Co-operative Curriculum Development in a Project of Participatory Action Research within Chemical Education: Teachers' Reflections

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Abstract

Participatory Action Research is a strategy for a cyclical and practice-related research using a team of researchers and teachers. The research process aims on the development of new teaching strategies, improvement of practice, and general knowledge about teaching and learning. The objectives of the research process are evaluated by alternative evaluation methods, such as written questionnaires or interview studies related to both students' achievement and attitudes and teachers' perspectives. The focus of this paper concerns teachers' reflections related to their involvement in a Participatory Action Research project within chemical education. The discussion mainly relates to teachers' reflections on their role in the project, their professional development, and the progressive changes across the different phases of the project.

Key words: Action Research, professional development of teachers, curriculum development

INTRODUCTION

During the last years, the gap between the main fields of chemical education (empirical research, curriculum development, and classroom practice) has been described (e.g., de Jong, 2000; Valanides & Angeli, 2002). It has been documented that research outcomes have low impact on classroom practice or curriculum development, and that innovations from curriculum development have not been implemented into practice and often have not been accepted among the teachers (e.g., Benett, 2002; Eilks & Ralle, 2002; de Jong, 2000; Taber, 2001; Valanides, Nicolaidou, & Eilks, 2003; van Driel, Beijaard, & Verloop, 2001). This failure to take into consideration research outcomes seems to be mainly attributable to the classical top-down strategies for curriculum change (Tobin & Dawson, 1992), and the absence of honest collaboration between researchers from universities, or external institutions, and classroom practitioners (Ralle & Eilks, 2002; Valanides, Nicolaidou, & Eilks, 2003). This gap is not specifically related to chemical education, but it does exist in other subject areas as well (Wilson & Berne, 1999). The only way to bridge the existing gap between research and classroom teaching, or curriculum development, is a 'sustained interaction,' as seen by Huberman (1993). Researchers suggested different forms of collaborative research in a partnership between researchers and practitioners as a way for a sustainable improvement of classroom practice in chemical education (e.g., Beijaard & Verloop, 1996; Lijnse, 1995). Other researchers related this collaboration to the tradition of Action Research (e.g., Bencze & Hodson, 1999; Feldman, 1996; Park & Coble, 1997; van Driel et al., 2001; Valanides & Angeli, 2002). The application of Action Research in Science Education appeared in different ways, and evidence was provided that these approaches seem to be promising. These range from more practitioner-centred (Bencze & Hodson, 1999; Feldman, 1996) to more research-oriented approaches (e.g., Eilks, 2002; Eilks & Ralle, 2002; Haigh, 2001).

These approaches focus, however, on the perceived role of the practitioners and the researcher-practitioner relationship (Altrichter & Gstettner, 1993; Eilks, 2002; Noffke, 1994), because any changes in classroom practice are strongly influenced by the prevailing knowledge of the teacher. The teacher is thus considered a key factor for implementing curriculum change (Benett, 2002; van Driel, 2002; van Driel et al., 2001), and teachers' knowledge should be made explicit from the point of view of facilitating teachers' continuous professional development.(e.g., Haney et al, 1996; Beijaard & Verloop, 1996; van Driel, 2002; van Driel et al., 2001).

The present study reports experiences from a co-

operative research project in chemical education following Participatory Action Research. The project dealt with the development and investigation of teaching concepts related to the particulate nature of matter in lower secondary chemistry lessons in Germany (e.g., Eilks & Moellering, 2001). The discussion focuses on the role of teachers and their self-reflections, while the data sources consisted of teachers' responses to a written questionnaire and group discussions among them.

Participatory Action Research within Chemical Education

The application of Participatory Action Research (PAR) in chemical education has been described in length in Eilks and Ralle (2002). This approach applies the ideas of Whyte, Greenwood and Lazes (1989), and it is related to other research projects described in science education research (Haigh, 2001; Parke & Coble, 1997). The research process is grounded on different pillars including a systematic analysis of empirical research outcomes and co-operative reflection with teachers, teaching experiences of practitioners, and teachers' intuition and creativity. The objectives aim to develop improved teaching strategies and materials, as well as general and empirically based understandings of teaching and learning. The improvement of practice, by means of developing quality practice within the classroom settings by the teachers involved, seems to be promising. Figure 1 presents the cyclic approach for the development of new teaching strategies, their consequent application and evaluation, and finally teachers' reflections, which initiate a new cycle of the process.

