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Effects of a Long-Term Participatory Action Research Project on Science Teachers' Professional Development

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This paper describes the potential of long-term co-operation between science educators and science teachers concerning the teachers' continuous professional development, based on Participatory Action Research in science education. The discussion is based on a six-year case study observing a group of about ten German chemistry teachers by chemistry educators from the university. Substantial changes in teachers' professional habits and views were found. These findings will be theoretically framed within the Pedagogical Content Knowledge (PCK) debate, a model representing three different modes of action research and the Interconnected Model of Teachers' Professional Growth (IMTPG). The following discussion will provide an explanation of the changes in the teachers' professional attitudes and views. This is based on a description of overcoming the participatory approach by addressing essential elements of teacher emancipation. Consequences for classical approaches of in-service teacher training are discussed.

Keywords: Participatory Action Research, PCK, IMTPG-Model, Teachers' Professional Development, Participation/Emancipation

INTRODUCTION

An action research project of a group of roughly ten secondary level chemistry teachers has been underway since summer of 1999. Originally accompanied by chemistry educators from the University of Dortmund, the project has been directed since 2004 by the University of Bremen (both Germany). The starting point for establishing this kind of co-operation came from considerations that substantial curriculum development at the university level can only be realized in a give-and-take process based on teaching experience and already existing research evidence (De Jong, 2000; Eilks & Ralle, 2002). Furthermore, this give-and-take process has the function of overcoming the '*two communities problem*': the difference in norms, rewards and working arrangements between researchers and practitioners (Huberman, 1993, p. 2).

The foci of the group's work largely concerned itself on the development, testing and evaluation of altered teaching approaches towards the particulate nature of matter in lower secondary school chemistry teaching (e.g. Eilks, Möllering & Valanides, 2007). Later, it also covered the implementation of innovative teaching methods, especially in the areas of co-operative learning (e.g. Eilks, 2005), the reflective use of ICT (e.g. Eilks, Witteck & Pietzner, 2009), and in recent years it has moved towards curriculum development for a socio-critical and problem-oriented approach to chemistry teaching (e.g. Marks, Bertram & Eilks, 2008). During the last six years a large amount of evidence-based curricular structures and materials have been developed. Also, data were generated to describe implementation and effects of structures and materials. Since 2004 some of the

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State of the literature

- Action Research is widely applied in science education. It is used as a strategy for research-based innovation of practice and supporting teachers' continuous professional development.
- Different models of Action Research are described in the literature. Three modes of Action Research are suggested to differentiate the single models, namely a technical-supportive, an interactive-participatory, and an emancipatory mode.
- Different constructs of describing teachers' professional development are available. Prominent in science education are approaches describing change in teachers' PCK or the Interconnected Model of Teachers Professional Growth (IMTPG). But, both models were not used so far to reflect teachers' professional development in science education by Action Research.

Contribution of this paper to the literature

- This study describes a six year long case study on chemistry teachers' professional development while working in a project of Participatory Action Research in chemistry education.
- Different models for understanding teachers' professional development are used to reflect the change in the teachers' professional development, namely models of PCK, the three modes of Action Research by Grundy, and the IMTPG.
- The paper interprets teachers' professional development while working in a project of Participatory Action Research in chemistry education by the ideas of participation and emancipation.

teachers started to disseminate an overall implementation of the changed approaches via publication of a new school book series in co-operation with the accompanying university chemistry educator (Eilks et al., 2005).

The two-communities-problem is not specifically related to chemical education, but it does exist in many other educational domains as well (Wilson & Berne, 1999). Huberman (1993) concludes that the only way to bridge the existing gap between research and classroom teaching or curriculum development is through *sustained interactivity*. He states that it is necessary to have '*multiple exchanges between researchers and potential "users" of that research at different phases of the study*' (Huberman, 1993, p.4). He suggests to looking for convergences between the scope of the research and the priorities and interests of the target public, as well as recruiting key actors in the target public to accompany the research and help to carry it out. This help within the carry out of the study is seen, e.g., in participating in the review and analysis of intermediate findings, or identifying data sets of greatest potential use to the target public. Finally, Huberman's understanding of *sustained interactivity* also includes common planning of how to make the results valuable to the target public and how to disseminate the findings into practice. A second motivation comes from different sources of educational evidence suggesting that sustainable reform and implementation can only be successful if teachers' beliefs, their prior- knowledge and attitudes are involved in the reform and are taken into account seriously (Haney, Czerniak & Lumpe, 1996; Nespor, 1987). That means that teachers' pre-knowledge and prevailing attitudes have to seriously be taken into account and must be developed step-by-step through experience-based learning and reflection (Huberman, 1993). That is why our project was based on action research, specifically on Participatory Action Research (Whyte, Greenwood & Lazes, 1989) in the interpretation for science education as described by Eilks (2002) and Eilks and Ralle (2002).

