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## **ON THE PROFESSIONAL GROWTH OF TWO MATHEMATICS TEACHERS AND THEIR MATHEMATICS DEPARTMENTS**

**Abstract:**

This paper first describes four dimensions of teachers' professional practice, namely action, reflection, autonomy and networking. Then it tells the stories of Gisela and Nora, two mathematics teachers at two different Austrian secondary schools and their departments of mathematics, using the four dimensions to reflect on the growth of these teachers. The paper shows that their professional development is essentially influenced by their pre-service education, by systematic reflection on their own practice, by sharing experiences with their colleagues, and – very importantly – also by general organisational conditions.

### **1 Dimensions of Teachers' Professional Practice: Action, Reflection, Autonomy and Networking**

The quality of education is a complex issue and cannot be simply reduced to the quality of teaching. It seems crucial to see the *teachers' contribution to the quality of education* in a broad context and to find dimensions of teachers' professional practice which are general enough to be used in different situations and where both the competence and the attitudes of teachers are given equal consideration (see more detailed in Krainer, 1998). The following four dimensions aim at describing teachers' professional practice:

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

*Reflection:* The attitude towards, and competence in, systematic and critical analysis of one's own actions and work;

*Autonomy:* The attitude towards, and competence in, self-initiated, self-organised and self-determined work;

*Networking:* The attitude towards, and competence in, communicative and co-operative work with others.

Each of the pairs, "action and reflection" and "autonomy and networking", express both *contrast and unity*, and can be seen as complimentary dimensions which have to be kept in a certain balance, depending on the context. The interplay between these dimensions seems to be of great importance: in general, more reflection contributes to a higher quality of action, and the sharing of experiences enriches one's own view and autonomous work; furthermore, a higher quality of action and autonomy promotes the qualities of reflection and networking, etc. Experience shows that there is *a lot of action and autonomy but less reflection and networking*, in the sense of critical dialogue about one's teaching with colleagues, mathematics educators, the school authorities, the public, etc. (see e.g. Krainer, 1998). Therefore, this paper puts particular emphasis on the dimensions of *reflection* and *networking*.

In the following we describe two mathematics teachers' struggle for professional growth and use the above mentioned four dimensions to reflect

- on their *own further development* and those of their *students*,

- on the *further development* of their *departments of mathematics*, and
- on the *further development* of the whole *school*.

Gisela and Nora – the names we have given them in this story – are members of mathematics departments at two different secondary schools in Austria in which the two authors have worked in the last few years. It is one intention of the paper to demonstrate that even two professional development projects, which are based on the same philosophy, can have quite different impacts on, among others, teachers and their departments due to different organisational contexts. The stories of Gisela and Nora and their departments are based on a wide range of data from professional development programmes and seminars, some teachers' reports in the annual school reports (only Gisela's school) and interviews with Gisela and Nora. In each of the above mentioned programmes, seminars or interviews, at least one author has been involved; in most seminars both authors have been leaders. Gisela and Nora have read all parts of this paper relevant to their careers and accept that it is a reasonable description of their development. The paper starts with the story of Gisela (for a more detailed description see Krainer, 1999), followed by a briefer story about Nora and a comparison between the developments of these two teachers and their departments. In general, stories in mathematics teacher education have recently been given much consideration (see e.g. Cooney, 1999, or Krainer & Goffree, 1999). The innovative part of the following two stories is that they embed teachers' growth in a wider context, and, in the case of Gisela, reflect on a teacher's long career.

## **2 The story about Gisela and her department**

Gisela was born in the 40s in a rural region in Austria. She intended to become a primary teacher but when she finished her studies she changed her mind and wanted to become a *mathematics and geography teacher in a secondary school*. She therefore went to university, where she financed her studies with private lessons.

### **2.1 Gisela's teacher education and her first years of teaching**

Gisela's *teacher education at the university* was nearly completely dedicated to the study of the subject matter (mathematics and geography), no matter whether someone studied for a diploma or wanted to become a teacher. The only exception concerning her mathematics study was a seminar in which the student teachers observed some mathematics classes and were introduced to the technique of calculating with the slide rule. The study of pedagogical issues was confined to elements of the history and theory of pedagogy. This was a big contrast to Gisela's *primary teacher education*, where she had learned to work with groups and had become familiar, for example, with the Montessori method. The mathematics teaching she experienced at the university was a pure mono-culture: one frontal teaching unit followed the next and there were only a few lessons in which the students had to show their individual attempts to solve mathematical tasks. The student teachers received knowledge in a broadcast-metaphor with nearly no content-related interaction among the students.

Gisela began work at her first school in 1971 and primarily taught mathematics from grades 9 to 12. Although she felt *mathematically well equipped*, she *lacked the pedagogical and didactic background knowledge* for teaching students of that age. As she had learned at the university, she used to teach the subject frontally, sometimes asking single students to work at the blackboard, none of which however allowed much communication among the class. This was also partially caused by the fact that Gisela had to work with about 36 students in small

classrooms. Many of her students had poor marks and results in mathematics. The longer Gisela taught, the more frustrated she became. She wanted to find opportunities to reflect on her teaching and to change it but she did not find adequate opportunities to do so. The in-service courses were rather traditional and did not meet this challenge. She attended courses on “communication for adults” in order to have a second choice for a career outside the school. Gisela really seriously considered leaving the teaching profession.

### *Reflection and networking*

During a recent interview, Gisela stressed that due to her *learning experience at the university* it was as if introducing higher mathematics in any other way was unimaginable. Referring to the four dimensions of teachers’ professional practice, we see that the teacher education at her university did not seriously promote student teachers’ reflection and networking. In her classes therefore Gisela too did not promote students’ reflection and networking. In addition, there was no professional communication among teachers either in the mathematics department or at the whole school. Most teachers felt they were experts in their subjects as they had been educated at the university, and hence remained as lone fighters in their classrooms. This also meant that on the school level there was a lack of reflection and networking. How teachers were taught as student teachers influenced their way of teaching students and their way of communicating with other colleagues at school. This influence shows the *interconnectedness of the systems “university” and “school”*. The cycle “student -> student teacher -> teacher -> [some of teacher’s students later become a] student teacher -> ...” produces and reproduces patterns of attitudes and beliefs. It is essential to investigate this cycle more carefully as it has implications for both systems and to launch projects where this cycle can be used constructively. Above all, it seems necessary to promote more reflection and networking among student teachers.