This kind of research is conducted as a co-opera-

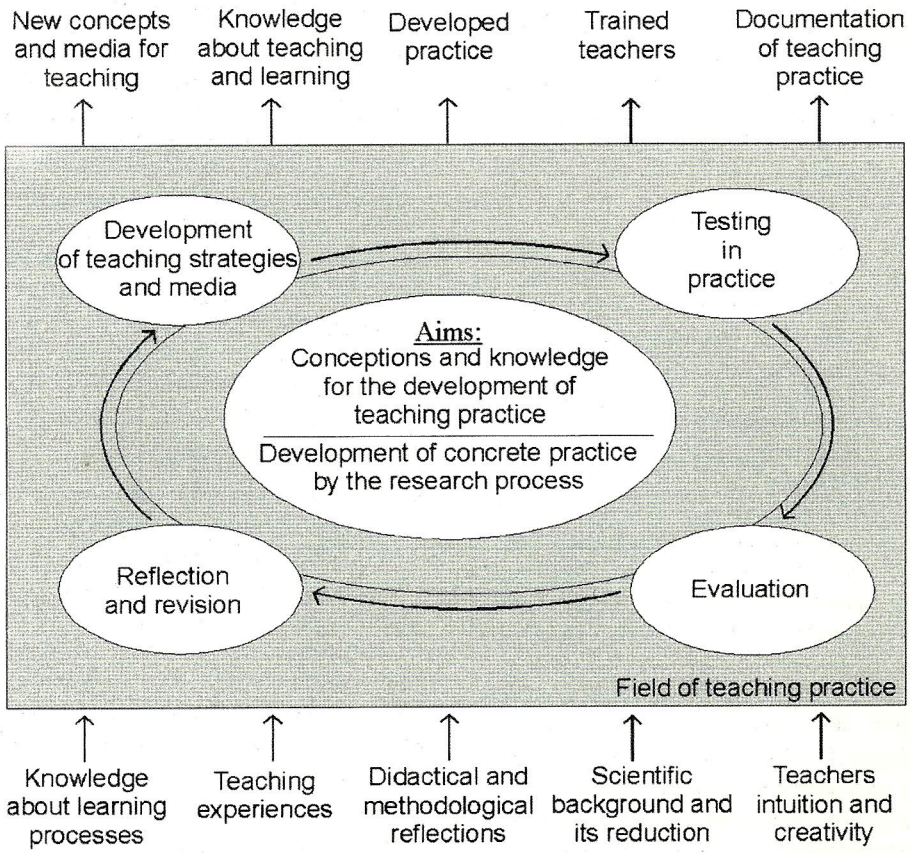

Figure 1. Applying Participatory Action Research within Chemical Education

tion between external researchers of chemical education from the university and classroom practitioners. Although within Action Research all these persons are, as a matter of principle, of equal status, in the model it is helpful to think of the two different groups as having different roles. The main task for the external researchers is to organise the research process, develop the strategies and materials for change in practice, evaluate the process and ensure research standards. Teachers are mainly involved in contributing and tailoring the newly introduced ideas, so that they are workable in practice and in carrying out these new approaches (Eilks & Ralle, 2002).

Following the discussion in Altrichter and Gstettner (1993), it seems important to be aware of and to reflect continuously upon the relationship between researchers and practitioners, in the light of their different roles (Dickson & Green, 2001). Otherwise, there is a risk that the external researchers dominate the team. This is generally due to the fact that teachers often believe that theoretical knowledge is of higher value than their own practical experiences. It is sometimes also due to the hierarchical relationship between universities and schools. But, the tension that arises between the two groups also makes it necessary for them to discuss their different points of view. This can lead to more awareness and reflection on the relative value of theory and practice, as well as new insights into the subjective viewpoints emerging from the teaching environment and from external researchers (Dickson & Green, 2001; Noffke, 1994).

One main aim of Participatory Action Research is the improvement of practice. This means that learning and achievement should be improved and that the teachers involved should receive in-service training. These two aspects require continuous reflection within the process. Following Noffke (1994), besides the evaluation of learning achievement among the students, the teachers' reflection upon their experiences plays an important role. This reflection allows insights into the feasibility of the new concepts and contributes to the consideration of success and achievement among the students. This implies that teachers' voice should be taken into account seriously and systematically (Beijaard &Verloop, 1996), and subsequent discussion (together with the researchers) seems to be the only way to address questions of their professional development in the context of in-service training.

TEACHERS' REFLECTION

Background of the Study.

After a first initial testing that took place two years ago and where only a researcher and two teachers participated, a bigger group has been established for the project "New ways towards the particle concept." The assumptions and objectives of the project are outlined in Eilks and Moellering (2001). This group was the research team for the second phase of development of the project of Participatory Action Research as described by Eilks and Ralle (2002). In the second phase, the main steps of development, evaluation, and the empirical reflection took place.