The original workgroup of six chemistry teachers was later expanded and currently is composed of fifteen teachers from various types of schools. The members have widely varying professional qualifications, ranging from now twelve to more than thirty years of teaching experience. Currently, ten group members take regular and active part in the monthly meetings. Of this core group, four teachers have been on board since the project's beginning, four more joined within the first year of the project, and the remaining two began in the second and third project years, respectively. The remaining five teachers are only loosely associated with the group and only infrequently come to the group's meetings, often due to the long travelling distances involved. Despite this fact, two teachers from the latter group were directly involved with the project for roughly the first four years of this study. This paper discusses this time frame, with the addition of data taken from the fifth and sixth years of the project. The group was accompanied by the same university chemistry educator over the whole time frame. Additionally, chemistry student teachers and doctoral students from chemical education were involved in the group's work from time to time.

During the regular meetings of the research group taking place every four weeks, minutes from the working group meetings were taken. Group discussions were conducted at least once a year to monitor potential changes in teachers' views and in their professional expertise. The group discussions were specifically evaluated with respect to any changes in the individual teachers' attitudes and their own estimations of the changes occurring in the practical aspects of teaching (Eilks, 2003).

This paper reflects the developments taking place over a six-year period and fits them into a new theoretical framework. This framework encompasses Shulman's (1986) concept of Pedagogical Content Knowledge, Grundy's (1982) differentiation of modes of action research and the Interconnected Model of Teachers' Professional Growth (IMTPG) by Clarke and Hollingsworth (2002). From this background, a perspective will be given for understanding teachers' professional development through the application of Participatory Action Research in terms of participation and emancipation.

Theoretical framework

One of the clear trends in science education which has shown itself both nationally and internationally in the past few decades is an intensified focus on questions about pre- and in-service science teacher training, including teachers' beliefs, their knowledge and professional development (De Jong, 2007). This has grown into the search for an understanding of teachers' subject matter knowledge base, pedagogical expertise, Pedagogical Content Knowledge (PCK) and into the growth of teachers' professional expertise in all these different fields. Especially with respect to the discussion about the PCK of teacher trainees and practicing teachers, researchers are constantly reminded of how little they really know about the personal knowledge, attitudes and learning processes of chemistry teachers. This is true whether we consider the subject taught by an individual teacher, specific content domains (Nespor, 1987; Pajares, 1992) or how such knowledge and attitudes interact with practical approaches to teaching (Calderhead, 1996). Today there is broad consensus that teachers need expertise in the subject matter area they teach, in general educational theory, and domain specific educational knowledge. But we also know that knowledge about teachers' knowing and thinking is essential for building effective teacher training programs (Eilks, Ralle, Markic, Pilot & Valanidis, 2006).

This paper stems from the background of domain-specific educational development and research, and thus primarily focuses on teachers' PCK. The term PCK was first suggested by Shulman (1986, 1987) to describe this specialized knowledge, which stands as a third support working in concert with the other two pillars: pedagogical and content knowledge. Originally, Shulman describes PCK as:

> *'The most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that makes it comprehensible to others.' (*Shulman, 1986*, p. 9)*

Using Shulman as a starting point, Van Driel, Verloop and De Vos (1998, p. 674) define PCK somewhat more generally as:

> *'Integrated knowledge which represents the teachers' accumulated wisdom with respect to their teaching practice. As craft knowledge guides the teachers' actions in practice, it encompasses teachers' knowledge and beliefs with respect to various aspects such as pedagogy, students, subject matter, and the curriculum.'*

Magnusson, Krajcik and Borko (1999) defined PCK as an independent and separate domain of knowledge, despite the fact that the borders between it, content knowledge and educational knowledge are not always sharply visible (see also Tobin, Tippins & Gallard, 1994). Magnusson et al. (1999) offered a framework dividing PCK into five areas: 1) orientation with respect to teaching, 2) knowledge of the curriculum, 3) knowledge of the testing of knowledge, 4) knowledge about learners and 5) knowledge about strategies of passing on knowledge.

In many cases, such knowledge is very specific and dependent upon the domain being taught. Teachers´ competence in the areas of general learning psychology and didactics - including a high level of subject matter knowledge - does not necessarily lead to ability to structure student-friendly teaching units on difficult topics in science. In this case, subject-specific pedagogical knowledge about alternative students´ beliefs (Lederman, Gess-Newsome & Latz, 1994) or available experiments, models and teaching concepts (De Jong, Van Driel & Verloop, 2005) is missing.

The PCK discussion also pushes teachers into the spotlight in their own capacity as learners, including the corresponding learning processes. The consideration is raised that such teacher learning is the key to bettering the quality of overall teaching (Anderson & Helms, 2001; compare also the discussions and results in Ralle & Eilks, 2002, 2004; Eilks & Ralle; 2006). In science education research there is a growing understanding that learning - even among teachers – is a constructive process (e.g. Eilks et al., 2006; Marion, Hewson, Tabachnik & Blomker, 1999; Wilson & Berne, 1999). This factor seems to be a frequently ignored idea in classical projects based on the top-down innovation of teaching practices. Teaching teachers demands time and must be based on changed practices, if innovation is supposed to be implemented in an intended and sustainable way (Eilks, 2003; Marion et al., 1999; Thompson & Zeuli, 1999; Van Driel, 2002). This thought is also reflected in the *Interconnected Model of Teacher Professional Growth* (IMTPG) by Clarke and Hollingsworth (2002). The IMTPG model reminds us that teacher training consists of a transfer process based on self-reflection and action, which is determined by four of the five domains important for learning. The personal domain (beliefs, attitudes, and pre-experience) and the practical domain (authentic teaching practices of the teacher) are equally important and play just as large a role as the external domain (topic requirements, media

