THEORY AND PRACTICE: FACILITATING TEACHERS' INVESTIGATION INTO THEIR OWN TEACHING:
Reflection on Barbara's teaching experiment

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1 The context: A professional development course

The Austrian professional development programme "Pedagogy and Subject-specific Methodology for Teachers" (PFL) aims at promoting secondary teachers of different subjects (among others in mathematics and science) in their efforts to improve teaching (see e.g., Krainer, 1999). Each PFL course is attended by about 30 participants, lasts for four semesters and consists of a variety of formats, in particular three one-week seminars, five one and a half-day group meetings and individual practical work.

Promoting active learning processes and reflecting on them is a basic strategy of PFL in a dual sense. Firstly, with regard to an epistemological understanding of learning which sees the learner as an active producer of knowledge rather than a consumer. Secondly, with regard to the conviction that the transfer from the course to the classroom – where students also should be seen as producers – is more successful if the participants learn such processes through their own experience. In the courses, an attempt is made to find useful ways in which teachers can engage in professional exchange of knowledge, making their innovative work accessible to others, and thus promoting a culture of communication on educational issues. It is an important intention of the programme to help teachers find ways to make their private ideas public.

Action research, which is understood as the systematic reflection of practitioners on action (see e.g., Altrichter, Posch & Somekh, 1993), is used as a means to achieve a broader understanding of situations and to improve the quality of teaching. Teachers are regarded as professionals who systematically aim at investigating their own practice. The teachers in the course are supported in writing case studies on innovations introduced in their schools.

The team members of PFL-mathematics (2000-2002) were two university mathematics educators and two experienced mathematics teachers. They were responsible for the preparation and realization of the course and for follow-up activities such as evaluation and publication (see e.g., Kröpfl & Peschek, in preparation). The team members supported the teachers in the writing of their *case studies*. In the following, a short description of the case study of Barbara (Pfeiler, 2002), a female participant of the PFL course, is given from an external perspective (the author of this contribution was not a member of the team).

2 The story: A teaching experiment on fractions

The *main idea* of Barbara was to create a learning environment where students could autonomously and collaboratively work out one of the rules for fractional arithmetic (+, -, x, :) and then were expected to teach their colleagues. Barbara did a lot of preparation work at home. In the classroom, however, she confined her role to giving support on a low intervention level and thus – which was totally new to her – had much time to observe the learning process of her students and to gather data in order to analyse the outcome of her teaching experiment. But how did this plan emerge and what was the question that guided Barbara's systematic reflection? Barbara describes herself as a teacher who likes to experiment and is always looking for something new[1]. In 2000, when a new PFL-Mathematics course started, she decided to participate and to use the course as an opportunity for improving the quality of her teaching. At that time, she had been working as a mathematics teacher for about ten years at the same urban secondary school (where she also had started her teaching career).

The *motive* for the teaching experiment was differences in achievements among her mathematics class of 6th grade students (16 girls, 18 boys), of which she also was the form teacher. Based on experiences with former mathematics lessons in this class where better students liked to help and were successful in helping weaker students when working with a programmable calculator, she wondered whether "students teach students" would be an approach that would allow her to improve her teaching in general. She looked for alternative forms of instruction where social interactions among students are intensively promoted. Barbara was convinced that social interactions might improve both the students' cognitive achievements and the classroom climate. From a colleague who taught another subject in her class she was informed about "jigsaw puzzle teaching".

In her *planning*, Barbara modified the method into a three phase-model: firstly, pairs of students have the task to work out one of the four rules for fractional arithmetic; secondly, four bigger "expert groups" meet where (in each case eight) students share their knowledge and prepare for teaching their topic; thirdly, eight groups of four students work in parallel whereby each of the four students is expert for one topic and teaches it to the other students; the two remaining students serve as observers of the teaching process. Before starting the experiment, Barbara checked the pre-knowledge of her students and prepared control tasks for the first phase. At the end of the unit she used two kinds of informal tests in order to evaluate whether the students had

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[1] The story about Barbara follows very closely the description in her case study (see Pfeiler, 2002). For example, "likes to experiment in teaching" and "always looking for something new" are verbal translations, however, in order to facilitate fluent reading of the story, they are not marked as quotations in the text.

acquired the knowledge intended and she also integrated one corresponding task on fractions into the next assessment test.

Barbara had a number of questions in her mind for which she wanted to get feedback. However, she was mostly interested if the students had really achieved the intended goals with that method. Therefore, she restricted herself to one *research question*: Is it possible, that, when using the jigsaw method of teaching, the students are able to work out the rules for fractional arithmetic (+, -, x, :) themselves and are able to apply them?