## **2.2 An opening in Gisela’s career**

In her tenth year of practice, a mathematics teacher at a neighbouring school told Gisela that she was participating in a *professional development programme* (1982-84) for mathematics teachers based on the “teacher as researcher” philosophy (PFL-Mathematics; see e.g. Fischer et al., 1985, Altrichter, Posch & Somekh, 1993, Krainer, 1994, and Krainer & Posch, 1996). She was learning a great deal there and she strongly recommended Gisela to attend the next run. Gisela and Werner – a new young colleague at her school – were able to attend the two-year university programme 1985-87 together with about 40 other mathematics teachers from secondary schools in Austria.

All participants attended three one-week *seminars*, five one-and-a-half-day *regional meetings* and carried out *teaching experiments* at their schools that were discussed at the seminars and at the regional meetings. Gisela was engaged in a variety of activities, for example as preparatory work for the first seminar she documented group work in one of her classes. This seven-page report shows Gisela’s wish to carefully observe and understand students’ actions and to promote students’ self-assessment of their work (e.g. they were asked to write down their views in protocols). Her report – like the reports of the other participants – was shared in a regional group of about ten people, supported by two staff members. She felt that professional communication among colleagues was a central feature of her efforts to bring about change.

The *regional group* became for Gisela and many others a continuous, homely, protected and powerful learning environment within the programme. Gisela stressed that the interview activities in one seminar had enhanced her patience in waiting for students’ responses and in

reflecting on her teaching. Amongst other things she also motivated the students to work autonomously in order to investigate things on their own. Gisela was an active participant throughout the professional development programme but she felt that sometimes she could have been more courageous. For example, the biggest part of the third (and last) one-week PFL seminar was dedicated to talks by participants on their studies, to working groups and to follow-up activities after the programme. Gisela was not among the 17 participants who presented results of their systematic reflections on their practice. She did consider it, but finally she hesitated and did not. Gisela really liked the reports of her colleagues and sometimes wished that she too had taken the plunge.

However much the professional development programme had a deep influence on Gisela's actions and beliefs, it had hardly any impact on other colleagues' teaching at her school. On the contrary, certain other mathematics teachers were irritated by her teaching experiments and showed some *resistance* in talking about teaching issues. Nevertheless, Gisela had a good contact in her young colleague Werner who participated in the same programme. They supported each other as "critical friends" but were relatively isolated among the other mathematics teachers.

### *Reflection and networking*

During our recent interview, twelve years after having attended the professional development programme, Gisela has come to regard it as the "rescue" of her teaching career. She indicates that she learned enough methods and ways of reflecting on, and changing, her teaching there. Gisela also stressed that she became more self-confident in respect of her didactic thinking and acting, a consequence which she had not expected before. Furthermore, she also learned to *present her views and arguments with greater self-confidence*. Finally, Gisela became aware that she can learn a great deal from *collaborating with colleagues*, but nevertheless, she has *to go her own way* since knowledge cannot be transferred from other people mentally. As a consequence, Gisela also increasingly regarded her students as producers of *their own* knowledge, and not as consumers of *her* knowledge. She introduced new modes of instruction where her students worked together and jointly reflected on their activities. However, sometimes general conditions, like classes with more than 30 students, hindered her efforts and she was not successful in achieving her pedagogical ideals in practice.

Referring to the four dimensions of professional practice, we might interpret thus: Gisela, being accustomed to *acting autonomously* as a lone fighter in her classroom, was challenged to *reflect* on her actions and to *share* her individual experiences and beliefs with other colleagues when she entered the PFL programme. Since *reflecting* and *networking* were fundamental principles in the learning community of this professional development programme, Gisela had to practice exactly those things which had been a blind spot in her career previously. She took the programme as the model for a teaching-learning process and transferred it to her own classroom. She increasingly introduced new modes of instruction where *students' reflection* and *networking* played important roles.

In the interview Gisela, looking back, stated that changing one's own teaching demands *a lot of energy for several years* and that this is also a reason why innovations concerning one's own teaching can only slowly have an impact on other colleagues. *Professional development processes need time and support*. The story of Gisela so far demonstrates that professional development programmes might provide *considerable progress for individual teachers* (and even rescue them from burnout or from leaving the teaching profession) but *do not necessarily have an impact on other teachers* at their school. If professional communication among teachers is not an important feature of the culture of a school (see e.g. Hord & Boyd,

1995, 10, cited in Loucks-Horsely, 1998, 182), innovations by individual teachers remain limited to their heads and classrooms. Even *a pair of colleagues* – like Gisela and Werner in our case – co-operating successfully might not be enough as a *critical mass*. Similar experiences were reported in Borasi et al. (1999, 75) pointing out that their professional development programme had additional benefits when not just pairs but a critical mass of teachers from the same school participated in the programme. Gisela and Werner, at that time, were not able to take a *leadership role* among the group of mathematics teachers, due above all to the fact that they were too much involved in their own learning process. Nevertheless, their ability to act as critical friends for each other was sufficient to promote their own professional growth, as we will see later in Gisela’s story (and in Werner’s too, who later became a regional co-ordinator of mathematics teachers).

Experience shows that it is not easy for individual teachers who have participated in professional development programmes to find colleagues who really want to join in their efforts to improve, or for they themselves to have enough motivation and perseverance to realise changes in the short or long run. Furthermore, innovative action at schools is often regarded rather critically and causes open or hidden resistance or opposition. Nevertheless, teachers engaged in *long-term in-service education programmes* (see e.g. Grouws & Schultz, 1996; Borasi et al., 1999) or research projects (see e.g. Crawford & Adler; Jaworski, 1998) which place an emphasis on professional communication and co-operation of teachers through promoting the discussion of their *investigations into their own teaching*, more efficiently support teachers’ efforts to bring about change. That such a programme gives birth to self-organised groups which remain together for a longer period (see e.g. Krainer, 1994) is more the exception than the rule. However, a lot of participants – like Gisela and Werner – act as “*agents of change*” in their region, are engaged in in-service courses or teacher pre-service education, and actively participate in conferences in which innovative work of teachers is presented. It has to be added however that professional development seminars and programmes can never reach all teachers. It is also often argued that participants on such seminars are “always the same” and those who really would need some improvement do not come.