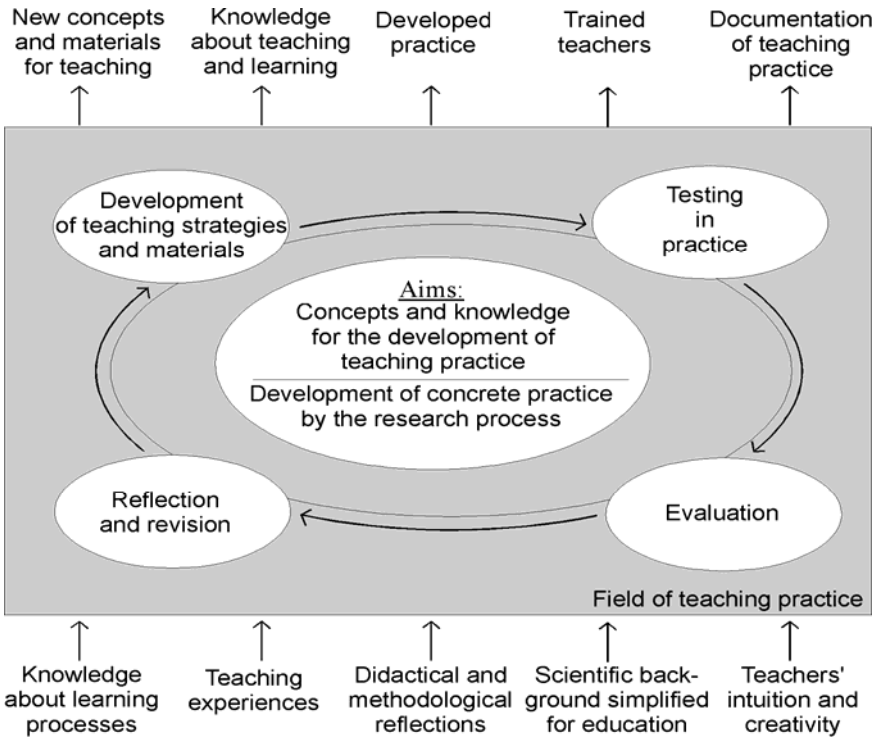

Figure 1. Research model of Participatory Action Research in science education (Eilks & Ralle, 2002)

and curriculum) and the domain of consequences (goals and effects).

Because of this, teachers should not be solely taught a persistent, structural process of innovation and in-service training, but rather one which also supports them in their own learning, thereby strengthening the ability to recognize and utilize their personal and practical beliefs. Huberman (1993) states that persistent and long-term interaction with people from outside the specific school setting is unavoidable for achieving research-based innovation of teaching practices. The process must be centered on collective reflections of both the teachers and their research partners with respect to current and altered teaching practices (e.g. Beijaard & Verloop, 1996; Haney et al., 1996; Riquarts & Hansen, 1998).

There are many different models capable of fulfilling this demand for sustainable interaction of practicing teachers and accompanying persons from the research domain. Each uses different methodologies and contains differing focal points under keywords such as *Content Focussed Coaching* (Staub, West & Bickel, 2003), *Teachers Learning Communities* (Putnam & Borko, 2000), *Knowledge-creating schools* (McIntyre, 2005) or various forms of *Action Research* (e.g. Bencze & Hodson, 1999; Eilks & Ralle, 2002; Feldman, 1996; Parke & Coble, 1997).

The following case study discusses the experiences and consequences of such long-term interactions in chemistry education in Germany.

Participatory Action Research in science education

The Participatory Action Research (PAR) model (Figure 1) has been described in many contributions to science education literature in recent years (Eilks & Ralle, 2002), either in a general form or regarding specific aspects (Eilks, 2002, 2003).

PAR attempts to disseminate better teaching practices through close co-operation of science education researchers from the university and practicing school teachers. It seeks to develop new curricular and methodological approaches and analyze them in authentic teaching situations, leading to an evidence-based understanding of results of the newly developed teaching approaches. The model also aims for the continuous professional development of all persons involved and sustainable change in the practice fields touched by the innovations. For achieving research-based innovation, a cyclical model of innovation, evaluation, reflection and revision is also applied. Furthermore, the ideas and suggestions for classroom innovations are constantly set into relation with available evidence from empirical research. For this connection, relevant research evidence is presented to the teachers in group discussion processes by the university researcher, and the results are compared to the experiences and attitudes of the practicing teachers. Such a process recognizes the consideration stressed by McIntyre (2005) that both empirically validated research results and experientially-based teacher knowledge are

two ends of a spectrum of knowledge about teaching and learning, both of which are equally important and have their own strengths.

