions and developments may mean that this historic aspiration is being seriously threatened” (p. 3).

However, there are recent developments and trends that have provided much progress in the field. In the following, some promoting and hindering factors for teacher professional development will be discussed. The lists are rather specific, as they ultimately reflect issues relevant in the context of this work.

Identifying Effects on Different Levels

Although there is a considerable body of research related to in-service education, what is lacking is a systematic empirical approach to the effectiveness of professional development regarding both improvements in teaching and in student outcomes (Terhart, 2002; Guskey, 2000; Sowder, 2007; Garet et al., 2001). Single in-service programs are accompanied by evaluation studies but their results are mostly too specific to provide general insight. Garet et al. (2001) summarize the situation as follows:

The research literature contains a mix of large- and small-case studies, including intensive case studies of classroom teaching, evaluations of specific approaches to improving teaching and learning, and surveys of teachers about their pre-service preparation and in-service professional development experiences. In addition, there is a large literature describing “best practices” in professional development, drawing on expert experiences. (p. 917)

Lipowsky (2004) provides an overview on research explicitly dealing with examining and identifying successful aspects of in-service training programs. His state-of-the-art is guided by the following questions, *What overall effects can be anticipated from in-service education? What characteristics influence the effects positively? How can these effects be gathered?* His summary of the literature review is orientated on a four-stage system that has already been established in some evaluation studies (Lipowsky, 2004, p. 3):

1. Teachers’ opinions and impressions
2. Changes in teachers’ professional knowledge

3. Changes in teachers' actions
4. Effect on students' performance

In the *first category*, teachers themselves are asked how they value the benefit of the specific in-service training, if they are satisfied with the chosen program and how they perceive the profit regarding their competence. As most important parameter with regard to transferring issues imparted at an in-service training into practice, teachers identify the relatedness to their classroom practice. Not surprisingly, the teachers also acknowledge the content both in terms of subject matter and pedagogical content knowledge and emphasize the importance of active learning. The next essential factor is collaborating with colleagues in terms of a prolonged exchange during as well as after the event.

Lipowsky (2004) further points to the evaluation of a specific in-service training program in Germany, the SINUS-project, which will be described in more detail in the following section. Besides emphasizing the relevance of collaborative work, the results gained in the context of that project hint at the importance of professional exchange in terms of sustained mentoring and effective guidance by externals. Obviously, community aspects essentially influence whether lasting effects will take place both addressing the collegial and the teacher educator level.

The *second category* explicitly deals with changes in a teacher's professional knowledge whereby the notion applied by Lipowsky (2004) follows Bromme's (1997) definition of professional knowledge, encompassing subject matter and pedagogical content knowledge, curricular knowledge, routines, reflective practices and beliefs. Lipowsky (2004) explicates that some studies have provided evidence for a causal relation between teacher knowledge and student outcomes, therefore in-service training should explicitly aim at changes in a teacher's cognition.

He moreover pays attention particularly to changes in beliefs and reports about studies indicating that any change in beliefs could occur even while reflectively dealing with them. In this regard, the supportive role of cognitive conflict or at least the necessity of challenging beliefs to make them accessible was pointed out. For instance, changes in beliefs towards a constructivist position were initiated while the teachers came to know different perspectives or got insight into students' ways of learning. However, there is a clear lack of empirical research dealing with the conditions necessary to make these changes being reflected in classroom practice.

Regarding the *third category*, Lipowsky (2004) provides information about studies dealing with the effect of in-service training events on teachers' actions in the classroom. While there is little empirical evidence on the general level, he states a well-researched area of microteaching, personal coaching or cognitive oriented training models. Microteaching is organized practice teaching, focusing on single actions in the sense of modular teaching, moreover favoring collegial exchange. Although its effect on changes in behavior is indisputable, the transfer from the artificial situation to the complex classroom one is questionable, i.e., it is doubtful if these changes will establish themselves in a teacher's repertoire.

Moreover, Lipowsky (2004) points out that with respect to specific models like inquiry-based learning changes in teachers' actions could be observed while, an

interesting point, their beliefs nonetheless remained the same. The situation was rather reverse for pre-service teachers who modified their beliefs but not their actions. The data was collected in the context of a long-term professional development program combining phases of theoretical and practical learning (cf. Luft, 2001).

In the *fourth and last category*, the effects of in-service training on students' outcome are questioned. Ultimately, all reform efforts are aiming at enhancing students' performance but only a few studies explicitly deal with a causal relation between those two. Lipowsky refers to Kennedy (1998), who provides a meta-analysis on 93 studies dealing with effects of professional development programs. Only in twelve studies, a positive effect on students' outcomes could be stated. In this respect, in-service courses addressing a change in a teacher's behavior were less successful than the ones focusing on providing specific knowledge.

Lipowsky (2004) concludes that in-service education is successful when the design is long-term, input and practice phases alternate, opportunities to test in the classroom are provided and adequate feedback is given to the teachers. No sustainable effect is attributed to short-term programs that do not offer opportunity to adequately contemplate the presented issues. What can be highlighted is the decisive role of intensive communication and collaborative work among teachers of the same school. The interactive work of colleagues teaching the same subject allows for discussing, testing and modifying new ideas.

Furthermore, Lipowsky (2004) stresses that successful in-service education and training do supply some specifications regarding content and goals but leave flexibility to consider self-determined and independent learning, as indicated in some studies. Regarding content, the focus should be on pedagogical content knowledge, concentrating on specific themes, allowing for deep reflection, for instance, on students' ways of thinking and problem solving.

What Lipowsky (2004) overtly underlines is to be aware of a teacher's beliefs and values, to make them transparent and accessible in order to understand how these effect any perception of classroom action. In this regard, a promising approach is to uncover discrepancies between one's own beliefs and corresponding actions, furthermore when these are reflected against the practices of other teachers. For this purpose, the use of video serves as a fruitful way to make the aforementioned processes evident.

Finally, these four categories also differ in how they can be empirically approached. Studies addressing level 2 (changes in teachers' professional knowledge) and level 4 (effect on students' performance) require an empirical and methodological expertise while level 1 (teachers' opinions and estimations) and level 3 (changes in teachers' actions) can be tackled on a qualitative basis. For example, asking teachers for their opinions during interviews can gather data on level 1 while a rather innovative approach to assess anticipated changes in teacher's actions as mentioned can be to involve students in the evaluating process.

Despite the fact that some aspects of effectively designing in-service education could be identified, many research questions, so Lipowsky (2004), remain unanswered. For instance, no results deal with the influence of personal parameters like a teacher's cooperativeness, his or her impressions of how the specific needs were reflected in the course offer and an overall feeling of satisfaction.

Another interesting contribution is given by Garet et al. (2001) who primarily deal with defining high-quality professional development while identifying characteristics relating to positive outcomes of teachers and students. The authors point out that although there is clearly progress in the field, “few studies have explicitly compared the effects of different characteristics of professional development” (Garet et al., 2001, p. 918). The data they gathered was related to a specific federal professional development program and was collected in order to shed light on the following assumed interdependency:

We designed this study to enable us to examine the relationship between features of professional development that have been identified in the literature and self-reported change in teachers’ knowledge and skills and classroom teaching practices. (Garet et al., 2001, p. 918)

Garet et al. (2001) draw their empirical approach on research concerning high-quality professional development. As a result, the analysis focuses on *structural features* and *core features*, whereby the former refers to “characteristics of the structure or design of professional development activities” and the latter to “dimensions of the substance or core of the professional development experience” (p. 919). More concretely, they identify the following structural features (Garet et al., 2001, p. 919/920):

- a) the form of the activity: (i.e., whether it is a reform type, such as a study group or network, in contrast to a traditional workshop or conference)
- b) the duration of the activity; including the total number of contact hours that participants spend in the activity, as well as the span of time over which the activity takes place
- c) the degree to which the activity emphasizes the collective participation of groups of teachers from the same school, department or grade level, as opposed to the participation of individual teachers from many schools

Additionally, Garet et al. (2001) discover three core features of professional development activities. The connection between those two types of features can be described as follows, “it is primarily through these core features that the following structural features significantly affect teacher learning” (p. 919):

- a) the degree to which the activity has a content focus (that is, the degree to which the activity is focused on improving and deepening teachers’ content knowledge in mathematics and science)
- b) the extent to which the activity offers opportunities for active learning, such as opportunities for teachers to become actively engaged in the meaningful analysis of teaching and learning (for example, by reviewing student work or obtaining feedback on their teaching)
- c) the degree to which the activity promotes coherence in teachers’ professional development, by incorporating experiences that are consistent with teachers’

goals and aligned with state standards and assessments, and by encouraging continuing professional communication among teachers.

To sum up, the authors gain a two-layer model for describing positive effects on teachers' growth. First, they identify core features relevant for the single teacher's learning, and second, they describe decisive structural features, which are both analyzed further regarding a possible interaction.

Identifying Promoting Factors

In the preceding section, different levels were distinguished while gathering aspects of effective professional development in general and in-service training in specific. That is, these effects were discussed with regard to the outcomes as structuring features. Now, the parameters leading to effective professional development will be elaborated on in more detail. Since effects can be reflected as being positive and negative, this section is concerned with promoting factors while the subsequent one deals with hindering factors.

In the following, the list of promoting factors also reflects current trends, and is surely not a final or complete one. Moreover, the factors are seized because they are relevant regarding both the particular professional development program that will be presented later as well as the results of the empirical study, which is in the focus of this work. In particular, what will be dealt with are the following aspects: (1) in-service education only makes sense pragmatically, (2) in-service education affects a learning system, (3) in-service education requires collaboration among teachers, and (4) in-service education connects research and practice.

In-service education only makes sense pragmatically. Some years ago, Cooney and Krainer (1996), a bit ironically, formulated the following two thesis as subsections in their contribution to the International Handbook of Mathematics Education (Bishop et al., 1996): "Thesis 1: We expect too much from in-service programs" (p. 1167) and "Thesis 2: We expect too little from in-service programs" (p. 1168). While discussing thesis one, the authors explicate that due to the increasing educational demands "the expected outcomes of in-service programs may become unrealistic" (Cooney & Krainer, 1996, p.1167). They particularly remind of the long way issues provided at an in-service training take to become implemented in the classroom:

From another perspective, we have a tendency to inflate our expectations when inservice is based on research which certifies that a particular teaching strategy or particular curricular approach positively affects students' achievement or attitudes toward mathematics. The question remains, however, as to how the teacher translates that knowledge into teaching strategies for her students. (Cooney & Krainer, 1996, p. 1167)

But it is not only that we expect too much from in-service training but from the single teacher as well, so Cooney and Krainer (1996), and refer to consequences like burn out as reaction on increasing demands and complexity that teachers feel not able to meet.

Interestingly, they formulate the opposite position as thesis two, when claiming that we expect too little from in-service programs. The authors explain that a central point is to integrate mathematics and pedagogy in any professional discourse. In this regard, a crucial approach is “to make it possible for teachers to experience new methods themselves and to develop similar activities for their students” (Cooney & Krainer, 1996, p. 1168). But, as Cooney and Krainer (1996) explicate, “most inservice programs fail to challenge teachers’ beliefs about what or how they should teach” (p. 1168). The authors consequently hint at the following:

When in-service programs fail to consider the circumstances and beliefs of teachers, they ensure that their effect will be essentially random, significantly diminishing any potential impact. Such an approach underestimates the potential of inservice programs to affect change and, in a sense, dishonors the potential teachers have for realizing reform. (Cooney & Krainer, 1996, p. 1168)

Once more, the emphasis is on honoring the potential of teachers since they are the experts for their specific learning. Krainer (1996) moreover explicates that rather traditional in-service approaches, which are based on bringing outside knowledge to the teachers, not at least fail due to the increasing demands on schools and teaching. In order to deal with the complexity, more attention should be given to the internal knowledge already existing, that is, teachers’ competencies and strengths. Finally, Krainer (1996) concludes that these two theses, though being contrary, so share understanding in-service education as being subject to change.

The issues mentioned by Cooney and Krainer (1996) shed some light on what is meant by the claim that in-service training does only make sense pragmatically. Certainly, the message that is transported is multifaceted, although the statement might sound rather disillusioning at first. Tenorth (2007), who also stresses that expectations on in-service programs are too high, reminds of viewing in-service training as taking place daily, being part of a lifelong and long-term process, or as Lave (1996) puts it, considers teachers as learners in practice.

Additionally, Tenorth (2006, 2007) underlines that teacher learning is rather *unlearning* than *new learning*, never occurring isolated but in an educational setting or context. That is why in-service education only makes sense pragmatically, i.e., as partly initiating change even in terms of unlearning or relearning moreover addressing and involving a learning system. In the last section of this chapter, consequently, the explicit focus is on teacher needs and expectations regarding in-service education and training rather than simply viewing them as consumers of a program.

In-service education affects a learning system. Closely intertwined with the aforementioned idea, is viewing in-service education as affecting a system. This aspect is only partly covered in the aforementioned categorization provided by Lipowsky (2004) since the identified levels of effects of professional development just consider teachers and students. Any global effects addressing the educational system that can be an outcome of an in-service education program which is, for instance, well documented in the context of the IMST-project in Austria (see chapter 3) is not brought up.

However, Krainer (2002) actually refers to the four dimensions of action, reflection, autonomy and networking to emphasize that it is the interaction of the people within the educational system that finally results in a learning system. In this regard, particularly reflection and networking addressing all relevant persons, is rather undeveloped. Professionals not only continue to grow through their professional lives, but their learning, so Krainer (2008b), is moreover situated in a broader context since different levels are involved:

Micro level: Individuals, teams

Meso level: Networks, schools

Macro level: Districts, nations

Krainer underlines the importance of each level and emphasizes the significance of a vertical connection. Further, he points out that research in teacher education has primarily been concerned with the micro level, neglecting the importance of the meso and macro level. But teacher education is more than teacher development on an individual level, teacher education is school improvement since all participants in the system learn (Krainer, 2002; Tenorth, 2007).

An issue that has so far not been discussed in this work is the following one by Palmer (2007), who states that “our large, complex institutions are increasingly unresponsive to external pressure, even on those rare occasions when an informed and organized public demands change”. However, impulses that develop bottom-up, first being initiated by teacher development and progress and second being imbedded in the school context, continue to be of relevance for the educational system as well. That is, a crucial approach is to focus on the single school, particularly for quality management and improvement (Daschner, 2004), thereby acknowledging that progress develops little by little emerging from inside rather than at a quick pace initiated from outside.

The understanding of in-service education and training as addressing a learning system naturally leads to the question, *Who is also learning?* Some answers will be given in chapter 3 when discussing the influence and effects of the IMST-project in Austria.

Another body of research centers on the learning of teacher educators, and considers them as developing professionals, too (cf. Llinares & Krainer, 2006; Sowder, 2007). Zaslavsky and Leikin (2004), for instance, report about the growth of mathematics teacher educators while engaged in a professional development context. In their work, they provide an interesting modification of Jaworski’s (1992, 1994) teaching triad for students’ learning. Since the teaching triad comprises the management of learning, sensitivity to students, and the mathematical challenge, Zaslavsky and Leikin (2004) adapted the corresponding triad for teacher educators as follows:

Accordingly, we consider the teaching triad of a mathematics teacher educator to consist of the challenging content for mathematics teachers (i.e., Jaworski’s teaching triad), sensitivity to mathematics teachers and management of mathematics teachers’ learning (see [Figure 1](#)). (p. 7)

One decisive parameter of the adapted triad is the sensitivity to teachers, which might have been rather underestimated in the past and is in the explicit focus of this work.

In-service education requires collaboration among teachers. Obviously, there has been a clear shift from the ethos of teacher isolation (Lortie, 1975) to collegial collaboration, or as Krainer (2003) remarks, an “increasing awareness of the social dimension in mathematics teacher education” (p. 93). Interestingly, in the 1980ies, it was Bauersfeld (1980) who emphasized the significance of the social dimension in the classroom. Furthermore, this shift has been accompanied by different theoretical orientations, so Krainer (2003), as indicated by “the emergence and usage of new theories that go beyond cognitive views on learning” (p. 93).

The notion of collaborative work has permeated the literature, whether in terms of teacher inquiry groups, communities of practice or networks of critical friends, and is closely intertwined with reflective practice (Krainer, 2003; Jaworski, 2006). Schoen (1983) coined the notion of reflective practice both in terms of reflection on-action and reflection in-action. Some authors extend the conceptualization to reflection about action, to strengthen that reflection means “thinking that is not just ivory-towered contemplation, but that is linked directly to practice” (Hargreaves & Goodson, 1996, p. 12).

Ultimately, the question of how practice can become reflective has resulted in fostering collaborations, providing opportunities for a shared understanding of issues relevant for teaching, further contributing to the growth of teachers’ knowledge regarding their own practice. With respect to the growing body of research, Hargreaves and Goodson (1996) conclude:

But what matters throughout this literature are the emphases that all teachers reflect in some way, that teachers can articulate and share their reflections more explicitly, that reflection is at the heart of what it means to be professional, and that teacher education, supervision and development should be constructed in ways that make such explicit reflection more feasible and more thorough. (p. 12)

Particularly, the contributions made by Lave and Wenger (1991) and Wenger (1998) on a social theory of learning, stress the significance of the four processes of learning, meaning, community, and identity (cf. Lieberman & Miller, 2005). Learning in practice is viewed “as social and collective - coming about through social participation in communities of practice where people feel a sense of belonging and a need to make a contribution” (Lieberman & Miller, 2005, p. 155).

Moreover, referring to Wenger’s work and in particular elaborating on the success of communities of practice, Krainer (2003) poses various questions:

How does this relate to those organizations that seem to be primarily responsible for knowledge and learning – to schools and universities? Are they loosing their monopoly for educational affairs? To what extent can an approach like “Community of practice” be applied to learning at schools and university?

What can we learn from “learning enterprises”? What implications for research in teacher education has an approach that builds on “community of practice”? (p. 96)

These thoughts apparently show that collaborative work is not only a key factor regarding teacher learning but in addition makes a systemic approach a subject of discussion in teacher education as well.

Lachance and Confrey (2003) provide some additional answers to the question why teacher communities in mathematics education should be promoted. They report on research indicating that “successful schools had teachers who had continual and substantive interactions” (p. 109). Further, they stress that “there is substantial research in the broader area of school reform that suggests that peer collaboration and support is a crucial prerequisite for teachers to be successful in restructuring their classrooms and their schools (p. 109). However, many initiatives have in common that they focus too much on the individual (Krainer, 2001) rather than on communities of teachers.

In-service education connects research and practice. A very decisive relationship is the one between research and practice, an issue that has earlier been touched while elaborating on the significance of teacher knowledge. In particular, the work of Cochran-Smith and Lytle (1999), who distinguish knowledge-*for*-practice, knowledge-*in*-practice and knowledge-*of*-practice in order to refer to different relations between those two, was presented. While the focus in that section was primarily on the knowledge aspect, in the following further possible connections are discussed.

For instance, Shulman (1997) so aptly emphasizes the role of research and its significance for practice when stating the following:

Research begins in wonder and curiosity but ends in teaching. The process of research is incomplete until the researcher can communicate his or her understandings clearly, persuasively, and effectively. (p. 6).

Correspondingly, Krainer (1996) deems a connection between research and in-service education as central perspective, i.e., “conceptualizing inservice as a context for integrating theory and practice” (Cooney & Krainer, 1996, p. 1155). Under the headline, *The fusion of teacher education and research*, Krainer (2003) stresses:

Working with teams, communities or networks of teachers and investigating their professional growth are activities where teacher education as a field of practice and a field of research merge (see e.g., Cooney, 1994). (p. 98)

A very specific merging is reflected in one of the constitutive parameters of the professional development program that will be presented in detail in chapter 4. That is, in-service training offers are made by tandems of a teacher educator and a teacher. Thus, from their very inception, courses are sure to combine research and practice in a fruitful way.

Talking about research and practice implies reflecting on the corresponding role of theories. In this regard, Jaworski (2006) emphasizes that “theories help us to analyze,

or explain, but they do not provide recipes for action; rarely do they provide direct guidance for practice” (p. 188). Likewise Sprinthall et al. (1996) conclude that “there is no linear equation from theory to practice nor the other way from practice to theory” (p. 667) and further pose the question, “is theory embedded in practice and is practice visible in theory?” (p. 667).

The quotations focus on the gap between research and practice whereas Shulman (2000) maintains a rather conciliatory position while reflecting the different roles that a researcher and a teacher are involved in as follows:

The problem is that our experiences as researchers and teachers are vastly different. Research does not end with our heaving a sigh of relief as we make a discovery or make a connection and say “I now understand it.” We aren’t done with the research until we have displayed it, summarized it, submitted it for peer review, and, once its quality has been attested to, shared it with as much of our community as will pay attention to. That’s what we do as researchers. As teachers, we’re almost like psychotherapists. We have these extraordinary encounters with groups of students – encounters build around our design, interactions, assessments of how the students did, and reflections of how it worked and how we would want to do it differently the next time. We engage in a full active investigation every time we teach a course, and then we bury it in our files, never to see the light of day again until the next time we teach that course and, if we’re lucky, we remember in which file we buried it. (p. 7/8)

By the aforementioned descriptions, Shulman (2000) makes explicitly clear that differences between research and practice cannot simply be viewed abstractly but have to be regarded in terms of different roles, goals and purposes of the persons being involved. Cochran-Smith and Lytle (2001) point to another interesting aspect of research and practice as conflicting or concurring areas as they point out the following:

Unfortunately, practice is often “juxtaposed with the terms theory and research to suggest both relationships and disconnections - as in the common phrases putting theory into practice and translating research for practice, and in the complaints that something is too theoretical, not practical enough [...]. (p. 54)

However, what has already been stressed earlier is that one crucial role of research definitely is to provide “outsider knowledge as a source of new ideas” (Wideen, Mayer-Smith & Moon, 1996, p. 195) and “outsider knowledge as a catalyst and support for collaboration” (Wideen et al., 1996, p. 194). To explicate the essence of a possible collaboration, Wideen et al. (1996) draw on the work of Hawkins (1967) who “asserted that we cannot gain competence and knowledge except through communications with others. Without a Thou, there is no I evolving. Without an It there is no content for the context”. (p. 47).

Shulman (2000) contributes to these thoughts by reminding of the fact that “the fundamental morality of the scientific and scholarly community is that we acknowledge the role of others. In fact, the word “acknowledgment”, with the word knowledge in its center, implies we can’t have knowledge without others” (p. 30).

The process of research does not end by gathering data but furthermore comprises to present results, give conclusions and discuss implications, that is, “the work of the scholar is incomplete until it is shared with others” (Shulman, 2000, p. 12).

Borko (2004) adds another interesting option for how this shared knowledge might contribute to general improvement. While calling for connecting research and practice on the level of researchers and professional developers, she considers it crucial to reflect on “multiple design/research cycles to refine the program and study its impact on the development of professional community and the learning of the individual teachers” (p. 12). However, another relevant issue is inextricably connected to such a viewpoint, that is, to consider and understand the researcher as a learner, too.

Bringing research and practice together is obviously an essential point, always keeping in mind that of course the agendas of teachers and researchers might be different. But what Cooney correspondingly (1994) stresses is, that “we are wise to think of the teacher as an inquiring mind rather than as the object of an inquiring mind” (p. 627). That is why the particular focus in this work is on considering teacher needs and expectations.

Identifying Hindering Factors

Again, the aim of this section is not to provide a complete list but rather some information about factors that hinder successful in-service education beyond simply reversing the aforementioned positive factors. The contribution is organized around the following topics: (1) influence of the previous teaching style, (2) decisive role of knowledge and beliefs, (3) non-effective issues and (4) systemic constraints. One should bear in mind that the headlines do not simply count as a list of factors, rather they comprise several aspects.

Influence of the previous teaching style. Cohen (1990) gives an impressive example for the constraints of professional development by his well-known case study of a teacher named Mrs. Oublier. The portrayal, as Sowder (2007) puts it, serves as “a generic description of a class of teachers who have misinterpreted the principles underlying the professional development they received” (p. 160).

Mrs. Oublier was very open for implementing new curriculum material and activities, that is, “she eagerly embraced change, rather than resisting it. She found new ideas and materials that worked in her classroom, rather than resisting innovation” (Cohen, 1990, p. 311). But surprisingly, the change initiated by the obtained professional development just remained at the surface (cf. Pehkonen & Toerner, 1999). Accordingly, Cohen (1990) concludes that Mrs. Oublier’s “teaching does reflect the new framework in many ways. For instance, she had adopted innovative instructional materials and activities, all designed to help students make sense of mathematics. But Mrs. O. seemed to treat new mathematical topics as though they were part of traditional school mathematics” (p. 311). Cohen (1990) describes her teaching style as *mélange* of “something old and something new” (p. 312) and underlines that “some observers would agree that she has made a revolution, but others would see only traditional instruction” (p. 312).

What is striking is that although the teacher was open for new approaches, well-established beliefs, knowledge, routines and scripts were not simply replaced but new experiences added or assimilated. The crucial point, so Sowder (2007), was that “Mrs. Oublier had little opportunity for sustained guidance and support. She had much to unlearn, but no one to help her do this unlearning. The lessons here for the need for sustained professional development and mentoring are significant” (p. 160).

Pehkonen and Toerner (1999) report on a similar observation and stress the influence of the established teaching style as follows:

Teachers can adapt a new curriculum, for example, by interpreting their teaching in a new way, and absorbing some of the ideas of the new teaching material into their old style of teaching. (p. 260)

Again, it is the old style of teaching based on established knowledge and beliefs that runs counter implementing, even appreciated, new aspects of teaching, a subject that is approached in the following.

Decisive role of knowledge and beliefs. Interestingly, a comparable case study referring to partly different aspects can be found in the literature. Toerner, Rolka, Roesken and Schoenfeld (2006) analyze the teaching practice of an experienced teacher after having participated in an in-service training course on using open-ended task in mathematics teaching. Since it was not the focus of the study to examine the effectiveness of the professional development event, it turned out that the teacher’s beliefs built a hindrance to successfully implementing new ideas.

The teacher started a lesson about introducing linear functions by using several open-ended tasks which the students worked on in small groups by using the computer. After apparently 20 minutes, the teacher gathered the results and the teaching style changed rapidly since the group work did not satisfy the teacher’s lesson goals.

Toerner et. al (2006) could show how in this situation old beliefs established over a period conflicted with new beliefs adopted recently, an issue that will be elaborated on later. While the teacher favored a student-centered approach by letting students deal with open-ended tasks in the beginning, she gave up in favor of a teacher-centered style during the course of the lesson. Particularly, her mathematics-related beliefs came into the foreground, which is commented by Toerner et al. (2006) as follows:

The underlying approach of the teacher caught in such a situation could be loosely described as follows: “When things really go wrong, who can afford to be interested in the pedagogy? One must only rely on the structure provided by the mathematical content.” Pedagogy then loses in the game ‘pedagogy versus content’ (Wilson & Cooney, 2002). (p. 10)

In order to understand the turn around in the teaching trajectory and the emerging discontinuities involved rationally, the authors additionally interviewed the teacher after the lesson (cf. Toerner, Rolka, Roesken and Sriraman, 2010). The teacher then reflected the developments during the lesson in retrospect; the open interview style incited her to justify goals and beliefs, partly without being explicitly asked to do so.

Remarkably, on the one hand, beliefs initiated by the issues imparted at the in-service training on open-ended tasks, and on the other hand, old beliefs in terms of deep teaching convictions came into conflict. That is, the teacher started the lesson with the belief that mathematics lessons have to be designed openly. She completely fulfilled this requirement in her lesson planning and realized this approach consequently in the first half of the lesson up to the aforementioned turning point. Then, reacting to the unexpected course of the lesson, she revised the use of open-ended tasks, an approach that was founded on rather recently experienced beliefs, in favor of the following one: “open questions have to be prepared” (p. 412). She then explicated that “open questions have to be drilled. You cannot simply throw an open question at the students and then say: Okay, start!” (p. 413).