All these arguments show that curriculum reforms, pre-service teacher education and individually-oriented professional development programmes – though very important – cannot be the only strategic interventions for improving the teaching of a subject in a national educational system. Alternative approaches which recently have become more popular are *school-based in-service courses* (for groups of teachers of a specific subject or combination of subjects, for example science and mathematics), *professional networks* of teachers and researchers, and *whole school development programmes*. Concerning the efforts of whole schools to grow professionally it is essential to establish how the further development of the school as an organisation can be interconnected to the further development of subject teaching.

### **2.3 Gisela as a mathematics teacher, department head and vice-principal at a new secondary school**

In 1989, Gisela got a position as mathematics and geography teacher at a *new secondary school* (grades 5 to 12) in the city. Gisela was *ready for a change*, looking forward to working with children from the age of 10 to 14 and was interested in helping to *build up a new school*. However, she was also sad because she lost Werner as a partner next door, and she was unsure whether she could establish an equally good relationship with other colleagues at the new school.

When Gisela joined the new school in its second year of existence, the teaching staff was relatively small. In contrast to her old school, she was an “unknown quantity” and she liked not being “burdened with a specific image”. At the very beginning, there were only three other mathematics teachers at this school. Gisela became the “custodian for mathematics” at her school, which is an Austrian lightweight form of a *head of department* of mathematics. She also liked having the opportunity now to teach students in the lower secondary grades 5 to 8. Although the group of mathematics teachers was very small there was hardly any professional communication about teaching among them at the very beginning, most communication being dedicated to school organisational issues.

In 1991, two years after her start at this new school, Gisela was appointed as the “administrator” of the school by the regional school board. This position at secondary schools in Austria can be compared with that of a *vice-principal* of a school, someone responsible primarily for the administrative agenda at the school, but also with the duty of teaching some classes (dependent on the size of the school). Due to her new function and role, Gisela had to learn a lot of new things (laws, computer software for developing timetables, etc.). Above all, her interest from now on was not only directed to improving her own teaching but increasingly also to contributing to the *further development of the whole school*.

Gisela’s school grew bigger and bigger and consequently communication and co-operation decreased only slightly, but continuously. In addition, more and more things became routine and when the first students who had started in the lowest class (grade 5) came nearer to the highest class (grade 12) in order to take the final examination, some parts of the teaching staff, the principal and Gisela felt that the school would need *refreshment*. Initiatives taken to start a school development process in the years around 1994 had no real success, however.

### *Reflection and networking*

It is interesting that Gisela initiated relatively few activities among the group of mathematics teachers although she was their custodian. However there was no real tradition in Austria of doing that. The custodians mostly dealt with administrative issues whereas the teachers felt themselves as *experts in their subjects* and worked as autonomous but lone fighters in their classrooms. The situation at Gisela’s school was a typical example of that tradition. In the organisational and school development literature terms like “professional bureaucracies”, “expert organisations” or “fragmentary schools” are used to describe organisations where *experts* are more *committed to their expertise in a specific field* (for example, subjects in the case of secondary schools and universities, or domains like surgery in a hospital) than to the whole organisation. Austrian schools, universities and hospitals, due to their *low degree of autonomy and decentralisation* until recent years, show a low but increasing level of individuals’ corporate identity with the organisation in which they work. *Systematic reflection and networking*, if they existed, were traditionally more directed to colleagues *outside* the organisation than towards professional communication among the members *within* the organisation. Recently, this has been changing tremendously, in particular with regard to the school system.

## **2.4 Professional development seminars for the department of mathematics**

In 1995, Gisela was asked to find a way for a new attempt to be made to refresh the school development process. She remembered her good experiences with the PFL programme and contacted those responsible at the university. It was arranged that a university team would support a team at the school in preparing a *professional development day* in October 1995 and that the presence of a well-known mathematics educator from the United States would be used

to organise a two-and-a-half-day *seminar* in March 1996 for the group of mathematics teachers at this school. Gisela was happy that her relations with the PFL people were being renewed and this promised a chance to initiate some change at her school, similar to her own experience.

The professional development day in October 1995 did not bring the expected success, namely a joint step of the whole teaching staff towards a renewal process. However, the two-and-a-half-day *seminar* in March 1996 for the group of mathematics teachers was successful. In the following we confine ourselves to describing briefly how it became the starting point for the further development of these groups.

- The first seminar for the mathematics teachers

The *two-and-a-half-day seminar* in March 1996 for the group of mathematics teachers at Gisela's school was led by two mathematics educators, one from Austria and one from the United States. As agreed at a preliminary meeting, the seminar for the eight participants was based, like the PFL programme, on a "*teacher as researcher*" philosophy and covered three major issues:

- 1) Joint planning, carrying out, observing and analysing *interviews with students* in order to understand better how they see mathematics, mathematics teaching, etc.
- 2) Joint planning, carrying out, observing and analysing a *little experiment towards more "open" mathematics teaching* in order to experience new approaches (e.g. the use of open-ended tasks), methods (e.g. team-teaching), etc.
- 3) Investigating *interconnections between mathematics and other subjects* in order to experience the potential of bringing the real world into mathematics teaching.

Although the seminar language was English and some participants – like Gisela – sometimes had difficulties in following the discussion, the evaluation showed that most teachers benefited considerably from the seminar. Gisela highlighted "the creation of a very constructive working climate" and the "scope of freedom for necessary communication" among the teachers. A young teacher who participated in the seminar was pleasantly surprised by the efforts of more experienced colleagues who also reflected critically on their teaching and strove for new ideas. She commented: "Even older colleagues try out new things". Gisela was very happy with the success of the seminar. Some participants declared at the end of the seminar that they had come with some scepticism, and one said openly that he had feared that the seminar would only be Gisela's pet idea (and the others had to join it because she was in a more powerful position), but now he would be ready for further activities. This open feedback shows that there had been reservations and fears at the beginning of the seminar that were not articulated at that time. This illustrates that teacher educators' attempts at getting informed about participants' situations and expectations by no means always bring to light the full complexity of teachers' goals and needs. The joint success of this seminar made it possible to speak about such tacit issues.