EFFECTS OF PROFESSIONALIZATION INSIDE OF PARTICIPATORY ACTION RESEARCH – A SIX-YEAR CASE STUDY

Method and Objectives

This case study aims to describe the potential of long-term co-operation between science education researchers and practicing chemistry teachers in Germany. It follows the model of Participatory Action Research (PAR) with respect to changing classroom practices via teachers' professional development. The process of changes in teachers' views as an essential prerequisite for sustainably varying their behavior is based on regular, non-influenced group discussions among the action research group teachers. Such discussions took place at the end of each school year for the first six years of this now ten-year (and still counting) project.

Each group discussion focused on a reflection of the project's activities. It lasted for roughly 60 minutes and was recorded on video and audio media. Analysis of the data was performed by qualitative content analysis as described by Mayring (2000).

Each of the discussions was started with the open questionnaire described in Eilks (2003) which - after cessation of the concrete content-based examination of the project entitled 'New Ways to the Particulate Theory of Matter' (e.g. Eilks et al., 2007) - was also employed in the fourth and fifth years of the study. A second focus was on whether the teachers' attitudes about their teaching and their role in the process of innovation had changed at all. Questions for the analysis included:

- ✓ *How did the teachers feel about the co-operative curriculum development taking place in Participatory Action Research? In particular, how did they view the relationship between research and practice, researchers and teachers, in-service education of the teachers, and the development of teaching practices and curriculum items?*
- ✓ *Did the teachers feel a change in their own role and/or behavior in the project after the respective school year? Had there been any change in the relationship between the science education researchers and teachers from teachers' point- of- view?*

From the fourth year on, a growing saturation in the change in teachers' attitudes was observed (see below). After year six, the focus of the group discussions was systematically shifted more towards questions about the content and potential future activities of implementation and dissemination.

The reflection after the first year

In the self-reflection activity after the first year of co-operation, the teachers stated that they were very hesitant to express their opinions. They were also quite unsure about the goals of such co-operative curriculum development. Their original assumption was that they were taking part as *'consumers of new teaching approaches'*, which had been concocted by '*[university] science education experts'*[1]. They expressed a feeling that the movement towards active participation in the group had taken about a year to develop. This was, however, still tied to continuing uncertainty about the sufficient trustworthiness of the newly-developed curricular and methodological approaches, including their own ability to securely and practicably apply them.

The contributions of the teachers in the first year consisted mainly in trying out the new concepts and in checking out the developments proposed by the university researchers to see if they were applicable in practice. These activities were primarily described as a process of monitoring development with a permanent eye towards the '*needs and limitations'* of teaching practices for the first year.

Because of the above-mentioned reluctance in implementation, the participants emphasized that the conviction needed to implement the newly-developed curricular approaches would only be possible '*in connection with personal experience'*. Only this path was described as '*normal and common sensical'* for actively bringing oneself into the project. In this manner, it was made clear to the researchers that convincing one must occur as the first step: '*I always ask…I have to be two-thirds convinced, otherwise I cannot support it and carry it out.'* There were only preliminary signs of recognition that the overall developments were supposed to be undertaken in a common process and that the product should also be a commonly-negotiated final outcome.

In any case, all of the teachers expressed a feeling that the new approaches were better than the old ones and that there were definite advantages which could be seen in the changed practices. One teacher explicitly addressed the differences seen in the acceptance of the suggestions which had been introduced into teaching practice via ordinary channels: '*What I really liked was that we were getting input from teachers who stand in the classroom every day on the one side and from science education research, from the researchers on the other. I have my copies of science education journals at home and leaf through them when I have time, but quite honestly I lack the time to translate them into teaching concepts. [The researchers] can really look at what is happening overall with methodology in Germany as a whole.'* Even at the end of the first project year it was readily apparent that

[1] All quotes are taken either from the teacher discussions or open questionnaire.

contributions in teachers' journals were being evaluated '*with a different view*' and that the point-of-view of the practitioners had begun to change. Evidence of an emerging attitude of '*personal ownership*' of the newly-developed approaches became repeatedly clear, as did a growing distance towards other experts (e.g. authors of curriculum materials in teachers' journals). Participants repeatedly stressed that the widely variant approach to the particulate nature of matter developed within the framework of this project - which had not been adopted from published scientific literature - could have been successfully introduced. Such published representations in teachers' journals and educational literature were frequently categorized as so unclear and inauthentic that the teachers would not be able to directly use them in their classes.

With regards to their personal development, one other idea dominated the thoughts of the teachers. This centered on the exchange of ideas about personal teaching practices among the group members (see Dresner & Worley, 2006). The participants stated that simply '*speaking with the others…and getting ideas…automatically raised the level of professionalism*' and that '*although the meetings were extra appointments, I always found it very helpful and interesting to exchange ideas with my colleagues*'.

Reflection after the second year

The second year of co-operative work showed an even stronger shift towards self-reflection among the teachers. Even the focus of the group discussions was different. Now, instead of mainly debating the advantages and disadvantages of the changed teaching approaches with respect to content, the group discussed the developmental process and the meaning of the process for the individual.

