THE PIKAS PROJECT – USING KNOWLEDGE GAINED FROM IMPLEMENTATION, SCHOOL DEVELOPMENT AND IN-SERVICE TEACHER TRAINING RESEARCH FOR THE DEVELOPMENT OF MATHEMATICS TEACHING PRACTICE

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Quality pre-service teacher training and materials or learning environments that support learning processes cannot be overestimated when it comes to implementing educational standards. To have a broader impact and more sustainable effect in practice, these elements should be supplemented by an intensification and systemisation of in-service training, more extensive provision of subject-related school development measures, and the setting up and development of networks on and between various levels. In this paper, we shall be reporting on experiences gained in this regard from the PIKAS project.

The nationwide German standards published in 2004 and the mathematics curriculum introduced in primary schools in the *Land* of North Rhine-Westphalia in 2008 provide for a decisive innovation: They not only list content-related, but also process-related competence expectations – such as discovering, reasoning or modelling. This upgrading of process-related competences furthers the switch from a teaching style that primarily imparts calculation techniques to one that encourages independent thinking and active mathematical activities – a decisive innovation that calls for support measures, such as the ones implemented in the PIKAS project, funded by the ministry of education and the Deutsche Telekom Stiftung. But how can such an innovation be supported?

FEATURES OF TRANSFER-FRIENDLY INNOVATIONS

If one follows the reasoning of Rogers (2003), many innovations will not spread automatically in a school context, but have to be accompanied and supported. Teachers do not always consider these innovations beneficial. They moreover find it difficult to reconcile many of the changes with their previous beliefs or subjective theories. The need for support is underscored by studies from the educational field concerning themselves with the dissemination of new curricula or teaching concepts (Euler & Sloane, 1998; Schellenbach-Zell et al., 2008).

When all is taken into account, the results indicate that guidelines are frequently not included in the teaching to the planned extent. The guidelines and innovations are moreover subject to distinct changes in the course of their implementation. The question how innovations - for example new teaching concepts, new curricula or research results - are disseminated in the educational system has already been studied for decades. It has been established ever since the early studies that the dissemination of innovations is often slow or hesitant. Many studies have concerned themselves with the causes of this "innovation inertia" (see Gräsel et al., 2006; Rogers, 2003). The cited reasons have included the lack of a scientific authority in the educational system, a shortage of "agents of change" who promote new ideas, organisation-specific characteristics, and a lack of

economic incentives. But what are the attributes of transfer-friendly innovations? In their analysis, Oelkers & Reusser (2008) identify the four key aspects listed below:

Recipient-orientation: The central level is teaching practice; whatever does not arrive there is lost.

System sensitivity: Innovations that fail to take the various implementation levels into account will not take effect. The decisive problem is the coordination between these levels.

Marketing: Innovations are not merely "implemented", they need to be elaborately communicated, and accepted.

Relevance: Innovations need to benefit the parties involved, the additional efforts need to make sense, and lead to success after a while.

These attributes derived from innovation research provide important knowledge for the development of materials and conceptions in the PIKAS framework, which need to be supplemented with the results of the school development research if they are to attain a higher level of effectiveness.

FEATURES OF GOOD SCHOOLS

Good and innovative schools are particularly distinguished from their not so good and innovative counterparts by lessons-related discussions, mutual teaching observation and evaluation, joint work on teaching lessons, and a joint effort to improve the didactic competence of the teaching staff (Little 1982). Studies clearly show that high quality teaching that leads to good learning results on the part of the pupils is provided by competent teachers whose professional development depends on a school management which provides support, but also on positive work relationships and cooperation amongst the staff (Bryk et al. 2010; Prenzel, Friedrich & Stadler 2008).

One model for effective teaching development that has been thoroughly researched in the meantime is provided by the professional learning communities approach (Lomos, Hofman & Bosker 2011). Typical teaching development strategies in professional learning communities include teaching-related cooperation (planning, preparation and evaluation of lessons), mutual lesson visits, a reflective dialogue on the teaching, and the accompaniment of new teachers (Bonsen, Hübner & Mitas 2013). The professional learning community concept therefore serves PIKAS as a model for internal school lesson development structures.

FEATURES OF EFFECTIVE IN-SERVICE TRAINING

Where propagating the PIKAS project is concerned, the in-service training is of vital importance. The following six guiding principles derived from the analyses conducted by Desimone (2009) or Lipowsky & Rzejak (2012) serve as a basis for the PIKAS in-service training concept developed at the German Centre for Math Teacher Training (Deutsches Zentrum für Lehrerbildung Mathematik; DZLM; Barzel & Selter 2015).

Competence orientation: An orientation towards the skills in-service trainees are meant to acquire is a decisive prerequisite for a didactic and organisational course structure that meets the need for sustainable effectiveness (Timperley et al. 2007; Lipowsky & Rzejak 2012).