Barbara collected a number of *data*. She organized observation and feedback from different perspectives: from two colleagues (each of them observed for one lesson different groups in the "students teach students" phase), from two students who were not involved in the learning activities but acted as observers, she herself observed the process and kept a diary and used the results of the students' achievements and their answers to a written questionnaire (evaluation of the whole teaching experiment) as data for her analysis.

Concerning the *results* of her teaching experiment, Barbara reports that – apart from some minor limitations – the goal has been reached: nearly all students understand the most important rules for fractional arithmetic and are able to apply their knowledge. The students worked with concentration on their tasks. Half of the students expressed that teaching other students was a very difficult task, however, also half of the students estimated that they understood the explanations of their colleagues very well. Even weaker students had experiences of success. All students stated that they would appreciate having a similar teaching more often. However, the analysis showed also some aspects where Barbara saw the need for improvements. For example, the division into the four rules was not optimal since the complexity of the task was rather heterogeneous. Partially connected with that, she realised that the teacher needs a sensible time management and in particular has to put attention to the pace of "slower groups". Barbara felt that she could have given the students more autonomy in choosing tasks and methods. Working with this approach is very time-consuming, therefore it is not possible to teach like this all the time. However, she really intends to carry out such projects again. *"It was fun"*, was one written feedback by a student, and Barbara feels that there is nothing better for a teacher than such a comment.

Apparently, the teaching experiment was a success for Barbara and her students. The PFL course provided her with a professional community where she was supported in planning, carrying out and evaluating her project and in writing down her experiences. There was a *strong connection between the two social systems*, her teaching in class, and her learning within the course. In the following, a theoretical perspective is presented which will be used to reflect on both systems and their interconnection.

3 The theoretical perspective: action, reflection, autonomy, and networking as dimensions of "learning systems"

The following considerations are based on the assumption that social systems (society, educational system, school, teacher education institute, mathematics department, classroom, family, teacher, student, etc.) can be very different, but, however, can be regarded through the lens of some general dimensions that are fundamental for their further development. Social systems can be seen as *"learning systems"* when the interaction of the actor(s) within the system or with relevant environments (other systems, e.g. sub-systems and higher-systems) are characterized by the following four dimensions[2]:

- Attitude towards and competence in experimental, constructive and goal-directed work (*action*).
- Attitude towards and competence in reflective, (self-)critical and systematically based work (*reflection*).
- Attitude towards, and competence in, autonomous, self-initiative and self-determined work (*autonomy*).
- Attitude towards and competence in communicative and cooperative work with increasing public relevance (*networking*).

The four dimensions are intentionally described in an abstract form in order to be able to apply them in different systems. Concerning a "learning school", for example, the dimension "autonomy" might refer to a team of mathematics teachers of that school. "Networking" then refers to their interactions with other relevant systems within or outside their school, e.g. other mathematics teachers, other departments, the principal, parents, a mathematics educator team at a university or the inspectors of the region. A joint relevant action of this team of teachers might be the development of a new curriculum, whereas reflection might refer to meetings of the team evaluating the progress of the implementation of the curriculum. Inviting experts (e.g. from university or teachers from other departments) in order to discuss their experiences can be regarded as actions that lead to more intensive reflection and networking, however, will probably result in the teams' improved autonomous actions.

The concept of "learning systems" makes use of several theoretical backgrounds: The interplay between action und reflection is e.g. a prominent feature of *action research* (see e.g., Elliott, 1991), the interplay between autonomy and networking marks a link between *cognitive and social constructivism* (see e.g., von Glasersfeld, 1991, or Ernest, 1994). System theory (e.g., Willke, 2000) puts an emphasis on considering different relevant environments.

[2] More details can be found e.g. with regard to teaching mathematics (Krainer, 1993), teachers' professional practice (Altrichter & Krainer, 1996), and "learning systems" in different matters of mathematics and science education (Krainer, 2002).

4 Explaining the progress: Barbara's classroom and her professional development course as "learning systems"

Barbara's teaching experiment shows a rich dynamism concerning the above-mentioned four dimensions. The first phase can be visualized as follows (fig. 1):