All of the participants said that their own level of activity inside the group had experienced a clear increase. They called this an '*exchange*' which occurred '*much more than in the beginning*'. This was often mentioned in the context of starting a second trial run of the changed approaches under supervision, especially the possibility of receiving feedback and carrying out joint reflections. Statements like '*Now I know what I should have done differently last year*' were typical for this mindset. The teachers also said that the long-term co-operation had led to increasing openness inside the group and a tendency to self-confidently and actively bring their own criticisms and ideas into play. Many of the teachers described an increasing feeling of being able to competently reflect upon their own teaching and ability to better exchange ideas. Listening as a group to how problems occur in other schools was seen as very helpful: '*You see everything more self-critically and examine your own teaching much more closely than you had beforehand*'. Three teachers in the group explicitly described themselves as increasingly '*more strongly reflective and more self-critical when compared to our previous, personal teaching practices. You examine many things more intensively, textbooks for example.*' One participant even defined the main value of working in a group as the hindrance of becoming '*pedagogically fossilized by years of teaching*'. Another outlined a learning process of his own personal '*misconceptions about the nature of learning*' of pupils.

The development of reflective competence goes hand-in-hand with a growing ownership of the changed curricular approaches and teaching methods. These become the personal concepts of the group and, thereby, of the individual educators. Two teachers described this change as leading '*from a teacher who initially wanted to be trained, into a colleague and convinced defender of the new concept*' or as '*from being a consumer in a group to an activist*'. However, it became evident that such conviction only took place when practitioners became comfortable with the new approaches, were supervised and were provided with concrete examples from the relevant subject matter. Additionally, it became apparent that '*to convince educators to change their own practices, it is necessary to couple this with their own experiences*'. Especially important was an exchange with other practitioners in order to negate the '*blindness of one's own actions*'.

Individual but persistent criticism was given of the recurring difficulties involved in successfully passing on relevant knowledge about personal teaching practices to the teachers'colleagues. A '*fog of disinterest*' was their general description, a perception which fits in tightly with the above-mentioned attitudes towards magazine articles as interesting, but never implemented. However, the participants placed the main emphasis during this phase not on a successful transfer of teaching materials '*that we are developing here, but rather that things generally change so that the co-operation between university and schools works with a little more common sense*'.

A change in teaching practices was also mentioned. However this was related back to the changed teaching concepts. The participants themselves expressed further changes due to their own professionalization with a focus on '*a totally different view towards methodological variety*' as the main point. As causes for this, the teachers named the exchanges taking place inside the group, the contact to science education research results and comparison of these realizations with their own beliefs and experience.

Reflections from the third year onwards

From year two onwards, individual practitioners began to start their own initiatives for the group, with an even larger jump seen in the third project year. These included activities in establishing in-service training courses with the presence of accompanying science educator, either in their own schools or in the

environment surrounding their own schools. First attempts were also made to transfer the changed teaching approaches and methods to other topics and/or other subject areas. This was a first central focus in the group discussion after year three. It showed a growth in self-confidence in being leaders for educational change and being able to change personal practices with an increasing independence from the accompanying science educator. The group discussions also took on another character in the third – but even more strongly in the fourth – project year. The reflections stemming from year two were confirmed and strengthened. New, hesitant arrivals to the group were even convinced to set aside their own reluctance based on personal experiences.

The main focus of the discussion quickly switched to a content-based train of thought. However, reflections about what had already occurred were rapidly replaced by an offensively-geared discussion of individual problems and the future of the group. The influence of the science education researchers on the subject-based content of the work began to lessen at this point. The teachers spoke of a '*change of roles*'. The competence of the supervision and the possibilities represented by the university background were still evaluated as integral and necessary. An outside-influenced determination of approach or main content emphasis, however, hardly took place after the third year. Parallel to this development, individual group members began to try out the group's ideas in their own teaching on other topics, and to actively introduce ideas and materials into the group. They also took over leadership of the group in certain phases. This development was also discussed and reflected upon by the team.

The discussions in the second year showed a marked reluctance to speculate on the motivations of the participants' colleagues in school, who were described as being '*feet dragging*'. By the fourth year, however, the participants presented themselves in a much more self-confident and convinced manner when dealing with this topic. This process increasingly grew stronger and is also clearly visible in the reflections stemming from the fifth year of the project. Realistically, however, it was also mentioned that a broadening and deepening of such changes is '*incredibly arduous, but I see hope in it, too*'. One suggestion to the colleagues was '*to start extremely small, beginning with a single worksheet*'. One of the teachers' main motivations of such efforts was called '*taking the heavy workload of teachers*'. The participants also expressed a wish for '*many, many more networks in this form*'.

Another growing focus of the discussions in the fourth to sixth year was an intensified discussion towards the role of stakeholders in the educational arena. Whereas in the first year one argument always touched upon the question of whether the new ideas fit governmental policy and the regulations set up by the school, the discussion now shifted. From the third year on, the described distance towards authors in teachers' journals and textbooks also expanded to include the educational authorities. Most often the teachers plead '*for going at least one step further*' than they had originally expected to take in the initial phase of planning. A growing distance towards the traditionalist approach of copy and pasting old syllabi into new ones and also making every textbook '*a compromise of the lowest common level*' were increasingly criticized. The teachers clearly demanded governmental regulations '*allowing for more openness and innovation*'. They felt free to stretch regulations set up either by governmental authorities or within the school as they actively implemented their practice of student-oriented, student-active chemistry teaching. Some of the teachers enthusiastically accepted the offer of becoming members of a team of textbook authors to implement and widely disseminate their work and ideas.