There were several *general organisational conditions* that influenced the seminar positively. We confine ourselves to sketching one "*miniature*" that emerged from a specific activity within the seminar. The participants were invited to look, in pairs, for good examples of interconnections between mathematics and other subjects from sets of journals, books and other material the seminar leaders brought with them. A particular *mathematics education journal* ("mathematik lehren") from which different volumes were chosen and analysed by

different teachers was found to be very fitting for use by these teachers. Some representatives of the group immediately went to the *principal* and persuaded him that this journal would contribute to the further development of mathematics at the school. The next time we visited the school the journal had been subscribed to and was prominently displayed in the school library.

This “miniature” tells a small story of its own. Firstly, it shows on a *micro level* the *importance of the principal* when, for example, financial resources come into play. As usual in Austria, the custodian or the group did not have the autonomy to decide to purchase the journal. They had to go to the principal and convince him. Certainly, it was an advantage that Gisela was the vice-principal and so could help the group to get what it wanted. From this small example of “micro politics” at schools we can see that principals have a great influence on innovations at schools and their willingness to support such initiatives depends tremendously on a variety of factors. For example, a principal’s decision might depend on how positive his view of mathematics or his subjective assessment of the professionalism of mathematics teachers is. For this and other reasons many mathematics teacher educators (see e.g. Peter, 1996) highlight the importance of principals and other important stakeholders, and the necessity of multiple perspectives concerning the professional development of teachers. Besides examples where principals play a more indirect role, there are also opportunities where they can actively and directly influence mathematics teachers’ work. Halai (1998, 298 f.), for example, describes how a principal in Pakistan in tandem with a teacher educator worked out the strategy of implementing professional development for mathematics teachers at a school. Principals and *other important stakeholders*, like regional subject co-ordinators or superintendents with different roles and functions in the school system, have their own ideas and beliefs about the nature of learning, teaching, mathematical knowledge, and reform (see e.g. Nelson 1998). They can greatly influence decisions concerning general conditions of the quality of teaching, therefore it is essential to pay more attention to their role in the professional development of teachers, both practically and theoretically.

Secondly, Gisela’s group had the advantage that the *whole group* participated in the seminar, so that the idea for subscribing to the journal emerged as a *joint wish*, and thus the representatives of the group were able to speak for the whole group. It would have been much more difficult for a single teacher coming back from an in-service course to convince his or her colleagues as well as the principal that the journal was necessary for the whole school. The “miniature” underlines the benefit of joint activities by groups of teachers of one school.

Looking back three years to that seminar, Gisela stresses that it was an important step for the group of mathematics teachers at her school. Above all, it *created trust among the colleagues* and produced the feeling that it is worth investing time to work together. Gisela reports that other groups began to envy the good climate and communication among the mathematics teachers, which in turn motivated the group to proceed further. The *newly established reputation of mathematics* at the school was partially created by an activity that we have only recently learnt about. After the seminar, Gisela, supported by others, wrote a short report about it. She published it in their *annual school report* and thus made the professional efforts of the group of mathematics teachers *visible* to all teachers, students and parents of the school. The report mainly builds on results of interviews with students and other investigations expressing, on the one hand, students’ views on mathematics and mathematics teaching but indirectly also the mathematics teachers’ attempts to improve their knowledge about students through a small research project within the seminar.



One *outstanding result* printed in the school report is a *picture* drawn by a female student in Gisela's grade 11 class. The students had been invited to draw a coloured picture that they felt characterised their notion of mathematics. They had then been asked to create a subtitle for their picture and to write a short description of the picture. The girl whose picture is presented in the school report shows a thick book entitled "The Great Book of Mathematics" which is locked by a clasp and a seal. The girl gave it the subtitle "Where is the key?" and described it as follows: "The sealed, closed book is not accessible to all. It is only possible to open the book with the key. But even when the book is open one need not necessarily understand the content. Either you have the understanding or not! In order to understand the book it has to be read from the beginning to the end!" For Gisela these results were like the two sides of a coin. On the one hand, she liked the creative work of this girl and her other students, their openness in speaking about their view of mathematics and the benefit she and the other teachers gained in discussing these results in the group. On the other hand, this pupil's view of mathematics and how she might have contributed to it irritated her. Nevertheless, Gisela saw it as a learning chance for her students, their parents, herself and other teachers and therefore chose this very picture for the report.

- The second and the third seminar for the mathematics teachers

In February and April 1997, *two further seminars* (each of one-and-a-half-days) with this group of mathematics teachers were held, both again at the school. The *first* of these two seminars placed the *emphasis on content-related aspects* (for example, project-oriented teaching in descriptive statistics, and teaching that builds on the many-sidedness of geometry) and aimed at helping the eight participants to find starting points for jointly planning teaching units after the seminar. Some colleagues did indeed take some steps in this direction but the time was too short to present concrete results at the next seminar.

The *second* of these seminars was the first in which all the (by now) ten mathematics teachers participated. The seminar had two major topics, the *mediation of conflict* between two group members and an introduction to a particular approach to *alternative assessment*. The topics served as a starting point for interesting developments, both at the group level but also on the personal level and concerning the whole school. This *close interplay of professional, personal, social and organisational learning* might explain why the participants' feedback to this seminar was the best of all the meetings with the group.

The *first major topic* was not planned but arose in the first minutes of the seminar when the participants articulated their expectations for the one-and-a-half-day programme. A hidden conflict between two mathematics teachers surfaced so the group decided to change the programme and to deal with that problem. The conflict basically was that one of the teachers had taken over the other's mathematics class and argued that this class was the worst he had ever had. This is in no way an isolated case at schools and often causes deep conflicts between teachers and hinders communication enormously. At this seminar, in a joint effort, an attempt was made to create a plan for coping with the challenge in a constructive way. Firstly the group aimed at a deeper understanding of the situation, in particular through listening to the different views of the two teachers (on the importance of listening see e.g. Cooney & Krainer, 1996), being only allowed to ask questions, but not to make suggestions or to criticise. The subsequent activity included planning, carrying out and interpreting interviews with students of this class. The answers of the students were both surprising and helpful (and showed their excellent expertise in evaluating teaching and their own work). Parallel to this work with the students, one seminar leader interviewed the two teachers. The analyses of all data brought

new views into play and enabled alternative ways of coping with the given situation to be found which were acceptable for all sides. Altogether, the group recognised their ability to succeed when dealing with bigger challenges.