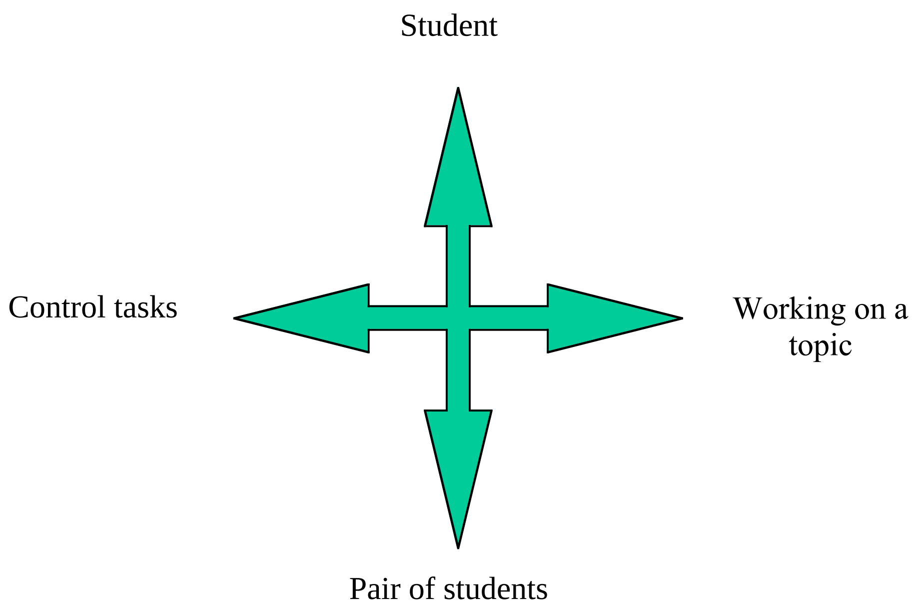

Figure 1: The classroom as "learning system"

The students worked in pairs and thus shared their knowledge on the specific topic. Control tasks by the teacher helped them to evaluate whether their learning actions led to the knowledge intended. In the second phase, all pairs who worked on the same topic met and formed an expert group. They exchanged their experiences and tested each other with different kinds of tasks, thus constructing more and more a common understanding of the topic. In addition, the joint planning process for the following teaching phase intensified that effect. Because each student knew that he or she would have to act as an expert in the last phase, all were interested to test their knowledge and to compare it with others. In the third phase, each student was one time the teacher and three times the learner. This not only meant that explaining something to others and reacting to their questions broadened the knowledge of the (teacher) students, the students also learned about different styles of teaching and learning, thus enlarged their meta-cognitive learning. The main contrast to traditional teaching is the fact that the teacher does not aim at transmitting knowledge directly to the students but at facilitating active and autonomous learning of the students. In order to enrich the learning process, the teacher promotes intensive networking of a student's learning with other students' learning and initiates reflections on their actions with the help of control tasks (which in turn helps the teacher to evaluate students' growth of knowledge). Reducing the teachers' role to a facilitator not only increases students' responsibility for their learning process but also gives the teacher time for observation, reflection and goal-directed help for individual students, groups or the whole class. Decreasing teacher's direct involvement in the process changes the kind of steering of the system. In traditional teaching the teacher steers the process by her own *input*. Alternative approaches put more emphasis on students' active construction *processes* and/or on steering by *output* (which in teaching can be regarded e.g. through the lens of competences in connection with the formulation of learning goals). It is assumed that vivid learning processes need a balance of all three aspects, namely input, process, and output. Barbara's approach increased students' ways of actively constructing their knowledge, however, the clearly formulated tasks and the relatively dense net of control tasks gave her always the feeling that students' learning routes remain in a certain field of expected development. On the one hand, Barbara expressed as a result of the experiment that she could have left more scope of freedom to the students; on the other hand, changing teaching habits needs steps that are not too big. Changing one's own teaching involves a delicate balance of trying out new ways while sustaining aspects that guarantee security.

Important features of security are one's own observations of the process and feedback by others who have some expertise in evaluating such processes. Apparently, Barbara's professional development course offers her opportunities to try out an investigative attitude and to find interested colleagues that share her struggle for improving the quality of her teaching. This seems to indicate that the course serves as an adequate "learning system" for teachers like her. Thus a closer look at the four dimensions seems worthwhile.

In PFL, all teachers are expected to investigate their own practice and to write a case study as a documentation of that process. The work on the case study is a major pillar of the course and is done within a "network of critical friends". The visualization below (fig. 2) sketches the interplay of the relevant dimensions.

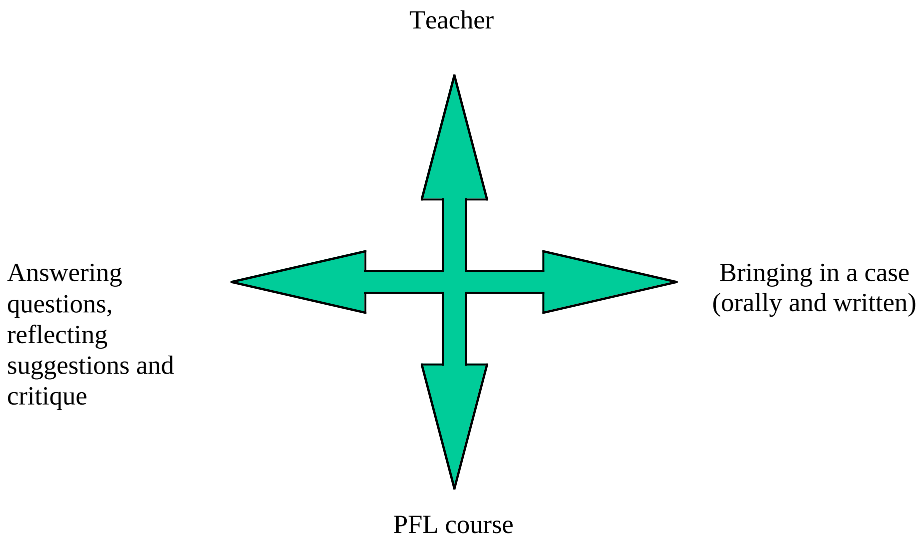

Figure 2: The professional development course as "learning system"