DISCUSSION AND CONCLUSIONS

There is a broad range of different interpretations of Action Research. The most common criterion of diverse forms of action research is the role that teacher has to take, including the consideration of who has the actual power in an actions research project (Grundy, 1982; see below). Emerging from rather research-oriented variants in the early beginnings of Action Research (Lewin, 1946), increasingly teacher-centered versions of this approach established themselves in the educational sciences by the 1970s (Altrichter & Gstettner, 1993). Therefore, Grundy (1982) and Carr and Kemmis (1986) (see also or Kemmis, 1993) differentiated three different modes of action research: technical, practical and emancipatory action research (Figure 2).

In Eilks and Ralle (2002) we came to the conclusion that more research-oriented variants seem to be the most promising avenue for educational research focusing on essential questions of domain-specific education research. This also includes those oriented on the wide dissemination of changed curricula and teaching methods. This should, however, never reach the point where research-based orientation reduces the role of the teachers to a purely technical form of support. In this case, the basic goals of every type of Action Research - geared towards professionalization of the practitioners - would no longer be achievable under the circumstances. These goals would be pushed so far into the background that the expectations, which the critical theory assumes as underlying philosophical baselines of action research (Moser, 1975), would become insignificant. This expectation would also ignore the importance of teachers' experience-based knowledge (McIntyre, 2005) and its potential for further developing their teaching practices.

As stated above, Grundy (1982) discusses three basic modes of Action Research which are mainly measured by the overall degree of personal responsibility of the practitioners (Figure 2). This especially includes the question of whether the participants must make important content-based, methodological and research-based decisions or whether such decisions are made by the researchers. It is even possible to discuss such decisions about co-operation in advance with the teachers. In one of our previous discussions of Grundy (Eilks & Ralle, 2003), we primarily used this classification as a structural model for deciding between different types of action research. With respect to carrying out and using experience in the project described above, however, Grundy's categorization seems to lend itself more to a model of professional development (Figure 3). Grundy (1982, p. 363) has already stated that there can be movement between the different modes:

'The differences in the relationship between the participants and the source and scope of the guiding 'idea' can be traced to the question of power. In technical actions research it is the 'idea' which is the source of power for action and since the 'idea' often resides with the facilitator, it is the facilitator who controls power in the project. In practical action research the power is shared between a group of equal participants, but the emphasis is upon individual power of action. Power in emancipatory action research resides wholly within the group, not with the facilitator and not with individual within the group. It is often the change in power relationships within a group that causes a shift from one mode to another.'

The above discussion shows that this project - originally conceived as a model of practical action research - was more similar to technical action research during the first twelve months, despite intensive levels of co-operation. It is entirely possible that the dominance of the science educator, especially in the first year of the project, led to this situation. However, we