Complementary to the fundamentally positive approach of designing lessons as open and discovery oriented, she fell back on her traditional teaching style, requesting, for instance, her students to give a mathematical definition. In the interview, she explained her behavior as follows, “the central term to be mediated in the context of linear functions is the concept of slope, which prepares students for the concept of derivative” (p. 415). Toerner et al. (2010) further explain that it is the following goal, “the term slope must be mentioned in this lesson” (p. 415) that caused the extraordinary turning point. Hence, the authors draw the conclusion, that, “all pedagogical content goals and beliefs lost their rather positive value and stepped aside to make room for subject matter goals and beliefs” (p. 416). Finally, the authors consider the systematic subject matter content as *safety net* for class situations developing as not planned.

Interestingly, a teacher who participated in a discussion on the lesson commented the situation as follows: “When the house is on fire, who will then worry about pedagogy? Then you can rely only on the systematic nature of the content” (Toerner et al., 2010, p. 416). Toerner et al. (2010) conclude that one reason for the turning point in the lesson lies in that the teacher had not hitherto developed a solid repertoire in successfully employing the new teaching approach. The observations are in line with the ones drawn by Cohen (1990). Knowledge and beliefs, which are reflected in goals and actions, are decisive and may substantially impede implementing new teaching approaches. New ideas cannot be put into practice ad hoc, adopting and modifying teaching takes time und guidance, maybe in form of substantial mentoring as part of a professional development program or collegial support within the school.

Non-effective issues. Beyond these two case studies shedding some light on hindering factors, Sowder (2007) refers to the work of Hargreaves (1995) who provides general information about reasons for professional development being not effective:

Teachers are likely to reject knowledge and skill requirements when (a) the requirements are imposed or encountered in the context of multiple, contradictory, and overwhelming innovations; (b) teachers (except for those selected to design teams) are excluded from the development; (c) professional development is packaged in off-site courses or one-shot workshops that are alien to the purposes and contexts of teachers’ work; or (d) teachers experience them

alone and are afraid of being criticized by colleagues or of being seen as elevating themselves on pedestals above them. (p. 171).

That is, Hargreaves (1995) found non-effective professional development not primarily lacking an appropriate offer of knowledge but criticizes that “it does not acknowledge or address the personal identities and moral purposes of teachers, nor the cultures and contexts in which they work” (p. 14). The importance of explicitly considering teachers’ needs and expectations is the focus of the subsequent section and is reflected in the project design of the initiative that will be presented in chapter 4.

Systemic constraints. Since a first approach was to reflect hindering factors that are mostly dependant on the teacher, in terms of knowledge, goals, beliefs, attitudes but also communication and ongoing support, there are also systemic constraints that impede teachers from even being able to participate in professional development. Smith and Gillespie (2007, p. 212, 213) refer to the work of Wilson and Corbett (2001) who identified the following hindering factors in their research: Time constraints, financial constraints, distance, information gaps, lack of face-to-face interaction, mismatch of goals.

That is, hindering factors are also time and financial constraints, which make it mostly impossible for teachers to participate in in-service training. Moreover, opportunities are often not locally offered but centrally located and therefore place additional demands on teachers. Information gaps and lack of face-to-face interaction particularly play a role when in-service training is not offered decentralized.

The more adequate approach would be to address all subject teachers from one school or the local region, in order to understand in-service education as a rather job-embedded model. Finally, a mismatch of goals is mentioned, that is, “the goals of the professional development and the individual practitioners’ professional interests” (Smith & Gillespie, 2007, p. 213) might not meet in an appropriate way. The next section deals with these professional interests in terms of needs and expectations.

TEACHERS’ NEEDS AND EXPECTATIONS

Shulman (1986) reminds of the fact that “teaching and learning is not a one way street”, neither is teacher learning and teaching in front of a class. Learning needs of teachers are of dynamic nature, they change over time and are consequently not easily accessible, even for teachers themselves. For instance, problems might occur in the aftermath of an in-service training course, i.e., the process of transferring knowledge into practice may result in different or additional needs that have not been on the agenda so far.

Mostly, teachers’ needs for professional development are considered from a very specific perspective. That is, so Ball and Cohen (1999), “teachers are thought to need updating rather than opportunities for serious and sustained learning of curriculum, students, and teaching” (p. 4). Even more sharply formulated, Day (1999) stresses:

Attempts both at local and national levels to provide INSET [In-service Education and Training] support for the CPD [Continuing Professional Development]

needs of teachers and schools are rarely conceptualized beyond the rhetoric of statements such as, ‘They should result in improvement’. (p. 132)

Comparable statements like *teachers should* as well as *administration should* have been mentioned in the introduction of this work, strict positions or hardened fronts that do not contribute to viewing professional development in a substantial way.

Effective in-service education depends on the axiom of being of one’s own choice, that is, such events being oriented on the specific needs of teachers is absolutely necessary (Day, 1999; Llinares & Krainer, 2006, Sowder, 2007). And this is what makes in-service education rather difficult, to meet the unique needs of teachers which are usually not well-known by teacher educators. At most times, trendy topics like, for instance, standards or cooperative learning, have easily dominated the offers, they, so to speak, upstage important topics of teachers.

In this regard, Day and Sachs (2004) recall that “the kinds of CPD [continuing professional development] which predominate at any given time often reflect views of teachers’ needs by those outside the classroom” (p. 9). Hence, it is frequently assumed that teachers need to be provided with something, like specific knowledge or skills, in terms of what they need to know and do (Sowder, 2007). In contrast, a more adequate view on in-service education would be that “it supports policies that enable good practice rather than prescribe it; recognize the knowledge, skills, and abilities of teachers; and provide incentives to increase their knowledge” (Lieberman & Miller, 2005, p. 153). Particularly reflecting the situation in mathematics education, Sowder (2007) argues, “even with increased recognition that teacher professional development must be a priority, the professional development offered in mathematics often does not meet teachers’ needs” (p. 159). Likewise, Simon (2007) considers professional development for mathematics teachers as mostly being unresponsive to teachers’ needs and interests.

However, Hargreaves (1994) adds an interesting point to the discussion while reminding of viewing in-service education in broader terms as professional development. In particular, he requests teachers to “begin to think less in terms of INSET [In-Service Education and Training] and more in terms of staff development and the need for whole-school policy to drive it” (p. 430). The change in perspective includes viewing in-service training needs not simply in terms of individual needs but concerning the subject department of the school. Hence, stressing a bottom-up approach does not mean to base it rather fragmentarily on a single teacher, but it explicitly addresses the collaboration among them. In this regard, the role and significance of the headmaster should further not be underestimated.

Hargreaves (1994) underlines that in the same way, as professional development is a lifelong process, teachers have lifelong professional learning needs. A crucial point, consequently, is considering teachers’ learning needs by enabling them to participate in planning for their professional development (Wilson & Berne, 1999). Schoenfeld (2006) reminds of the fact that “some of the most interesting approaches to professional development are those that take the notion of teacher learning seriously” (p. 485). Krainer points to the same direction when arguing that traditional in-service programs lack considering teachers as learners, a viewpoint that has been elaborated earlier. Logan and Sachs (as cited in Day, 1999, p. 135) identify

three aspects while characterizing more closely what teacher learning is about and what issues need to be addressed by in-service training:

Re-orienting in which teachers develop their capacities to make ‘significant revisions’ to current practices as a result of the introduction of new teaching methods, different working conditions, changed management procedures or expectations, or as a result of a change of role;

Initiating in which teachers are inducted into new roles (social initiation) or incorporate new ideas and practices learnt through reorienting programs into classrooms and school life (technical initiation),

Refining in which teachers’ current practices are strengthened and extended.

That is, Logon and Sachs (as cited in Day, 1999) provide some kind of clarification what teacher learning means and what processes are involved and hence, what issues are necessary to be touched upon besides merely focusing on content. Remarkably, they not only elaborate on commonly shared aspects like re-orienting and initiating but furthermore refining as learning that serves to connect to teachers’ current practices.

Nonetheless, in-service training courses are mostly externally provided and from this perspective primarily a temporary intervention but, and that is the crucial point, are placed into teachers’ learning lives (Day, 1999). The consequences occurring when teachers’ needs are not paid adequate attention are described by Day (1999) as follows:

Teachers’ professional development will be restricted rather than extended and fragmentary rather than coherent whilst the breadth of their learning needs continues to be ignored; and professional learning will come to be associated not with capacity building for the use of insightful judgment exercised in complex situations, but with one-shot events specifically targeted at immediate technically defined implementation needs as determined by others. (p. 141)

What is moreover stressed is that “need identification, it follows must be a matter for negotiation between the interested parties, rather than prescription by one at the expense of the other” (Day, 2000, p. 109). Bolam (as cited in Day, 1999, p. 136) provides an interesting need matrix while linking system and individual needs with respect to group performance, individual performance, career development, advanced professional education, and personal education. Nevertheless, the matrix lacks providing a more elaborated relationship between those two. However, at least what is transported is that the relationship between system and individual needs is not static but dependant on what aspect of professional development is stressed.

Issues like ownership, participation and equity are of important relevance, even more so since they ground on a teacher’s own responsibility and promote accountability (Day, 1997), maybe resulting in rather far-reaching effects like establishing leaderships of teachers (cf. Lieberman & Miller, 2005). Day (1999) provides an overview on teachers’ preferences regarding professional development, i.e., he

CHAPTER 2

lists successful activities that met teachers' expectations for the following needs (p. 147, 148):

Targeting needs. They were focused upon needs specific to the particular age range taught, i.e. relevant.

Content needs. They increased knowledge/awareness, reinforcing and reassuring current thinking but encouraging participants to see issues from different perspectives.

Utilization needs. They provided direct curriculum development benefits and application to classroom practice.

Process needs. Successful courses presented a balance of activities which were well-structured, involved working with colleagues and sharing experience.

Leadership/Modelling needs. Successful courses were led by tutors who were well-prepared, enthusiastic, caring and aware of group dynamics.

Time and energy needs.

Day (1999) distinguishes between short and extensive in-service training and identifies the latter as contributing significantly more to long-term growth needs. Teacher needs that are related to "longer, more reflective and analytical in depth learning opportunities" (p. 149) are the following ones:

'Vision' needs. Participants had been able to relate their experience of practice to theory, to reconsider critically their assumptions, predispositions, and values (the 'why' as well as the 'how' and 'what' of teaching), and the contexts in which they were taught.

Skill development needs. They were able to develop new skills over time.

Intellectual needs. They were able to engage in systematic reading which, 'otherwise I wouldn't do'.

Personal needs to build self-esteem, so important in these days when we're continuously being battered from all sides as regards our skills as professionals. (Day, 1999, p. 149)

However, while the work on teachers' needs provides some answers, the following issue stressed by Krainer (2002) that the freedom of defining one's own research questions is, among other aspects, a decisive factor for teachers' growth, should not be underestimated. Hence, the questions trivially remaining are the following ones, *What do teachers want to have in their in-service training? What do they want to learn?* In order to understand teachers' needs from an inside perspective, explicit attention ought to be given to their views, beliefs, values, expectations, experiences, goals as well as hopes regarding their professional development.

What is striking, too, is that so far little attention has been given to the relevance and "importance played by teachers' life histories, situated lives (within the culture of the school) and personal circumstances and motivations" (Day, 1997, p. 40).

Especially the field of affect is only partly touched in the context of professional development or in-service education, and as the data presentation in chapters seven and eight will show, ultimately plays a crucial role for the effectiveness of any offer.

SUMMARY AND IMPLICATIONS

The first two chapter were concerned with elaborating the international theoretical discussion on mathematics teachers' professional development. Different theoretical perspectives were presented that led to identifying the relevant variables. Further, numerous theoretical models were discussed in order to elicit the relevant processes. So far, in-service education and training are a valuable contribution to professional development of teachers. Since the focus is on teachers' lifelong and continuous learning, in-service training offers are supposed to be of long-term orientation, job-embedded and aligned with a teacher's actual job. The conceptualization is wide-ranging and assigns a crucial role to the relation of knowledge, beliefs and practice.

Developing professional knowledge is primarily considered as an interactive process responding to teachers' growth needs. Professional development is not simply an individual endeavor but is most powerful in terms of collaboration, particularly among subject teachers of the same school. Identity formation is thus seen as ways of belonging to a broader constellation, hence, a specific community of practice, which moreover contributes to a teachers' identity.

In view of that, teachers are regarded as mostly responsible for their professional growth. Related to their personal goals and associated reflective practice, it is stressed that only authentic teachers are able to take care of their personal and professional development. A decisive approach, hence, is to integrate teachers in planning with regard to their needs, and to implement their choices.

However, professional development also contributes to teacher as well as school development. That is to say, a "growing synthesis between a more sophisticated conception of professional development and a strong commitment to institutional development" (Hargreaves, 1994, p. 424), can be stated. The corresponding challenge is the balancing of individual and organizational needs. Likewise, Hargreaves and Goodson (1996) sum up as follows:

For at the end of the day, teacher professionalism is what teachers and others experience it as being, not what policy makers and others assert it should become. (p. 22)

Correspondingly, all the recommendations reflected in the aforementioned thoughts, trying to improve teacher education and schooling, should avoid, as mentioned earlier, *either/or* approaches and focus on *both/and* ones.

In chapter 4, a specific professional development initiative that particularly takes into account these fundamental issues is outlined.

CHAPTER 3

MATHEMATICS TEACHER PROFESSIONAL DEVELOPMENT

A German Perspective

OVERVIEW

So far, professional development has been discussed from an international perspective. Since chapter 4 is concerned with presenting a specific initiative for professional development, the particular context of mathematics teacher education in Germany will be outlined in this chapter. The last comprehensive overview goes back to the work by Andrea Peter in 1996 who reflected the specific national situation against the Australian one. Much progress in the field can be stated from that time on, particularly, a shift from viewing in-service education as being rather isolated to being part of continuing professional development has emerged. What is elaborated on in the following are the current educational debate in Germany in general and aspects of mathematics teacher in-service education and training in particular.

Finally, the developments in the context of two specific professional development programs are reflected and discussed against the theoretical positions as supplied in chapters one and two. Thereby, the focus will be firstly on describing that initiatives, and secondly on working out the significance of both for the general discussion on professional development. Finally, the last subsection presents a short summary and some implications.

EDUCATIONAL DEBATE

During the last years, in the context of mathematical literacy as proclaimed by the OECD (2003), TIMSS and PISA have led to an intensive discussion in Germany about the concept of learners' competency, thereby opening the question of its equivalent for teachers (Baumert et al., 2001; Prenzel et al., 2004). In the aftermath of Germany's poor performance in TIMSS and PISA, a flurry of debates and discussions concentrated on students' mathematical knowledge and skills, i.e., competencies. Consequently, educational standards in mathematics and other subjects were launched by the Standing Conference of the Ministers of Education and Cultural Affairs of the Laender in the Federal Republic of Germany¹ (Kultusministerkonferenz, abbr.: KMK) in 2003.

New demands on school mathematics emerged, particularly on the teacher level (cf. Blum, Druke-Noe, Hartung & Koeller, 2006). In this context of improvement and change, the professional knowledge of mathematics teachers in Germany has been researched in depth and from different perspectives (Baumert & Kunter, 2006;

Brunner et al., 2006, Blum et al., 2006). Particularly, in the COACTIV² study associated to PISA 2003, the aim was to investigate the professional competence of teachers, cognitively activating instruction, and the corresponding development of students' mathematical literacy.

Moreover, other studies have been concerned with improving school quality, like for instance BIQUA³, and with identifying conditions, a school needs to have in place to enhance their students' learning. Especially, the SINUS project that is presented later has aimed at supporting teachers' professional development in the context of school improvement efforts while the TEDS-M⁴ study analyzes knowledge and beliefs systems of prospective teachers. The TEDS-M related preparatory study MT21 (Mathematics Teaching in the 21st Century) yielded first national results (Bloemeke, Kaiser & Lehmann, 2008). With respect to these findings, Kaiser et al. (2007) conclude that "future teachers' knowledge and beliefs depend heavily on how they are trained. They gain knowledge in those fields emphasized in teacher education and their beliefs change in accordance with the curriculum taught at their institutions" (p. 3120).

So far, it can be considered basic progress that in the last ten years, the discussion of competency models, as happened in the aforementioned studies but in particular in the context of COACTIV (c.f. Baumert & Kunter, 2006), has produced a substantial theoretical background on both the student and the teacher level. Even though it may seem obvious that teaching to enhance students' competence demands special teacher qualities, the question of how sheer teacher knowledge sparks its counterpart in students still remains mostly open. In this respect, the efforts of Tenorth (2006) to moderate in the current German debate on teachers' professional development are particularly noteworthy.

While the emphasis has been on competency models, Tenorth (2006) tries to draw more attention to teaching practice and its associated essential routines. He points out that it is not sufficient to just focus on knowledge and derived competencies but also necessary to consider professional schemes, which represent the practical organization of teaching for a live in-class performance. The provocative subtitle of his paper *Theory stalled but practice succeeds* does not herald an argument against knowledge (which must, if anything, be stronger in practice than in theory!), but one against abstractly theorizing about knowledge.

Nevertheless, in Germany, to sum up, the developments built the basis for a theory of professional knowledge, which further led to a model of competence, characterized by a dynamic interplay of professional knowledge, beliefs, motivational orientations and self-regulative skills (Brunner et al., 2006). Surely, there is much value in the considerations, in particular as they have influenced the discussion on the aims of in-service education while broadening the view to the notion of a competent teacher as, for instance, reflected in the standards.

However, with respect to the current situation, the following statement by Jerome Bruner (1996) is rather relevant:

These debates have been so focused on performance and standards that they have mostly overlooked the means by which teachers and pupils alike go about their business in real-life classrooms - how teachers teach and pupils learn.

The work of the COACTIV group on professional knowledge is close to the one of Ball and colleagues (cf. chapter one), but maybe not all relevant teacher competencies are covered in the model. One can ask, for example, whether these categories catch the difference between a seasoned teacher and his novice colleague when the latter, lacking established routines, enlivens his classroom actions by improvisation (cf. Roesken, Hoechsmann & Toerner, 2008). Maybe, a shift in paradigm from theorizing rather proficiency than competence, as Schoenfeld called for at his talk at the 2008 AERA's annual meeting in New York, would be the more appropriate approach.

However, teachers in Germany are under growing pressure to perform, that is, experienced teachers need to modify their practice to adapt to decisive changes in the German educational system. Besides implementing educational standards, the reduction of time at school (high school diploma after 12 years), central exams in grade 10 and a central exam at the end of high school put increasing demands on German mathematics teachers and constitute a non-habitual output orientation for the single school.

IN-SERVICE EDUCATION AND TRAINING IN GERMANY

In Germany, responsibility for educational affairs lies with the Departments of Education in each of the 16 Federal States (Laender). Specific institutions under their purview provide in-service education, thereby the aims are to assert and update the qualification obtained by pre-service education. In the final report (Terhart, 2000) of the commission constituted by the Standing Conference of the Ministers of Education and Cultural Affairs of the Laender (KMK), a threefold differentiation regarding teacher in-service training is provided, and will be outlined in the following.

In-service training is characterized as being (1) supply or demand oriented, provided (2) externally or school intern, and addressing (3) subject matter or pedagogical content themes (cf. Terhart, 2000).

Supply or Demand Oriented In-service Training

As Terhart (2000) points out, in-service training courses can be distinguished between being primarily supply or demand oriented. Thereby, a clear domination of externally provided supply oriented courses, addressing single teachers, is stated. This trend presents the traditional way of providing help for practicing teachers, as it is subject of the departments of education to take care of and support teachers' lifelong learning.

Demand oriented courses more precisely address teachers' needs and are mostly provided by external institutes, which adjust their offer with regard to this market. That is, the courses are already designed but teachers can ask for pursuing their specific demands. As will be shown in the next chapter, *courses on demand* constitute a decisive parameter of the initiative *Mathematics Done Differently*.

Regarding these two conceptions of supply and demand oriented in-service training, Terhart (2000) points out that the former takes the risk of not meeting teachers' needs and therefore might have just a limited, if any effect. The latter conception deals with different problems. If in-service training is just offered according

to a specific demand, it might happen that teachers do not notice either a need for professional development, or that they obtain difficulties to sufficiently formulate their demand.

Finally, Terhart (2000) emphasizes that the conceptions should not be viewed as being contrary or alternative to each other but both as being present on the market and bringing supply and demand together.

Externally or School Intern In-service Training

An important differentiation, so Terhart (2000), is to distinguish between externally and locally provided in-service training. Externally organized training courses are clearly not job-embedded and rather distant from the everyday life in school, which at some point might even be a relief for teachers. These events are mostly participated by single teachers, which is the reason why the transfer is largely questionable since no support by colleagues is given and, to the contrary, teachers might be confronted with their reluctance when trying to implement new issues and ideas.

The transfer problem can be minimized by addressing all subject teachers of one school and providing school intern in-service training. But Terhart (2000) also recalls considering that this form might be an additional strain for teachers. Finally, he stresses that the two conceptions of in-service training both serve to enhance school development and foster professional profiling of the single school.

Subject Matter or Pedagogical Content Themes Provided by In-service Training

In the last categorization, in-service training courses are categorized regarding the content they address, whether the relevance is on subject matter or pedagogical content knowledge. Subject matter knowledge oriented courses contribute to updating or enhancing teachers' specific knowledge, and to offering possibilities to conceive new trends and developments within the subject discipline. Pedagogical content related courses more directly aim at teachers' actions in the classroom, taking into account students' cognitive and motivational orientations.

Another thread of courses, so Terhart (2000), is formed by those emphasizing general pedagogical topics on a rather meta-level, going beyond merely subject related problems, in order to supply teachers with a systematic pedagogical support.

All three conceptions of teacher in-service training do have different aims, weaknesses and strengths. What the commission stresses, and that is a very interesting point, is that any course design should take into account the possibilities and scopes of all the different conceptions rather than generally favoring one at the expense of the other. Therefore, Terhart (2000, pp. 133–135) gives an overview on some principles worked out by the commission instead of assessing the different in-service training approaches:

In-service education that is institutionalized is only part of a life-long learning process and is therefore considered as giving an impetus to initiate or substantiate teacher learning.

Intensifying teacher in-service education should not result in cancellation of lessons. That is, teachers are thought to bear the responsibility to pursue their professional development when they do not have classes.

One major goal is to overcome the conception of professional development being a short-term event and an individual endeavor in order to enforce a designated transfer. Intensive research is needed to systematically design, investigate and evaluate in-service programs.

Stronger than hitherto, in-service training should aim at teachers' actions in the classroom. What is mostly lacking is to train new teaching approaches in practical situations. As a major goal, the effect of training courses should reach not only the classroom but also the learning of students. Alas, the actual work in the classroom still mostly contributes to individualism than professionalism.

Voluntariness is a crucial point as well. Firstly, teachers are legally bound to pursue their professional development. Secondly, it is important not to view in-service education as being a solely individual choice but an essential part of staff development within the single school.

Concerning locally or externally in-service training, it should be considered that teachers do not necessarily need to be specialized in the same qualification. The interplay of different competencies contributes more effectively to successful progress. All teachers of the department are asked to develop together a plan what competencies are needed, and how they could be acquired.

The suggestions made by the commission are permeating the field and, to be sure, contribute to an innovative view on professional development. However, what can be stressed so far, regarding the second aspect of making teachers accountable for professional development even in their free time while maintaining the *axiom* that no lesson should be cancelled, calls for a more appropriate and supportive attitude on the part of the administration.

Nevertheless, the situation in Germany is still dominated by short-term training and single-session workshops rather than program settings, mostly centrally organized rather than locally. But alternative forms have taken place, not at least the SINUS project, which will be elaborated on in the next section, has significantly contributed to change towards more innovative approaches.

Developments are different within the Federal States. The Department of Education in North Rhine-Westphalia⁵, for instance, provides an innovative conception of in-service education, mostly in line with the suggestions made by research. That is, school development is regarded as key in the development of the educational system, the single school is consequently assigned an autonomous role, and in-service education viewed as being embedded in the life and work of the school. Further, federal money serves as a budget for in-service training and is delivered directly to schools. Primarily, a social market view is anticipated, and schools are accordingly considered as entering the market as consumers. Another crucial variable is quality management, relating to this, evaluation is seen as a necessary and indispensable

obligation. The situation is rather interesting for the project that is outlined in chapter four, for one long-term goal is establishing the initiative within the educational system.

How to contribute to teacher professionalism is currently a highly discussed topic in Germany. Rather alarming, the national educational report (Autorengruppe Bildungsberichterstattung, 2008) worked out on behalf of the Standing Conference of the Ministers of Education and Cultural Affairs of the Laender and the Federal Ministry of Education and Research indicated that about 76.000 students left school in 2006 without any qualification. Remarkably, the expenses for education meanwhile decreased from 6.9% to 6.2% of the gross domestic product (GDP).

More recent, during an educational conference in one of the Laender, different politicians again stressed that the focuses of any reform endeavor should be on more responsibility of a single school. What is particularly favored is to give autonomy to schools regarding staff issues, for instance, the engagement of personnel. With respect to in-service education, it was advocated to establish a system of credit points for participating in-service courses, which should also partly being offered at the university. The latter aspect takes into account that knowledge in the subject domains changes and develops at any time.

Quite recently, in an interview, Koeller (2008) who at that time was working at the Institut for Educational Progress⁶ (Institut zur Qualitaetsentwicklung im Bildungswesen, IQB), also stressed not only the importance of the single school, but first and last the single subject department. All subject teachers from one discipline should meet on regularly basis to work altogether on further developing their teaching. Support could be given by external experts in order to coach teachers and help them reflecting on their practice (cf. Zedler, Fischler, Kirchner & Schroeder, 2004). Koeller (2008) assigns a decisive function to school inspectors and their role of helping schools in their particular development and considers it a reachable goal to institutionalize these together with experts for professional development, independently from school administration.

TWO SPECIFIC PROFESSIONAL DEVELOPMENT PROGRAMS

Since the TIMSS study diagnosed a significant weakness of students' mathematical understanding, the initiatives SINUS⁷ (Increasing Efficiency in Mathematics and Science Education) in Germany and IMST⁸ (Innovations in Mathematics, Science and Technology Teaching) in Austria have been launched. While the former program initially aimed at improving the efficiency of mathematics and science teaching in lower secondary school (BLK, 1997), the latter addressed upper secondary school and additionally provided impulses for the whole educational system (Krainer, 1999).

The different conceptions are due to different assumed reasons for students' poor performance. In Germany, the failure was explained by taking a rather local focus, i.e., in terms of lessons and schools. In Austria, the criticism addressed primarily the entire educational system. Correspondingly, the programs provided different issues for improvement, which will be outlined in the next sections. The initiatives will then also be discussed regarding their contribution to teacher professional development in Germany.

SINUS – a German Intervention

The national initiative SINUS was first composed to last from 1998 to 2003. As reaction to the still poor performance of German students at PISA, it was extended two times (2003–2005 and 2005–2007) while additionally aiming at upper secondary school. Thus, the successful program has been expanded in stages, which led to the labeling of SINUS-Transfer. Although the actual project finished in August 2007, successful ideas and approaches have been pursued further in the networks built in the participating Laender or have already been implemented into new projects (Prenzel, 2007); an immediate continuation has only been realized in one of the Laender.

In the course of the project, the organization shifted from being centrally (IPN Kiel⁹) to being decentrally arranged, in responsibility of the participating Federal States. An extension of the project to primary school namely SINUS-Transfer Grundschule started in 2004 and lasted until 2009.

The initial SINUS project was composed to aim at lower secondary level in different school types. Besides mathematics, other subjects namely biology, chemistry and physics were in the focus as well. At first, the project started by involving 180 schools, six schools each were grouped together to so-called sets. Networking between schools organized in these sets was particularly stressed, and each set was looked after by a coordinator, that is, a teacher who took on a specific role. The networking included contacts to universities and specific institutions responsible for in-service education.

More and more school sets were established, at the beginning of the school year 2003/04 the first expansion was launched in 13 of the Laender and reached 700 participating schools while the second expansion in 2005 attained 1800 schools. The idea of transfer encompasses discussing methods, concepts and materials, ultimately aiming at a large-scale dissemination. Thereby, the cooperation of schools, which were already involved in the program, so-called reference schools, and newly participating ones in a common set was especially valued (Baptist, 2007; Baptist & Raab, 2007).

