

**In-service between top-down and bottom-up –
Exploring a problem posing design to develop PCK in mechanics**

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Outline of the study

Science educational research provided many new insights on science learning over the past few decades, but many science curriculum innovation projects that were meant to implement these insights did not improve classroom practice (Anderson, 2007). Van den Akker's (1998) analysis of curriculum innovations suggests that these results may be caused by discrepancies between curriculum developers' intentions and teachers' views and experiences. Strategies for professional development should attend to these potential discrepancies but use either a top-down or bottom-up approach. Top-down approaches tend to align with research and pursue large-scale impact, but teachers may be asked to work towards educational goals which are not their own. A bottom-up approach focuses on teachers' personal concerns and aims but may fail to fully utilize educational research and to have transferable impact on educational practice. It is argued below that if the design of professional development is based on a so-called problem posing approach, the advantages of both strategies may be used while their pitfalls are avoided. This design-based case study is meant to yield an empirically validated didactical scenario of this kind for developing teachers' subject-specific professional knowledge, skills and values pertaining to a specific curriculum innovation project in Dutch secondary school mechanics.

Theoretical framework

Lijnse (2005) describes the construction of a "didactical scenario". In a problem posing approach the learner, at each time of the learning process, has his own motives to undertake the next step in the process working toward a pre-stated final goal. A problem posing scenario should propose a worthwhile final goal, suggest a coherent sequence of

attainable challenges to reach it (or several sequences), and anticipate the various ways learners choose to rise to these challenges. It is assumed that, in the case of this project, the curriculum innovators are providing potentially viable solutions to subject-specific educational problems, such as outdated content, learners' problems or under-used teaching strategies. Teachers may not be able to envisage immediately how the intended innovation addresses these problems, or how the innovation is meant to be implemented. But they are expected to acknowledge the problems and to be willing to work on solving them: in that sense, innovators and teachers have aligned intentions and motives. Optimizing the full potential of these solutions provides, in that case, a viable overall motive for teachers to engage in specific professional development activities. A successful design describes the professional problems teachers can be expected to encounter in this process; predicts how teachers will respond to these given their existing knowledge, skills and values; offers instruments based on the innovative design that assist teachers in achieving their overall aim, of developing the knowledge, values and skills required to optimize the implementation of the innovative design. The strategy is partially top-down in that the innovative design is predetermined and externally established. It is also partially bottom-up, by assuring that teachers remain intrinsically motivated to learn throughout the process. Teachers do not have to share the innovators' intentions; it suffices if they gradually develop the professional expertise to utilize the innovators' instruments to address the problems that both agree should be addressed.

In this study professional development will take place in reflective, collaborative communities of learning (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003).

Research Questions

A problem posing approach guides the choice of content and structure of professional development activities, but their design involves more than that. This study makes use of five basic design principles identified by Loucks-Horsley *et al.* (2003) that are not problematised in this study.

Professional development aimed at implementing the innovative problem posing approach of the developed module connects with the first principle. Professional development in this study is therefore directed at optimizing the intentions of the

specific curriculum innovation it is associated with, with an explicit focus on the content and educational approach of this innovation. Professional development experiences focused on the learning of students fits with the second principle. In line with these principles, the first pillar of the design is established through answering the following research question:

1. *What are the pedagogical and content characteristics of the intended innovations in mechanics teaching and learning that should be targeted in professionalization process that is to be designed?*

The third principle of Loucks-Horsley *et al.* is that professional development starts from existing content-specific knowledge and experiences of teachers. This implies that professional development not only depends on characteristics of the module and intended PCK of developers but also on expertise and vision of teachers. The same is true for the fourth principle of Loucks-Horsley *et al.*; principles that guide the reform of student learning should also guide professional development of teachers. This leads to the second research question which provides the second pillar of the design of professional development in this study:

2. *Which knowledge, skills and attitudes of teachers are essential of a suitable professional development course implementing the developed innovative module?*
 - a. *Which views can be utilized to evoke the motivation to pursue a learning process aimed at implementation of the innovative approach?*
 - b. *Which existing knowledge, skills and attitudes of teachers can be used in developing coherent steps for the professional development course?*
 - c. *Which knowledge, skills and attitudes for teachers are required to successfully implement the developed module?*

According to the fifth principle of Loucks-Horsley *et al.* professional development must utilize knowledge and experiences of both teachers and developers, coming from classroom practice as well as formal research. A didactical scenario for professional development based on a problem posing approach should take into account teachers views and ideals as well as developers intentions and purposes. The third research question of this study asks how, precisely, an effective balance can be established in pursuing the fifth principle:

3. *Which didactical scenario establishes a learning process that aligns teachers' and designers' intentions, by having teacher develop the knowledge, skills and attitudes appropriate for the innovative design as a result of following the motives for learning and innovation that the process evokes in them?*

Methods

The research questions will be answered by using design research (Van den Akker, Gravemeijer, McKenny, & Nieveen, 2006) that is meant to yield an empirically tested problem posing scenario for a professional development program. Either pedagogical and content characteristics for the innovative module and already existing and still to be developed knowledge, skills and attitudes of teachers are important elements in the scenario. In the first (explorative) phase – now concluded - those important elements were identified through interviews with the authors' team, analysis of teaching materials and manuals, interviews with the teachers, and classroom observations to establish how teachers teach the course. In the second phase – April 2009 until June 2010 - analysis of these data is meant to guide the design of a problem posing scenario that is elaborated in a sequence of activities for teachers. In the third phase – September 2010 until December 2010 - design research will be used in communities of collaborating teachers to trial and test the first tentative version of the scenario. In further cycles of implementation, evaluation and adjustment the scenario can be expected to acquire growing reliability and validity (Lijnse, 2005).

Preliminary results

Professional development is to be designed for the implementation of an innovative module that uses a problem posing approach to present the central concepts of mechanics in an original way. The interviews show that teachers appreciate the innovations in the module both in terms of content and didactic however focus of professional development has to be on content only. They do not want to be told which PCK to use in classroom practice; they are interested to learn about what to teach, not how to teach. To connect to teachers' attitudes the first activity of professional development is content based only. In the trial of the tentative version of the scenario teachers did undertake this activity enthusiastically. Meanwhile motives were evoked

for following activities both related to content and educational approach. When testing the scenario some remarkable situations were noticed in classroom practice. For example: in the second activity teachers declared to use the module in classroom practice according to developers' intentions, but classroom observations showed otherwise. A characteristic developers' intention is to activate students working in small groups to enhance their participation in concept development. Teachers however tend to continue using their familiar approaches, often involving frontal expository teaching. On occasion teachers did activate small groups of students but they focused on practicing assignments instead of developing concepts. In this specific case teachers were not able to distinguish the purpose of similar student activity in two different situations. Teachers however did not see the interest of using classroom practice according to developers' intentions while both students' satisfactions and students' grades are in advantage of the teachers approaches. One teacher was convinced that only telling and explaining the students mechanical concepts resulted in understanding concepts. Part of professional development is aimed at letting teachers use other approaches to discover advantages and yields for students.

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