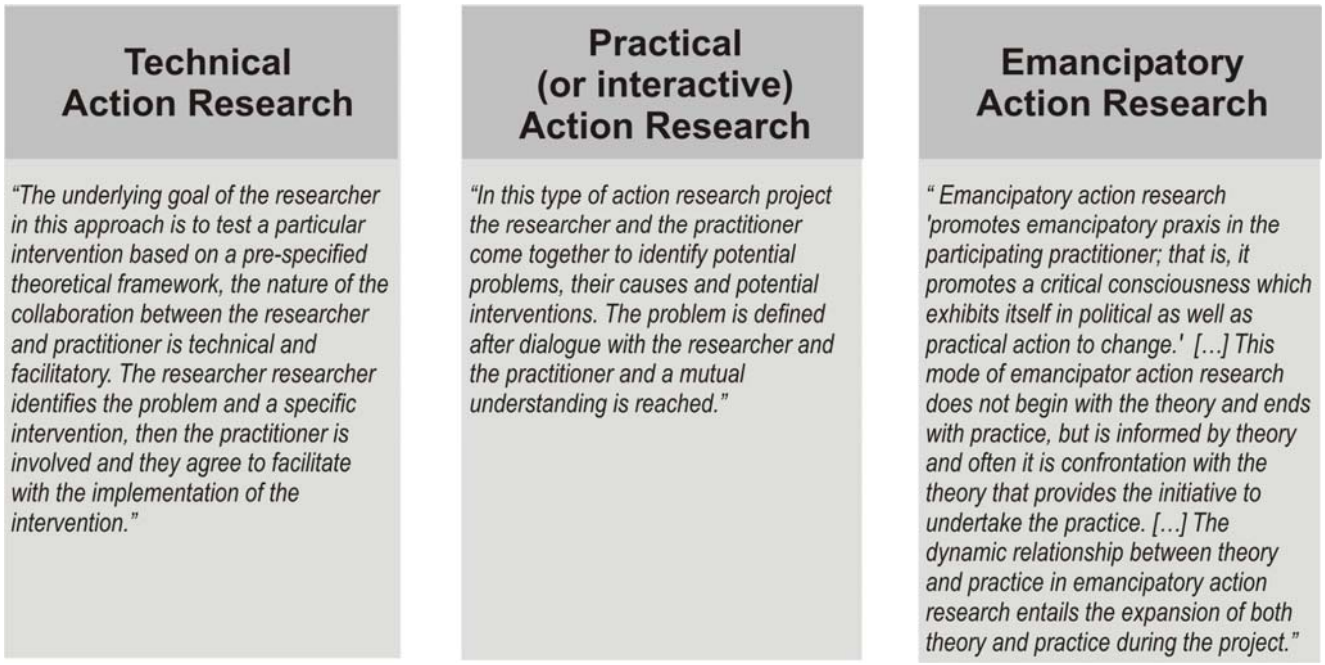

Figure 2. Three modes of action research in the means of Grundy (1982) illustrated by quotes from Masters (1995).

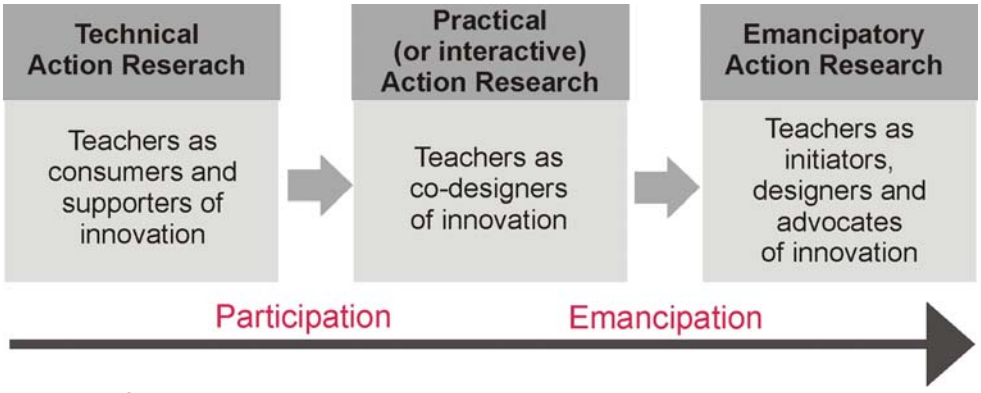

Figure 3. Structural development of action research

must also realize that a slower approach at the start might have further confused the clarity of the project's goals or even had a negative impact on the motivation of the participants. The structure of the co-operation in the second and third years increasingly became one of practical action research, in which the teachers still worked under the influence of the science educator, while simultaneously recognizing and stepping into the expanding role envisioned for them in Eilks and Ralle (2002). When added to a growing sense of self-sufficiency among the teachers, this turned out to be an important and highly influential factor in the overall process.

The systematic build-up process of developed and equal roles as envisioned by Altrichter and Gstettner (1993) and the model of Participatory Action Research (Eilks & Ralle, 2002) were increasingly noticeable during this time of the project. This aided in the dismantling of obstacles and hierarchical attitudes between participants and researchers as suggested by Noffke (1994) and Dickson and Green (2001). It also led to better understanding between teachers and the accompanying researchers. Even in the switch to this practical mode of action research there were clear signs of emerging teacher emancipation, at least with regards to authorities from outside the group, i.e. authors of textbooks and teachers' journals. This trend became especially strong in the third year.

Nevertheless, the teachers still rely on guidance available through the external expertise of the science educator. But, now this can be seen as a thoughtful decision instead of an insecure or stop-gap reaction. Maybe now we can view the participants' increasing habit of self-reflection and growing decision-making abilities about when to follow and when to oppose particular changes as a successful contribution to the teachers' emancipation process.

If we take the usual procedures of curriculum innovation through syllabi or textbooks, this type of innovation is normally steered by outside sources. In this case, teachers often are very critical of required changes and choose to distance themselves from the whole process. In many instances, innovation is never implemented. This possibly occurs because the practitioners on the front lines of teaching have limited access to the process and the actual reasons behind the curricular innovations. Emancipation from this form of outside regulation quite often happens through a teacher's refusal to act or obey orders.

The project presented here, however, documents that the attitude towards innovation can change drastically when introduced and aided by a participatory approach. When teachers are involved in long-term innovative research and are given equal rights as described above, their attitudes and competencies change with respect to testing and implementing new ideas in a positive sense. This leads to teacher-based innovations stemming from their own convictions in the sense of a constructive rethinking of their ideas. Their PCK changes permanently. The teachers develop themselves into the driving forces and self-determined causers of a change in teaching practices. The necessary competencies for this structuring – including the knowledge about possible changes in the sense of PCK – made themselves plainly visible in the above-mentioned case study. Independent of the fact that many of the innovations cover various suggestions and requirements stemming from science education, the switch from technical to emancipatory action research mirrored the central elements of teachers' emancipation. They can be seen as a step-model for teachers' professional development within this kind of co-operation, using external partners from educational research domains (Figure 3).