Primarily teachers were considered as key in the process of quality enhancement and management. Across the whole country, professional development was fostered in terms of a bottom-up approach while drawing on available teacher qualification and experiences. Correspondingly, quality management was regarded to start on a school level by means of assigning an autonomous role to the single school. However, regarding content, eleven modules to probe and explore in the classroom were made available and proposed for schools and sets. Problematic topics of teaching mathematics were addressed, and hints for an appropriate treatment were given. But, despite of the supplied material, schools were at the same time asked to take into consideration their local and regional particularities. The modular concept was based on providing basic information, but the topics were moreover understood to be developed individually according to the school staffs' needs. Thus, teachers have been actively involved and assigned responsibility for the concrete implementation of the suggested themes.

The modules covered the following topics: developing a task culture, working in a scientific manner, learning from mistakes, securing basic knowledge, cumulative learning, experiencing subject boundaries and interdisciplinary approaches, promoting boys and girls, promoting student cooperation, autonomous learning, assessing progress, and assurance. Every module was outlined on the project homepage in the Internet; further material for information and practical use in lessons was made available on the project server.

On a regional basis, the coordinators supported the school sets. On a central basis, additional help was offered by the project organization. The central principle drew on the collegial work of teachers within a school department and a network of neighboring schools. Hence, SINUS was primarily build around teacher collegiality and reflection. Baptist (2007) describes the philosophy of the project as follows:

We had succeeded in integrating the teachers in the development of ideas and materials and therefore they have accepted changes in teaching. Mathematics turned out to be an experimental science - at first an unfamiliar point of view for most of our teachers. (p. 16)

The initiative has been guided by the idea that school improvement only takes place from inside by small steps rather than instantaneous by outside forces and therefore is perfectly in line with many suggestions made in the context of professional development. One crucial point is to foster the responsibility of the single school, and to acknowledge that innovations cannot be initiated top-down. Interestingly, the initiative IMST in the neighboring country Austria started rather at the same time and for the same reasons, but addressed some different issues, as will be shown in the next section.

IMST – an Austrian Intervention

In Austria, IMST was launched in 1998 and first composed as an analyzing project in order to explicate Austrian students' weak performance at TIMSS and to work out advices for appropriate actions. Initially, the program addressed upper secondary schools and from 2004 on it was expanded to other school forms as well (Krainer, 2008a). The findings of the initial project led to the developmental project IMST² (2000–2004) that was piloted for one year and then extended to three years. IMST² was organized around four priority programs, especially emphasizing mathematics in the school profile, which are: basic education, school development, teaching and learning processes, and research in practice. Additionally, a gender program was offered. Krainer (2005b) outlines the central objectives of the program as follows:

- 1) to initiate, promote and showcase innovations in the teaching of mathematics as well as of science and technology, to carry out a scientific analysis and to disseminate such innovations, with the emphasis on generating good practice concepts and to professionalise teachers;
- 2) to take part in setting up a support system for the further development of school practice in the fields of mathematics as well as science and

technology, in particular by encouraging practice-oriented, scientifically grounded subject didactics. (p. 9)

In the school year 2000/01, 34 schools and institutions participated in the program by choice while the number increased to 62 in the school year 2003/04. A great demand led to a doubling of participating schools; thereby no interested school was rejected. IMST3 lasted from 2004 to 2006, addressing the entire secondary level of schooling. From its very conception, so Krainer (2008a), IMST3 presents a sustainable support system that primarily aims at spreading and broadening the IMST initiatives and establishing them in the educational system. Thus, primarily in the focus of IMST3 was implementing the second point of the objectives presented above. Thereby the following key measures, contributing to three different levels of the educational system, are guiding the process (Krainer, 2005b, pp. 10–12):

At the local level (schools):

(M1) Upgrading the role of the local subject coordinators

At the regional level (federal states):

(M2) Upgrading the role of regional subject coordinators

(M3) Setting up regional centres for subject didactics and school development

(M4) Setting up new or upgrading existing regional networks

At the national level (Austrian educational system):

(M5) Setting up national subject didactic centres

(M6) Setting up the MNI Fund

(M7) Operative steering of IMST3

The seven key measures are thought to support high quality teaching in mathematics. Remarkably, different levels are explicitly mentioned, and underline the systemic approach of the Austrian project. The theoretical conception of IMST draws on constructivism and unsurprisingly systemic theory while the methodological foundation is in action research. The main procedural intervention is to enhance reflection and networking.

Significance of the Interventions for the Professional Development Discussion

Both programs present successful initiatives to enhance school quality in their countries. However, there are commonalities and differences in the programs regarding the underlying philosophies, their systemic effect, and the relationship between research and practice, which led to rather different conceptions. Remarkably, the initiatives are mostly in line with regard to content, that is, the addressed topics and themes. Especially, they share providing possibilities to conceive a different culture of teaching and learning in the mathematics classroom, fostering autonomous and self-initiated work while emphasizing on reflection and collaboration among teachers.

The differences are obvious when discussing the grade of autonomy. In this regard, Krainer (2007) points out, that SINUS provides a more explicit idea what a good task or good teaching is; the corresponding view is theoretically and empirically founded. IMST² also brings in research expertise but is more reserved to purport such statements. As already mentioned in the introduction of this work, Krainer's (2005) attitude in this regard is, that in order to answer the question what good teaching is, teachers have to work for themselves at all times. He further stresses that the intention of SINUS is more on implementing modules already worked out by researchers. However, SINUS does not simply offer ready concepts for teaching nor provides any recipes but draws on concrete problems of the participating teachers and actively involves them (Baptist & Raab, 2007; Prenzel, 2000).

In contrast, participants of IMST² do collect their starting points and innovations by themselves and obtain support if necessary. Within a priority program offered by IMST², single projects are thus conducted mostly autonomously. As Krainer (2007) emphasizes, all developments base on individually identified issues and proposed aspects to enhance mathematics teaching and learning. Only marginal orientation is thereby given by research; although, announcing the specific priority programs at least provides a frame and conceptual orientation. To sum up, the bottom-up approach of the Austrian program is arguably more consequent.

The aforementioned aspects do not only touch the grade of autonomy but also the relationship between research and practice. For that reason, it makes sense to discuss the programs against the theoretical background provided by Cochran-Smith and Lytle (1999), see chapter one. Both projects contain a *knowledge-of-practice* conceptualization even though different nuances can be stated. IMST² can definitely be assigned to this category while SINUS is located rather at the borderline to the *knowledge-for-practice* category. Nevertheless, SINUS emphasizes sustained mentoring and effective guidance by externals while input and practice phases alternate. Remarkably, although mostly initial knowledge is provided by research, the philosophy does not persist in this rather strict conception but develops with the project and its participants.

IMST² is based on action research, that is, the emphasis is on systematic self-reflection of teachers while being involved in collaborative work. The collegial work contributes to discussions on both practical and theoretical issues. With respect to the relationship between the involved parties of research and practice, the one of IMST² seems to be more equitable while providing additionally input for the people engaged in research. In this regard, Krainer (2007) points out that one characteristic of the learning system is that it involves teacher educators and teachers as taking both the status of experts and learners.

In contrast, SINUS does more strongly involve expertise by research in the beginning and then focuses on teacher learning. Likewise, Ostermeier, Carstensen, Prenzel & Geiser (2004) stress that "the BLK-program SINUS is based on an implementation approach, where teachers further develop their teaching while working problem oriented and based on modules. The implementation thereby decisively depends on the locally available conditions¹⁰" (p. 220). The success of SINUS, and that is what the programs definitely share, can be attributed to reflection and

networking as well. However, IMST² is the more complex initiative since the approach has been very open and flexible to the interests and wishes of the involved teachers.

While the focus in Germany was primarily on making a difference in the classroom and on fostering networking between schools, in Austria the emphasis was additionally on a general discussion about basic education, moreover aiming at strengthening the subject didactics. In order to overcome a fragmented educational system in Austria, in the initial IMST report the advice was given to acknowledge and establish conceiving the educational system as a learning system (Krainer, 2007). Accordingly, as pointed out in the preceding paragraph, IMST² aims at improvements at the university level by fostering collaborations between teacher educators and teachers, which contribute to the growth of the former, too. Krainer (2005a) draws the following conclusion:

Since SINUS is primarily composed as an *intervention in the school system* steered by research, IMST is stronger understood as an *intervention of teammates in the common educational system*¹¹. (p. 7)

Regarding the systemic approach, IMST² addresses the local, regional and national level, while offering concrete measures for development. SINUS acted mainly on the local level, i.e., in schools but also on the regional level as the program was widely noticed and supported by the Departments of Education of the respective Federal State.

However, although maybe not initially contributing to a systemic approach, SINUS has influenced the educational system as well. Not least, evaluation data confirmed that one successful approach has been to launch innovations across Federal States borders (Klein, 2008). SINUS modules found their way into curricula, and the Laender signaled readiness to continue the program, at least partly, after the official end (Prenzel, 2007). Concerning the latter, definitely lacking is a shared conception of how to continue and further develop the networks established during the project phase. In this respect, Klein (2008) reminds that even successful innovative projects bear the risk to just contribute to increasing competence of the participants but fail to broaden good ideas and being sustainable. He further points out that distributing basic approaches must hence be framed as being long-term and systematic learning. Particularly, support is needed not only by the participating Laender, but also on a national level.

Definitely, the main difference between the programs is that IMST² has also reached the national education level. However, just recently, the German chancellor called for a common meeting (Bundesgipfel) of Laender und Bund concerning education in general.

SUMMARY AND IMPLICATIONS

Since this work started by presenting the state of the art regarding theoretical aspects in mathematics teacher professional development, this chapter has been concerned with the specific situation in Germany. The current educational debate was outlined in order to give an impression of, on the one hand, what subjects are under

discussion within the educational community and, on the other hand, what substantial theoretical background has been provided in the context of various projects.

Even more important, the statements on teacher in-service education provided by the KMK-commission were reflected upon, since they further serve as background to discuss the particular initiative that is presented in the subsequent chapter. Finally, two successful projects were presented and their significance for the discourse on professional development was outlined. Both are very interesting since they draw on many of the theoretical aspects that have been presented in this work. Altogether, the information serves to better understand the current situation in Germany in which the initiative *Mathematics Done Differently* was launched.

NOTES

- ¹ The *Kultusministerkonferenz* unites then ministers resp. senators of the Laender responsible for education, higher education and research as well as cultural affairs and draws on an agreement between the Laener, cf. <http://www.kmk.org/>.
- ² COACTIV (Cognitive Activation in the Classroom), <http://www.mpib-berlin.mpg.de/coactiv/index.htm>
- ³ BIQUA (Quality of Education), <http://www.ipn.uni-kiel.de/projekte/biqua/index.html>
- ⁴ TEDS-M (Teacher Education and Development Study in Mathematics), <http://www.iea.nl/teds-m.html>
- ⁵ <http://www.kompetenzteams.schulministerium.nrw.de/Leitungsfortbildung/>
- ⁶ IQB cf. <http://www.iqb.hu-berlin.de/>
- ⁷ SINUS is the abbreviation for “Steigerung der Effizienz des mathematisch-naturwissenschaftlichen Unterrichts”, cf. <http://sinus-transfer.uni-bayreuth.de/>
- ⁸ IMST, cf. <http://imst.uni-klu.ac.at/>
- ⁹ IPN Kiel, <http://www.ipn.uni-kiel.de/>
- ¹⁰ Translation of: Das BLK-Programm SINUS beruht auf einem Implementationsansatz, bei dem Lehrkraefte problemorientiert und ausgehend von Modulen ihren eigenen Unterricht weiter entwickeln. Die Umsetzung haengt entscheiden von den vor Ort vorliegenden Bedingungen ab.
- ¹¹ Translation of: Waehrend SINUS vor allem als eine seitens der Wissenschaft gesteuerte *Intervention in das Schulsystem* angelegt ist, versteht sich IMST² staerker als *Intervention von Mitspieler/innen* im gemeinsamen Bildungssystem [...].

MATHEMATICS DONE DIFFERENTLY

A Professional Development Initiative

OVERVIEW

This chapter is concerned with presenting the initiative *Mathematics Done Differently* for fostering mathematics teachers' professional development. The empirical study that is presented in the next two chapters was conducted in the context of this project. What is elaborated on in the following are the aims and scope of the project as well as the underlying philosophy and design. The latter encompasses discussing the various constitutive parameters, i.e., explaining the marketization view on professional development, the specific course system encompassing *courses à la carte* and *courses on demand*, the *tandem* approach, the importance of teachers' collaborative work, the evaluation of all courses, the cooperation with administration and the successfulness of the flexibility provided by the project. Finally, some concluding remarks as well as implications are given in the last section.

GENERAL REMARKS

In September 2006, Mathematics Done Differently¹ started by intensely preparing the basis of the planned initiative for fostering mathematics teacher professional development. In October 2006, an online questionnaire was delivered to teachers in the whole of Germany in order to get important information about teachers' needs, expectations as well as preliminary experiences regarding their professional development. Contemporaneously with the opening session in January 2007, first courses in different thematic fields were offered on the homepage and made available for interested teachers. Deutsche Telekom Stiftung², a foundation related to the company that is internationally known as t-mobile, funds the initiative. The project organization is located at two universities in Germany: Humboldt-University of Berlin and University of Duisburg-Essen. The project duration was initially scheduled for three years with an additional option for partly ongoing support while finally aiming at establishing the initiative in the educational landscape.

Involved partners in the project are also experts from psychology and pedagogy departments who support all relevant decisions so that mathematicians, educators and psychologists work and bring together knowledge from different but related disciplines.

In what follows, the design of the initiative is elaborated on. That is, the goals of the involved researchers are made explicit and it is described how the aforementioned theoretical aspects are reflected in the project. Particularly, one focus will be on specific efforts to explicitly consider teachers' needs while respecting them as *involved* instead of *concerned* people.

AIMS AND SCOPE

The initiative gathers, on the one hand, in-service training courses that have already been successfully conducted in Germany and now makes them available and even accessible nationwide. One main concern has been to not reinvent the wheel but to consider and involve expertise from colleagues in form of already established professional development offers. Of course, there are many acknowledgeable initiatives in Germany. Unfortunately, most of them are just locally known, thus one intention of the project is to provide a new and comprehensive platform.

While the educational system in Germany is decentralized due to federalism, expanding opportunities for professional development in mathematics by spreading and broadening regional programs nationwide is one of the aims of *Mathematics Done Differently*. Additionally, and that is a matter of our³ particular concern, the project aims at meeting the unique needs of teachers. Consequently, we design courses regarding these needs, an issue that is explicated in detail later. The newly designed courses are then also made available on the project homepage, and thus contribute to our broad range of in-service courses.

There is a clear shift in European mathematics teacher education to elaborate on teacher education as a field of both practice and research (Llinares & Krainer, 2006). This trend is reflected in one of the constitutive parameters of the initiative *Mathematics Done Differently* since a tandem of a university teacher for mathematics or mathematics education and a practicing teacher offer the in-service courses. A fruitful connection of research and practice, i.e., researcher knowledge and teacher knowledge, is thus already interwoven in the course design. In-service education in this way serves as a context for integrating theory and practice (cf. Cooney & Krainer, 1996) and results in a learning system, particularly involving researchers as learners.

We respect teachers as being responsible for their professional learning and understand our role as being supportive in this process. All we provide is no more, no less than one contribution within this lifelong learning process. Ultimately, it is up to the teachers to pursue their specific ways. In this respect, all offers address teachers not as individuals but as groups that work together collaboratively. As a minimum, a group of 15 teachers from one school department or neighboring ones can request an in-service training course. Thereby, one of the teachers is actively involved in the on-site organization since the course will be offered in the school, thus contributing to job-embedded professional development.

The costs for the trainers, i.e., the payment as well as reimbursing the traveling expenses are covered by the project. Further, we offer refreshments during the sessions and appreciate that environment and atmosphere are decisive variables, too that should not be underestimated.

PHILOSOPHY AND DESIGN OF THE PROJECT

Unfortunately, there is no “paint by numbers kit” for professional development, as Loucks-Horsley et al. (2003, p. 7) point out, and at the same time, it is also fortunate that there is none. Hence, inevitably attention has to be paid to the needs and concerns of the people addressed. That is, one crucial approach within the project has been

to get “to know about teachers and their knowledge and beliefs about teaching and learning as well as their learning needs as they relate to students’ learning needs” (Loucks-Horsley, 2003, p. 8). In this respect, huge amounts of data were collected before the start as well as during the project.

As indicated in chapter one, philosophies on professional development are crucial since they largely influence the design of any initiative both on a micro as well as a macro level. Viewing professional development includes many facets and is coined, if only implicitly, by views on mathematics, its teaching and learning, and the role of the teacher. Regarding the latter, Malara and Zan (2002) impressively remind of the impact of such subjective convictions:

Seeing the teacher as decision maker or problem solver, rather than as executor of procedures, has a strong influence on the theory-practice relationship, as well as on theory itself. (p. 562)

The view of the teacher and his or her role particularly influences the tension between theory and practice. Since this is a crucial point for our project design, it is elaborated on in the following.

Firstly, we follow the encompassing definition provided Day (1999) and consider professional development as bringing together natural learning experiences and intended activities, being of benefit for the individual and even the educational system by acknowledging a process through which teachers grow. Secondly, the defining characteristics given by Guskey (2000) are explicitly valued and professional development thus considered as an intentional, ongoing and systemic process.

In the project, the teachers are regarded as learners, and our aim as implementers is providing appropriate learning opportunities. Hence, the view on professional development is clearly driven by accentuating teacher growth, far away from paraphrases like *teachers should* or *teachers do need* and from being mainly prescriptive. The course offers are understood to empower teachers and strengthen their previous practice or to enable changes while providing new insights.

The project is particularly open for involving teachers actively and consequently gives them *agency* and *ownership*. Finally, specific attention is paid to the different domains and processes described in the Interconnected Model by Clarke and colleagues (cf. chapter two). The value of the model lies in stressing the development of knowledge and practice in terms of possible growth networks, key change domains and mediating processes like enactment and reflection. The development of knowledge *and* practice is especially in the focus of our project while different interdependencies between those two are favored (cf. Cochran-Smith and Lytle, 1999).

Drawing on the three different philosophies described in chapter one, the aforementioned issues make it obvious that the main approach of the project is founded on a marketization view. Slightly different to Elliot’s (1993) categorization, the individual teacher is valued rather with respect to authenticity than autonomy or individualism. The issue pointed out by Laursen (2005), that authenticity contributes to a sense of self as mathematics teacher, which mainly develops in interaction with colleagues, is regarded as crucial element. We therefore do not state a field of tension between the individual and the school development, as Elliot’s criticism has been, but promote

a mediating view since in particular, collegiality and collaboration among teachers is stressed. Hence, from our perspective we also take a humanistic view while especially valuing the people addressed and involved (cf. Roesken, 2007; Roesken, 2008; Roesken & Toerner, 2007).

However, the crucial question is, *How well does our design reflect the knowledge supplied by research?* (cf. Loucks-Horsley, 2003, p. 33). The project is in line with what has been generally established in the research literature, and subsumed under the headline of promoting factors. That is, besides the more general philosophy outlined so far, the marketization view, a specific course system while distinguishing courses *à la carte* and courses on *demand*, the *tandem* approach of trainers, collaborative work, evaluation, cooperation with administration and finally the flexibility of the project are considered as constitutive parameters.

Marketization

At the very starting point of the initiative, we at first seriously contemplated the question, *What do teachers want to have in their in-service training courses?* Assuming that we would open a shop offering professional development products for teachers, we asked ourselves what to put on the shelves. A very honest answer was that actually we do not know although we surely kept some ideas in mind but these were mostly based on our experiences and our theoretical background. In this respect, the very first conclusion was to decide that we would ask the teachers themselves, what their experiences and their concerns are. A questionnaire was thus delivered to teachers from all school types and approximately 1800 data sets were gathered. The analysis yielded huge amounts of information about teachers' retrospective experiences concerning their professional development as well as their prospective view expressed in needs and expectations.

However, questioning teachers' concerns was not only relevant in the initial project phase but at any time. That is, we have gathered qualitative data during all the project phases that has contributed to understand more precisely what teachers' demands are. Both data sources will be outlined in the following subsections.

Hence, the philosophy underlying our understanding of professional development as being dependent on *supply* and *demand* led to a marketization view, i.e., we entered the field as a market of professional development. As a result, teachers' needs and concerns are automatically decisive since courses are to be offered according to their demands: firstly, by identifying needs on a general level and offering appropriate courses, and secondly, by explicitly designing courses for specific needs. While the topics were identified, the courses then offered by colleagues have contributed to high standard professional development.

We a priori focused mainly on the *products* as being crucial on the market. Meanwhile we have acknowledged that it is in particular the process all around these products, which is decisive for effective professional development. Thereby, intensive communication between teacher educators and teachers adds to providing in-service training as being this pair of product and process. In-service training is then not restricted to being this individual session but comprises prearrangement

and follow-up as well. Negotiation among teachers and teacher educators results in an educational discourse that might also confront the different parties since they are involved in a complex educational world. While the compound system encompasses different subsystems, marked by mutual dependencies, tensions are likely to occur when changes take place at some point in the system.

The marketization view entails acknowledging that educational issues are discussed in the language of business, thereby giving relevance to aspects like efficiency, effectiveness, economy and profitability. Going back to the metaphor of opening a shop for professional development, crucial questions besides the one raised in the beginning of this section are the following ones:

- How to launch a product?
- What is a good product?
- Are there non-sellers?
- ...

The list is by choice not a final one since many questions have resulted from the progressing project. Apart from that, questioning efficiency and effectiveness give rise to think about how to evaluate such a complex in-service program, an issue that is stressed later on. However, some answers are given in the following subsections that are concerned with exploring the market both from a quantitative and qualitative approach.

Exploring the market: quantitative data. In November 2007, before the official start of the project, huge amounts of data were collected by means of an online survey. An elaborated questionnaire was delivered to teachers in the whole of Germany who were working at all school types encompassing primary to secondary education. More than 3000 teachers participated, finally 1715 data sets were yielded and analyzed. Even though no representative sample was obtained because the Federal States were not adequately represented, at least a comprehensive inventory of mathematics teachers' professional development in Germany was gained. The questionnaire was composed of two main parts, i.e., the questions covered a retrospective and a prospective view. While the former addressed teachers' experiences with professional development dating back to the beginning of 2005, the latter acquired information concerning the current situation.

In the following some findings will be exemplarily listed; for more information see Jaeger and Bodensohn (2006, 2007). Surprisingly, one result of the study was that astonishingly many participants have taught mathematics without possessing an adequate qualification. Even in the Gymnasium⁴, 5,9% of teachers did not study mathematics or mathematics education. Regarding their professional development, 63% of the participants stated that they had attended one or two events in the years 2005 and 2006. As it was expected, the professional development opportunities were mostly single sessions (68%), only partly, they lasted several days (20%) and some training courses took place on the weekend (12%). An equal share of teachers attended the courses all alone, and together with colleagues of their school. The participants were also asked for their willingness to pay for professional development on their own. While 30% of the teachers refused to take a share, 29% would pay up to 50 Euros.

The relevance of themes was estimated as follows. Since we provided a huge thematic differentiation to choose from, we were able to get broad information about what teachers are interested in. Although the choices were dependant on the specific school form, some general trends could be spotted. The choices teachers made were rather conservative but also influenced by current trends as, for instance, the educational standards discussion. Regarding general topics, rather conventional themes like *Basic Knowledge and Standards* as well as *Discovering, Inquiring and Experimentalizing* were chosen. Regarding mathematical topics, *Geometry* was in the focus. Finally, teachers favored pedagogical themes like *Promoting Competence in Problem Solving, Motivational and Emotional Aspects of the Learning of Mathematics* and *Diagnosing*. The data also enlightened the requirements teachers consider as important regarding their professional development; these findings are presented in detail in chapter seven.

To sum up, the survey contributed broad information about relevant issues in the context of mathematics teacher in-service education, addressing both content as well as composition of professional development events. The findings influenced the design and implementation of the supply provided by *Mathematics Done Differently*. Moreover, the items build the basis for the accompanying evaluation of the initiative.

Exploring the market: qualitative data. As mentioned earlier, at first we started with a focus on the products in terms of individual in-service courses. Our initial aim was to provide an optimum of course offers but increasingly we have experienced and learnt that even a very multifaceted supply, guided by the information gathered by the quantitative approach, can be far away from what teachers really need. We therefore were eager to get in contact with groups of teachers, in order to get to know how to diversify our business.

This aspect of exploring the market was primarily dedicated to get into direct contact with teachers, also addressing those already engaged in specific networks. The discussions have provided insight in specific demands that could partly be satisfied by a special course offer. Moreover, the conversations contributed to a better understanding of the products and processes relevant in the context of professional development. Since the qualitative data is a main part of the empirical approach (cf. chapters 8), this section is restricted to just providing a general overview. Nevertheless, what can be concluded so far is that so conceived in-service training puts some new demands on teachers and trainers since they are confronted with rather unfamiliar roles. That is, teachers are not used to formulate their professional development needs and trainers or teacher educators are not used to provide in-service courses correspondent to such teachers' needs.

Course System: Courses à la Carte and Courses on Demand

The course offer of *Mathematics Done Differently* comprises courses *à la carte* and courses *on demand*, i.e., we address supply and demand oriented professional development. Explicitly, we are in line with the recommendations given in the final report of the KMK (cf. Terhart (2000), chapter 3), and do not maintain a questionable dichotomy of in-service being either supply or demand oriented. Therefore, our aim

has been to broadly offer courses in different thematic fields since this may allude to a latent need of in-service training, too. However, contrary to traditional settings, where teachers are primarily expected to change to more or less explicit goals formulated by the implementer, these courses are not finally designed but open to take into consideration specific teacher concerns.

Regarding the topics, we also favor a bottom-up approach: the teachers themselves bring up the themes. All courses share that they aim at offering possibilities to develop and enhance teachers' knowledge, beliefs and instructional strategies. We want to provide learning opportunities instead of telling teachers what to do. Finally, we take the following phrase, strengthening the strengths and weakening the weaknesses as guideline for our activities.

In order to get the project started, we collected different course offers from our colleagues and consequently gathered professional development programs in different thematic fields under one roof. These courses *à la carte* were then made available on the Internet. The categorization provided by Shulman's work (1986) thereby served as heuristic device to differentiate firstly between rather mathematical content oriented models and pedagogical methods oriented models. Secondly, we have included international expertise of our colleagues from all over the world. Courses *à la carte* are thus available according to the following themes:

- *Mathematical content* oriented models: these courses mainly address subject matter and pedagogical content knowledge to different topics.
- *Pedagogical methods* oriented models: here the focus is more on the pedagogy and the overarching didactical approach than the mathematical content.
- *International models* to inspire mathematics teaching in Germany: interesting approaches that were developed in other cultures and might enrich mathematics in school are offered in this category.

Meanwhile, 39 courses are bookable on the project homepage and we are still open to broaden the range. Reflected in the courses are currently interesting mathematics topics as, for instance, stochastic and geometry. Course titles like *Geometry Unplugged* or *Everything You Always Wanted to Know About Stochastic But Were Afraid to Ask* refer to the wide spectrum of approaching these themes. But also topics like discrete mathematics, modeling, technology, open-ended tasks, educational standards as well as interdisciplinary courses are offered. Training courses that deal explicitly with providing a different view on mathematics and its teaching and learning complete the supply. One particular goal is not only to offer cognitive challenging courses but also to address teachers' beliefs since they are crucial regarding any developmental processes.

The aforementioned course *Geometry Unplugged*³, for instance, particularly aims at showing a different way of dealing with geometry in the classroom besides using dynamic geometry software. The decisive point has been to involve teachers like students in discovering how simple items like a mirror can be used to make measurements in the environment. Meanwhile, this course has been realized several times and obtained very good evaluation results. The following pictures taken from a session provided in Berlin in the Botanic Garden give an impression of how the teachers were challenged in this course. At first, simple measurements were conducted while using mirrors and measuring tapes, as can be seen in [figure five](#):



Figure 5. A first approach to discover 'Geometry Unplugged' was to use a small mirror and measuring tapes to calculate distances.