The *second big topic* was a reaction to the group's interest in reflecting on alternative assessment. One seminar leader reported on her teaching experience with a specific method, the so-called "learning goal oriented assessment" (with the German abbreviation "LOB" which means "praise"). The teachers were really impressed by the method, which motivates students to take responsibility for the progress of their own learning. Gisela and some other teachers took concrete steps in this direction in their subsequent teaching. Again the group reported on the seminar and their follow-up activities. This apparently made a deep impression on other teachers and led to the invitation of one seminar leader to work half-a-day with the *whole school staff* on the topic "learning goal oriented assessment". The meeting was a big success. Some teachers were inspired to try this method in their teaching, and in particular Gisela was very happy. Although she had handed over her function as the school's mathematics custodian to another teacher in the group two years earlier, Gisela continued to feel co-responsible for the mathematics group's development and felt really proud that it was the activities of her group that had contributed to *an impetus at the school* to think about a new culture of teaching and assessing.

#### *Reflection and networking*

How can we describe the professional development of Gisela and the group of mathematics teachers since the school-year 1995/96? At least *three different phases* may be perceived. The *first phase* started with Gisela's initiative in making use of the offer from the university institute to organise a two-and-a-half-day-seminar for the mathematics teachers of a secondary school. In this phase the mathematics teachers were more or less a loosely associated assembly of lone fighters who had been talked into the seminar by Gisela.

The *second phase* started with the preliminary meeting and had its most important milestone in the two-and-a-half-day seminar which was then followed by the report on it in the school's annual report. The most prominent outcome of this phase was the *transition process* from the *loose association* to a *well-formed group*. At the organisational level, Gisela, as the custodian of the group, continued to play a leadership role, whereas in relation to the learning process she felt and behaved as a normal member of the group i.e. one part of the newly established learning community of critical friends. This helped her and the others to maintain their progress as a group, and they were encouraged by the report about their joint activity in the annual report. It was in this phase where the story about Gisela basically became *a story about the group*.

The *third phase*, which started with two shorter seminars, was an additional step forward by the group. In particular, the joint work on the conflict was a crucial test. Strengthened by this experience of success as well as by the activities on alternative assessment which seemed to fit in perfectly with their current needs for professional development, the group was again encouraged to report on their activities. Increasing *questions and feedback by other teachers* were the external appreciation of their process. The fact that Gisela had handed over the function of custodian to Veronika, another member of the group, and that the report was a critical reflection on the activities of the whole group, made it easier for the other teachers and groups to regard the alternative assessment topic as a *possible starting point* for their own professional development. Like Gisela, who never claimed ownership of the group's growth for herself, the group did not fall into the trap of playing missionaries with other teachers (an approach that hinders many innovations at schools) and were mainly interested in improving

their teaching and their communication within the group. It was apparent to the other teachers that this group seemed to have found *a joint basis* for their growth. Therefore the initiation of the half-day seminar on alternative assessment for the whole staff was a natural step and built *a bridge* from the professional development of a group to an initiative in school development. Although the work on alternative assessment was by no means the only school development activity, it was a remarkable event as the majority of teachers participated in the seminar, and it gave them an insight into the mathematics group's *culture of organising professional development for themselves*. It must be stressed that this development was certainly not just a one-way street from the group to the school. For example, without the school's long tradition in making good examples of students' and teachers' work visible (in the annual school report, through project presentations, ...) it would not have been automatically accepted that the group writes a report about their activities. Without a school culture that appreciates innovations (or even regards these as natural and daily actions) and without the support of the school's managers the group's growth would not have had such an influence on the whole school.

All in all, the group's growth since the preliminary meeting in February 1996 showed that *working continuously* with such a group might yield some *advantages* which should not be underestimated when discussing professional development programmes for mathematics teachers:

- It is possible to take the "culture" of the school (the context in which the teachers live and work and which is a decisive general condition of what is or is not possible) into consideration;
- The collaboration among individuals might develop towards the establishment of a group;
- The teachers could have the encouragement of others (who work next door to them) or even colleagues who were ready to join their efforts to improve their mathematics teaching;
- Innovations would be more likely to become a relevant component of mathematics teaching (or even of the whole school);
- Mathematics teaching could be more visible and could play a greater role in the school.

Let us again refer explicitly to the four dimensions of professional practice. The seminars with the group of mathematics teachers put a strong emphasis on reflecting and networking. Through joint efforts the mathematics teachers, slowly but continuously, turned from an *assembly of lone fighters* into a *network of critical friends* (see e.g. also the term "critical collegueship" in Lord, 1994, cited in Nelson, 1998, 210-211, or "professional culture" in Loucks-Horsley, 1998, 194-199).

It was essential that the group *wrote down their experiences* and *made their reflections visible* to all teachers, students and parents in the school. This form of *networking of innovations* finally led to a seminar for the whole staff of the school, which meant that, at least concerning a specific topic, the group's innovations spread to a bigger circle. The school's tradition in making good examples of students' and teachers' work visible, which is a particular feature of networking and provides an opportunity to reflect on the quality of the school, positively influenced the professional growth of the group. On a more general level, promoting school development processes means initiating learning environments where teachers, and in many cases also students and parents, jointly reflect on recent and future activities of the school,

thus increasing the network of critical friends of that school and building a *corporate identity* that sees *innovations as natural and daily actions*.

On all these levels the *promotion of reflection and networking* plays a decisive role. Concerning the further development of the teaching profession, the educational system and its interaction with society as a whole, one might ask, for example, the following *critical questions*:

Is there efficient communication among mathematics co-ordinators (in regions, countries, or internationally)?

Is there fruitful collaboration between mathematics teachers (researchers, ...) and teachers (researchers, ...) of other subjects?

Is mathematics seen as an important learning field at schools and in society?

Do the general conditions at schools (e.g. working climate, curriculum, availability of new media) etc. promote innovations in classrooms?

What kind of influence do teachers have on regulations (curriculum, assessment, etc.), on standards, or on the status of their profession?

Is teachers' reflection on their profession seen as a relevant contribution to the education system? Does it promote professional communication and collaboration among teachers? Is it promoted by mathematics educators and researchers?