Even after six years of co-operative work, teacher emancipation in the sense of total independence from university supervision has been purposely avoided by the teachers. The understanding that both teachers and science educators stand on an equal footing and have different roles (Eilks & Ralle, 2002) is now deeply engrained on both sides. The co-operation and simultaneous participation of both parties in their profession and teaching practices has led to wishes for intensified contact between schools and university. This was for quite simple and pragmatic reasons. These include access to information and resources, and an understanding of the different, but complementary, types of expertise of the researchers and practitioners in the project (McIntyre, 2005).

The project introduced here clearly proved that Huberman's (1993) call for sustained interaction between research and practice as the basis of effective innovation is attainable. The process-based interaction of the four IMTPG domains (Clarke & Hollingsworth, 2002) was also systematically carried out: (i) foreknowledge and needs of the participants (the personal domain), (ii) influences from empirical and curricular teaching/learning research (the external domain), (iii) testing in authentic classroom situations (the domain of practical relevance) and (iv) the recording of and reflection upon the effects of changed practice (the domain of consequences). This sustained interaction of the four domains taken from the IMTPG seems fundamental for the success and productivity of the project.

This research model, however, had further effects in its scope with regards to stronger teacher professionalization. The teachers changed their views, PCK and attitudes about teaching and learning. They developed competencies in the structuring and critical examination of teaching practices. Furthermore they

developed other attitudes in view of their own teaching approach and the necessity of innovation and translated these into action with self-confidence. Such long-term interaction allows us glimpses into the interplay between an emerging PCK of the in-service teachers and their personal actions, an area in which large research deficits still exist (Calderhead, 1996). With respect to the five PCK domains defined by Magnussen et al. (1999), we found that our integrated approach covered all five areas: 1) a common orientation in regard to teaching occurs, 2) the original curriculum is reflected upon, consciously changed and further developed, 3) aids given through evaluation add to competency in the area of knowledge inspection, 4) knowledge about learners is expanded through dealing with empirical teaching/learning research and personal self-reflection, and 5) knowledge of strategies for conveying concepts to others develops with the creation of new teaching/learning environments (see above).

On the other hand, we must also allow questions about the potential of traditional top-down models of in-service training, whose efficiency with regards to innovation has repeatedly been called into question (e.g. Smith & Neale, 1989). Such methods often have only selective points of approachability, even if they take the form of a series of lectures or are offered as courses lasting several days. The temporal horizon shown by this study should serve as a reason to both re-question and re-evaluate the selective approach – even if it is repeated – or the constantly discussed multiplicator model of the past. Reasons for debating the efficiency of off-and-on or sporadic training methods for in-service education become clear after reading the above-described process. Even the multiplicator model with its short cycles of training seems problematic, if no sufficient supervision by professional and experienced caretakers is given to younger generations of educators. How long future multiplicators require achieving a permanent change in their personal attitudes and growth of their PCK is widely different among individuals. The process discussed in this study, however, demonstrates clearly that multiplication taking place too early hides a danger that innovations may not be (able to be) instituted in the intended fashion. Additionally, the question of source for the materials used in in-service education and their broker ability arises. In this case, we have only the very limited possibility of a top-down innovation based on pre-produced materials and ideas (Tobin & Dawson, 1992). One question arising from the above-described case study is how effective such materials can be for permanent, long-term changes, if they are not coupled with believable and authentic – and in the best case, personal – experiences.

What remains are naturally the limitations in the reach of the model presented here. University science education groups can only utilize such intensive participation models in selected situations. The carriers of innovation in educational systems must ask themselves whether such intensive supervision might represent one possible way to introduce changes in teaching practices sustainably, one which might just be worth the investment.

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Abstract: The current science education reform movement emphasizes the importance of professional development as a means of improving student science achievement.Â The National Science Education Standards (NRC, 1996) call for more long-term, coherent professional development plans. Evidence on this point, though, is mixed.Â Effects of professional development. 967. based models. Projects must have a shared comprehensive vision of science education reform incorporating national content, teaching, professional development, and assessment standards.Â While some teachers had participated intensely in professional development, others had only slight involvement, and still others had no LSC professional development at all. 1 Research in Higher Education Journal Participatory Action Research for School-based Management and Teacher Professional Development Abstract Chalermsri Jogthong Nakhon Ratchasima Rajabhat University, Thailand Rosarin Pimolbunyong Nakhon Ratchasima Rajabhat University, Thailand The new five-year curriculum for a bachelor s degree in education with more than one year internship at a school site has provoked Thai educators concerns about the qualification of. cooperative teacher professional development schools (CTPDS). These two successive studies were conducted at a primary school in order to Participatory action research (PAR) seems to be a suitable approach for developing such an innovation for the chemistry classroom. This paper reflects on the adoption of a PAR model to teacher-centered action research. A project is discussed aiming at iteratively improving lessons on chemical bonding in a Swiss vocational school. The lesson was focusing on self-determined, autonomous learning in small groups in a multimedia-supported learning environment to foster student motivation for learning.Â Games Gastrointestinal Disorders (GastrointestDisord) Gels Genealogy Genes Geosciences Geriatrics Healthcare Heritage High-Throughput Horticulturae Humanities Hydrology Informatics Information Infrastructures Inorganics Insects Instruments