Teachers then worked together to construct a Foersterdreieck⁶, which is a specific device used by rangers:



Figure 6. At second, a specific device to measure distances more comfortably was built in group work.

Finally, the Foersterdreieck was applied outside to measure trees and buildings, as can be seen in figure seven:



Figure 7. Finally, the Foersterdreieck was applied to measure trees and buildings.

All courses are well outlined regarding their content, their aims, the underlying didactical approach, the addressed people, the possible duration and informative literature. Though the courses do supply some specifications regarding content and goals, enough flexibility is left to consider self-determined and independent learning.

That is, the courses are not of the type *one-size fits all* but teachers can negotiate with the trainers what their specific requirements concerning the topic and their school types are. The educational system in Germany is, in contrast to other countries, rather fragmented. Since lower secondary education comprises three different school types with respect to students' abilities, in-service teacher training needs to be adequately aligned.

The training courses do not only address school types from primary to upper secondary school separately, but also the interfaces between them. For instance, the course *Children Invent Mathematics*⁷ recently brought together kindergarten educators and primary school teachers and contributed to a fruitful exchange among them. Different materials were given to the teachers in order to demonstrate what possibilities are inherent in an approach that allows children to discover regularities while dealing with identical quantities, as can be seen in figures eight to ten. One group of teachers, for instance, started to work with an amount of clothespins (cf. figure 8).



Figure 8. Different materials were given to teachers in order to experimentalize and mathematize.

The teachers then worked together and built different patterns of which one is shown in figure 9:



Figure 9. Example for how the firstly unstructured amount of clothespins was assorted by some teachers.

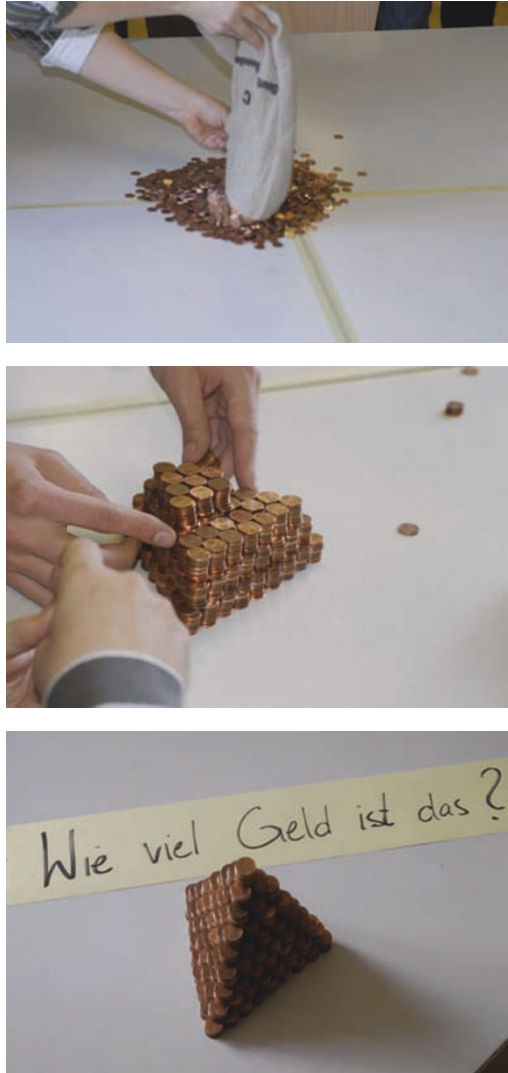


Figure 10. An amount of coins was given to the teachers. One group of teachers built a pyramid out of the coins. Finally, the group arrived at estimating the amount of money.

Other teachers started to assort multiple coins (figure 10) and worked out several arrangements, finally resulting in the question, *How much money is it altogether?*

One future goal is to pay more attention to courses like the aforementioned one that address teachers from different educational pathways.

A particular concern of the project is, that teachers can apply for courses on *demand*. They have even more input in planning their professional development

when asking for a specific course that is not comprised in the online supply. A course will then be offered according to teachers' very specific needs. These courses are rather demanding to organize and to design since they initiate a time consuming procedure, encompassing the following steps:

- Supporting and encouraging teachers to concretize their needs
- Classifying the request with regard to research
- Literature review
- Searching for experts that may serve as *trainers*
- Designing the course
- Offering the course on the project homepage
- ...

The long-term goal is to establish a net of experts in these different fields of demands in order to contribute to highly professional development close to teachers' needs. The courses on *demand* are particularly challenging, firstly while they require building up an understanding from a research perspective and secondly while implementing the request into a specific course.

Tandem Approach

A special characteristic of all courses that are offered is that the trainers always operate in pairs, consisting of an academic and a practicing teacher. What is mainly addressed by this constitutive parameter is a specific relation between theory and practice, which is considered as problematic by Malara and Zan (2002). Thus, from their very design, the courses are sure to combine theory and practice. Regarding the model provided by Cochran-Smith and Lytle (1999), which allows for distinguishing different knowledge and practice relationships, the favored category is the one knowledge-*of*-practice (see chapter one). In this regard, the *tandem* approach initially helps to mediate between formal and practical knowledge. The role of theory is providing an interpretative framework encompassing experiences in practice and allowing for making mostly implicit processes transparent.

Thereby, the schoolteacher is assigned a decisive and supporting role while especially pursuing issues relevant in practice. Since the views of teacher educators and teachers typically differ, the various viewpoints and accentuations contribute to a comprehensive picture of the single topic. Providing in-service training courses by involving teacher educators and teachers also contributes to their learning since they have to negotiate the themes while coming from different disciplines.

Collaborative Work

We encourage teachers from the same workplace to participate together. Courses are not offered for single teachers but for groups of no less than 15 teachers from one or neighboring schools. Ideally, most teachers of the subject department of the single school participate the course. However, due to constraints of time and the request that no lesson should be skipped for in-service training, this demand cannot be met in all cases. However, our understanding of in-service education is that we give no more, no less than an important impetus to the specific department of the school. That is to

say, we clearly aim at initiating staff development in school besides strengthening processes that have already been in progress. Issues imparted at an in-service training are not likely to be transferred into the classroom when the single teacher obtains no support by colleagues or is even criticized for innovative approaches. Nevertheless, observations of many in-service courses indicated that in case of a single department participating, hindering group processes might occur that are not on the agenda when departments of different schools come together.

Even though teachers apply for a course as a group, a particular teacher is responsible to organize the in-service training on-site and to get into contact with the trainers. The latter encompasses scheduling the course as well as negotiating the specific needs of the group. The prearrangement is rather important in order to make the course fit precisely to the needs of the individual groups of teachers.

Evaluation

An external institute, that is, the Centre for Educational Research⁸ (zepf), located at the University of Koblenz-Landau, was concerned with evaluating all courses in the first two project years. The evaluation was based on estimations of participants and trainers. Corresponding data was collected at three different measuring points, i.e., four weeks before the in-service training, directly after the course and finally four weeks later. The evaluation did not only provide a comprehensive picture about the success and sustainability of all courses but for each single course as well.

The evaluation comprised the participants' expectations, and their assessment of the individual course as well as the transfer. Expectations and assessment were further differentiated with respect to the course and the trainers. Additionally, at the second measuring point a self and group assessment was gathered. In the following, some findings are reported, for more and detailed information see Jaeger, Lang and Bodensohn (2007).

In the first two project years the evaluation yielded that the courses are well accepted and positively valued. Merely the professional exchange with colleagues was rated to be only moderate. Very important for the participants were the following variables: Clarity of the Goals, Structure of the Course, Up-to-datedness of Content, and Choice of Texts and Material. Environmental Variables are valued the best while the aforementioned ones are assessed rather positively, too.

Pedagogical Content and Subject Matter Qualification of the trainers are highly valued. Interestingly, the assessment exceeds all expectations. The trainers were actively involved in the evaluation since they were asked to deliver 10 items in which they formulated the learning goals of their course. After the in-service event, all trainers received a detailed description about the evaluation data concerning their single course. By the comprehensive evaluation, additional information about teachers' expectations and needs was gathered. The work even contributed to enlighten this terrain more specifically.

However, the evaluation was redesigned in the third project phase. One specific aim has been to establish the project on the market, going beyond any project duration. An associated concern therefore was to gain an evaluation that is less costly and

time consuming. In order to meet this request, the experiences gained by the hitherto performed evaluation were used to guide a redesigned version that can be handled by the researchers working in the project themselves.

In the first two project years, the focus was on getting a comprehensive feedback to the single course. As problematic turned out the low response rate to the two measuring points lying after the in-service training. Further, we wanted to get more specific information concerning the constitutive parameters, like the *tandem* approach, of the project.

On the basis of the first evaluation, 216 items were generated and piloted. Factor analysis led to a reliable instrument containing 53 items that could be assigned five dimensions:

- General estimation of the course
- Benefit of the course for practice
- Atmosphere for study in the course
- Cooperation of the trainer *tandem*
- Announcement of the course

The courses are evaluated directly after the session. In line with the findings gained during the first phase of the evaluation, the general estimation of courses is very good and teachers feel confident that the imparted issues are useful for their practice. The good atmosphere of study and the *tandem* approach are highly valued. However, the announcement of courses needs further improvement.

Cooperation with Administration

The long-term goal is to establish *Mathematics Done Differently* in the educational landscape of our country. Since it is perfectly in line with recent developments within mathematics teacher education in Germany (cf. Terhart, 2000), we are sure to place the initiative on the market. Thereby, not only financial support subsequent to the official project end is subject of discussion but rather gaining a win-win situation for all partners. What we are particularly offering are the constitutive parameters of the project design that have mainly contributed to its success: the *tandem* approach, the courses *on demand*, the evaluation, the impulses for sustainability and on a more general level, our experiences with and knowledge of this market of in-service education.

While the project is proceeding, we have had some meetings with people responsible for in-service education in the Departments of Education in some of the Federal States. Even with regard to the SINUS project (cf. chapter three), one approach is to sustain the already initiated networking and to give further support for these groups of teachers. On top of this, while the project especially addresses communities of practice, new collaborations can be initiated. Of particular interest for the administration side is the theory-practice relationship that is favored in the project.

Particularly, the involvement of teachers and researchers helps to overcome gaps that are indicated by those different positions and to reconcile between theory and practice. Not at least, involving expertise from our colleagues contributes to consider newest research results gained in different thematic fields.

The interest by administration is also documented by specific demands, e.g., requesting courses for their trainers who are responsible for in-service training courses provided by certain institutions under their purview. Particularly those Laender, which are currently concerned with restructuring their in-service education, are highly interested in cooperation. Besides further qualifying their trainers, the concern encompasses our experiences with evaluating courses, and designing an appropriate Internet offer.

As main advantage, a project is financially, organizationally and with regard to content independent. More specifically, *Mathematics Done Differently* is an intervention from outside. Since the project does not rely on already existing structures that may impede new ideas and approaches, our obvious advantage lies in the flexibility that we are able to provide. Due to that, individual needs can be more adequately addressed and experiences be made that might not be accessible on the administrative level.

Flexibility of the Project

One essential conclusion that has been taken at any point of the project is that we as teacher educators, of course mainly responsible for the project design, are part of a learning system. To design and run a project is not a static endeavor but part of a developing process, also leading to partly refinement and adjustment. That is, one crucial point is documenting our own process of revising the initial approach and acknowledging that we are professional developers, too (cf. Loucks-Horsley, 2003).

Simon (2001) elaborates on the close connection between research on teacher development on the one hand, and theory of mathematics teaching and learning on the other hand. Particularly, he states a bi-directional basis for framework refinement, an interesting approach that is explicitly paid attention to in the project. Likewise, Sachs (2004) refers to the developmental processes characterizing teacher professional development when stating the following:

Rethinking the practice of teacher professionalism requires that all of those involved in education negotiate and renegotiate meanings and processes in order to engage teachers in the broad project of teacher professionalism. (p. 24)

The learning system results from the fact that the involved parties enter an educational discourse that might be rather controversial and in which the involved teacher educators as well as teachers both take the position of experts and learners. The learning of the implementers can be measured in the flexibility of the program.

What has also been under progress has been the so-called philosophy of our project. Though our intention was surely not guided by compensating for deficits, we started by rather naively acknowledging the role of teachers as learners (cf. Roesken & Toerner, 2007). In the initial project phase, the focus has surely been on simply offering in-service education. That is, the courses presented were mostly supply oriented, even though the proposed themes were left rather open with regard to the individual implementation. Over the course of time, due to project presentations and conversations with teachers, the demand-oriented approach has become

increasingly important. Hence, through marketization we have grown into mandating a humanistic view on professional development (cf. chapter one).

OVERVIEW ON THE COURSE SITUATION

Meanwhile, we are in project phase five and the following overview gives an impression of how many courses have been provided so far, are scheduled or just in preparation. At the start of the project, we agreed to have six courses in the initial phase, and 40 ones per project year. The extremely high demand surpassed all expectations and led to extending the actually planned course situation. In [table two](#) a general overview on the course statistics is given:

Table 2. Overview on the course statistics

<i>Courses</i>	<i>April, 2007 to August, 2010</i>
Performed Courses	331
Scheduled Courses	10
In Preparation	33
Total	374

Additionally, the following table provides information about how the courses are distributed in the different Laender.

Table 3. Overview on how many courses have been performed, are scheduled or in preparation with regard to the different Laender in Germany

<i>Federal state</i>	<i>Total of courses</i>
Baden-Wuerttemberg	14
Bavaria	12
Berlin	33
Brandenburg	13
Bremen	4
Hamburg	4
Hesse	23
Mecklenburg-Vorpommern	19
Lower Saxony	38
North Rhine-Westphalia	140
Rhineland-Palatinate	36
Saarland	0
Saxony	20
Saxony-Anhalt	8
Schleswig-Holstein	6
Thuringia	0

The in-service training courses have for now reached 14 of the Federal States, another indication that the initiative is known nationwide. We also present short-term workshops at specific events in order to call further attention to our professional development initiative.

SUMMARY AND IMPLICATIONS

In this chapter, the initiative *Mathematics Done Differently* was discussed against the theoretical background (cf. chapter one and two) and the specific situation in Germany (cf. chapter three). In particular, the constitutive parameters of the initiative were presented in detail and reflected regarding research. The issues were elaborated on to scientifically reflect the design of the project, in which context the empirical study was conducted that provided the data presented in the following.

To sum up, it is the process of professional development that has explicitly been valued, and the issues contributing to teachers' growth. This process is characterized as being intentional, ongoing and systemic. The initiative explicitly values the persons addressed and involved, considers teachers' professional learning needs, and thus the underlying philosophy is grounded in a humanistic view.

Offering professional development is primarily understood in terms of marketization. Therefore, the teachers are asked for the themes and topics they want to learn. Consequently, the project provides a certain flexibility in order to consider individual needs of groups of teachers working together collaboratively. Such an approach is partly a rather uncommon endeavor since teachers are not used to think about their needs and to take their professional development into their own hands. The empirical study that is presented in the next two chapters draws on teachers' views on their professional development and enlightens factors they consider as essential for effective growth.

NOTES

¹ <http://www.mathematik-anders-machen.de>

² <http://www.telekom-stiftung.de/home>

³ In contrast to the other chapters, the description of the initiative *Mathematics Done Differently* is not conducted in passive voice. The "we" addresses the persons responsible for and working within the project.

⁴ Secondary education in Germany is divided into three school paths: Hauptschule, Realschule and Gymnasium, which students attend according to their performance in primary school.

⁵ The trainers of the course *Geometry Unplugged* are Prof. Dr. Matthias Ludwig, University of Education, Weingarten, Germany, and Mathias Heidenreich.

⁶ cf. <http://de.wikipedia.org/wiki/Foersterdreieck>

⁷ The trainers of the course *Children Invent Mathematics* are Kerensa Lee, Konzeptdesign ZahlenRAUME, and Ulrike Thesmann, Germany.

⁸ <http://www.en.zepf.uni-landau.de/>

EMPIRICAL APPROACH AND METHODOLOGY

OVERVIEW

The previous chapters were concerned with presenting the theoretical framework and background, exploring the specific situation in Germany, and describing the initiative *Mathematics Done Differently*. This chapter deals with providing a synthesis of the issues explored so far. That is, the undertaken literature review results in listing the research questions that are guiding the empirical study.

Moreover, this chapter informs about how the aforementioned research questions have been approached empirically. As pointed out in chapter one, the conceptual frame of the empirical study considers various theoretical perspectives on mathematics teachers' professional development. Correspondingly, theoretical and methodological triangulation was chosen in order to include a wide range of views. The data collection thus draws on the different paradigms of quantitative and qualitative research. All methodological choices will be thoroughly discussed while addressing both of them explicitly. Thereby, the focus is on elaborating the basic principles and methodological justifications, the development and implementation of the research design, and finally the collection of data.

SYNTHESIS AND RESEARCH QUESTIONS

Conceptual diffuseness, multiple perspectives, and a lack of an overarching research-based theory characterize the field of professional development. However, there is some consensus on important variables that are crucial for effective professional development in general and in-service training in particular (cf. chapters one and two). Since much of the research conducted in mathematics education is concerned with elaborating on aspects of teacher knowledge, the focus of this work is to shed light on professional development from a broader perspective.

That is, the focus of the empirical approach is on the personal domain, the individual teacher as part of a professional world of practice. A key factor in ensuring effective professional development is matching professional learning opportunities to professional needs of teachers. Hence, teachers' related beliefs, subjective theories, experiences and learning needs are in the focus. Data that explicitly allows for looking into the subject from the corresponding teacher's point of view will be presented. Since Malara and Zan (2002) point out that "most studies are about teachers but not with or for teachers" (p. 554), the approach of this work is to stress the *with* and *for*.

All data is gathered in the context of the initiative *Mathematics Done Differently*, which is specifically dedicated to designing professional development opportunities

according to teachers' needs (cf. chapter four). In the empirical study, the first level of Lipowsky's (2004) four-stage system of examining and identifying successful aspects of in-service training programs is operationalized, i.e., teachers' opinions are explored. Thereby, the objective is to illuminate the following issues: professional learning and learning needs, professional and collegial exchange, professional identity, affective aspects and beliefs, as well as the relationship between theory and practice. What will be particularly elaborated on are factors identified by teachers as contributively to successful professional development.

As pointed out in the theory section, an encompassing *big* theory in teacher education is missing on the research agenda. The field is characterized by a huge variation of approaches, but there is at least consent on some key issues. In the empirical study, approaching teacher professional development thus draws on theoretical triangulation (cf. Cohen, Manion & Morrison, 2007). In particular, the following research paradigms have been stressed:

- Professional development is teacher learning.
- Professional development takes place in a field of tension between theory and practice.
- Growth processes not only occur in terms of knowledge but beliefs.
- Developmental processes initiated and supported by collaborative practice contribute to identity formation.
- Professional development explicitly considers teachers' needs and expectations.

The main assumption guiding the empirical approach is that teachers' view on professional development is structured and consequently unravelable. Clarifying the subject under investigation aligns with the aforementioned paradigms.

Corresponding research questions are listed below and are grouped into three different main dimensions, which are of course intertwined but are mainly addressed separately:

- *Teacher learning*: Professional development is regarded as a lifelong and continuous learning process. How do teachers perceive their learning and which variables do they consider relevant? Do teachers deem their professional development as a long-term career-related process? From a teachers' point of view, what makes professional development effective? What supporting or hindering factors can be identified? Which relationship between theory and practice is required in the field of professional development?
- *Teacher growth*: Influential for teacher growth processes are affective aspects and beliefs related to professional development, which play a decisive role in any learning process. What attitudes and beliefs do teachers hold towards professional development? What previous experiences influence the reception of current professional development events? What are the underlying views of the participants? How do they perceive any change processes? How is the role of professional collaborations valued?
- *Teacher needs*: A decisive approach in the field of professional development is to take teachers' needs and their expectations seriously. What are teachers long-term professional development needs? What is the teachers' motivation to actively engage in professional development or to participate in-service training courses?

How can those needs be differentiated with regard to aspects of content, context and community?

These research questions guide the empirical study that is presented in chapters six and seven.

METHODOLOGICAL CHOICES

The empirical study comprises the following proceeding: First, quantitative data was gathered in the run-up of the project *Mathematics Done Differently* concerning teachers' experiences, expectations and needs regarding professional development. Second, qualitative data was collected by providing interviews with teachers throughout the course of the project. Third, observations made while monitoring many of the in-service training courses complete the overall picture. However, the focus of the empirical study is on the first two aspects. The following subsections, which are dedicated to informing about the empirical choices, therefore just address those two.

Basic Principles and Methodological Justification

Various theoretical aspects on mathematics teacher professional development serve as a conceptual framework in this thesis. Theoretical triangulation allows for including this variety of viewpoints. The synthesis of different approaches provides broad insight and enables a widespread overview. The abovementioned divergent research paradigms were selected with regard to the addressed issues. Ultimately, teacher development is a specific aspect of human behavior, whose complexity demands "studying it from more than one standpoint and, in so doing, by making use of both quantitative and qualitative data" (Cohen, Manion & Morrison, 2007, p. 141).

Combining different methods of data collection thus allows for including different perspectives. According to this, more general quantitative data was gathered in order to get a first comprehensive overview. Furthermore, qualitative data, enabling a deeper analysis of the subject under discussion, was taken into account. Data collection in the study hence contributes to methodological triangulation (Cohen, Manion & Morrison, 2007). This strategy prevents the data from simply becoming an artifact of one specific method of collection. The two methodologies are used equally and in parallel and they both contribute to presenting a bigger picture of teacher professional development. In particular, the results section informs about the consistent findings and shows how these different approaches complement one another.

Quantitative approach. The favorite approach to investigating knowledge and beliefs concerning a specific construct in psychological settings is a quantitative one. Correspondingly, one choice was to collect comprehensive data by means of a questionnaire. This questionnaire was also developed in order to get information about teachers' issues connected with professional development both in general and domain-specific in mathematics. The approach was chosen in the run-up to the project *Mathematics Done Differently* and the gathered data was essentially considered in the initial design phase (cf. chapter four).

Different dimensions normally structure attitudes towards a specific construct. The relevant question pursued in the quantitative analysis is to determine important dimensions for mathematics teacher professional development. The approach encompasses their perception and cognitive representation of beliefs and knowledge concerning issues of professional development. Factor analysis is employed to statistically discover the aforementioned dimensions in which participants categorize their experiences.

The choice of method inevitably determines the direction of research, and partly the perspectives included in the results. That is, the quantitative approach by using a questionnaire preliminary constitutes the scope within which teacher needs, expectations and perceptions on professional development manifest themselves. However, range of dimensionality and content of the dimensions are not determined. These two sets of parameters only emerge through the statistical analysis of the data even though theory-driven dimensions are already comprised in the questionnaire.

The obtained factors cannot be interpreted as presenting a final structure because the results are not simply determined by participants' choices, but also depend on the sample, the items and the basic factor model. Hence, number as well as content of the dimensions is subject to some context factors and choices; statements about the dimensionality can only be made hypothetically.

In the introduction of this work, while rephrasing the title of an article by Bauersfeld (1980), it was questioned whether there are *hidden* dimensions in the reality of professional development that are not covered by research in this area. The qualitative approach that will be outlined in the following is dedicated to giving the floor to the teachers in order to explore their personal view and individual interpretations on the phenomena under investigation.

Qualitative data. Since human perspectives are more or less encoded when using quantitative data, additionally, qualitative data was collected. Interviews with teachers allow for giving broad insight into their perspective. It has been of particular concern to use the words of the teachers themselves to show what professional development looks like from their perspective. Cohen et al. (2007) describe the advantage of providing interviews as follows:

Interviews enable participants – be they interviewers or interviewees – to discuss their interpretations of the world in which they live, and to express how they regard situations from their point of view. (p. 348)

For their quality, interviews rely on the nature of the interactions between the persons involved; this also includes the person of the interviewer (Partington, 2001). Kvale (1996) refers to the literal meaning of the term interview as actually being an *interview*, e.g., people do interchange their views on a specific topic, a socially situated interaction in which knowledge evolves by dialogue.

With regard to the aspects discussed above, the qualitative study contributes firstly to a deeper understanding of the quantitative findings, and secondly to gaining additional insight. That is, the questions used in the interviews are concerned with concretizing some of the issues reflected in the obtained dimensions, in particular

with regard to context, and also to explore what further aspects are relevant for teachers.

As a disadvantage in the qualitative paradigm, the researcher becomes an instrument of data collection, and results may vary greatly depending upon who conducts the research. This issue is particularly relevant when interviews are not entirely standardized. But in view of the wide range of information provided by teachers, as will be shown in the results chapter, this approach has proven to be a good choice, i.e., rich data could be collected. Nevertheless, this qualitative approach is time-consuming, in regard not only to collecting, but also to analyzing data.

Development and Implementation of the Research Design

The research design of the empirical study was developed in connection with the author's engagement in the initiative *Mathematics Done Differently*. Throughout this work, much information about relevant issues in the context of professional development, even from a teacher's perspective, was gained and contributed at the very least to the ultimate qualitative empirical approach. In chapter four, while presenting the initiative, the significance of a learning system that also includes the teacher educator learning was stressed.

Research questions were basically developed regarding the theoretical input but furthermore, daily experiences while dealing with teachers seeking their specific professional development, left their mark on the researcher's interest, too. In the following, important information on the choices that have been made concerning this matter are given in detail.

Development and implementation of the questionnaire. As already mentioned, the quantitative data was gathered before the actual project started. Addressed were teachers' retrospective as well as prospective views on their professional development. A huge questionnaire comprised of 272 items was employed to obtain information about the following topics (cf. section four; Jaeger & Bodensohn, 2006):

Demographic variables: Age, gender, education, and occupation.

Professional development in 2005: quantity, in mathematics, general content, domain-specific content, and own initiative.

Relevance of topics for professional development: subject matter themes, pedagogical content themes, interdisciplinary themes, pedagogical themes, and general themes.

Choice of topics: pedagogical content themes and general themes.

Attitudes towards and experiences with professional development: need for professional development, support by school, transfer and sustainability.

Expectations regarding future professional development: content and design, conditions, financial share, and trainers of the courses. (p. 9)

Of specific interest to this work is the part of the questionnaire that deals with attitudes towards and experiences with professional development. A preliminary and shorter version of the questionnaire was developed and tested in spring 2006 (Roesken & Toerner, 2006), and primarily draws on two different quantitative approaches (cf. Lipowsky, Thußbas, Klieme, Reusser & Pauli, 2003; Frey & Balzer, 2005). The segment relevant in this discussion dealt with 26 four-level Likert-items. In the following, the dimensions are labeled, and some examples for the items used are given:

- *Need for professional development:*
 - I see necessity for myself regarding professional development.
 - While exchanging with other colleagues during an in-service training, I became aware of my own deficits and needs.
- *Support by school:*
 - My school administration supports me in my endeavor to attend an in-service training course.
 - School administration honors attending in-service training courses by different measures.
- *Transfer and sustainability:*
 - I experienced that I gave up new ideas and suggestions after a short time and went back to the approved methods.
 - The implementation of issues learnt during in-service training has turned out to be difficult because my school only slowly prepares for new content.

The respondents were asked to rate each item on the following scale: 1 = agree strongly, 2 = agree somewhat, 3 = disagree somewhat, 4 = disagree strongly. It should be noticed that the questionnaire was administered in the German language. Since there is no adequate translation of the internationally used term of professional development, the notion in-service training course dominates the formulation of items.

Methodological aspects of the interviews. Interviews were conducted with participants of several in-service training courses provided by *Mathematics Done Differently*. One goal was to capture sensitive data covering teachers' attitudes and opinions towards their professional development by establishing a face-to-face encounter supplementary to the rather anonymous quantitative approach. This encompasses teachers' experiences with professional development in general as well as in the context of the initiative in specific. It should be noticed that the objective of the interviews was surely not to evaluate the provided courses, but to gather information on a meta-level.