Participant orientation: In-service training courses should address the varied, individual requirements of trainees in a targeted manner, before developing them further as needed for their specific tasks. Advanced training courses are not meant to be one-way communication, but participatory, enabling the trainees to play an autonomous part in the required organisation and implementation (Selter 2006).

Stimulating cooperation: The trainees should be able to cooperate in the implementation in their own practice of what they have learned in the in-service training. This promotes the teamwork between the trainees while also providing stimuli for a more sustainable cooperation (Garet et al. 2001).

Case relatedness: The orientation towards everyday situations ("cases") serves both as a starting point and an application field for teaching and learning in an in-service context. Especially an orientation towards the practical experience acquired by the trainees forms an essential point of reference for the organisation of in-service training courses (Timperley et al. 2007).

Versatile design: PIKAS in-service training proposals enable their trainees to play a part in the organisation, to experience self-efficacy, and provide transfer skills. The methodical mix of variously organized periods of attendance, private study, cooperative work in twos or a small group, and e-learning serves to interlace input, trial and reflection stages (Kennedy 1999).

Fostering reflection: The trainees are inspired to enter into a joint reflection and self-reflection on discussed topics, such as their own teaching practice (Putnam & Borko 2000; Boyle et al. 2005).

Looking at **organisational features**, many studies agree that the long-term character of advanced training courses is an important attribute for successful advanced training (Borko 2004; Garet et al. 2001), which is also the reason why this has been implemented in PIKAS as well.

GOALS OF THE PIKAS PROJECT

The innovation research findings led to the establishment of the PIKAS project in the beginning of 2009. The initial key objective of the project was to provide support services and develop support material on the following levels:

- Development of training materials that can be used by multipliers in their training and advanced training activities.
- Regular performance of advanced trainings for multipliers to introduce the developed training material and engage in an exchange about focus areas and problems of the advanced training.
- Development of teaching materials on the basis of the new curriculum, and their provision on the project website.
- Working with partner schools to test the developed teaching materials and further develop the maths lessons from the perspective of the new curriculum.
- Elaboration of information material aimed at explaining the development of the maths lessons and objectives of the new curriculum to parents and all interested parties.

- Development of information and stimulation materials for school administrators, expert groups and other parties interested in the development of the teaching.

Overall, PIKAS offers a **broad range of contents, freely available from the website** in the form of teaching, advanced training, information and school development materials. Merely making concepts and materials available for the lessons would not suffice, however, without active support for their use. The further development of the lessons is understood as the objective of school development measures requiring support activities on various levels to succeed.

PIKAS therefore consists of two closely linked sub-projects: the PIK project (process- and content-related competences) with a focus on mathematical didactics, and the AS project (encouragement of subject-related school development) with a focus on school development issues, which are to be outlined in the following two chapters. A project description in English is available here: pikas.dzlm.de/196.

THE PIK SUB-PROJECT

The principal conceptual notions of the project are illustrated by the arrangement of the website materials in ten "houses" (H1 to H10), each of which is dedicated to a central theme of the curriculum development (http://pikas.dzlm.de/pik). This is aimed at maths lessons that …

- advance process-related as well as content-related skills (H 1),
- keep an eye on the long-term development of skills from a pre-school to secondary school level (H 2),
- realize the prevention and diagnosis of numeracy issues and provide the corresponding support as an integral part of the lessons (H 3),
- consider language development a central task of maths teaching too (H 4),
- maintain a balance between own ways of thinking and prescribed competence expectations (H 5),
- put the variety of the pupils' attainment levels to a productive use with concepts such as 'natural differentiation' (H 6),
- use rich exercises that challenge the pupils rather than only keeping them occupied (H 7),
- enable pupils to play an active and self-responsible part in shaping the lessons and their learning process (H 8),
- regard continuous monitoring of the attainment level that is also always oriented towards the strengths as an indispensable basis for individual advancement (H 9), and
- also realize process-oriented performance assessment and dialogic performance feedback in the subject of mathematics (H 10).

The structure is quite deliberately not based on definitive issues (such as symmetry or tables up to ten), but on interdisciplinary topics permeating the entire curriculum. PIKAS offers a framework concept with exemplary, well-crafted and documented materials. PIKAS is not able or meant to replace the guiding medium of the lessons (usually the textbook), or the teacher training. But the PIKAS proposal is able to provide a basis for a reflected teaching and training practice that is flexibly adjustable to the specific local implementation conditions.