The research team consisted of two researchers, one exclusively from the university and one who works as a full time teacher, and 15 teachers. Ten of the teachers attended the regular meetings every three to four weeks. In these meetings, the changes in practice were discussed and refined. Six of these teachers have been in the project, since the group was established two years ago, while the rest joined the group later. Additionally, two teachers were co-operating with the group, but they were not able to attend the regular meetings. Another three teachers entered the group a short time ago, but they have only attended few of the meetings to date.

For this paper, only the reflections of eight teachers have been analysed. All these teachers are from the group who attend the regular meetings. Of these, six teachers were within the group from the beginning and two teachers for more than six month. Five of these eight teachers were working at grammar schools, two were from middle schools, and one teacher from comprehensive school. All teachers were fully trained chemistry teachers. Their teaching experience in school ranged from three to more than twenty-five years.

At the end of each school year, an evaluation took place. This included a shared reflection within the research group. In this reflection, group discus-

sions among the teachers are central. After the first year, the external researchers moderated the group discussion. After the second year of co-operating within this project, the teachers completed a written questionnaire with 5 open questions (Figure 2) prior to the group discussion. This questionnaire was then used as a stimulus for the group discussion. Both group discussions lasted about 60 minutes. The group discussions were videotaped and subsequently transcribed.

Evaluation of the data was done by qualitative content analysis (Mayring, 1999). The analysis started from key interests of the researchers, who were interested about the teachers' consideration of the developed teaching strategies and materials, and their self-evaluation of their role in the research process. Along several cycles of analysis, the two key questions became more precise leading to some key questions. After the first year of co-operation, key questions were:

1. How do the teachers consider the developed teaching strategies and materials in regards to feasibility, suitability to practical needs, suitability to students' learning capabilities, and authenticity? How do the teachers consider the strategies and materials compared with materials conventionally presented in teachers' journals or on in-service training courses? What had been their experiences in using these materials?

2a. How do the teachers consider this kind of co-operative curriculum development following Participatory Action Research, and concerning the relationship of research and practice, researchers and practitioners, in-service training, practice development, and curriculum development?

After the second year, an additional focus was added to the question:

2b. Do the teachers feel a change in their role/behaviour during their participation within the team? Is there a change in the relationship between researchers and practitioners?

With respect to the purpose of this paper about the role of the teachers, the data is discussed only concerning the questions 2a and 2b.

1.	The core of our project is the development of a new approach towards the particle concept. This development now is nearly complete. Please set out in keywords: How do you consider this approach in comparison with the conventional strategy? Where are differences, advantages, and disadvantages?
2.	During the last years a series of concepts, materials, and media has been developed. Set out in keywords: How do you consider these concepts, materials, and media in comparison to those, conventionally presented in didactical literature or by schoolbook publishers? Where are differences, advantages, and disadvantages?
3a.	Characterise in keywords the role of the teachers within the project group.
3b.	Did the role of the teachers change during the project? If yes, how would you describe these changes?
4.	You are voluntarily participating in this project. How important is this co-operation for you personally or in general?
5.	Does your co-operation within the project group have any impact on the everyday practice in your school beyond your own teaching? If yes, in which direction?

Figure 2. Questions from the Written Questionnaire

Results from the Written Questionnaire

When coming into the Action Research group, the teachers saw their role primarily in collecting up new teaching strategies and materials, which had been developed before hand by researchers from the university. This point is still of importance to

the teachers. But, they progressively integrated into their perceived role an understanding of their continuous influences of the process of development, which took into account their practical needs and practical restrictions. The teachers saw their participation more and more in testing the presented concepts and contributing to a revision, so that the concepts became more feasible and improved after different cycles of testing in practice. The teachers considered the activities as practical and effective, and the results so far as very successful.

In their answers related to questions concerning the content and outcome of the project, there is evidence that they took ownership of the project and its objectives. All teachers mentioned the advantages of the new strategies for their teaching. The coherence of the common developed approach and the feasibility of the developed materials had been considered as valuable. Compared with materials developed and disseminated in conventional ways, especially development outside school practice and dissemination via teachers' journals or part day workshops, a greater feasibility was considered. The teachers considered as suitable for these kind of Action Research projects not only to care on improvements in details, but also on the development of overall approaches concerning didactical structure, textual approaches, alternative teaching settings and appropriate media.