All interviews were semi-standardized. Open-ended questions were used, but followed a preliminary theoretically grounded conceptualization. The broad and overall questions were the ones generally guiding the research. In addition, first impressions derived from the quantitative data analysis led to questions that were more precise and ranged from being descriptive to normative. An interview guide, indicating the topics to be covered and their sequence in the interview, was employed (cf. Kvale, 1996). That is, the guide contained a general outline of the

relevant topics as indicated by the research questions and more specifically, some interview questions:

- *Teacher learning:*
 - Regarding your professional development, do you have specific learning needs?
 - Is attending an in-service training part of a continuous process or rather a spontaneous decision?
 - What are your expectations regarding the in-service training course?
 - From your point of view, what makes professional development effective? Can you point out some supporting or hindering aspects?
 - How do you evaluate the tandem approach, e.g., that all courses are provided by a pair consisting of a university teacher and a schoolteacher?
 - What relationship between theory and practice do you deem as essential?
- *Teacher growth:*
 - What general goals do you want to achieve with regard to the in-service training?
 - How are your experiences with professional development so far?
 - From your point of view, what is important for your professional development?
 - How important is it that colleagues from your school accompany you to an in-service training course?
 - What does change in your classroom practice after attending an in-service training event?
- *Teacher needs:*
 - What are your long-term professional development needs?
 - What is your motivation to attend an in-service training course?
 - How important is support by your school administration or your colleagues?

However, the wording and the order of questioning were not standardized. But at least, the interview guide served as framework within which the teachers could respond in a way that represented their point of view accurately and thoroughly.

Obtaining sound qualitative data is a complex task and places high demands on the interviewer. While identifying problems in technique, Partington (2001) stresses the significance of the following issues in a research interview: empathy and rapport, listening and questioning, restatement, clarification and persistence. In the following, some clarifications are given with respect to these variables.

Questions format varied from direct to indirect. Mostly an indirect way, for instance, asking for the respondent's view on professional development in a rather general manner, was favored. Indirect approaches are more likely to obtain frank and open responses. Thereby, questions ranged from inviting factual answers to asking for opinions. Even though the interviewer is in charge of structuring and directing the questions, one advantage of the semi-structured interview is that the arrangement is essentially dependant on the interviewee. The primary technique applied during the interviews was trying to stimulate teachers to deepen their descriptions and explanations. That is, the vocabulary used by the interviewees was further taken up, and used as stimulus to probe for more in-depth responses. In most cases, the interviewees were sensitive to this invitation and elaborated on their statements.

This technique helps to avoid pre-determination by the interviewer as well as interpersonal dynamics. Besides, the definite course of the interview stays undetermined with regard to content. Further, the interviewer also remains flexible to a person's choices and the emerging themes. These issues were particularly relevant since the basic concern was to get information about teachers' thoughts, experiences and basic perceptions. As a result, interesting or even unexpected ideas and themes were raised by participants and were, in case of relevance, additionally explored.

Various themes occurred naturally and the results section reports on those. The statements given by teachers did not only cover descriptive, but also explicative information and enabled understanding issues of professional development more deeply. At a certain point, interventions turned out to be necessary in order to keep the interview functional.

COLLECTION OF DATA

Questionnaire

The questionnaire was administered as an Internet-based survey and was widely announced among teachers. In 2006, teachers had access to participate from the 3rd of November to the 3rd of December via the homepage of the Centre of Educational Research¹ (zepf), for more and detailed information see Jaeger & Bodensohn (2006). Participants came from all over Germany and many different school types. The filling out of the online questionnaire took 22 minutes on average. 1715 teachers participated in the study, which serves as an inventory, but is not a representative study since the Laender are not adequately represented in the data (cf. chapter four).

The age of participants ranged from 22 to 65 while the average age was 47 years. Further, 82% of teachers had studied mathematics or mathematics education while remarkably 18% did not. Teachers came from different school types of secondary education, and were engaged in primary education and some special schools as well. Finally, 72% of teachers were working full time and 28% part time. More detailed information about the demographic variables is given in Jaeger and Bodensohn (2006).

Interviews

The interviews were scheduled to last about 40 minutes. In reality, the interviews then varied from 20 to 60 minutes; the setting was dependent on the teachers' choices. Nine teachers participated in the interview study; three of them were male. Most of the teachers were interviewed in a room of their own school and during their working hours. Participants came from all over Germany and from different school types²: elementary school, Realschule, Gymnasium, comprehensive school and Berufskolleg. They were chosen out of approx. 2000 teachers who had participated in the initiative *Mathematics Done Differently* up to that point in time.

The age range was from 32 to 61, yielding an average of 50 years. Teachers were mostly experienced, five of them looked back on more than 20 years of teaching,

three of them on more than 10 years while one teacher was rather young and possessed only four years of experiences in the job. All teachers were assigned some special roles within the school community. Some of them were quite familiar with respect to being actively engaged in professional development, for instance, in the role of a teacher leader. In case that this information is relevant, a respective indication will be given in what follows.

Interviews were conducted in accordance with an interview guide by the author of this work; further, they were undertaken in the German language. Responses of the participants were recorded on tape and later carefully verbatim transcribed. In any case, a student assistant provided a first transcript that afterwards was carefully reviewed by the author and partly retyped. Those parts selected to be subject of an intensive analysis were then translated into English. Thereby, the aim was to translate literally as far as possible, but also in an accessible way. However, the data analysis also drew on rehearing the recorded interviews several times.

NOTES

¹ <http://www.en.zepf.uni-landau.de>

² For an overview on the German educational system see http://www.partners-in-education.com/pages/germany/prolog_germany.html

RESULTS OF THE EMPIRICAL STUDY

Quantitative Data Analysis

OVERVIEW

This chapter is concerned with presenting the quantitative results of the empirical study. All choices in connection with the data analysis are thoroughly explained, followed by explicitly displaying the results. The quantitative data is reduced by means of *factor analysis*. Presenting the findings includes determining the number of factors that are relevant in the context of mathematics teacher professional development, reporting about the empirical dimensions of teachers' needs, their internal consistency, teachers' answering behavior within those dimensions, and the relations between them. Finally, the presentation of the quantitative results concludes with some remarks and reflections on this methodological approach and the corresponding relevance of the results.

QUANTITATIVE DATA ANALYSIS AND RESULTS

The quantitative data has been analyzed by exploratory factor analysis since the goal was to explore the field of mathematics teacher professional development and to discover the main dimensions relevant from a teacher's perspective. As chapters one and two indicate, this research area is a highly complex theoretical field that necessitates generalization. At least partly, factor analysis yields simplification and reduces interlacement by indicating what the important and main variables are. The aim of the quantitative approach is to display interrelationships among variables that operationalize different aspects of teacher professional development as an aid in further conceptualizing this construct. Several facets included in the items are reduced to a few dimensions, which then are analyzed in detail. Additionally, relationships among dimensions are unraveled. As method, principal component analysis has been applied. Since the expected dimensions are supposed to be uncorrelated, orthogonal rotation was chosen. In the following, methodological decisions going beyond common practice of factor analysis are thoroughly substantiated.

Determining the Number of Factors

Since the conducted factor analysis was concerned with exploration rather than hypothesis testing, factors have not been extracted to a predesignated number. In contrast, several factor solutions were carefully tested. A perfect reproduction of the data can definitely be obtained by extracting enough factors. Nevertheless, the task and

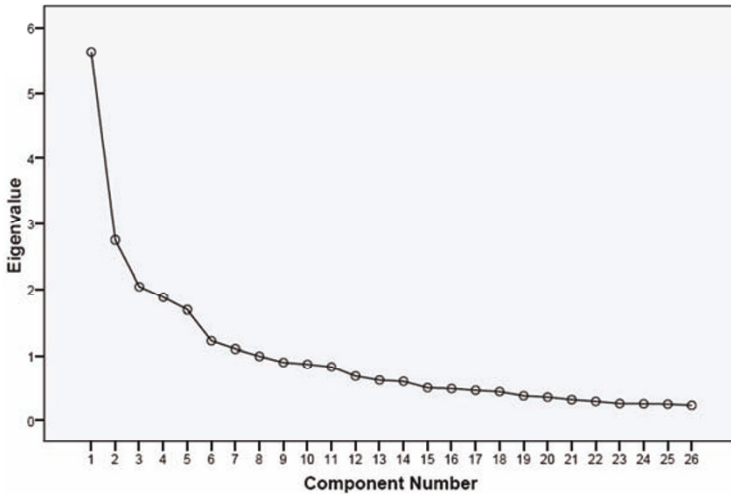


Figure 11. Scree plot.

challenge is to uncover a limited number of factors representing an adequate amount of the original information (Gorsuch, 1983). As a first guess, an arbitrary number of factors was extracted and principal component analysis led to seven eigenvalues greater than one. The scree test (figure 11) suggested the extraction of five or six factors (Kline, 1994).

In accordance with the results of the scree test, a six-factor and five-factor solution was tested. Ultimately, the decision how many factors are to retain was based on the following criteria:

- Each factor should contain enough items with high loading.
- Internal consistency estimated by Cronbach's alpha has to be sufficiently high.
- A factor must account for a suitably high amount of variance.
- The factors should be homogenous and meaningful regarding content.

As best fit for the data, item loadings above .30 with no or few crossloadings and a minimum of two items per factor were considered. Since in the six-factor solution, the fifth factor only comprised two items and the sixth one possessed weak Cronbach's alpha (.49), the five-factor solution was favored. In the five-factor model, reliability was satisfactory with coefficients between .67 and .83. Varimax rotation of the factors was an efficient way of obtaining simple structure. In four cases, items also loaded on another factor. However, these side loadings were moderate as they were located in the range from .33 to .43. Percentage of variance accounted for by the five factors is presented in table four.

The first factor accounts for 22% of variance, the factors 2 to 5 for values between 11% and 6%. When additionally extracting a sixth factor, the contribution is lower than 5.0%. The five factors are homogenous with regard to content and consequently suitable to interpret; the interpretation will be elaborated on in the next section. Summarized, the best fit to the data is obtained by accepting a 5-factor solution.

Table 4. Total variance explained

<i>Component</i>	<i>Extraction sums of squared loadings</i>		
	<i>Total</i>	<i>% of variance</i>	<i>Cumulative %</i>
1	5.633	21.666	21.666
2	2.754	10.592	32.259
3	2.043	7.856	40.115
4	1.876	7.214	47.329
5	1.687	6.488	53.816

Empirical Dimensions of Teachers' Needs

The part of the questionnaire relevant in the context of this work consisted of 26 items. Factor analysis led to five dimensions describing relevant issues of teachers' view on their professional development. In what follows, items and loadings for each dimension are presented and information about naming and interpreting the factors is given. All factors possess salient loadings, contributed by variables that are mostly loading only this factor up. Factors are interpreted according to the highest loading variables. A meaningful label displays the summary of the interpretation. Items and loadings for the first factor are shown in [table five](#):

Table 5. Items and loadings of the first factor

<i>Factor 1</i>	<i>Loadings</i>
In the subject department of my school, general principles of teaching are arranged.	.778
In the subject department of my school, agreements about schedules and topics are made.	.759
Materials delivered during in-service training courses are distributed in the subject department of my school.	.742
In the subject department of my school, principles and criteria of assessing students in mathematics are agreed.	.723
Contents of in-service training courses are reported to colleagues.	.697
Professional exchange with colleagues of my school based on school internal in-service training is fruitful.	.475

Factor 1 comprises six items of which only the last one has a low side loading of .331 on the third factor. Content analysis reveals that the high loading items are concerned with issues of teachers' subject affiliation and departmental organization at their own school. Particularly, the relevance of collegial and shared work in the subject department is stressed. This collaborative work comprises agreements about general principles of subject matter teaching, schedules, topics, assessment, and access to resources provided by in-service training. Hence, the factor is labeled, *Importance of the subject department*.

In table six, items and loadings for the second factor are listed:

Table 6. Items and loadings of the second factor

<i>Factor 2</i>	<i>Loadings</i>
School administration practically supports the transfer of issues imparted at an in-service training to daily practice.	.810
School administration is interested in bringing issues imparted at an in-service training into daily practice.	.761
School administration honors attending in-service training courses by different measures.	.713
My school administration supports me in my endeavor to attend an in-service training course.	.711
School administration checks for changes in classroom practice after attending an in-service training course.	.679
Supervisory school authority supports me in my endeavor to attend an in-service training course.	.549

In the second factor, no items have any side loadings. The factor refers to support by the school administration, first concerning the implementation of issues imparted by an in-service training, second attending training courses in general and third possible changes as effect of an in-service program. Additionally, the last item mentions support by a superior level, namely supervisory school authority. As regards content, this factor is consequently named, *Support by school policy*.

The following factor consists of seven items and alludes to teachers' needs regarding their professional development:

Table 7. Items and loadings of the third factor

<i>Factor 3</i>	<i>Loadings</i>
I also see necessity of professional development for my colleagues.	.749
I see necessity for myself regarding professional development.	.721
It is important to cooperate with other teachers when implementing results of an in-service training.	.591
While exchanging with other colleagues during an in-service training, I become aware of my own deficits and needs.	.521
Professional exchange with colleagues of other schools is profitable.	.502
A successful in-service training course considers the individual needs of the participants.	.471
I attach importance to attending in-service training events together with colleagues from different school types.	.429

The items of the third factor refer to general needs of teachers concerning professional development. These requirements are not only brought up as a personal issue but primarily as a collaborative one. Cooperation with other teachers is regarded helpful in order to become aware of own deficits, but also profitable to sustain professional exchange. Interestingly, professional development is not simply regarded on the individual level but intertwined with collaborative aspects. One item possesses a moderate side loading: The item *Professional exchange with colleagues of other*

schools is profitable also loads on the fifth factor (.429). Finally, the factor is labeled, *Necessity of professional development*.

Items and loadings of the fourth factor are presented in [table eight](#):

Table 8. Items and loadings of the fourth factor

<i>Factor 4</i>	<i>Loadings</i>
Implementation of issues learned during in-service training is difficult because the content was not sufficiently related to practice.	.777
I experienced that I gave up new ideas and suggestions after a short time and went back to the approved methods.	.736
Suggestions obtained by an in-service training course proved to be impractical afterwards.	.718
Implementation of issues learned during in-service training has turned out to be difficult because my school only slowly prepares for new content.	.563
Implementation of issues learned during in-service training has turned out to be difficult because the colleagues of my subject department at school only hesitantly prepare for new content.	.427

While considering the highest loadings, it is clear that this factor is concerned with the challenge of implementing new ideas and issues learned by in-service training. Teachers very quickly fall back on approved methods and the practicability of new aspects appears questionable sometimes. Besides the focus on individual experiences with transfer into practice, the support by colleagues or the school is mentioned. The last two items have negative side loading on the first factor. The fourth factor is named, *Implementation and practicability*.

Items and loadings of the fifth factor are given in [table nine](#):

Table 9. Items and loadings of the fifth factor

<i>Factor 5</i>	<i>Loadings</i>
The contact to the trainers of the in-service training led to professional exchange.	.777
The contact to colleagues I met at previous in-service training events led to professional exchange.	.736

The fifth factor only contains two items, which stress the relevance of contact and professional exchange to trainers and colleagues after attending an in-service training course. However, the factor covers aspects not yet treated in the other dimensions, but is obviously not optimally operationalized. As factor label is chosen, *Sustained collaboration*.

Each of the five dimensions describes a field of consistent answering behavior towards a homogenous item group. The rationale of specifying factors is to obtain dimensions defined by items and their loadings that account for a particular relationship. These dimensions structure teachers' perception, cognitive representation, and affective assessment towards professional development. All dimensions were interpreted from the content of the items that loaded on them.

Obviously, the first two dimensions are related to context variables since they stress the relevance of colleagues teaching the same subject area and the supportive role of school administration. The third dimension elaborates on the necessity for professional development as both a personal and a community issue. A successful in-service training course considers the individual needs of the participants, actually a trivial demand, but in the reality of professional development, many conflicts arise from that. Within the fourth dimension, the effect of professional development is subject of debate since possible implementation of issues imparted at an in-service training and practicability in general are raised. The fifth and last dimension is concerned with sustained collaboration in terms of professional exchange. In the next two sections, these dimensions are further scrutinized while elaborating on their internal consistency and the frequencies within them.

Internal Consistency of the Dimensions

As the preceding analysis showed, each factor is constituted by items, which almost singly load on it, and is homogenous with regard to content. By factor analysis, items were grouped together according to their correlative coherency. A formal criterion for proving homogeneity is given by Cronbach's alpha. Table ten shows the scales' Cronbach's alpha reliability coefficient for internal consistency:

Table 10. Cronbach's alpha for the factors

<i>Factor</i>	<i>Labeling of the scale</i>	α
1	Importance of the subject department	.834
2	Support by school policy	.834
3	Necessity of professional development	.668
4	Implementation and practicability	.709
5	Sustained collaboration	.818

For the dimensions *Importance of the subject department*, *Support by school policy* and *Sustained collaboration* Cronbach's alpha is good with values higher than .8, for the dimension *Implementation and practicability* it is acceptable while for the dimension *Necessity of professional development* the value is a bit lower than .7. In sum, all Cronbach's alphas are found to be sufficiently high and indicate internal consistency of the dimensions.

The reliabilities for individual statements are under the limit of 0.9 demanded for psychological tests, but in the following, group statements are defined for which only a reliability of 0.7 is needed. Insofar, the reliabilities are good and acceptable for four of the dimensions, and even the third dimension can be considered as being satisfactory as the value is close to .7.

Frequencies within the Dimensions

The identified dimensions structure teachers' attitudes towards and experiences with professional development. However, the conducted analysis so far does not provide any indication about the answering behavior of participants within the dimensions.

Therefore, this section deals with defining appropriate scales. That is, scores for the individuals on the extracted factors were computed. A scale for all dimensions was calculated as follows. For every participant, item responses were simply summed to create a score for the group of items presenting a factor. By linear transformation¹, a common scale for all dimensions was calculated ranging from 0 to 40. The simple sum score scales were not only transformed but stretched and led to similar intervals for each of the dimensions. As an advantage, a constant interval length of 0.75 was attained and therefore central tendency bias could be diminished. An overview on the common scale scores and their meaning is given in [table 11](#):

Table 11. Scales for the dimensions

	Scales score from ($>$) ... to (\leq)	Averaged value in a single item
Agree	00 – 10	1.00 – 1.75
Partly agree	10 – 20	1.75 – 2.50
Partly disagree	20 – 30	2.50 – 3.25
Disagree	30 – 40	3.25 – 4.00

The obtained scales are unweighted. As showed, the salient loadings on the extracted factors are close to each other so that a simple unweighted model was favored. In what follows, the ranking of the participants along the identified dimensions is presented in detail.

Importance of the subject department. The scoring of participants on the first dimension *Importance of the subject department* as well as the corresponding histogram is presented in [figure 12](#):

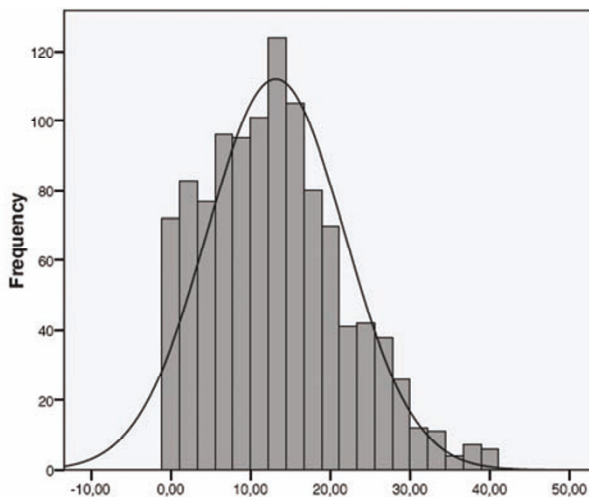


Figure 12. Histogram and table of frequencies of the dimension 'importance of the subject department'. (Continued)

	<i>Scales score from (>) ... to (≤)</i>	<i>Percent</i>
Agree	00 - 10	38.8
Partly agree	10 - 20	44.0
Partly disagree	20 - 30	13.5
Disagree	30 - 40	03.7
	Total	100.0

Figure 12. Histogram and table of frequencies of the dimension 'importance of the subject department'.

The measures of central tendency are located in the range of partial agreement (mean 13.15, std. error of mean .26, median 13.33, mode 13.33), but close to agreement. The data are slightly positively skewed (skewness .56, kurtosis -.04), that is, the higher values disperse stronger; the standard deviation is 8.63.

Nearly 83% of teachers perceive their subject department as a collegial work place where information about professional development and school issues are shared. In total, 18% of teachers do not experience their subject department as relevant and supportive regarding the aforementioned aspects, and among them 4% of participants totally disagree with that view.

Support by school policy. The second dimension is concerned with *Support by school policy*. The scoring of the participants of the study is displayed in figure 13:

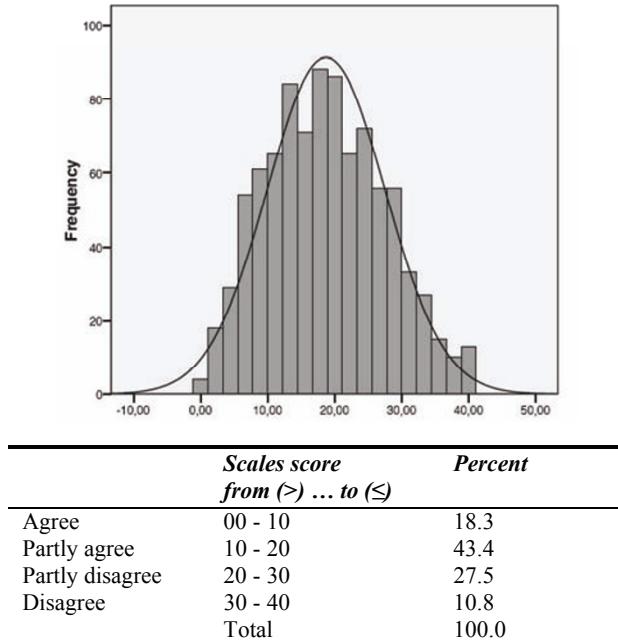


Figure 13. Histogram and table of frequencies of the dimension 'support by school policy'.

The central tendency of the data is located in the range of partial agreement (mean 18.72, std. error of mean .29, median 17.78, mode 17.78), close to partial disagreement. The data are slightly skewed (skewness .21, kurtosis -.58). As the histogram indicates, the variability of the data can be described as follows: dispersion is higher in the range of disagreement while the standard deviation is 8.8.

61% of teachers feel supported by school policy in their endeavor to pursue professional development while 37% of teachers do not. Among the former ones, 18% of teachers are very pleased with the provided support. In contrast, 11% of the teachers are dissatisfied with the help and assistance provided by the persons responsible in their school.

Necessity of professional development. The third dimension is concerned with *Necessity of professional development*. The distribution of data according to the different ranges is shown in [figure 14](#):

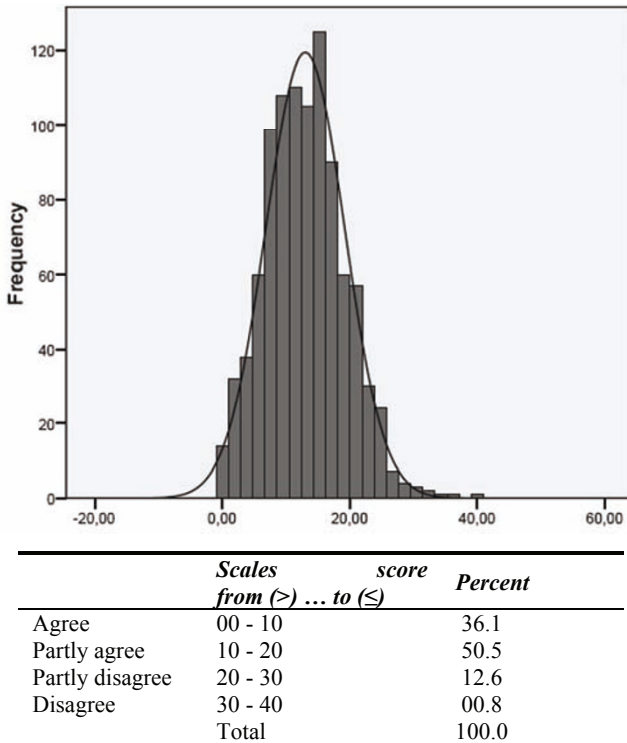


Figure 14. Histogram and table of frequencies of the dimension 'necessity of professional development'.

The center of the distribution is located in the range of partial agreement, close to the one of agreement (mean 13.00, std. error of mean 0.20, median 13.33, mode 15.24).

The standard deviation is rather small (6.18), the distribution of scores extends from the mean further towards the larger values (skewness 0.33), and there is a higher concentration of scores around the mean (kurtosis 0.25).

Individual and general need for professional development is widely stated by almost 87% of teachers, and remarkably, 36% of them fully agree that such support for practicing teachers is required. Only 13% of teachers do not consider need for professional development and only 1% even denied any.

Implementation and practicability. The fourth dimension deals with *Implementation and practicability* of issues imparted by an in-service training. The scoring of the participants is presented in the following figure:

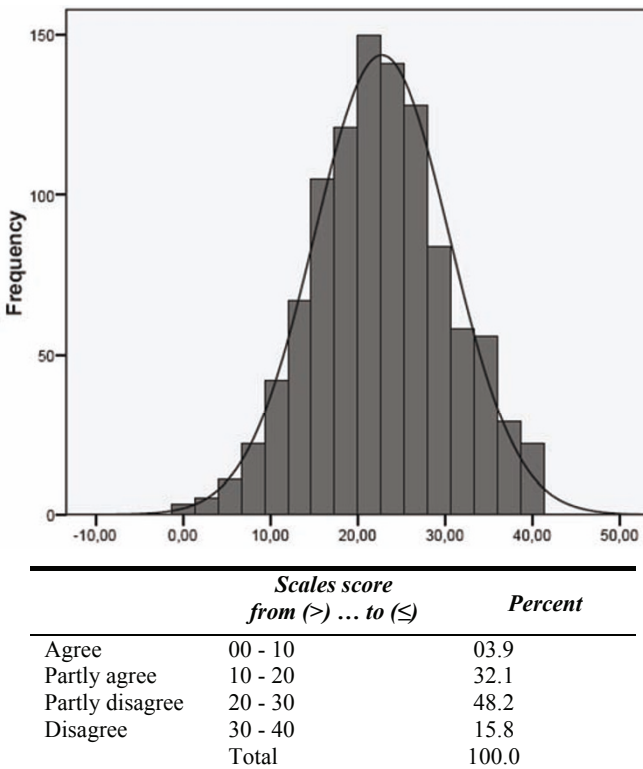


Figure 15. Histogram and table of frequencies of the dimension 'implementation and practicability'.

The center of the data is in the range of partial disagreement (mean, 22.75, std. error of mean .24, median 21.33, mode 21.33), but close to partial agreement. The standard deviation is 7.73 and the distribution is symmetric. A low concentration

of scores around the mean can be stated, that is, the distribution is relatively broad (kurtosis -0.21). Contrary to the other scales, the orientation of this dimension is negative.

Not surprisingly, almost 36% of teachers do not assign practicability to issues imparted by an in-service training. They consider the implementation of new issues as difficult. Interestingly, although much research in the field is concerned with effects of professional development events, the majority of teachers (64%) regards the learnt issues as practicable and does not question their implementation.

Sustained collaboration. The fifth and last dimension is concerned with *Sustained collaboration*. The measures of dominant tendency identify the range of partial disagreement as center of the data (mean 25.07, std. error of mean 0.36, median 26.67, mode 40.0). The standard deviation is rather high (12.00), the distribution of scores extends from the mean further towards the smaller values (skewness -0.36), and the distribution is relatively narrow (kurtosis 0.79).

Table 12. Frequencies of the dimension 'sustained collaboration'

	Scales score from (>) ... to (<=)	Percent
Agree	00 – 10	10.0
Partly agree	10 – 20	31.0
Partly disagree	20 – 30	23.5
Disagree	30 – 40	35.5
	Total	100.0

41% of teachers agreed that encounters with colleagues or trainers during an in-service training course led to sustained professional exchange while 59% of teachers did not. Remarkably, only 10% fully agreed to the statement and in contrast, nearly 36% of teachers fully disagreed. That is, experiences of teachers in the field of professional exchange are quite different. Although collaboration among teachers and teacher educators is highly valued in the research literature, the experiences of teachers indicate that in this regard, much development is needed.