THE AS SUB-PROJECT

Based on these considerations, PIKAS supports schools in the development of their maths teaching by way of professional learning communities. The attendant materials elaborated to support the subject-related lesson development are primarily addressed to head teachers and persons engaged in the collegial development of maths lessons in individual schools or school networks – such as symposium chairs. The PIKAS website provides practical tools for school development: Sample concepts showing what a lessons-related cooperation of teachers can look like in practice have been elaborated at PIKAS partner schools – in cooperation with the teaching staff.

For this, head teachers have documented the development of the lessons at their schools chronologically, which interested parties can use as a stimulus for development efforts at their own schools. There is a short film showing how three teachers cooperate and which topics they are working on. Besides descriptions of the professional learning community concept, the PIKAS website also provides material for establishing cooperative ways of working (e.g. forms for work reports and planning sheets). Teachers and head teachers are furthermore provided with stimuli for colleagues sitting in on classes, and the subsequent feedback. Three sample report sheets have also been developed for this.

MATERIAL DEVELOPMENT IN PIKAS

Modelled on the 'Chemistry in Context' project (Demuth et al. 2008), the implementation is always integrated in PIKAS, which is evidenced not only by the inclusion of research findings (see above), but also by the fact that the top-down strategy of introducing a new curriculum is pursued by way of a symbiotic (and bottom-up) implementation strategy (Gräsel und Parchmann 2004; Snyder et al. 1992), where actors with various backgrounds and perspectives cooperate in the implementation of the innovation.

All the teaching and training materials have been developed, and as a rule tested and revised two or three times, in close cooperation with mathematics education experts, educational researchers and the PIKAS teachers and teaching staff at the project schools deputized by the Ministry of Education (based on the development research paradigm, see Gravemeijer and Cobb 2006). The revisions were based on observations in the lessons and/or training events, an analysis of the pupils' written results and/or assessment of the evaluation questionnaires used, and on the outcomes of joint debriefing sessions held by the parties involved after every trial.

TRANSFER OF PIKAS

The PIKAS project is structured in three phases. The three-year **development phase** (February 2009 to January 2012) initially involved the conceptual work and a large part of the development, testing and revision of the materials. Besides completing the conceptual work and development activities, the **distribution phase** (February 2012 to July 2014) was primarily dedicated to expanding the project work in cooperation with the five District Councils and, initially, 21 of the 53 education authorities in North-Rhine Westphalia.

Ill. 1: Cooperating education authorities in NRW

The **implementation phase** (from July 2014) finally serves the perpetuation and expansion of the cooperation to what are now 44 education authorities in NRW (see Ill. 1). The different colours refer to the different starting points of the cooperation.

Furthermore, the cooperation with other *Länder* has also been intensified since February 2015, where propagation is ensured by cooperating with school networks (Saarland, Thuringia), the continuous training of maths multipliers (Bavaria, Hamburg, Rhineland-Palatinate), or promotional events and an integration in projects provided in the regions themselves (Hessen, Saxony-Anhalt). For more information on further cooperation ventures, please see http://pikas.dzlm.de/kooperationen.

CONCURRENT PROJECT EVALUATION

Two major teacher surveys about the implementation of the curriculum in maths teaching have been carried out in 2010 and 2011 in North-Rhine Westphalia as part of the PIKAS project. 10 % of the primary schools were selected for this on a random basis. 1,502 primary school teachers from 218 primary schools in North-Rhine Westphalia took part in the voluntary and anonymous written survey. 330 teachers took part in both surveys. A detailed description of the sample, methods and results can be found in Hübner-Schwartz (2013).

The two surveys have different focus areas: The first was more strongly focussed on the new maths curriculum, the implementation of this curriculum by the teachers, and the factors on a teacher level

assumed to affect the implementation of the innovation. The second, shorter survey was focussed on changes perceived by the teachers in connection with the curriculum innovation at their school and in their teaching, and on the actual information, training and teaching materials developed in the project.

Overall, the survey findings from the initial phase of PIKAS show a good match between the support needs expressed by the teachers at the time and what PIKAS had to offer: the teachers regarded individual encouragement, good exercises and performance assessment as important subjects, and trainings and training materials as important materials, as well as directly usable proposals relating to the lessons (exercise sheets, teacher comments on textbooks, lesson templates). The materials for direct use in the lessons and the latter's preparation were found to be the most helpful. The awareness level for the materials, mainly distributed online, was also already high in 2010 and 2011: PIKAS was known to 70 % of the teachers surveyed in NRW at the time.

Regular surveys have been carried out in the PIKAS trainings since the end of 2014 with the aim of evaluating information about the transfer of training contents to school routines. Given that PIKAS aims to support the professionalisation of teaching staff in cooperative settings, as described above, the collected data are also focussed on this. It will be possible after the completion of the data collection to correlate the individual surveys to the separate persons concerned in an anonymous fashion. This supports the creation of longitudinal 'survey profiles', each of them including a 'context survey', one or several 'interim surveys', and a 'final survey'.

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