These questions again show that the *professional development of individuals, organisations and the educational system are closely linked with one another*. Here is an example which intentionally exaggerates the situation to a certain extent. Consider teachers who work in an educational system with narrow regulations on curriculum and assessment, who have had no influence on those regulations in the past and who will not be having any in the future, and who were educated at universities where lecturing was the dominant teaching method (which leaves the audience to reflect upon the learned content). Assume they are currently teaching at a school with a low level of communication among the teachers and are now confronted with in-service courses oriented only towards their weaknesses. Clearly they need very strong motivation not to regard students as "knowledge receivers", in the way they themselves have been educated. On the other hand, too often teachers complain about restrictive regulations that tend to hinder their innovations in classrooms, thereby underestimating the freedom of action they have or could establish. However, in just the same way as research on students' mathematical understanding shows that we systematically underestimate students' creative ways of thinking (when our focus is not restricted to hearing only things we want to hear), *we seem to systematically underestimate teachers' creative attempts to improve their teaching*. Many experiences of our work with teachers prove that fact.

### **3 The story about Nora and her department**

Nora, born in 1965 in the countryside, started her teaching career very early. Since the age of four, her uncle, a principal of a primary school, often took her with him into his classroom. When she actually did start primary school it was very boring for her. Nevertheless, she gained her first experiences as a teacher by correcting compositions and helping weaker pupils. Her decision to become a mathematics teacher in a secondary school was influenced both by different teacher personalities (her uncle, and the mathematics teachers in primary and

secondary school) and her own experiences of being a good mathematician who was successful in teaching other pupils.

### **3.1 Nora's teacher education and her first years of teaching**

Nora began her university studies of mathematics and sports enthusiastically. Unfortunately, she soon had to give up her sports studies due to a severe disease. Struggling with her situation and looking for alternative possibilities she decided to study mathematics and history at another university. Unlike the first university where she was one among many, here the number of students was rather small and she enjoyed the familiar and pleasant atmosphere. She financed her studies with private lessons and took different summer jobs.

In her 'Mathematical curriculum vitae' and in one of the interviews, looking back, Nora stressed that her learning experience at the university had a great impact on her teaching. In particular, she liked teacher educators who put an emphasis on student teachers' understanding. She also highlighted one professor's clear and structured design on the blackboard and his ability to create an atmosphere which encouraged the students to put questions. However, with some exceptions, her teacher education at the university was mainly dedicated to the study of the subject matter and the teaching culture was mostly teacher-centred. Nevertheless, she often felt that her teacher education would be very useful for her teaching career. After finishing her mathematics and history studies at the university and successfully completing the practical year in a secondary school in 1991, Nora could not get a job as a teacher due to a lack of vacancies in schools. However, she was successful in gaining employment for three years (1991-1994) in charge of students after classes in the afternoon. The job was a great challenge for her because she had to cope with a lot of different problems all at the same time. There were 20 to 25 students ranging from the age of ten to the age of eighteen and they all had different mathematical difficulties and needed different teaching help. She had to invent a variety of methods to assist and motivate the students. Therefore Nora felt that this time was spent effectively and was instructive for her career.

In 1994, Nora got her first job as a mathematics teacher in a secondary school (grades 5 to 12). She enjoyed teaching mathematics to younger students but felt uncomfortable with the fifteen-year-old ones when her efforts to engage and interest them remained rather fruitless. In addition to mathematics she had to teach computer science ("Informatik") which, due to a lack of an adequate education, caused her much stress. Although the contact among the mathematics teachers at this school was open and, for example, Nora shared teaching materials with a younger colleague, she did not get much professional support to meet the great challenges of her teaching.

A year later, Nora was happy to get a permanent job in another school near her place of residence. She gained teaching experience with pupils in all grades from 5 to 12 and soon became a member of the annual school report team. Nora's teaching style is mainly teacher-centred, although sometimes she gets students to work in pairs. She tried once or twice to implement group work in her teaching, but she was not successful, felt unhappy with the result and did not try it again. She thinks that in particular the weaker pupils need algorithms and recipes to solve tasks. If she perceives that the pupils have a problem in understanding, she explains again or she tries to find another task. Nora has learnt from experience that detailed preparation for lessons is an important aspect of good teaching, therefore she creates different approaches to a mathematical topic in order to be able to react to all the students'

demands. Nora does not only feel responsible for teaching mathematics but also for a good atmosphere in her classes. If there are outsiders in the class or students weaker in mathematics she makes sure that they are accepted by their classmates, and in this way she contributes to the class community. She points out that the contact with her mathematics teacher colleagues is friendly, but there is little communication about teaching methods or problems in mathematics teaching.

### *Reflection and networking*

Nora, who is about twenty years younger than Gisela, was educated at a university and at a time where teacher educators apparently put more emphasis on the understanding gained by their student teachers and on the topics that might be applicable for them in their career as a teacher. Nevertheless, the teaching culture remained mostly teacher-centred and group work was more the exception than the rule. Although reflection and networking among student teachers have been promoted several times, student teachers' actions as lone fighters dominated their teacher education. Influenced by that, Nora's teaching is also mainly teacher-centred but sometimes she uses partner work. Therefore subject-related reflection and networking among students remain limited to a few situations. In the same way, professional communication among teachers is more the exception than the rule and is confined to a few contacts with single teachers.

### **3.2 Professional development seminars for the department of mathematics**

In 1997, Nora was invited by the custodian of mathematics of her school to get involved in a school-based professional development project during the school-year 1997/98 in collaboration with an university team (for more details see Krainer & Thoma, 1998, and Thoma & Krainer, 1998). At the start-up meeting all five female members of the mathematics department participated. One male mathematics teacher was not able to come while another male colleague showed no interest in this project. The group of five teachers was mainly interested in alternative teaching methods. Nora was particularly looking for alternatives to her teacher-centred approach in classes of about 35 pupils. Her hopes for the project were both that she could improve and revise her teaching ideas and that the project could initiate, within the group, an exchange of experiences with alternative teaching and learning methods and the development of common new ideas.

During the one-year project, five to six participating mathematics teachers took part in four seminars led by the university team. With the exception of the first, which was a one-day seminar, each seminar lasted for one-and-a-half-days, spread across the school year in December 1997, January, March and June 1998. Similar to the collaboration with Gisela's department, the seminars were based on a "teacher as researcher" philosophy. One different feature was that each participant was expected to investigate one challenging aspect of his or her teaching practice during the school year, being supported by a friend from the group offering constructive criticism. In addition, the experiences with this practical work should be reported and shared during the four seminars.