But for the teachers, it was not only the cyclical process of development and testing that was leading to positive results. Nearly all teachers, had also mentioned the regular meetings as important. These meetings and the communicative process about the research content were considered as really useful in redefining their own assumptions about the research task, and providing insights about their own practice beyond the project. All teachers underwent a change in their role over the years. They mentioned a change towards a more active role, and towards becoming more open and self-confident to examine their own thoughts and needs. The teachers have described this change in different ways, such as: *"from a teacher, who wanted to be trained, towards a colleague and convinced promoter of the new concept,"* or *"from a receiver within a group to an activist"*.

Concerning their involvement in the project, different aspects were mentioned. Thus, they mainly mentioned the exchange of ideas and information with colleagues and the positive development of the teachers' classroom practice. More concretely, the exchange of ideas among the teachers was valued, because they shared experiences and ideas, reflection and discussion about teaching and learning, and the developed competencies towards individual reflection upon their own teaching. The teachers also mentioned an improvement of their practice, either because new materials have been developed or because they considered their participation as a kind of useful in-service training. Teachers also mentioned the implementation of chemical research outcomes presented by the researcher as a way that promotes more reflective teaching. For example, one of the teachers described that his involvement was useful to prevent *"becoming pedagogically covered with a crust of practice after years,"* meaning that he might become not to be open for new teaching approaches, and no longer to have a critical distance from his/her own pedagogical knowledge and teaching practice. Finally, half of the teachers also mentioned that it was important to have external influence and to be involved in the curriculum development. One teacher explicitly mentioned that the feedback from the evaluation results were useful for assessing his/her own teaching.

In addition, four of the teachers mentioned that there was no interest among colleagues of their schools, because the colleagues felt that their work was effective, or they did not have enough time to be involved in additional activities. Two teachers gave in-service courses about the project together with the researchers in their own school. Both teachers reported that the course has had an influence on their colleagues. Some of them are using the approaches and materials from the project in their classes. In two schools, the teachers themselves worked as trainers, bringing their colleagues into contact with the materials, without support from the researchers and without explicit course.

Results from the Group Discussions

In the group discussion after the first year, questions reflecting the objectives and outcomes of the first year's work were central. The role of the teachers and the relationships within the group was also an issue. Teachers' uncertainty at the beginning of the process was clearly mentioned. This indicates that teachers changed their ideas concerning their role from consumers towards active members of the group. Teachers also stated that they became more and more familiar with new ideas and teaching strategies. These changes were not primarily attributed to the role and activities of the researchers. From the teachers' perspective, only their own experiences in testing the new approaches influenced their attitudes to participate in the project more and more actively. This involvement seems to be the only way for teachers to get ownership of the new approaches – and this takes time.

One teacher explicitly reflected about the apparent contradiction with equivalent outcomes from conventional curriculum development. He concluded that he now looks on publications in teacher journals *"with another view."* But, he also mentioned that he possibly would have not adopted the approaches developed within this group without having been involved. The image of the recommended new approach, as it is explained in relevant papers, is usually not clear enough to be easily applied in practice and the potential benefits often seem not to be authentic enough (Benett, 2002). Coming into contact with colleagues from one's own or other institutions, including common planning and reflection of teaching, and sharing experiences was considered valuable.

In the group discussion after the second year, the central task changed. Starting from the written questionnaire, the group discussion focussed much more on the development process and the work within the research group. The most important topic of the discussions was the meaning of the process for the teachers. Starting from the comments given in the questionnaire, teachers repeatedly came back to and agreed about the points they felt that really benefited their practice in terms of their professional development and their personal growth.

They felt themselves as becoming *"more reflective and critical concerning one's own previous practice."* They pointed out that they learned about *"own (teachers') misconceptions about students' learning,"* and to have improved their professional knowledge about learning and instruction. This was especially related to teaching styles and methods, where one of the major focuses in this project was towards more informal and co-operative learning. Teachers stated that they learned to apply new methods coupled with concrete examples. This co-operative work within the team has been also described as *"help against blinked attitude to one's own work."* This is especially true in schools where other colleagues are not usually motivated to change their teaching strategies and methods. The work within the project was repeatedly described as helpful for preparing lessons, because the input from the researchers and teachers' colleagues was considered to be beneficial.