To sum up, the different means, medians and standard deviations for all dimensions are presented in table 13:

Table 13. Means, medians and standard deviation for the dimensions

Dimension	Mean	Median	Std. deviation
Importance of the subject department	13.15	13.33	8.63
Support by school policy	18.72	17.78	8.80
Necessity of professional development	13.00	13.33	6.18
Implementation and practicability	22.75	21.33	7.73
Sustained collaboration	25.07	26.67	12.00

However, the means do not provide the detailed information that could be displayed by the previous analysis. The measures of central tendency as well as dispersion differ widely. Further analysis, like exploring mean differences for specific groups, is not provided since the aim was primarily to capture the dimensions relevant for teachers in the field of professional development. The more interesting question is thus to find out about the relationship between the dimensions; this issue will be elaborated on in the following subsection.

Correlations among the Dimensions

The correlations between the dimensions give some information about the global structure of teachers' attitudes towards and experiences with professional development. The partial correlation coefficients are presented in [table 14](#):

*Table 14. Partial correlation coefficients (**correlation is significant at the 0.01 level (two-tailed))*

	<i>Importance of the subject department</i>	<i>Support by school policy</i>	<i>Necessity of professional development</i>	<i>Implementation and practicability</i>
Importance of the subject department				
Support by school policy	.467**			
Necessity of professional development	.227**	.175**		
Implementation and practicability	-.253**	-.242**	-.003	
Sustained collaboration	.213**	.245**	.275**	-.084**

As expected with respect to the choices made while applying the specific factor analysis model, correlations are not that strong, but significant with one exception. They provide some information about how the dimensions relate to each other. Not surprisingly, a positive relationship can be stated between *Importance of the subject department* and *Support by school policy* since both dimensions strongly attach relevance to the school environment. This relationship is characterized by the strongest correlation. The dimensions *Necessity of professional development* and *Sustained collaboration* also correlate positively with those two. That is, teachers attach importance to the collegial work within the subject department, feel supported by their school policy, identify need for professional development and report about sustained collaborations while actively engaging in professional development.

A negative relationship can be assigned to the dimension *Implementation and practicability* and the ones of *Importance of the subject department* and *Support by school policy*. Those who score highly on the two last-mentioned ones, whereby the scale range is from agree to disagree, have low scores on the dimension *Implementation and practicability*, which is of course negatively oriented. In short, a considerable connection can be stated between the support by colleagues and the school as well, and applying and testing ideas provided by in-service training courses.

CONCLUDING REMARKS

Teachers' views on professional development are structured and include different facets. By means of statistical analysis, five dimensions relevant in this broad context were derived, that yielded the best approximation to teachers' consistent answering behavior. That is, semantically related items were replied to in a similar way. Regarding content and correlative aspects, the obtained dimensions were analyzed in detail. Nevertheless, the questionnaire had determined the scope of the analysis and consequently the initial structure within which the dimensions then constituted themselves. The procedure is hence limited with respect to the contributed information.

As mentioned earlier, statements about dimensionality and content strongly depend on the factor-analytical results and the choices made beforehand. But besides denying a clear objectivism, the results are surely not derived subjectively or randomly as they present the best match of structuring the answering behavior according to content. Since the results of the factor analysis can only clarify a certain percentage of the total variance, it may well be possible that the answers to the individual items depend on additional, specific factors. The following presentation of the qualitative results is hence dedicated to further exploring the dimensionality of teachers' professional development. However, the quantitative findings additionally serve to partly framing the subsequent analysis.

NOTES

¹ The simple sum scores were treated as interval data. The following transformation formula was applied: $((\text{Sum of items within a factor}) \times 10 / (\text{amount of items} - 10)) \times 4/3$.

RESULTS OF THE EMPIRICAL STUDY

Qualitative Data Analysis

OVERVIEW

The qualitative data is explored by content analysis. The chapter informs on that procedure in detail to keep the proceeding transparent. The approach encompasses explaining the process of content analysis, reporting about the gained dimensions of professional development explicitly from a teacher's point of view, and finally, discussing some final remarks.

THE PROCESS OF CONTENT ANALYSIS

The analysis of the quantitative data primarily follows a well-established algorithm. The more challenging question surely is, *How to present and report about the qualitative data?* In the following, this data is explored by applying content analysis to generate categories for the various descriptions and explanations provided by the interviewed teachers. Contrarily to the quantitative approach, the aim is not to identify a statistically representative set of responses, but to use the views of individual teachers to get a better understanding of the processes relevant in the context of professional development, particularly from a teacher's perspective.

Variants in content analysis are huge and have been discussed against different backgrounds in the research literature. The content analysis applied to the present interview data encompasses both: categories were initially derived deductively during a theory-driven approach to the data and inductively while supplementary emerging from the data. That is, the formulation of categories was guided by the research questions and the pre-existing dimensions as provided by the quantitative analysis. Newly emergent themes complemented the approach to reveal and describe patterns within the responses. Correspondingly, Kvale (1996) characterizes the intention of the qualitative analysis as follows:

The *analysis proper* involves developing the meanings of the interviews, bringing the subjects' own understanding into the light as well as providing new perspectives from the researcher on the phenomena. (p. 190)

Thereby the focus was on creating meaningful categories that serve as units of analysis (Cohen et al., 2007). When such decisions are made, the remaining challenge is to reduce the huge amount of written data, while ensuring its quality. The raw data consists of many quotations, and only those that were considered as essential were ultimately chosen to be translated into English, and to be presented in the subsequent

categorization. The qualitative data comes from the project *Mathematics Done Differently* and thus the conception of the initiative at least partly influenced the experiences of teachers. However, it was not in the decisive focus to qualitatively evaluate the program.

The information arising from the interviews varied, and was of different value for the subsequent analysis. In the following, participants' view on the phenomena under investigation will be presented, comprising important factors of teachers' professional development, also in terms of teacher demands and needs. Since the qualitative research interviews dealt with facts, opinions, and attitudes related to such factors, they also allude to what contributes to effectiveness of professional development events.

The analysis of the qualitative interviews encompasses the following steps as introduced by Lamnek (2005, p. 402):

- a) Transcription
- b) Single analysis
- c) General analysis
- d) Control phase

First, the interviews were transcribed by a student assistant, and then carefully scrutinized by the author of the thesis. That is, the transcripts were reread several times in order to quote verbatim the collected interview data. Secondly, all interviews were analyzed individually. This process included marking the significant text passages to make them accessible for the content analysis. The derived concentrated interviews were then commented with regard to their characteristics, particularities, and general features.

As a next step, a rather general view was taken while commonalities of all or some of the interviews were composed, which served for typifying the single statements. According to Lamnek (2005), this process was undertaken carefully to avoid artificially obtaining homogeneity with respect to content. In this regard, differences among the participants within the categories were also worked out. That is, both commonalities and differences led to tendencies that could be assigned to some of the interviewees. Finally, a control phase was established in order to prevent misinterpretation that might occur through the process of gradually reducing the data. Therefore, besides the concentrated interview transcripts, the original ones as well as the tapes were repeatedly considered, either through rereading or rehearing¹.

DIMENSIONS OF TEACHERS' VIEWS ON THEIR PROFESSIONAL DEVELOPMENT

In total, 74 statements alluding to teacher professional development were taken from the interview data that could be compressed into three categories. The dimensions that were initially derived deductively while theory-driven approaching the data serve as an overarching construct: teacher learning, teacher growth, and teacher needs. The next step of analyzing teacher statements more in depth yielded a fine-grained

categorization within the single dimension, which was inductively derived while supplementary emerging from the data. In the following, the sub-dimensions are labeled and thoroughly explained by giving some excerpts out of the teacher statements.

The dimensions are not discrete entities, and the statements were assigned to them according to the most relevant given explanations. All data will be presented as anonymized comments, i.e., the names that occur in the analysis are not the original ones. The interviews were conducted in the German language; the displayed commentaries and excerpts were very carefully translated into English.

Teachers' statements will not just simply be presented, but also commented with regard to both background information, that is helpful for the reader to understand the relevance of the single quotation, and theoretical positioning. As already mentioned, all interviewed teachers participated in the professional development program *Mathematics Done Differently*. Due to the range of the program, quite different types of teacher's involvement have to be considered. Nevertheless, since it is not the focus of this work to evaluate any characteristics of the program, no distinction regarding the different course offers was made while presenting the qualitative data.

As mentioned earlier, the program ranges from *supply* to *demand* oriented in-service training courses and one type of courses should not be favored at the expense of the other. All courses surely differ with regard to the degree of autonomy, but ultimately various aspects contribute to effective teacher professional development, and the interviews help to enlighten those. In case that participants raise specific aspects that strongly depend on the course design, the corresponding background information is given. However, not all teacher statements refer to courses provided by *Mathematics Done Differently*, but draw on their general experiences with in-service education.

In the following, the teacher statements are listed and assigned to the different dimensions and further distinguished to the categories within them. Finally, an overview on all the dimensions and their essential categories will be provided.

Teacher Learning

In the first dimension, the emphasis is on teacher learning and related processes. In particular, the focus is on lifelong and continuous learning. In this respect, teachers' views on their learning and the variables they consider as essential are in the focus. What is particularly elaborated on are issues that, from a teacher's point of view, contribute to effective professional learning and development. Finally, the role of the interplay between theory and practice in this learning context is enlightened.

Continuous learning. Teachers' views on their professional learning processes, whether in terms of continuous or of spontaneous learning, or the variables they regard as essential differ widely. The subsequent analysis hence is dedicated to list the most informative statements and to allude to some rather different positions that seem to be relevant in this discussion. Mostly, and not surprisingly, the interviewed teachers did not provide an elaborated view on their professional learning. As stated in

the research literature, not only we as researchers, but teachers, too, fight shy of using learning in relation to themselves, i.e., when it comes to their individual learning.

Edith organized two different in-service training courses for her school, which were part of the *à la carte* program of *Mathematics Done Differently*. The interview was held after she attended both courses. She provides the following information about how she views professional development:

Edith: What I see as the most important point is that one gets learning gains, which have to be fostered. Related to the in-service training course provided by *Mathematics Done Differently*, it is like this: the good thing is that one can do that together with colleagues, and to do so within a community, is also a different experience than to go anywhere alone to an in-service training course.

Edith rather vaguely refers to learning gains and at the same moment, she elaborates on in-service education as being a collegial endeavor. Aspects of in-service education, for her, are strongly connected to professional collaboration, an issue that she also stresses in the following remark:

Edith: Continuous learning, well, I think it must be a continuous process, so that one does it with colleagues and not alone, within the teaching staff or well allocated within the department, so that all colleagues develop further.

Again, Edith remains in the position of reflecting her learning not primarily individually but collegially, and provides a strong commitment to the department as a community. Another teacher, Pam, also refers to aspects of individual and collegial learning, but with quite a different focus. She organized an in-service training course *à la carte* for her group of teachers, which was composed to last four sessions. The interview was held after two of the courses were performed. At first, she describes her learning as given below:

Pam: And these little changes, these ideas I have to learn by myself. I can learn them. When I know in what direction it should go, how I should think, think differently.

Pam points out that she needs new insights and awarenesses, so that she can head for another direction in her learning. She emphasizes both learning as “a lone fighter”, as given below, and learning within a group of colleagues:

Pam: Meanwhile, I feel as part of a team, but of course also as lone fighter. But not any longer in the sense that I have the feeling I must fight. For me it is also that I learn incredibly much from it.

Another teacher gives the following remark while he was asked to reflect about professional development as a continuous process. Peter is part of a group of teachers who had applied for a course *on demand* that was explicitly designed for their needs. The interview had been conducted before the course took place.

Peter: Well, I must say that actually there haven't been that many mathematics in-service training courses. We always have had, when curricula made

it necessary, an in-service training course. Concretely, for instance, while we also had to impart differential and integral calculus, we had an in-service training course specifically regarding this domain. In other respects, we haven't pursued a continuous process.

Obviously, the teacher does not possess an elaborated view on his personal professional development, but of a position, that is determined by an outside orientation. For him, professional development is something that is offered from outside, no connection to continuous and ongoing learning that actually takes place every day is made. From Peter's point of view, changes that are caused externally, like the introduction of new curricula, put a demand on him to further engage in professionalism.

Jack applied for a course *on demand* that was concerned with the use of the programmable calculator in the classroom. In his statement, he refers to the continuity of professional learning, but he also points to the same direction as Peter, when explicating the following:

Jack: Well, I do think that one always has to develop professionally. [...] There are many offers to attend in-service training courses. Then it was like this, topics were presented, single themes, and how to implement them in the classroom, examples of how to get any topics started. Well, basically, that is what has been offered.

Although Jack at first considers professional development as a continuous endeavor, he does not really address his learning processes, but he reflects on the continuously available offers for professional development throughout the course of his career. In the last two positions, interestingly, to engage in professional development is not seen as a self-determined and reflective process, but an other-directed one. Either demands are imposed because of general educational changes or professional engagement is oriented at available and given offers.

Some of the interviewed teachers link the continuity of learning to in-service education. That is, they stress the processes that were initiated by one or two of the courses that they had attended. These teachers consider applying for additional sessions, as mentioned in the subsequent statement:

Ann: To build up on this, we already thought, [...] that we would invite the two [the trainers] once again, or make use of other offers in the area of stochastics. Yes, in other respects, one certainly tries to take along from in-service training courses as much as one can, since finally the 'Bezirksregierungen², are no longer offering that much, and this is why one is actually in search of offers.

Not astonishingly, some teachers conceive professional development primarily in terms of in-service education, and therefore elaborate on respective issues. Representative for other teachers as well, Ann points out that attending a first course is in a way initiating continuous needs. The teacher's focus, hence, is not simply on the single event, but on several sessions, either to the same topic, as indicated above, or to different ones, as mentioned by other teachers.

However, some teachers contribute aspects, which were not expected in this context. The next commentary given by Kathryn, who belongs to Peter's group of

teachers reveals the following self-concept when being asked for her continuous professional learning:

Kathryn: Although I haven't been teaching that long, I do help my younger colleagues and we talk much about the issues that happen in the classroom, which experiences we've collected, where the problems are, etc. And then I go to the elderly colleagues with these problems, who then partly have acquired more experiences and I ask them how they deal with.

With respect to continuous learning, she firstly excuses herself for being short on experiences, but then she provides some information of how she exchanges with colleagues. Thereby, she continues to differentiate between elderly and younger colleagues while conceiving herself as a novice teacher.

Successful in-service training. Teachers were asked for what concretely makes professional development and, particularly, in-service training successful for them. In most cases, teachers provided elaborated statements, which indicate that they deal with these issues very reflectively. In the following, the floor is given to different positions of teachers. To start with, Deborah mentions a crucial point: in-service training courses should address very concretely the needs of teachers. She explains how teachers behave, when their needs are not adequately touched:

Deborah: That the motivation is right. That is, an in-service training that is imposed on teaching staff, per se gets the short end of the stick because everybody is particularly critical and the hands go like this [she demonstrates], they get crossed and then: let the one in front show what he then is able to do first. Then, it is really not easy to break this barrier that then exists, and to really break through for the one conducting the in-service training course. That is to say, a need must be there, emerging from inside the teacher. Then this need preferably ought to be concretely formulated, the person conducting the in-service training course should know it beforehand, so that he can orientate thereon concerning the contents, or that he places emphasis on.

Deborah is very concrete about necessary aspects of in-service training courses. She mostly underlines that teachers' attitude is decisive, and therefore she insists on the right motivation. Remarkably, she concretely values teachers' needs as decisive variable and that those need to emerge from inside. For a group of teachers, which Peter and Kathryn belong to, she ordered a course *on demand*. She further points out the following:

Deborah: The composition of the in-service training course should not only be a moderated presentation, it should indeed be an in-service training and not only a tapping of systemic existing knowledge that someone then just summarizes. It should really have the character of an in-service training course, i.e., I need an expert, someone who has to say something to us that we didn't know before, who can provide a new view on an issue. The second part of an in-service training course also means that one does not only get out and says: I've heard

that all, and what should I do with it now? But a gentle push into action must take place, an example, that the colleagues or a teacher in general can try out and test. That doesn't have to be the entire spectrum of the course, but the core issues should really attain to performance, like a kind of workshop character, whereby one definitely can introduce issues like group work.

In the statement given above, Deborah stresses various aspects relevant for effective in-service training courses: the course should provide new insights, the ideas should attain to performance, teachers need time and possibilities to try new things out and test them, teacher learning is active learning. Alan is also part of the teaching staff for which Deborah was the main organizer of the in-service training course. His remark given below refers to quite similar thoughts:

Alan: That is, well, it [the course] gave us what we expected, what we needed, and then one can very easily put it into practice. If it did not get across like that, then there is need for subsequent work, that one says, how do I deal with, what will I do now with it, and how can I apply it.

For Alan, it is important, that his needs and expectations are met and that he gets enough information to apply new things so that he is able to implement them in his teaching.

The aspect of getting new insights is also accented in other teacher statements like in the following one given by Ann:

Ann: Well, yes, certainly when new issues come. I have been working in school for ten years now, and specific issues are still new, or one doesn't have that much experience with them.

Another teacher also stresses that it is important to get new input, but moreover information how to implement these new awarenesses into practice. In the next statement, successful in-service training is thus characterized as follows:

Pam: When a mixture of theory and practice is provided. When it doesn't get stuck in theory, but goes into practice, when one goes into issues in detail. Thus, to see how I can implement it, how I can organize it for two different grades. [...] Then I find an in-service training successful. Thus, when one is able to perform on the basis of practical examples, which do not restrict me, so that I ultimately have to do them, but th

at they also provide degrees of freedom.

Pam particularly points to the different inputs given by theory and practice. She underlines the importance of feasible examples that do not restrict her too much, but are applicable to her teaching.

The next variable that is considered as being essential is the trainer's personality, as Ann points out below-mentioned:

Ann: Partly it always depends on the trainer, what I found as definitely being true in mathematics. It is often like this: we had an introduction for the graphic

calculator, at first for this graphic calculator so much time is needed when people don't know that device. [...] It is always a pity, when these things are so time-consuming til one gets to the actual topic.

Ann refers to personal variables while looking back to an in-service training course that was not really timed by the providing trainer. Implicitly included in this statement is the aspect that a trainer should know about the teachers' requirements that he will encounter. Otherwise, he cannot assure that his offer is adoptable to the needs of all the teachers in the group.

Edith lists some factors of successful in-service training courses that partly have already been mentioned:

Edith: Well, on the one hand, absolutely, the fascination for the subject mathematics. On the other hand, and what also makes [the course] successful, definitely is this tandem of research and school, this interplay, the exchange with colleagues, that one can experience it in companionship.

She highlights the tandem approach, i.e., the specific interplay of theory and practice, which is a constitutive parameter of all courses provided by *Mathematics Done Differently*. Besides also valuing the significance of collaboration with colleagues, she underlines an affective parameter, when referring to the fascination of mathematics.

Relationship of theory and practice. From their very conception, the courses provided by *Mathematics Done Differently* are sure to combine theory and practice since a tandem of a university teacher and a schoolteacher provide them together. This relationship has already been touched in the section above, the statements given below offer some further information. The interviewer asked Edith for the importance of the teacher within this tandem, and she gives the following comment:

Edith: Incredibly important, since he has the experience, he knows what's going on in school. Yes, he knows what he is talking about and this experience, that he possesses, one can't simply appropriate it to oneself. One has to go through it in order to understand it and to pass it on.

Most of the teachers particularly value the role of the schoolteacher within the trainer tandem, who in some sense ensures that all issues are well practice-oriented and practice-related. However, teachers also acknowledge the role of the university teacher who stands for research knowledge and theoretical aspects. Accordingly, Pam reflects about the relationship between theory and practice as follows:

Pam: Well, these aids that Paul and Thomas [the trainers] provided, well, they have such a wholesome mixture of theory and practice. [...] Thus, this mixture is really helpful. [...] Well, this practical part, I could do that as well, but what I don't have is this theoretical background.

For Pam, the interaction between the university teacher and the schoolteacher is important. Moreover, she explicitly appreciates to get theoretical information and

background. Accordingly, Agnes comments on the significance of the university teacher as follows:

Agnes: Well, of course, I find this combination of theory and practice really great. Well, at first it is good that people lean back, they get an input from somebody who is working at the university, and so on, and they listen to it, and then they discuss mathematics a bit, these school teachers.

Agnes is a very engaged and experienced teacher who applied for a course *on demand* out of the program of *Mathematics Done Differently*. At first, she describes that it is important for teachers to get input from someone working at the university. Then, a bit sardonically, she points out that this encounter also initiates teachers' discussion on mathematics on a meta-level.

However, in contrast to the other teachers, Ann does not draw a sharp distinction between theory and practice while pointing out that there is also theory behind practice:

Ann: I would say, well, there is also theory behind the practical site. Claus [she refers to the school teacher as part of the tandem] also sits at home and then this course is also theoretically worked out and prepared, like he also did it at the university. But he can also say, in this moment the students will react one way or the other and that is useful for teaching. And he even knows how it is in the classroom, and insofar it was really important for us, to get this feedback how we can implement the new techniques there.

Interestingly, she also conceived of the schoolteacher as providing theoretical input and information.

Thus, teachers experience the *tandem* approach differently. Most of them explicitly and positively value this conception of a trainer *tandem* bringing together expert knowledge from research and practice, while a few of them emphasize more the important role of the school teacher.

Teacher Growth

In this section, teachers' growth processes are enlightened while in particular the role of previous experiences with professional development and in-service education are presented. In the light of their experiences, crucial aspects that depend on teachers' beliefs and their attitude towards professional development are discussed. Formed over a period, it is mostly these strongly held beliefs that impede any change processes and developments, and even when unconsciously held, give rise to a considerably reserved attitude. Finally, issues of sustainable professional exchange and collaboration will be broached from a teacher's perspective.

Previous experiences. Deborah ordered an in-service training course for her mathematics department that was clearly a demand-oriented course, designed for the specific needs of her school. She looks back on different experiences with in-service training, and she firstly states the following:

Deborah: Once again, I surely expect a new attempt from the in-service training course.

She then explicates some previous experiences of the staff with in-service training and she states the following:

Deborah: In this respect, we had an in-service training course before, whereby the younger colleagues thought rather positively: hm, this is something for me and the elderly ones thought: I won't go there any longer. Therefore, they didn't even participate in the next course because they were partly not really met where they were. Unfortunately, no opening-up, in the sense that I had actually hoped for, did occur.

Deborah mentions a very interesting point, i.e., to meet teachers where they are. Undoubtedly, in-service education follows the rules of learning. According to this, teachers' experiences and in particular their hitherto existing knowledge is decisive for any process of accommodating new information. Based on her experiences, Deborah was very concerned with agreeing in advance what the specific needs of the group of teachers are, an issue that will also be elaborated under the headline of teacher needs.

Interestingly, Deborah's school is very experienced in the role of being a self-organized school. Issues of autonomously organizing professional development of the entire teaching staff are, therefore, endeavors that have already been practiced successfully. In this respect, the following quotation gives some illuminating hints to related experiences:

Deborah: Well, as a self-organized school we are used, well for five years now, to develop certain rights and duties. We've done that with enthusiasm related to different areas. In this context, we had compulsive in-service training. These courses provided many experiences for the colleagues, some of which they wanted and some of which they didn't want, some that pleased them and some that did not. And now, in retrospect, the head of the school takes the view that if we need in-service training courses then they need to be tailored to the colleagues or the department or the group. Now we've got that, this one is the third one we are organizing for ourselves. Not all went well, and with the one we get from you, we don't know yet. One went very well, and with one, we felt flat on our faces, although the agreements were very concrete. Again, that led to considerable resentment.

Based on previous experiences, Deborah now really orientates at the needs of the teaching staff and she is very concerned with preparing the in-service training course, in particular with regard to an adequate prearrangement. Deborah also raises an interesting point, namely that experiences in the field are also important for teachers to clearly define what they want and what they do not want. To reach a point where it is possible to announce individual needs is a process that takes time. She further explains the feelings of resentment, when the training course does not appropriately meet the needs of the teachers.

Interviewer: One is disappointed then.

Deborah: Yes, I was disappointed because I spent two hours to get the agenda and wishes of the teaching staff across very concretely, and for me it was an enormous disappointment that these wishes were not fulfilled. The colleagues

were also disappointed because again, they invested time and actually, they still stayed where they were.

In-service training is also time-consuming for teachers, and they feel like wasting their precious time. Deborah takes up this topic again, and explains further, why teachers are frustrated when in-service training courses do not meet their expectations and needs:

Deborah: Well, we all have a lot to do. That is exactly the point, I think, why teachers are very sensitive in case someone steals their time. It means that they have to stay here, that they have expectations, and that they want to take something with them. When there is nothing, they could have prepared their lessons in that time, or engaged in other forms of developing lessons.

Alan also refers to previous experiences with an in-service training course that went beyond the issues that were relevant for him and the group of teachers. He, thus, explains in few words what he is expecting from the upcoming course:

Alan: And, concerning this subject, we have already attended other in-service training courses, and now we've got this course, and we expect from it that it is better related to our situation, and that we can take something with us.

Alan feels frustrated because of the past events. For him, it is important that the next course will meet his expectations, however, he does not sound confident.

Beliefs. Expectations of teachers are high and, as the above-mentioned statements showed, they are mainly based on previous experiences. In this context, the decisive role of beliefs towards professional development should not be neglected. This aspect will be enlightened by the commentaries given below. However, it should be noticed that these experiences are mostly not acquired in relation to the initiative *Mathematics Done Differently*. Jack, for instance, a very experienced teacher, who has been teaching for 34 years now, was asked for the most important issue in the context of in-service education and he states the following:

Jack: Once again, to get this idea, to get new incitements.

At first, he generally refers to new incitements as being most central. But in the following, what can be understood from his words is how the previous experiences become decisive for his overall attitude towards in-service education. This attitude is obviously not only acquired with respect to hitherto attended in-service training courses, but reflects the whole conception of his learning:

Jack: What I consider important for an in-service training course is that someone tells me what one can do and not like this, "try it out and try it out again". [...] This is not effective.

By these previous experiences, beliefs are clearly accentuated. Jack is very disappointed by a specific type of in-service training. He was then asked for what has proved to be effective for him and he announces the following:

Jack: No, in former times I also learnt by listening to somebody who said something to me. [...] I listened to it and then I tried it on my own. That's how

we learnt at the university. We went to attend the lectures, then we got the exercises, we did the exercises together with colleagues, with students. Why should I change that?

He possesses strong beliefs about his learning processes and needs that emerge from that, and which have been built over a period, and even go back to his learning at university. Not surprisingly, he comments any process of change and development like follows:

Jack: I only have to work here for four more years, why should I change my methods?

This comment sounds quite disillusioning, but of course, there are developments that have led to such a perhaps unconciliabile position. In the course of the interview, Jack reports about the many changes that he has encountered in his teacher life and which were primarily set from outside. His resistance to change has been accompanied by trusting his own approach, which, as he indicates, has also proved to be very effective in terms of his students' performances. In the following remark, he tackles a very interesting point that has already been touched in the introduction of this work:

Jack: My elderly colleagues, who are just a bit older than I am, who just left, they always said: set theory came, set theory went.

By the comment he points out, how the teachers of his school reacted when they felt not really addressed and met by hastily placed educational changes. That is, one consequence that might occur when the needs of teachers are disregarded is that they nonetheless remain the same. In this context, Jack provides some interesting thoughts concerning the many current developments in education, which also contributes to a better understanding of his position.

Jack: Part of education are calmness and composure, one needs to have time, one has to deal with the children, the juveniles. One needs to have time, so that one helps them to advance, not only subject-specific, and that doesn't work when constantly, always something is adapted. And then there comes something new here and there, which is not properly thought through at all.

Professional development can have many facets and wears many hats; even a position like the one just mentioned is surely not just an individual opinion. Issues that do not reach the realm of the teachers, entail learning processes that might be contra-productive for those looking from an outside perspective, and at one time are very effective the other way round, i.e., from an inside perspective.