At the *first seminar* in December 1997, six mathematics teachers participated. The seminar, like the following two, was held at the university. It covered three major issues:

- 1) Reflecting on the teaching practice of the participants;
- 2) An introduction to the idea and the methods of action research; and
- 3) Supporting the participants in finding their individual research questions.

Nora, having had negative experiences with her few attempts to implement group work, became curious again and the first draft of her research question was: “Why does group work or not work with me? In what situation does group work make sense? Which factors promote or hinder group work? What are important conditions for group work?”. Nora, back at school, was always confronted by these questions while continuing to teach her classes teacher-centredly. Her motivation and willingness to change something was very high during the seminar but decreased gradually during her daily work.

At the *second seminar* in January 1998 there were just five participants. The only male member gave up because, being fully engaged with a private part-time job, there was not enough time available. When at the beginning of the seminar the members of the group reflected on their ongoing individual investigation process, Nora pointed out that she knew what she wanted, but that she could not put it into practice. Her feeling at that time was ambiguous: “Although I have no feedback from my pupils I assume that they enjoy alternative methods, but I am worried I am wasting time with them.” Nora’s dilemma emerged: thinking about the large amount of teaching material needed, she felt under time pressure but she was also aware that she would not be able to investigate her research question without implementing group work in some of her lessons. Her motivation was given new life when during this second seminar she had to go some steps further in the planning of her investigation process and to discuss it with a critical friend (one of the other teachers) in a special format called “collegial advice”. This required both Nora’s clear presentation of her project and the colleague’s absolute attention in order that she might be able to understand the process, to ask for more details and to give critical commentaries and advice. Nora gave some reasons why this part of the seminar was so successful for her: “I learnt a lot in relation to my specific practical investigation project, team spirit was reinforced and conversation became more open.” In particular, the “collegial advice” reminded her again of the importance of listening and she recognised that sometimes effort and pressure are necessary to be creative. At the end of the second seminar she had the impression that her ideas had progressed. Having designed the next steps in investigating her research question and knowing that her friend would support her, she was now ready and confident to start with her experimental work at school. She introduced the students in her “study class” (39 fourteen-year-old students) to group work, beginning with a discussion of its rules. After a careful study of relevant literature on group work and after a detailed planning process, Nora organised two different group work tasks within the next ten days. Aiming at getting concrete results before the next seminar, she designed and conducted a questionnaire in order to find out how her students had reacted to this alternative teaching method. Nora was very surprised when she looked at the students’ answers. Concerning the question “Considering the whole teaching time - what would you like? ... % teacher-centred, ... % individual work, ... % group work” the students on average wanted the following mixture of teaching methods in mathematics: 50 % teacher-centred, 8 % individual work and 42 % group work. Nora was also impressed by the students’ seriousness and their fairness in answering the questions concerning the advantages and disadvantages of group work. In addition, she had not expected that her students would enjoy being allowed to express their opinions in such a way.

When at the *third seminar* in March 1998 Nora gave a report on her practical activities and when she analysed the answers and reactions of the students she felt extremely proud. Analysing the questionnaire in the group again, she pointed out that the question concerning the mixture of teaching methods was the most interesting for her. She even stressed that this answer “dramatically opened my eyes to the students’ wish for alternatives in comparison to

what I have done until now!” Comparing and evaluating her questions, the group of mathematics teachers at the seminar discovered that 80% of her questions involved decisions (the answers should help her to decide if she should use alternative methods or not) with 20% of her questions (the two last which she added later to her first draft) involving opinions (the answers should help her to understand the group work's effects on the pupils).

Since the beginning it has been very important for Nora to have entered the co-operation project. Now, however, all the expectations she had had at the beginning of the project had been surpassed. Originally, she had expected to get recipes as answers to all her questions and she did not know a lot about investigating her own practice. Her attitude towards research was ambivalent, because research seemed for her so far removed from what happens in school. Now she has learnt that she can do her own small-scale research and thus find answers to her questions. Back at school, Nora put some ideas into practice which she picked up during the third seminar. There the university team designed actual examples of introducing a mathematical topic to enhance pupils' understanding. In addition to that, Nora critically reflected on the curriculum and changed her attitude towards it, no longer believing that all mathematical issues are of equal importance: “I will try to focus on those issues that have relevance for the pupils' everyday life and to use more alternative teaching methods.” Although Nora sometimes felt that she had, for example, time difficulties with group work she was not happy to be forced into stopping the students presenting and discussing their results. She continually tried to broaden her teaching style and to give more freedom to the students, all the while creating situations which challenged them to become more self-reliant. One strong motivation for this is her desire that the students feel comfortable with such situations and hence she respects their wishes.

At the *fourth seminar* in June 1998 five female teachers from the school again participated. However, the custodian of the mathematics department had become pregnant and in her place, another colleague, coming back from her period of rest, joined the group. In addition, one teacher knew that she would not be at the school in the next school year, but nevertheless she decided to take part in this last seminar with the group. This fluctuation within the group sometimes slowed down the communication process. Things that had been negotiated earlier had to be (re-)constructed again, pairs of critical friends had to rearranged, etc. This time the seminar was held in the city where Nora had begun her university studies. This city was chosen because the group wanted to observe the mathematics teaching of one of the seminar leader's classes in order to experience methods (e.g. group work) with students who were accustomed to alternative teaching styles. An essential part of the seminar was carrying out student interviews and jointly analysing them. When Nora, together with her critical friend, interviewed a group of three students, she became disappointed in finding that these students did not appreciate alternative styles much. It seemed to her that it was not worth the large amount of time and effort which such teaching involves.

In November 1998 and March 1999, again at the university, two two-hour meetings were held with the three teachers who remained from the original group in order to get informed about their further developments in the following school year. Nora reported that she had successfully carried out some group work in different classes. She pointed out that she learned much from the co-operation project and that she is now well equipped and capable of undertaking the next steps. In particular, Nora is busy in further developing her approach to assessment. She indicated that the communication is good and that a climate of helpful support exists within the group of mathematics teachers.