Teachers agreed that effective in-service training is only possible *"if it is connected with experiences in applying new approaches."* A *"conviction to change one's own practice only will take place among teachers, if it is based on one's own experiences."* Teachers themselves felt the need to become more aware about the needs of change and more open for alternative teaching strategies. Nevertheless, the process and the outcomes had only low impact outside of the research group. For the teachers and researchers, it seems difficult to attempt to involve more and more practitioners. The group size of about 15 persons was considered as an upper limit. Groups that are bigger than 15 are not easily managed and difficult especially during the regular meetings. The teachers also reported low success in disseminating the group results to other practitioners from outside the research group, e.g., colleagues from their schools. Dissemination of the outcomes in the conventional ways of in-service teacher training and publication seems to be limited, although they stated that related publications might have been more easily accepted due to their development in authentic classroom practice. Teachers clearly stated that only active involvement within such groups has the potential to change practice. Thus, they pleaded for more Action Research.

In the group discussions, teachers described that

their role became progressively more active, and teachers considered their involvement as a correcting factor within the process. They also pointed out that the work on the project changed more and more towards a game of exchange between researchers and practitioners. Another major issue was the relationship between chemical education research and teaching practice (Ralle & Eilks, 2002), and similar remarks were made as those discussed in van Driel et al. (2001), van Driel (2002), Benett (2002), and Eilks & Ralle (2002). From teachers' experience, chemical education research without real involvement of teachers does not meet teachers' needs. Conventionally developed concepts have been described as coming from *"the green table,"* and these mostly focus on peripheral instead of core problems of practice. Teachers pointed out the necessity of a *"systemic approach"* in chemical education research that will focus on practice improvement and feasible teaching concepts. This explicitly has to include a *"co-operative work and a cyclical procedure instead of conventional in-service training courses and publication."* Using Participatory Action Research is seen as a chance to *"connect input from the teachers with input from domain-specific educational research,"* and bring *"practical experiences to the researcher."*

CONCLUSIONS

The results showed a very positive attitude of the teachers towards a process of co-operative curriculum development following Participatory Action Research. The strategies and materials were considered to be highly feasible, and, from their own perspective, close enough to their needs. They repeatedly stated the difference in their attitudes towards the strategies and materials jointly developed compared with the reception of empirical or curriculum development research outcomes presented in conventional ways (e.g., teacher journals, in-service training courses). It also became clear that the implementation of the new approaches, although developed together with the teachers, is not an act of only designing, explaining and applying new ideas (Thompson & Zeuli, 1999; van Driel, 2002). It is rather a process of learning, which starts from the prevailing practical knowledge. It takes time and needs several steps of becoming familiar with the teaching strategy and learning how to use it effectively.

Coming back to the discussion of Altrichter and Gstettner (1993), a change occurred in the self-esteem of the teachers. Due to the process, the teachers considered themselves to have started from being a consumer within the group to become an active member and contributor to the development. The group processing and the exchange of knowledge and experiences improved over time, and were considered valuable for the practitioners. Some teachers partially changed their role and progressively started to participate in tasks that were initially considered as being on researchers' side. This implies that teachers started contributing to the publication and presentation of the results as well as being involved in in-service teacher training about the outcomes of the project (e.g., Leerhoff et al., 2003).

Several aspects of in-service teacher training also played an important role in the teachers' reflections. They considered themselves to be more familiar with the outcomes from empirical research. Similar attitudes towards empirical research are considered of high value. Teachers felt more and more competent in the teaching approaches introduced by the project for teaching the particulate nature of matter, implementing open and co-operative methods of teaching, and using new media in chemistry teaching. The teachers considered themselves as more sensitive towards students thinking concerning the particulate nature of matter. They mentioned that this co-operative work could be a possible way of disseminating these results into practice.

Teachers considered Participatory Action Research within chemical education as effective in progressively closing the existing gaps between classroom practice and chemical education research and theory. Teachers attributed high potential to Participatory Action Research in terms of development of their professional competencies and their self-consciousness in developing their own practice and their curricular approaches. Still problems exist in disseminating the results to teachers who were not involved in the research group. Effective ways towards

involvement of more practitioners are at the moment only available in a limited and still not sufficient form. Nevertheless, teachers and university researchers consider projects of Participatory Action Research as a very influential approach towards practice within chemical education, concerning either classroom practice and curriculum development or empirically-based research on learning and instruction.

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The third meeting of the Leonardo Project on Safety in Chemical Laboratories was held in the University of Bremen during the period 5-9 November. All the partner universities were present as well as the umbrella organization for schools (ICASE). Detailed work was carried out by small working groups on the various packages including the proposed modules, the set of symbols and the glossary. (see September issue of the ICASE Journal Volume 14, Number 3, pages 47/48). Further information about the project can be found on the dedicated web site: <www.chlasts.org> and another article will appear in the next issue of the Journal. The next international meeting related to CLASTS will be in Cyprus, April 14-18, 2004.