Beliefs are highly subjective and therefore vary according to the different bearers. In any discussion, beliefs can be differentiated with respect to the different objects they are attached to. Although the focus here is on how teachers view their professional development, a different but of course related object breaks its way through, i.e., how teachers are encouraged and incited to experience mathematics differently. However, the beliefs section so far has been concerned with rather negative influences

of belief. In the following, the inspiring effects and the creative power of beliefs are highlighted.

Edith, for instance, points out that she got some insights while attending the in-service training course, that were of course not relevant for her students, but led to new awareness for herself:

Edith: But for me, it was a mathematical highlight that once more pleased me. Well, that it is simply enlightened from a different view, so that one, not only preserves the overview from above, but that one sees, aha, there is something more than just the things we are doing, that is really important.

Interviewer: That one gets another view on mathematics?

Edith: Yes, that one has this meta-level.

Edith raises an interesting point that is clearly related to issues of beliefs when she mentions how she came to see mathematics in a different way. For her, looking at the subject from a meta-level provides essential awareness and information for her daily work, even though an immediate benefit in terms of concrete teaching advises is not provided. In the following, she explicates how her students avail from such an elaborated experience:

Edith: What teacher would I be if I said, “Math ohh”, but instead to make it clear for the students, I say, look at how beautiful it actually is and what things have to do with math, and this is nice, the inspiration. [...] But what is inside the students’ heads, is that in school mathematics, there are so many abstract issues, like formulas and calculating, and they don’t see where in real life math is included. They don’t open their eyes. So the course is nice and those are impulses that I even got for myself through the in-service training course.

Likewise, in many of the teachers’ statements, to get new insights and ideas is mentioned as a decisive aspect while attending an in-service training course. This aspect goes beyond simply obtaining new information, towards yielding a new viewpoint, or even a *higher* standpoint, as described in Edith’s statements above-mentioned.

Affective variables. Much research in the whole field is concerned with the cognitive domain, whether in terms of knowledge or partially in terms of beliefs. What is considerably neglected, is the affective domain. In the following, affective aspects are highlighted that underline how teachers’ positive attitudes are primarily influencing any process that takes place in the aftermath of a professional development event. The following excerpts point out some interesting coherences. Edith, for instance, describes the following experiences while attending the in-service training course:

Edith: I can really see that they [her colleagues] have had fun and that they were looking forward to, and they even said that they would look forward to, the next in-service training course.

Edith notices that her colleagues took much pleasure in engaging during the course, and on top of this, that they felt delighted to obtain an additional session. In the

following remark, she provides some more information about what processes took place after the course:

Edith: It is amazing, it is really amazing, this ‘flashlight’, it is such a pity that you [the interviewer] did not hear what the colleagues said at the end of the course, colleagues who initially were tired of attending in-service training courses.

Interviewer: Those who were actually tired of attending in-service training, what did they say?

Edith: Oh, it was terrific, and as I said, I am looking forward to the next in-service training course.

Interviewer: Fine.

Edith: Or that questions occur like, how can we do that, we could do some team teaching together. Yes, really new ways open up, that colleagues then say, oh couldn’t we teach such a lesson together.

In this short interview excerpt, Edith aptly describes that even colleagues that had actually not been very interested in attending an in-service training course, shifted their opinions and were open for getting involved with issues provided by the specific course.

Deborah also refers to affective variables in the area of professional development, but with a quite different focus:

Deborah: My department is extremely team-oriented. People support each other, nobody holds back something. What is even more positive is that everybody is allowed to complain. [...] Nobody has to be afraid, that one is looked at askantly and anyone thinks: no wonder with him or her, or what else it could be. Because the doors are closed, when you as a teacher disappear into the classrooms, and that I must say is outstanding. We are a group of very young colleagues, very open.

Deborah raises an important issue, i.e., that teaching at all is a lonely endeavor since the classroom doors are closed. Nevertheless, in her school, the barriers disappear due to exceptional collegial support that contributes to an atmosphere of trust. The in-service training course that will be offered according to the specific needs of this group of teachers will be implemented into an already existing supportive atmosphere. That is, teachers have been working together to support each other in enhancing their teaching, to sharpen the previously existing skills, or to try out new teaching approaches.

In the following, Deborah reports about two teachers, who do not possess real openness with respect to their professional development:

Deborah: Although, especially in mathematics the composition of the teaching staff is so that I have two very experienced colleagues that are teachers of the old school, who are not very courageous regarding new ideas, who rather in

the first place see the problem: that will go awry, or I would waste too much time on that, or they [the students] will not be able to do so, who are very critical towards others ways, and at the same time often complain that everything fails. To make this discrepancy apparent and to break it open is a difficulty that exists at the moment.

The teachers within the department are in their own way open to encounter new ideas, and Deborah's attitude is very sensitive to the different needs of the teaching staff. Obviously, teachers possess an elaborated value system, which makes them easily resistant to any change processes. Deborah describes this phenomenon aptly, when she states that those teachers at first rather see the problem than the good idea. Because of their a priori critical attitude, these teachers miss out on the chance to gain new discernments.

Changes that are initiated by an in-service training course sometimes might not lead to direct improvement, but entail developments of more global character. Edith, for instance, reports about the following incident that, among others, has arisen from the single in-service training course:

Edith: Well, that is really much, and what, for instance, is a good example is what has risen from this in-service training provided by *Mathematics Done Differently*, what has risen from that for us, [...], is that next year, for instance, we'll get the exhibition 'Mathematik zum Anfassen',³ to our school.

By this statement, the teacher illuminates what general movement was generated by the input of the course. As she further explained in the interview, the teaching staff did not only decide to apply for more in-service training courses, but agreed upon several specific events for the school. In particular, they arranged an appointment with the minister of education of North Rhine-Westphalia for visiting the school.

Professional collaboration. Another interesting aspect is how teachers value the role of professional collaborations, an issue that has also been touched in the aforementioned sections. Undoubtedly, this is the most uncritical dimension in the discussion of effective professional development, since positive influences have abundantly been documented and reported. However, the following teacher statements contribute some additional and interesting aspects. At first, Ann summarizes the following positive factors concerning professional collaboration:

Ann: And it was pretty good that we, as colleagues who are teaching the same subject, as a department, got the opportunity to attend it [the in-service training course], to swap ideas, or just to get the opportunities to look, ah, this is how the other schools do things. This also happened during the coffee breaks or at lunchtime, sort of active exchange took place, that was good.

The in-service courses provided by *Mathematics Done Differently* do address teachers from one school or neighboring ones. To meet teachers from a different school close by has been valued not only by Ann, but by other teachers as well. New networking

of teachers within the region of the school could be established by this requirement. Alan refers to the aspect of close collegial collaboration as follows:

Alan: I simply consider it as important that one then goes there [an in-service training course] together. More ears hear more. More eyes see more and afterwards one can better swap ideas.

Alan pragmatically gets to the point when stating that more ears hear more and more eyes see more, in particular, when teachers who are working together have a chance to reflect afterwards about the issues, that might of course be of different relevance for them.

Another teacher, Pam, very concretely reports about professional exchange of colleagues. The in-service training course that she organized was a *blended learning* course (Hellmig, 2008). That is, the course comprised four rather theoretical sessions with practical phases in between those. During the practical phases, the teachers had rich conversations and discussions via an Internet platform. By the following statement, Pam provides some insight on how the teachers exchanged their ideas:

Pam: Well, that is really important. Because colleagues are now involved who are teaching fifth graders for the first time and they could hardly deal with the new demands of a new learning culture. It is really difficult to catch up conceptually and then also methodologically. That they adopt many suggestions or ideas, and well, they say: I try that the way you did it. And so on, and then they report about that. And I really think that more and more colleagues will open up. One notices, their texts get longer, well, and one checks excitedly for new messages. And there are no longer such curt answers but it slowly opens up.

Pam reports that the teachers got increasingly used to discuss the issues via the Internet. She continues to describe the initiated process as follows:

Pam: I am really astonished that through this contact and this debate, curiosity is stirred up. And this curiosity, I think, one has to sense and to pick up and to give help to these people so that they can make it and do not get frustrated.

The author also had access to the discussion platform and noticed that at the beginning, the teachers were rather reserved to report about their ideas. But after a short while, the discussion became really substantial and teachers reflected their approaches together, and exchanged their teaching experiences. In particular, they put some of their ideas on how to implement specific issues into practice up for discussion and elaborated, for instance, on how their students reacted and what worked in classes and what did not.

Finally, Agnes, who made some experiences while being engaged as a teacher leader in the SINUS project adds some interesting aspects to the significance of professional collaborations:

Agnes: Of course, the colleagues have changed, they must change because of the new central exams, and so on, but for me that's too little. [...] Well, for me that's too little. I really have an itch to change. [...] For me personally, it is not going fast enough.

Although Agnes often underlined during the interview that she appreciates very much working together with colleagues, she reminds of an important factor, i.e., that teachers possess a different pace. Teachers develop in their own time, and she feels disappointed that they do not proceed equally effective. In the next statement, Agnes points out why she considers it really important to address the whole mathematics department of a school:

Agnes: Remember also, what happens by consequent in-service education, professional development, changes in interests when giving lessons, in comparison to someone who does not do so. It is simply that the gap between them is getting wider and wider. One should clearly see that, and actually, that should not happen.

In case that not all subject teachers from one school engage in in-service education, a negative effect can be that differences among the teachers increase.

Teacher Needs

Undoubtedly, to meet the needs of teachers is the biggest challenge when providing professional development opportunities. In the sections above, some information has already been provided about the negative effects that take place when teachers are not met where they are. In the following, teacher commentaries are displayed that enlighten aspects of need identification and adequate prearrangement of the individual in-service training course. Teacher needs are also reflected in their motifs, and in the support they require to pursue their professional development so that these aspects are accordingly subject of discussion in this section.

Need identification and prearrangement. Actually, the request to meet the needs of teachers is a trivial axiom in the field of professional development, not at least with respect to teacher motivation and engagement. However, in-service education mostly concentrates on the single event rather than on the prearrangement, which is a decisive parameter with respect to really considering the needs of teachers. In fact, the possibility to agree upon content and specific themes is mostly not even optional in traditional settings when courses are primarily provided in a predetermined way. The following statement given by Deborah illustrates that making special agreements before the event is essential to make the course appropriate to the needs of the group of teachers:

Deborah: We entered into a rough agreement that happened via e-mail, which I composed based on the talks held with the colleagues. Well, I've had my colleagues tell me exactly what they want, where we want to head and what shall happen in the course in order to make it fit precisely, and so that they really feel addressed and met where they are.

As Deborah points out, she spent much time to elicit the needs of the group of teachers, in order to make the course the best fit. By the following remark, Alan,

who is a teacher from the same school, refers to a previous course that did not meet the expectations of the teachers:

Alan: Right, there we also were optimistic and had pretty high hopes and unfortunately, these were not fulfilled.

The statement impressively underlines that professional development needs to be thought of from a teacher's perspective since that expectations are decisive. As mentioned above, the teacher has had some negative experiences with in-service courses that were not close enough to the specific needs of the group of teachers. And even though a detailed prearrangement does not assert an adequate course, it is at least an important parameter for meeting the needs of the teachers.

Another teacher, Edith, states the following while being asked for professional development needs:

Edith: Well, in-service education, just simply that one realizes needs over a period, which one has, where one is not fit enough, for instance, in stochastics it was like that, some colleagues even did not encounter stochastics during their studies.

Edith refers to some specific learning needs concerning a mathematical topic. As she was asked whether learning needs are of personal or rather collegial nature, she gave the following answer:

Edith: I think it is both, as well as that one sees on his or her own and that one then in conversations, during always too short breaks, talks to colleagues [...].

She remains rather vague in describing how she notices her learning needs, and distinguishes between aspects that she becomes aware of on her own, and others that emerge through conversations with colleagues. Other teachers provided detailed information about their individual needs or those of the entire teaching department. That is, they also mentioned designated themes and topics they were interested in, or which they are obliged to teach because of changes in education. Also interesting is the following remark given by Agnes:

Agnes: From my point of view, from educational changes, a great need for professional development emerges. But colleagues need to realize that they do have that need. And one can't assume that all colleagues overnight teach according to the new curricula, how it is arranged there.

She insists on the importance of *becoming aware* of a *need* for professional development. Obviously some of her teacher colleagues do not consider any necessity for engagement, although, for instance, new curricula constitute a corresponding demand. Closely connected to teachers' needs are teachers' motifs to apply for and ultimately attend in-service education, an issue that is elaborated on in the next subsection.

Teachers' motifs. Not surprisingly, teachers' motifs to attend in-service training courses differ, but at least two essential positions could be derived from the interview data. That is, teachers that are organizationally engaged in planning in-service

education within their school possess a different view compared to teachers that are not. The former position leans very strongly on a conception of professional development as an ongoing learning process that generally fosters developments in teaching, i.e., a strong link to school development in general can be stated. The latter position takes into consideration more thoroughly the individual needs or is based on the conception of professional development as being a personal process. Thereby, the interview excerpts that are aligned with the last category can further be distinguished with respect to different accentuations, an observation that is discussed in the following.

Giving corresponding teacher statements portrays the different positions. While Deborah is responsible for the development of the department, her motifs are strongly bound to aspects of staff and school development:

Deborah: It belongs to my job as ‘Bildungsbegleiterin,’⁴ in some way to think about what the department’s needs regarding in-service training are, in order to put developments in education into practice. And therefore one takes one or two themes again and again, either out of the colleagues circle itself, when they say, we want this and that, or because we were set designated tasks that we need to accomplish, or because it is, for instance, noticed from outside, that something should possibly be changed. There are different reasons for why one thinks about in-service training.

Deborah is very concerned with balancing the needs of her staff that emerge throughout the daily teaching practice, and those that are placed by developments in education. She further takes a position on a meta-level since she strongly considers the development of the teaching staff in terms of school development. Obviously, the course offer *on demand* that is provided by *Mathematics Done Differently* fits very well to the overall needs of this group of teachers. Correspondingly, Ann who works at a different school reports on how her department deals with issues of professional engagement:

Ann: And then, in the last year, we had a meeting of our department and then I presented the in-service training courses in mathematics that are available and then, within the department we reflected about what themes would be a possibility. [...]. We made the decision together in the department; while doing so all colleagues did participate.

Her department also agrees about topics for in-service education, thereby all subject teachers participate in taking the respective decisions. Ann concretizes in the statement given below how the school engages in professional development:

Ann: Well, we aspire, which is also fixed in the school program, to have a school-intern in-service training day per year. [...] Well, insofar, in-service education is closely linked to our school program. Therefore, we have a special group for school development, a working group, and there we even discuss what we will make, what we will do and from this usually also emerges what we’ll do at this school-intern in-service training day.

Ann's school is experienced in actively participating in school development, a special group agrees about possible events and in particular, one day per school year is dedicated to school-intern in-service training.

Contrarily, Edith concentrates much more on progress in learning whether individually or collegially, however, her view is rather concerned with learning gains and development:

Edith: The motifs for now are that it is important to improve one's skills, to foster learning gains, because otherwise one does not develop further, I think, or one advances too little.

Her initial motifs are not strongly tied to school development although this aspect emerges throughout the entire staff's engagement in in-service education. As stated elsewhere in the interview, and as already mentioned in the preceding sections, she reports about the processes that got started within her school.

To sum up, in the first position, in-service education is seen from a meta-level, whereby the teaching staff and the individual teacher are also in the explicit focus. In contrast, the second position is located on a micro level, although developments also have an effect on the others levels as well. That is, both levels are strongly connected, although the current focus and the corresponding view differ. However, the below-mentioned teacher statements that can also be assigned to the micro level are different from the attitude that was adopted by Edith since in these positions, clearly no broader view towards school development is included. That is, the aforementioned reciprocal connection, or relationship between the different levels is missing in the subsequent teacher views.

Kathryn, for instance, closely connects her motifs to attend an in-service training course to her teaching needs:

Kathryn: For me, the necessity to attend this in-service training course lies in that I noticed by myself, in my teaching, that the students have come from different 'Realschulen' and that the quality of these schools becomes noticeable.

She refers to her teaching, in particular to the students she is teaching, and continues to strongly argue that she needs help in order to deal with their heterogeneity:

Kathryn: Well, for me, the motivation actually comes from teaching, since I think that a student then, hmm, doesn't feel slowed down, but they very easily find it boring and how can I help those that do not have easy access to mathematics. [...] For me, the motivation solely is how do I handle the different acquirements of students.

Kathryn works at a special school that is restricted to secondary education. The students enter her school in grade 11 and come from very different school types. The problems she encounters in the classroom emerge because of these heterogeneous students.

Kathryn: Well, that is the motivation for me, but also my problem, what approaches do I have to deal with.

Her motivation to attend the in-service training course is to get informed about pedagogical and didactical themes, that would help her to improve her teaching.

Another different, yet related teacher position on the micro-level is the following one. By the commentaries given below, Peter explains why he engages in in-service education. Like the teacher before, he focuses very much on his students while being asked for his motifs to attend an in-service training course, but with different emphasis:

Peter: The students we have today cannot be compared to those we had in former times in regard of their behavior, their mathematical knowledge, acquisitions, and abilities. [...] Concretely, knowledge in basic arithmetic operations is lacking [...] Second issue perhaps: the ability to concentrate today is not as developed as what we would need for the lessons. [...] Thus, those are two points that spontaneously came to my mind, why students currently need to get a different attitude, also the teachers, compared to how it worked in former times.

The teacher provides a detailed statement why he feels forced to attend in-service education. Thereby, he explicates what has changed over the last decades with respect to the students. The position centers on the students, and reminds of accusing them because he feels forced to engage and participate in in-service education. The interviewer intervened and asked for Peter's concrete goals with a view to the training course and he stresses the following:

Peter: Actually, everything goes round in circles, these deficits are there and we can't deal with them appropriately, i.e., we have a time problem. That is, in the curricula it isn't explicitly addressed, but we must simply assume that acquisitions, for instance, for the rule of three are missing, and we have to account for that.

The teacher remains in the position of mainly focusing on his students. Since they have changed, he feels a necessity to change, too. However, the crucial point is that the initial movement does not emerge from his original needs, but is pushed from outside. Professional development is primarily conceived as trying to meet an obligation rather than really being on the move towards professional learning. In the above-mentioned commentaries, he sounds a bit resentful, a position that obviously impedes perceiving the individual process as being related to a greater context. His attitude is not open for development, a position that has been indicated above as at first rather *seeing the problem than the good idea*.

Another teacher, Jack, gives a quite analogous explanation for his motifs to apply for an in-service training course that deals with using the programmable calculator in classes:

Jack: Well, the first motif simply is that we have to introduce it [the programmable calculator], and we have no clue how to do so. That's why we have to deal with those things. [...] Thus, we have to tackle it, we are obligated to introduce that some day and we want to take up the challenge.

A bit similar to the motifs pointed out by Peter, this teacher also feels obliged to attend an in-service training course in order to deal with the changing variables.

In Germany, as pointed out in chapter three, a clear shift towards an output orientation in education has taken place. Obviously, due to this development, teachers, although they are not officially forced to attend an in-service training, feel like they have to since the necessity clearly evolves in terms of demands from outside. Jack further points out that he then feels left alone:

Jack: Strangely, one does not get instructions for those new things.

He explicates how he also felt not supported in a similar situation, i.e., when he tried to get used to the computer. He spent much time and effort on his own, and got additional help from his son, but there was nobody from school authority providing help for him.

Finally, the last position that is outlined is the one of Alan, who states the following:

Alan: Actually, the goals are set for us. Within two years, we have to bring the students to a level where they can pass a final exam, which has to be authorized by the 'Bezirksregierung'. And the goal is to get as many students there as possible.

Analogously to Peter and Jack, he feels forced from outside to invest in any professional learning.

As the presented discussion shows, some teachers' view on their professional learning and the corresponding motifs to engage in professional development are more on a meta level while others argue clearly on a micro level that is centered around their own teaching, their individual experiences and perception. Both levels can be connected through a reciprocal relationship, while the teacher's view on learning is just assigned to a different starting point but also considers the other direction.

Not for all teachers, such a view on professional learning as being a continuum ranging from individual advancement to institutional and systemic development could be assigned. Some of them clearly remain on the micro level, and are concerned with a perceived outside pressure to perform differently. These teachers appear as being mainly extrinsically motivated to attend in-service education, and some of the statements clearly pointed out how easily reluctances and obstacles can therefore emerge and can play a decisive role. Nevertheless, one should acknowledge that all teachers, even when following their own way, are in search for best approaches, which help them to help their students.

Support for teachers. Teachers need support in pursuing their professional development, whether in terms of simply showing appreciation, as the first of the listed teacher statements indicates, or by concrete institutional support, as is pointed out in the other commentaries. Concerning the former, Edith mentions an interesting point when explaining that she felt very privileged to get this *tandem* of a university teacher and a schoolteacher to her school:

Edith: And if we then, and I am now talking of *Mathematics Done Differently*, are fortunate that such terrific mathematicians come into the school, this here

is an experience that one could not have if one would drive elsewhere to attend an in-service course. [...] That we as teachers see that support from outside is provided, that we will be supported, is important, and one should not underrate something like this, in a positive sense.

One decisive parameter of the initiative *Mathematics Done Differently* is showing unreserved appreciation for the teachers. The above-mentioned statement points out how receiving support from outside is perceived positively. Obtaining the occasion to invite and work with mathematicians and mathematics educators in a direct contact is highly valued by the teacher. Moreover, Edith favors the opportunity to invite these trainers to the own school. That also breaks barriers between mathematics education, on the one hand, and mathematics teachers, on the other hand. Although some of the courses have already existed beforehand, the project made them available for all teachers in the whole of Germany.

Aspects of support for teachers encompass also simple financial help. Edith reports about how the teachers feel supported from outside, in particular, because they would not be able to procure money for that.

Edith: In-service education always goes with financial costs, and we as a school could not finance this kind of in-service training. That would absolutely not be possible, since the budget for in-service education is so small that we as a school can not afford to do so. Surely this is an important aspect, that the budget of schools for in-service educating is incredibly small, and that this goes beyond the possibilities of managing it in the school, of what we are able to afford.

Edith points out that her school would not have been able to provide the in-service training course since the school does not suppose of sufficient funds.

Another crucial issue in the field of professional development is support by school policy, either with respect to initially organizing an in-service training course, or follow-up meetings that focus on aspects of sustainability. Deborah stresses the significance of the support by school administration as follows:

Deborah: In consultation with the principal, in our school how we work depends a) on the character of my superior and b) on the issue of being a self-organized school. We work very independently in our positions as “Bildungsgangleiterin”.

She underlines that support by the headmaster or administration in general is very important to pursue school development independently. Accordingly, Pam reports about how she applied by the school administration for the in-service training course that was composed to contain four sessions:

Pam: In advance, I had asked my headteacher if she would allow a daily event. Well, and I said it costs nothing. Anyway, then I just said, it lasts four days and it costs nothing.

Most schools do not allow in-service training courses to last the whole day. The statement given by Pam shows that she anticipated problems to get this in-service

training approved. Therefore, she put in a good point when referring to the courses being free of charge provided by the project. In the following, she concretizes the obstacles for long-term events:

Pam: Well, daily events are not really welcomed in the state Berlin. Thus, there also is an instruction that not on any account should an in-service training course start before 2 p.m. Hence, as a rule, possibly after 3 p.m. And it is really an exceptional situation that administration of schools allowed that course, really. Well, this daily course, everybody is astonished that it worked.

Impressively, Pam points out that it was not taken for granted to get the permission for the course, particularly with respect to four days within the school year being necessary. Much of the research discussion related to professional development concentrates on abandoning short term and single events, but in the reality of professional development administrative restrictions are a matter of particular concern and run counter a long-term orientation.

Support by school policy encompasses fostering follow-up course work to enhance new or different teaching approaches. Agnes, for instance, stresses the importance of extensively dealing with the new input in the aftermath of a training course:

Agnes: Well, I think basic module for in-service education must be, well, successful to get all colleagues on board, to get them all to participate. Then, one has to develop a concept how the department can deal with, what the department can do with the insights provided by the in-service training course. How they can implement the school-intern curriculum, that they take homework from this in-service training, and meet again after six weeks, and that one then compares the homework. Well, thus a sustainable concept, regarding what needs to follow up.

Agnes emphasizes the fact that the in-service training course just presents one component. Much and collaborative work is needed within the department to implement incitements and ideas.

Accordingly, Ann broaches the following issues while reporting about how the staff will rework the input given by the in-service training course:

Ann: Definitely it [the issues imparted by the in-service training] will be taken up, well, and we will have a department meeting next Monday, where it will be reflected.

Ann's school is very seriously engaged in school development. In this context, she took over a leader role with respect to being responsible to administer funds for professional development:

Ann: Hence, it is simply like this: events are mostly offered to introduce the new core curricula, what they look like, what will be implemented and so on. Well, the school gets a budget for in-service education provided by the 'Bezirksregierung', and the school has to administer it on its own, that is, we have to watch out ourselves what trainers we invite, how much money we

have available. [...] That has to be maintained, and this lies even more in our responsibility than in former times.

She describes what developments have taken place, that in particular gave more responsibility to the individual school, even with respect to organizing in-service education. Given below, she points out that she informs her colleagues about specific events or advises them in related issues:

Ann: I am the one to organize those in-service training events, and the one who calls colleagues attention to it, like to point out that there are now more possibilities for in-service education and so on and so forth.[...] It is no additional money, in former times, hence, such issues always were submitted and accounted for by the 'Bezirksregierung'. That is, the 'Bezirksregierung' currently simply gives it to us, and has nothing to do with any longer, and therefore has much less work.

At first, Ann values that currently the single school gets funds to organize in-service education on its own, but she then deliberates about this trend and gives reason to think about it differently. That is, she also stresses that actually it was not the point that no money was available for the schools for in-service education, but that all events were administered centrally.

However, in the last statements she points out that fortunately establishing this fund has also initiated developments in the school:

Ann: Well, and insofar, if one now makes more out of it, it is maybe like that, because I walk around and refer to some in-service training courses, that we maybe do a bit more than in former times. But, in sum, at our school, it is like that, I do have the impression, that in the last years we have established pretty much and much things happened.

She finally concludes that decisive movements have taken place, also to further advance in school development.

SYNTHESIS AND CONCLUDING REMARKS

Both approaches of the empirical study, the quantitative and the qualitative one, contribute together to a comprehensive picture of how teachers conceive their professional development. At first, by means of a questionnaire, the following five dimensions, that structure the field of mathematics teacher professional development, were derived:

Table 15. Overview on the dimensions that result from the quantitative analysis

<i>Dimensions resulting from the quantitative analysis</i>
Importance of the Subject Department
Support by School Policy
Necessity of Professional Development
Implementation and Practicability
Sustained Collaboration

The dimensions were then analyzed in detail (cf. chapter six), a procedure that yielded some interesting aspects, of which some are briefly sketched in the following. Most teachers conceive their school as a collegial workplace, and feel supported by their school policy. However, a considerable amount of teachers does not state a supportive culture in the field of professional development. Furthermore, teachers widely acknowledge an individual and general need for in-service education, an issue that also played a decisive role in the teacher commentaries provided in the interviews.

Remarkably, much research in the field underlines the missing sustainability of in-service training, but the majority of teachers, i.e., almost two-thirds of them, consider the new issues imparted as feasible and practicable, and are thus much more positive in their estimation as generally thought. In turn, slightly more than one-third of the teachers stressed that no sustained professional exchange either with trainers or colleagues took place in the aftermath of an in-service training course.

Undoubtedly, teacher collaboration is a very decisive issue on the agenda of successful in-service training education, but the teacher estimations show that much development in this regard is needed. However, one should consider that this assessment, of course, refers to traditional forms of providing in-service education, where primarily single teachers from a school participated in centrally organized courses. Finally, with one exception, all dimensions were found to correlate significantly with each other. Connections are thus manifold, and they differ in their strength.

The qualitative findings correspond to the information collected by means of the questionnaire. That is, all dimensions were also included in the qualitative findings, although the labeling partly varied. However, the analysis of the qualitative data contributes to a better understanding of the specific attitudes and opinions of teachers. Particularly, the role of beliefs, affect, previous experiences and teachers' concrete needs are explored in detail and supplied a huge amount of interesting aspects.