### *Reflection and networking*

How can we describe the professional development of Nora and the group of mathematics teachers in the school-year 1997/98 in terms of reflection and networking? Before the project started, the mathematics teachers at Nora's school were more or less a loosely associated collection of lone fighters. There was some communication among them, in most cases however it was not related to the challenge of teaching mathematics. Many teachers complained about the lack of professional development days and the lack of a culture of open communication. Like most of her colleagues, Nora preferred teacher-centred instruction. For example, only two of them pointed out at the start of the project that they had experience of group work. Nora was among them, but her experiences had been rather negative. The four seminars gave the group an opportunity to reflect on their practice and to share their experiences. Often teachers, motivated by reports from their colleagues, picked up ideas and put them into practice in their own teaching. The fact that participants also reported about experiments that were not very successful, encouraged them to speak more openly about their problems and to build mutual trust. On the one hand the decreasing size of the group was partially felt as a loss of identity and power, on the other hand it gave the remaining participants more time to reflect deeply on several issues. All teachers who participated till the end of the project stressed that they benefited from the professional communication among the group, in particular from the support and constructive criticism of their friends. In general, the teachers increasingly aimed at giving the students more freedom in learning mathematics and questioned their traditional role in the classroom. The four seminars brought the mathematics teachers closer together, however it would be an exaggeration to say that after the project they were a close-knit group. The relationship to the (provisional) principal was not very close during the project. He tried to motivate the mathematics teachers to write down their experiences, e.g. to publish the experiences in the local newspaper or to give a short report of the project which he could present to other principals in one of their meetings. The principal was seen as someone who aimed at advertising his school's projects in external domains whereas his teachers were more interested in internal change processes. Therefore he was not quite successful in motivating the mathematics teachers to write about their activities. As a consequence, the annual school reports do not refer to the group's efforts. However there was one pedagogical conference at the school at which the custodian of the mathematics teachers reported briefly on their project.

#### **4 Comparing the stories of Gisela and Nora and their mathematics departments**

What makes it worth comparing the stories of Gisela and Nora and their mathematics departments? Certainly both stories give an insight into a variety of factors that influence the professional development of teachers. Furthermore, they show the advantages and limitations of individually-oriented programmes and seminars in contrast to school-based approaches. However, one key argument for the comparison of the two stories is the opportunity to show that even two professional development projects, which are based on the same philosophy, can have quite different impacts on teachers and their departments due to different organisational contexts.

At first glance it seems justified in regarding the development of Gisela and her department as being more successful. However, taking into account the different contexts in which these

teachers, their groups and their schools work and live, this first impression becomes more and more questionable.

In the following, the two cases are compared at different levels in order to highlight some major differences in their contexts:

- *The two teachers Gisela and Nora:* Both are very active mathematics teachers who also feel committed to the further development of the whole school. Gisela, about 20 years older and thus having much more experience, plays a key role at her school. Having an intensive professional development programme as a background, she has been promoted to custodian and later to vice-principal of her school. Nora, in contrast, has not yet achieved such a position of power hence in this respect she represents a more “normal teacher”. In both cases, the teacher pre-service education had a great impact on their didactic actions and beliefs and led to a teacher-centred style, whereas the professional development initiatives of the mathematics department promoted their reflection and networking and motivated them to change some features of their teaching.
- *The two mathematics departments:* Both groups started the professional development initiative with about the same number of participants, namely 6 or 8 mathematics teachers (in each case having one teacher at the department not joining the group). However, whereas Gisela’s group remained more stable and – due to the schools’ growth – even increased in size, Nora’s group was partially handicapped by fluctuation and decreasing size due to personal and organisational issues. Whereas Gisela’s group from the very beginning consisted of three male teachers, Nora’s group – with the exception of one seminar where one male colleague (of two) participated - consisted totally of female teachers.
- *The two schools:* In Gisela’s case the principal, the vice-principal and the custodian played very crucial roles for the department. One main reason for this is the fact that Gisela herself is the vice-principal, was the former custodian of the group, and hence she has a good relationship with the principal who is an experienced manager of the school. He supports initiatives by teachers but keeps himself more in the background. The school undertook several attempts to proceed further in organisational development, and the promotion of innovations is a key strategy of this school. This made it easier for Gisela’s group to write down their experiences in the annual school reports. For Gisela and her group it was clear that the seminars should be held at their school. The culture of the school as well as its suitable accommodation supported this decision and thus contributed to the success of the professional development initiative. In contrast, Nora’s school had a provisional principal who did not know for sure whether he really would become the principal of that school in the future. The vice-principal is a member of the group of mathematics teachers but she was never the custodian of that group and she is very busy in tackling many of the school’s internal challenges. During the project, the custodian became pregnant and had to hand over her function to another colleague who later got a job at another school. Nora’s school, partially because of the uncertain situation regarding the principal, did not show extensive and joint efforts towards its own further development. The provisional principal sometimes tried to motivate the mathematics teachers to report about their activities but, however, they felt that, at least in part, this could be seen more as an opportunity for him to demonstrate his success than for them to demonstrate their struggle for professional growth. For several reasons Nora and her group preferred to hold the meetings away from their school which then had an impact on the professional development initiative. For example, it was not possible to integrate working

sessions with students spontaneously or to have contact with other colleagues or the principal.

Given all these factors that influenced Nora and her department, and considering the relatively low external support and the small amount of time, namely four meetings during one school-year, one can surely point out that these mathematics teachers were relatively successful in further developing their practice.

All in all, the stories of Gisela and Nora and their departments of mathematics tell us that professional development activities that put an emphasis on reflection and networking can promote teachers' growth considerably. Nevertheless, helping foster developments is essential and requires:

- different kinds of *internal and external initiatives and support*,
- enough *time*,
- *general conditions* on
  - the *individual* and the *organisational level* (e.g. importance of principals and school culture),
  - the *educational system level* (e.g. support of school development processes, role of mathematics in society).

The stories show that these three levels are *closely interconnected*. The *quality of mathematics teaching* does not only depend on issues concerning mathematics in a narrow sense, but to a great extent also on organisational aspects that should not be underestimated in mathematics education. If we, as mathematics educators, are not ready to raise these issues we will be confined to working in general conditions that are constructed by politicians, educational researchers, test developers, etc. To improve mathematics teaching paradoxically means to detach ourselves sometimes from mathematical issues in order to be free to enhance its importance in our society.

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