The choice of the topic of a case study is an autonomous decision by each participant and builds on his/her own interests and needs. The teachers get support within the PFL course at several stages.

In general, the second one-week seminar includes units where the research question and other relevant issues are discussed. This is mostly done in smaller working groups where participants meet who have similar topics for their investigation. After the second seminar, these groups – each supported by one team member – refine their individual plans, carry out and analyse their investigation and meet one or two times before the third one-week seminar in order to share their concerns and open questions. All teachers present their specific cases, answer questions and reflect on suggestions and critique. These small *professional communities* not only support each participant to proceed with his or her own project but also generate a deeper understanding of critical reflection of one's own teaching, of formulating research questions, of looking for evidence based on viable data, and on methods that help to gather that data. At the third one-week seminar, again all participants meet and provisional forms of the studies are discussed. Writing down the experiences is for many teachers a real challenge. It means not only an additional circle of reflection but also a way of formulating the process and the results in a way that others can benefit from it. Therefore, the team members pay special attention to the efforts of writing the case study within their working groups. This includes, among other things, written feedback to at least one provisional form of the case study. In order to keep the process of facilitating teachers' investigation at a comparable level, an intensive exchange among the team members is organized. Each written feedback to a case study is checked by a "critical friend" or even negotiated within the whole team. Partially, this holds also true in the case of oral feedback. Thus a lot of reflection and networking among participants, among team members, and between these two groups are promoted. This leads not only to a higher quality of autonomous thinking and acting of teachers and educators, but also to a further development of the course as a "learning system". Reflective knowledge of mathematics teachers is made visible and accessible to a wider public and thus contributes to the further development of the teaching profession. In addition, more practitioners develop a sense of research in mathematics education and thus the number of research-interested people is enlarged and more *links between theory and practice* are built.

The plenary panel at this conference itself shows elements of a "learning system" since it organizes time and space for sharing different cases of theory-practice-relationships, and thus helps our scientific community to deepen its understanding with regard to that issue. The panel provides the participants alternative views and reflections, which might have an impact on their own practice, and probably inspires them to organize *joint reflections of theoreticians and practitioners* on classical research projects, or on investigations of teachers (at universities and schools) into their own practice.***References***

Altrichter, H., Posch P. & Somekh, B. (1993). *Teachers investigate their work. An introduction to the methods of action research*. London: Routledge.

Elliott, J. (1991). *Action Research for Educational Change*. Buckingham: Open University Press.

Ernest, P. (Ed.) (1994). *Mathematics, education and philosophy: An international perspective.* London: Falmer Press.

Krainer, K. (1999). PFL-Mathematics: Improving professional practice in mathematics teaching. In B. Jaworski, T. Wood & S. Dawson (Eds.), *Mathematics teacher education: Critical international perspectives* (pp. 102-111). London: Falmer Press.

Krainer, K. (2002). Ausgangspunkt und Grundidee von IMST_. Reflexion und Vernetzung als Impulse zur Förderung von Innovationen. In K. Krainer, W. Dörfler, H. Jungwirth, H. Kühnelt, F. Rauch & T. Stern (Eds.), *Lernen im Aufbruch: Mathematik und Naturwissenschaften. Pilotprojekt IMST_* (pp. 21-57). Innsbruck, Wien, München, Bozen: Studienverlag.

Kröpfl, B. & Peschek, W. (in preparation). *Lehrerinnen und Lehrer auf dem Weg zur Professionalität. Dokumentation des Universitätslehrgangs „Pädagogik und Fachdidaktik für Lehrer/innen (PFL) – Mathematik.* München, Wien: Profil.

Pfeiler, B. (2002). *Schüler unterrichten Schüler – oder der Puzzleunterricht in Mathematik (Students teach students – or Jigsaw teaching in mathematics).* Case study within PFL-mathematics 2000-2002. 39 pages. Klagenfurt: IFF.

von Glasersfeld, E. (Ed.) (1991). *Radical constructivism in mathematics education*. Dordrecht, Boston, London: Kluwer.

Willke, H. (2000). *Systemtheorie I: Grundlagen* (6th. Ed.). Stuttgart: Lucius & Lucius UTB.