So far, additional perspectives on decisive parameters for in-service education could be provided, as can be seen in the following table:

Table 16. Overview on the dimensions resulting from the qualitative analysis

<i>Dimensions resulting from the qualitative analysis</i>		
<i>Teacher learning</i>	<i>Teacher growth</i>	<i>Teacher needs</i>
Continous Learning	Previous Experiences	Need Identification and Prearrangement
Successful In-Service Training	Beliefs	Teacher Motifs
Relationship of Theory and Practice	Affective Variables	Support for Teachers
	Professional Collaboration	

The significance of the qualitative findings lies in exploring essential aspects of professional development in detail from a teacher's perspective. Thereby, the teacher statements provided by the interviews were at first assigned to the following three main dimensions: teacher learning, teacher growth, and teacher needs. These dimensions

were then further differentiated with respect to teachers' commentaries by which they informed about *their* views and experiences towards professional development.

However, as the detailed data analysis showed, the categories are of different value for teachers. In particular, the subcategories of the dimensions *teacher growth* and *teacher needs* revealed many interesting aspects that have not yet been explicitly reported on in the research literature. Correspondingly, the significance of beliefs and affective variables, the necessity of need identification and prearrangement, the role of teachers' motifs and the absolute need for support while pursuing their professional development should be highlighted.

NOTES

- ¹ For the sake of preserving teachers' and other persons' anonymity, the original transcripts cannot be found in the appendix, but are available from the author on request.
- ² The 'Bezirksregierungen' are special, regional organizations of the department of education, which provide in-service education in the state North Rhine-Westphalia.
- ³ <http://www.mathematikum-unterwegs.de/>
- ⁴ The term 'Bildungsbegleiterin' refers to a specific role of a teacher leader, the verbatim translation would be 'a person accompanying education'.

CHAPTER 8

CONCLUSIONS

OVERVIEW

This work was concerned with exploring the field of mathematics teacher professional development from a teachers' perspective. At first, the topic was approached theoretically while providing an overview on the relevant research literature from an international perspective. At second, one chapter was clearly dedicated to outline the specific situation in Germany. At third, a concrete mathematics teacher professional development program was presented and discussed against the theoretical background. Finally, the field of professional development was empirically brought into focus, from both a quantitative and a qualitative perspective.

GENERAL REMARKS

As made explicit in the introduction, the statement made by Krainer (2005a) that teachers have to work all the time for what constitutes good mathematics teaching, has also been crucial for the approach in this work. Ultimately, the teacher him- or herself decides what constitutes appropriate professional development. Weinert (1998) provides an analogous comment when arguing that "good teaching can be realized in quite different, anything but arbitrary ways" (p. 17). However, from its very connotation, the term *good* can only be interpreted subjectively, and teacher educators need to be cautious and self-critical with respect to their own understanding of professional development. While referring to Weinert's statement, Elsbeth Stern in a talk at Hamburg in 2007 argued that what research can only contribute is knowledge about issues that are hindering and do *not* work.

Lessons Learnt from Teachers

The rich data portrayed in this work gives some information on what does not work for teachers regarding their professional development. However, it has proved to be worthwhile and necessary to further elucidate what issues teachers consider as essential in the field. In total, the results provide a complimentary insight in terms of promoting and hindering factors. The empirical findings shed light on interesting aspects relevant for teachers in the broad contexts of professional development in general and in-service education in specific. Teachers discussed their interpretations on professional development and expressed their understanding. The diversity of viewpoints, attitudes and opinions, as well as experiences and expectations contributes to a bigger picture framing teachers' *reality* of *professional development*.

The leading objective of this work has been to fathom some *hidden dimensions* in this *reality of professional development* that have not been in the research focus so far. Much information has been provided by recent research that of course contributes a catalog of dimensions relevant in the field of teacher professional development. In total, the situation can be characterized as a '*professional development iceberg*' symbolizing that there are many decisive dimensions, which are not visible at first sight.

In the following, some theses will be listed that, on the one hand, trace a path through the empirical findings and can be understood as lessons learnt directly from teachers. On the other hand, these theses are inextricably linked to experiences made in the course of the professional development program *Mathematics Done Differently*, which built the context for the research that was reported in this work. Thus, the aspects mentioned below also present what we have learnt from our ongoing project and related research on teachers' views on professional development.

As mentioned in chapter one, innovative approaches are sensitive to teachers' needs and their conceptions, and are not of the type '*either/or*' but '*both/and*', as Ann Lieberman from Carnegie Foundation for the Advancement of Teaching formulated at a conference in Germany. All following aspects thus refer to such either/or-patterns, i.e., duality aspects. Alluding to this duality opens a new view on professional development that is more likely to understand any offer as being of the type '*both/and*'.

Understanding professional development as continuous learning between theory and practice. Mostly teachers do not possess an elaborated view on their professional learning, or a conception of professional development as a permanent learning endeavor that is not at least, initiated by learning daily through practice. They remain rather vague with respect to their own learning processes (cf. chapter one). The question that is left unanswered is what conception teachers really possess concerning their own long-term professional development. Any developmental processes need a kind of vision or commitment as initiating forces. When such a view on professional development is missing, events are partly conceived as being of punctual character, which might further explain that in the best case only gradual changes can take place.

Unfortunately, there are many contributions and recommendations in teacher education, which do not reach the realm of teachers. Obviously, what is needed is a culture of reciprocally sharing experiences, in the sense that theory informs practice and vice versa. In some of the interviews it was described how even little incitements can serve as initiating motivation and change processes and surely, research already supplies us with many adequate occasions. In the project, a very specific relationship between research and practice is favored while the in-service training courses bring together an academic teacher and a schoolteacher as a trainer *tandem* (cf. chapter four). The former is valued since he or she allows for a widespread theoretical view on the content, while providing an interpretative framework encompassing the experiences from practice. The latter is additionally appreciated in a supportive role, since he or she ensures that all courses are very practice-oriented. The views of teacher educators and teachers typically differ, so that the various accentuations offer a comprehensive picture on the single topic when put together.

Establishing a supportive culture for teachers pursuing their professional development. Undoubtedly, teachers need support in pursuing their professional development. So far, external support provided by school leadership or educational policy, for instance, concerning the allocation of resources has widely been discussed. But teachers' statements in the interviews moved the discussion onto another level as well, i.e., showing appreciation like pointed out in the following was considered as a very valuable approach. The fact that teachers obtain the opportunity to work with mathematicians and mathematics educators of *their* choice and to invite them to *their* own school has been respected highly by the teachers.

One teacher mentioned explicitly how privileged the school staff felt to get this tandem of a university teacher and a schoolteacher to their school, and how they felt supported from outside classroom reality (cf. chapter seven). In another case, a group of teachers applied for a course *on demand*, i.e., a specific theme that was not part of the supply of the project. The teachers already informed themselves and got some information by a research book. Fortunately, we could make it possible to hire the book author as a part of a trainer tandem, who then designed a course with respect to the very needs of this teacher group.

One recent development in Germany has been to delegate more responsibility to the individual school. However, the emerging question is if schools are ready to shoulder the new role. At least, schools and teachers need support, and a market that holds ready interesting and appropriate offers for teachers to choose from. By the project *Mathematics Done Differently* a kind of landscape could be established that also involves expertise from our colleagues from all over Germany since already existing in-service courses are made accessible nationwide (cf. chapter four). Meanwhile, quite different course offers are available via the project homepage that are partly also initiated by specific demands of teachers, for instance, courses that address the interfaces between kindergarten and primary school.

The difficult situation for schools in terms of procuring money for in-service education has been topic in many of the interviews. The options provided by the project are of course exceptional since the funding makes things easily possible. One additional concern has also been to provide all in-service courses in an esteeming atmosphere, e.g., teachers were provided refreshments during the breaks.

Another essential aspect is support by school policy with respect to releasing teachers from teaching. Not only the single in-service training needs time but possibly follow-up meetings and course work to enhance new or different ideas, too. In the interviews, teachers reported about their difficulties to get support for in-service training events that required a whole day and again, the following teacher statement is cited, which so aptly catches the difficult situation:

In advance, I had asked my headmaster if she would allow a daily event. Well, and I said it costs nothing. Anyway, then I just said, it lasts four days and it costs nothing. (cf. chapter seven)

Much of the research discussion related to professional development concentrates on banning short term and single events from the agenda, but in the *reality* of professional development administrative restrictions are a matter of particular concern

and run counter a long-term orientation. Thus, a supportive culture is indispensably needed for teachers engaging in professional development.

Providing professional development offers as needs-based education. Since teachers are assigned a key role in educational affairs, they are naturally and necessarily in the center of reform but the crucial question is whether teachers' needs are, too. Many professional development offers do not explicitly involve teachers in planning, but a crucial point is that in-service education then takes the risk of going beyond what is actually needed. Sometimes the debate on in-service education centers on favoring either *supply* or *demand* oriented approaches, but actually, needs are the roots of motivation (Hannula, 2006). Consequently it is important to pay attention to teachers concerns and to focus on their needs, instead of nurturing such an unhelpful dichotomy. Some teacher groups may find interesting offers from the course supply while others do not, who then need a very specific course designed according to their concerns.

Regarding needs-based education, one teacher pointed out that a need for professional development must be there, emerging from inside the teacher, and that the crucial point is to meet teachers where they are (cf. chapter seven). The teacher statement hints at an essential prerequisite for effective in-service training, namely the necessity of an adequate pre-arrangement that teachers and trainers agree upon before the course starts. The issue has been rather neglected until now, but would help to discover the individual needs of the group of teachers that go beyond the designated themes and topics. Actually, meeting the teachers where they are is or should be a trivial axiom. In order to get informed about teachers' requirements and to make the courses fit accordingly, these agreements are needed.

Need identification in the field of in-service education hence adds another point to the single event, that is, the prearrangement, an issue that is also elaborated on later when discussing the role of products and processes. So far, in the research literature little is reported about identifying teacher needs. Even empirically, this research topic is not really accessed. That is why in the run-up of the project *Mathematics Done Differently* huge amounts of data were collected as a mean to firstly approach the field of teacher professional development.

Enabling teachers to develop a sense of ownership and partnership. Closely connected to aspects of needs oriented education are those of agency and ownership. When demands and changes are imposed from outside that do not touch the teachers' needs, they will probably find a way to deal with them. Even when they stay the same, like one teacher mentioned how he and his colleagues tend to comment such a situation with the words "set theory came, set theory went" (cf. chapter seven). That is, teachers are very sensitive regarding hastily placed educational changes. Or as one teacher put it, they very easily react negatively when they feel like someone is stealing their precious time (cf. chapter seven).

In the field of professional development, issues of ownership and the question, *Who has the agency?* also address the discussion about change processes. As already

mentioned (cf. chapter one), the perspective taken in this work is that we cannot change another person, and in particular, that teachers cannot be developed passively. But what we can do is providing rich and substantial professional development opportunities for teachers, who then ultimately hold the ownership of change in their own hands. Addressing teachers' needs involves a paradigm shift from viewing them simply as objects or recipients to clients and designers of their professional development. Engaging in professionalism must be a choice, not only with respect to attending a specific course, but to all other involved levels as well, that in sum contribute to an active participation.

What has been discussed here under the headline of ownership does not in the first place address the individual teacher but groups of teachers working together at one school or neighboring schools. Issues imparted by an in-service training are not likely to be transferred into the classroom when the single teacher obtains no support by colleagues or is even criticized for innovative approaches. It is essential that teachers get the opportunity to swap ideas and to discuss issues that they have encountered. One teacher put it pragmatically, that more ears hear more and more eyes see more (cf. chapter seven). In addition to this, the value of professional collaboration lies in sharing reflective exchange and practice. Necessarily, authenticity contributes to a sense of self as mathematics teacher, which mainly develops in interaction with colleagues (cf. chapter one). Therefore, a concern of in-service education clearly is to aim at initiating or supporting staff development in school.

Offering possibilities for in-service education like we did by our project is no more, no less than an important impetus upon which the involved persons decide what aspects to further take up. However, teacher motifs to participate in a specific event can be distinguished with respect to different levels. It appeared from the teacher statements in the interviews that the motifs to attend in-service education in the favorable case intertwine a micro level, the own progress, and a macro level, the professional growth on a larger scale. Some teachers just remained on the micro level, mainly those whose motifs did not emerge as their own needs but were pushed from outside (cf. chapter seven). Thus, intrinsic motivation is more likely to be tied to aspects of school development.

Acknowledging teacher beliefs and affect in the field of professional development.

In general, beliefs serve as affordances in mathematics teaching and learning, an observation, which encompasses the field of professional development, too. Beliefs are linked to the self-concept of the bearer, and they serve as a kind of self-assertion, which protects him or her against uncomfortable ideas (cf. Goldin, Roesken, Toerner, 2008). Hence, beliefs and affect can clearly impede an open attitude towards new ideas. In this respect, one should consider that teachers mostly possess rich experiences related to in-service education, which undoubtedly establish various expectations.

For instance, when discussing the teacher statements given in the interviews, kind of disappointment was reported when teachers felt like they were wasting their precious time. Another crucial finding was that a teacher's view on his or her learning can influence the general attitude towards an in-service training course (cf. chapter seven). Thus, beliefs about learning and professional development are interrelated

since the view on learning of course shapes the perception of learning offers provided by in-service training.

Some teachers possess an unconciliabile position concerning developmental processes and are therefore easily resistant to any progress. In general, change can either be exciting or frightening depending on how it is viewed, based on hitherto experiences. In a rather negative attitude, like the teachers that at first rather see the problem than the good idea, professional development offers are easily experienced as a me against situation. That is, in order to grow one actually must give up the struggle to remain the same. Obviously, teachers do possess an elaborated value system, which can impede being really open to new ideas and suggestions. Unfortunately, such a critical attitude might lead teachers to miss a chance to gain new incitements and awarenesses.

So far, the focus has been on rather negative influences of beliefs and affective variables but in the following, positive and inspiring effects will be highlighted. For instance, teachers informed about how the in-service training contributed to developing new insights, to looking on the subject from a meta-level, and finally to yielding a new view or a *higher* standpoint. One teacher pointed out how colleagues who were actually not really willing to attend in-service education shifted their mind after attending the course (cf. chapter seven), and how they were then looking forward to the next session. Obviously, one important role of professional development is to provide challenging experiences so that new ways for teachers can open up, like one teacher who was actually not open for the in-service training in the beginning, but then asked his colleagues if they could teach a corresponding lesson together.

There are few if any beliefs with which the bearer associates no affective loading (Goldin, Roesken & Toerner, 2008), like the above-mentioned remarks indicate. Beliefs are interwoven with affective variables, like math is fun or can be fun or even fascinating, as one teacher stressed (cf. chapter seven). Teachers' positive attitudes primarily influence any process that occurs in the aftermath of a specific professional development event. Obviously, an atmosphere of trust as well as emerging enthusiasm are good indicators for pursuing new issues. Teachers from the same department that support each other, who are open and frank, are likely to benefit from professional development.

In his talk at the ICME 11¹ conference in Monterrey, Mexico, Jeremy Kilpatrick discussed the work by Felix Klein on the double discontinuity that teachers encounter on their way from school to university and back to school. Particularly, he stressed that Klein's concern was to provide opportunities for teachers to obtain a *higher* standpoint, a notion that is sometimes labeled as an advanced standpoint. However, the latter English translation does not adequately meet the German expression since the original aim of Klein, as Kilpatrick pointed out, was that he wanted the future teacher to stand above his or her subject, and to arrive at a more panoramic view. Since the results presented in this work give renewed emphasis to the profound relevance of beliefs and affect in the context of professional development, any offer should provide teachers with rich opportunities to obtain such an elaborated view.

Establishing a market view on professional development. As mentioned before, assigning more responsibility to the individual school indispensably calls for providing

an adequate market of professional development. This market can be viewed as being dependant on the law of supply and demand. Consequently, issues of ownership and teacher needs are automatically in the focus, since the approach demands asking the teachers themselves, what their experiences and their concerns are. The project chose a very specific combination of both *supply* and *demand* oriented in-service education. To sum up, the initiative gathers in-service training courses that have already been successfully conducted in parts of Germany, and now makes them available and accessible nationwide. In addition, a particular concern has been to meet the unique needs of teachers by designing courses especially regarding to those requirements. To consider both approaches similarly important enables a good view on teacher education since one avoids the danger to value one on the expense of the other.

However, rather naively, we started by focusing strongly on the products as being crucial on the market and favored offering supply oriented in-service education. Over the course of time, through conversations and discussions with teachers, the demand-oriented approach has become increasingly important, which is characterized as being very close to teachers' needs. Identifying what offers are needed calls for observing the market attentively and for being sensitive for trends or specific topics. Quite recently, we adapted our supply in stochastics to make it, in terms of course modules, more fit to the needs of a specific customer. Nevertheless, to rely only on this course format, i.e., on the themes raised by teachers, is a tough and time-consuming job since it also requires establishing an adequate net of experts in the respective thematic fields. Not at least Simon (2007) reminds us to consider that teachers' prior knowledge also serves as an assimilatory scheme, and that therefore themes provided by teacher education research can help to inform practice. A very good way, hence, is to also supply an offer, e.g., specific courses, and make those adaptable to the very needs of a teacher group.

Meanwhile, we have acknowledged that it is in particular the process around all these products, which is decisive for effective professional development. Pre-arrangement and follow-up support are then essential variables and supplement each in-service training course. The initiated discourse between teacher educators and teachers also adds to providing in-service training as being a *pair* of product and process, a development that is far from just focusing on the individual session. Taking a market view on professional development, as we did in our project *Mathematics Done Differently*, allows for both spreading research knowledge and providing a forum for teachers' needs and concerns.

To sum up, this market of professional development addresses many duality aspects while mediating between providers and customers, demand and supply, products and processes, theory and practice. We also acknowledge that there are competitors in this market, for instance, the federal institutes providing in-service education, and we understand our role to search for sustainable collaborations.

Providing flexibility instead of standardization while offering professional development. Finally, to take teachers' needs seriously puts high demands on the teacher educators responsible for providing professional development activities. Correspondingly, Cochran-Smith and Lytle (2001) conclude that "professional

development is associated more with uncertainty than certainty, more with posing problems and dilemmas than solving them” (p. 56). One might tend to deem the aforementioned statement as disillusioning, but what has made the project so successful is that the offered bouquet is huge and therefore, makes it possible to supply a varied mixture. Such a broad offer is necessary since teachers as learners bring with them diverse mathematical histories, diverse amounts of prior knowledge and thus, diverse concerns and requests. The supply is not restricted to addressing the cognitive domain, but involves the affective as well, since teachers encounter new ideas through their knowledge *and* their beliefs.

The most decisive characteristic has been to keep ready flexibility with respect to both content and context. In case, a school orders a very short in-service training course due to time constraints, it does not help to theoretically argument against. Instead, the specific necessity must be met. Standardization is not helpful when professional development is considered as being needs-based education.

One essential conclusion that has been taken at any point of the project is that we as teacher educators are part of a learning system. According to the teaching triad (Jaworski, 1992, 1994), in the adapted version for mathematics teacher educators by Zaslavsky and Leikin (2004, cf. chapter two), one crucial aspect is the sensitivity to teachers, on which our learning has been build. To design and run a project can by no means be a static endeavor but is indispensably a developing process. Thus, refinement and adjustment are consequently part of the agenda and document our own learning process of revising the initial approach. Throughout the project progression, we have acknowledged that we are professional developers, too and we experienced growing into the practices in which we have been engaged (cf. Jaworski, 2006).

Concluding Remarks

Teachers are crucial to students’ learning of mathematics, thus they play a key role for gaining educational excellence. Undoubtedly, professional competence in a professional role requires adequate professional development opportunities. Continuing professional development then is more than some special events at some days during the school year. A comprehensive understanding considers context factors like the cultures and the organizations in which the teachers work, and addresses all levels in the educational system. The statements listed above provide a concise overview of dimensions relevant for teachers and teacher educators in the field of professional development in general and in-service education in specific. Based on the aforementioned theses, we² propose an overarching research-based model of professional development that is characterized by the following parameters:

- Professional development of mathematics teachers is a continuous and a lifelong process.
- Teachers need a supportive culture for pursuing issues of professional development.
- Professional development must be needs-based education that allows for developing a sense of ownership.

- Professional development for in-service teachers is understood as a market, being dependent on supply and demand.
- The market involves all expertise in the field of teacher education available in the country.
- The market holds ready offers for teachers' continuous learning while balancing theory and practice.
- In-service training courses unite theory and practice, while involving both a university teacher and a schoolteacher as a trainer tandem.
- The in-service training courses take into account the teachers' knowledge and beliefs.
- In-service training addresses groups of teachers working at one school or neighboring ones.
- ...

In sum, the model that is shown in figure 16, describes possible growth pathways of teachers through different fields of tension. The underlying philosophy of professional development is driven by a marketization and a humanistic view (cf. chapter one), which allows for pursuing quality management in terms of efficiency and effectiveness, and for meeting the different needs of the people involved:

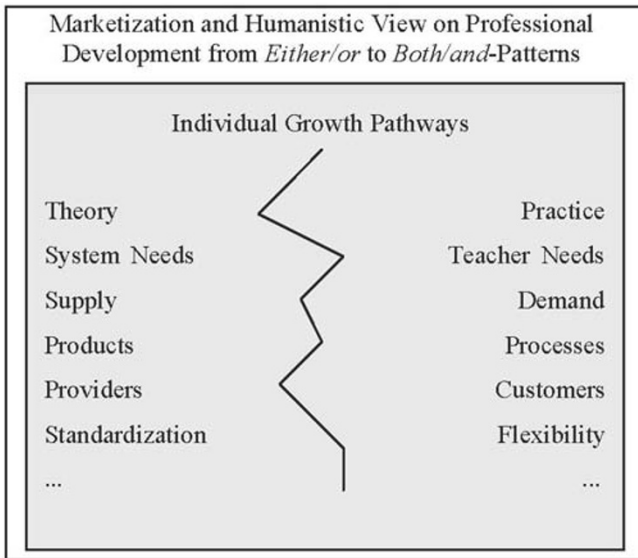


Figure 16. Model of a market for mathematics teachers' continuous professional development.

The model can be understood as providing implications for constructing practices of professional development that are based on what teachers really need. The direction for professional development is guided by the knowledge-of-practice conception as

described in the analytical model by Cochran-Smith & Lytle (1999, cf. chapter one). That is, any offer encompasses both a teacher's experiences in practice and theoretical input given by research.

The model is further characterized by balancing the needs of the system and the needs of the teachers, the relationship between theory and practice, supply and demand oriented education, products and processes in the field of in-service training, and finally by allocating flexibility for the different demands.

Development and change are regarded as processes rather than single events, addressing various levels in the educational system. Correspondingly, sustainable professional development initiatives have an influence on the community and context inside and outside their scope. Teachers professional identities are rich and complex, as is teaching practice, thus diversity and flexibility are crucial on a market of professional development. Hence, the only remaining claim can be to transcend diversity.

The philosophy of the proposed model is primarily determined by a marketization view (cf. chapter one), in terms of the characterization provided by Elliot (1993). Nevertheless, what we strongly advocate is to add a humanistic view on teacher professional development. While discussing different approaches to offer in-service education Cochran-Smith and Lytle (1999) underline that not the methods are decisive, but the views on the teachers. Unfortunately, very often proposed changes and new models for professional development are built around very old conceptions, beliefs and convictions. As a result, these offers center on the position that teachers are rather considered objects that need something.

Clearly, the model concentrates on structural features. Since educational expertise, available in the country and on an international basis, is involved both in terms of already established courses, or in the persons that are actively engaged as trainers, a content discussion is not necessarily required in the first place. Ultimately, the knowledge debate is integrated, since all experts are responsible for the courses that they provide. In a sense, the model leaves untouched the prevailing conception of in-service training as entailing a team of researchers offering a course for which they are the experts in the field. An essential advantage of the proposed model lies in the fact that the marketization view on professional development practices can be realized as an intervention from outside, by simultaneously involving expert knowledge available inside the country. However, such an initiative is from its very conception more likely to provide flexibility to be able to meet the needs of all the people involved.

Professional development is often determined by *black and white thinking*. Either issues are considered as being good or bad, or statements like *teachers should*, *teachers must* or *teachers need to* are transported. But thereby, it is easily forgotten from which perspective the judgment is taken, surely it is not the teacher's one. Toerner (2008), while referring to a statement of Felix Klein, reminds of the following:

Teacher preservice and in-service education need to be thought from a teacher's perspective, since the efficacy of the personality matters much more than methods or curricula. Not until we succeed in such professionalism, and we are able to create a new approval culture, a real incentive for lifelong learning will be given.

Obviously, what he is referring to, the vision of Felix Klein, articulated 100 years ago is still relevant:

In particular, I would like to let the individuality of a teacher's confer freedom. I believe more in the effectiveness of personalities than that of the sophisticated methods and curricula. (as cited in Schubring, 2000, p. 70)

Profoundly respecting and cherishing the teachers and their needs, allows for arriving at a vision of professional development that is *for* and *with* teachers, instead being simply about them.

FUTURE PROSPECTS

So far, based on theoretical considerations, empirical findings, observations, and experiences in the context of a specific professional development program, some suggestions were provided how to approach the field. Consequently, the next step is pointing to some future directions for ongoing research related to the findings presented in this work. The overriding topic, of course, is supporting the scholarship of teaching by taking the teachers themselves, their needs and concerns seriously. Given that professional development does only make sense when those needs of teachers are explicitly addressed, prearrangement and follow-up support naturally get into the focus and release the sustainability discussion from being restricted to a rather artificial level. Ann Lieberman is quite right when arguing that professional development does not help in terms of *either/or* but needs to be of the type *both/and*, as cited several times in this work. The implication is, that we need a system of variety and diversity while supporting teachers to get articulated about their practical requirements.

Teachers provided rich insight in their interpretations on professional development and expressed their point of view. By means of quantitative and qualitative data, rich information was collected. The quantitative approach indicated that a teacher's view on professional development is structured and, consequently, unravelable. The obtained dimensions could then be characterized with regard to the degree of agreement, and to the relationship between them. Particularly, the latter helps to make transparent the dynamics involved in the interaction of dimensions. However, the qualitative approach provided some supplementary insight in what is relevant for teachers, so that the data can be used to further develop the quantitative approach. That is, the interview data analysis yielded a rich basis for refining items or adding aspects that have not been addressed so far.

The qualitative approach addressed level one of Lipowsky's characterization that was presented in chapter two, who, in this context, already called to mind that some research questions remained unsolved, mainly those dealing with personal parameters. The findings presented here indicated that particularly, teachers' beliefs and affective variables are crucial (cf. chapter seven), and that this field of research needs further clarification.

Many theoretical aspects were discussed and reflected from both perspectives while approaching the field theoretically and empirically. However, Holzkamp (1995)

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provides an interesting statement when concluding that the contribution of the known converges just against zero in view of the unknown. Perhaps, this remark is very pessimistic, but it calls to mind that there are many additional issues to explore. The author's understanding of the contribution of this work to research in the field leans on the following statement by Atkinson (2000):

The purpose of education research is surely not to provide “answers” to the problems of the next decade or so, but to inform discussion among practitioners, researchers and policy-makers about the nature, purpose and content of the educational enterprise. (p. 328)

In this sense, this work is also to be understood, i.e., as informing the educational discourse about the teachers' views in order to get ultimately continuous professional development from their very perspective high on the school improvement agenda. However, by so doing, too, the following remark applies to what has been reported here:

[...] a narrow focus on ‘what works’ will close the door that leads to new possibilities, new strategies, new ways of reframing and reconceiving the educational enterprise. (Atkinson, 2000, p. 328)

This work contributed some interesting and remarkable findings. Nevertheless, future research, either theoretically or empirically oriented, will discover further and different aspects, but what really matters is the view and perspective the researcher takes when exploring the field of professional development.

NOTES

¹ <http://icme11.org/>

² The model was developed together with Prof. Dr. Guenter Toerner, University of Duisburg-Essen.

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