A model for teacher learning in the context of a curriculum renewal

Fer Coenders, University of Twente, The Netherlands
Cees Terlouw, Saxion University of Applied Sciences, The Netherlands

Corresponding author:
Fer Coenders. University of Twente. Enschede, The Netherlands. fer.coenders@utwente.nl

Abstract

Teachers play a crucial role in curriculum changes, as they are the ones to implement a new curriculum in class. Therefore, teachers need to bring their knowledge and beliefs (pedagogical content knowledge) in line with the new curricular demands. The reason for the study is the introduction of a context-based chemistry high school curriculum in the Netherlands, and the question was how to best prepare teachers for such a new curriculum. Teacher learning for two groups of teachers form the bases for this model. One group developed and subsequently class enacted student learning material for this new curriculum, and the other group only class enacted this learning material. The combination of developing student learning material and class enactment proves instrumental for teacher learning. In the model, an extension of the Interconnected Model of Teacher Professional Growth, teacher learning during the development phase and the class enactment phase becomes visible. The consequence of this model is that for teacher learning in the context of a curriculum renewal to take place, both a (re)development phase as a class enactment phase are essential. Especially the design of the External Domain facilitates initial teacher learning.

Keywords: teacher professional growth, professional development, model for professional development.
Introduction

A new context-based chemistry curriculum for upper high school, initiated in 2003 in the Netherlands (Driessen & Meinema, 2003), is tried out in a few selected schools, and will be implemented nationwide in 2013. In this type of education, appealing contexts for students are used as a starting point for learning. Context-based education adopts the view that science content is negotiated within realities, evolving and flexible (Bencze & Hodson, 1999), not just a set of rules and principles to be memorized. Specific forms of context-based chemistry education were developed in different countries like the United States (Schwartz, 2006), United Kingdom (Bennett & Lubben, 2006), and Germany (Parchmann et al., 2006).

A curriculum change affecting classroom practices is a complex endeavor, having an effect on the development of various curriculum components such as learning materials, instructional strategies and assessment methods and instruments (Loucks-Horsley & Matsumoto, 1999). Teachers play a crucial role in curriculum changes, as they are the ones to implement the new curriculum in class (Fullan, 1998). This means that teachers need to bring their knowledge and beliefs in line with the new curricular demands (Cotton, 2006; Pintó, 2005). Because classroom practices influence teachers’ knowledge and beliefs (Veal, 2004), enactment of new acquired knowledge and beliefs should be part of a professional development program. The knowledge and beliefs teachers use in their teaching has been described as pedagogical content knowledge (PCK) (Shulman, 1987). Several authors have further defined and researched PCK (Schneider & Plasman, 2011). We adopted the five PCK components from Magnuson, Krajcik, & Borko (1999): 1) orientations toward science teaching, 2) knowledge and beliefs about the science curriculum, 3) knowledge and beliefs about instructional strategies, 4) knowledge and beliefs about students understanding of specific topics, and 5) knowledge and beliefs about assessment
PCK is a complex construct, developed and shaped in school practices through reflection-in-action and reflection-on-action (Park & Oliver, 2008), active processing, and the integration of contributing components (Abell, 2008).

In the next sections we will first look at models for teacher learning and then focus on the context for teacher change in this research followed by the questions that guided this study.

**Models for teacher learning**

Teacher change has long been seen as a result of training, as something done to the teachers. In this model in-service will lead to new knowledge which will result in changes in class that will positively affect student learning. Guskey (1986) presented a model in which the order of events is different: professional development leads to changes in classroom practice which will result in improved student learning and this finally results in changes in teachers’ knowledge and beliefs. We conceptualize teacher change as growth or learning, as a natural and expected result of professional teacher activities. Three frequently found models portraying in-service teacher learning will briefly be described below: (1) the Concerns Based Adoption Model (CBAM) from Hall and Loucks (1978), (2) the training components described by Joyce and Showers (1988), and (3) the Interconnected Model of Teacher Professional Growth (IMTPG) portrayed by Clarke and Hollingsworth (2002).

The Concerns Based Adoption Model (CBAM) considers teacher change as the process each teacher will go through in times of an innovation. Teachers will experience seven stages of concern, in time arranged in four phases: initiation, adoption, implementation and incorporation. The initiation phase serves to acquaint teachers with the basic aspects of the innovation and to make them susceptible to learning more about it. In the adoption phase teachers explore how the
innovation will affect them. The implementation phase dealt with the materials, the effect on the learners and the relation to colleagues. The incorporation phase provides opportunities to exchange experiences and to improve the innovation. Especially the first three stages will be accompanied by uncertainly and anxiety for the teachers.

According to Joyce and Showers (1988) the following combination of training components proved to be successful: (a) theory: an explanation of the rationale behind the innovation; (b) demonstration: demonstration of how the innovation facilitates learning; (c) practice: the practice of innovative components under simulated conditions; (d) feedback: non-evaluative feedback from others as soon as possible after practice; (e) coaching: to take place in the workplace following initial training. In a later version of their model the feedback phase has been removed and instead attention should be paid to elements allowing teachers to become more effective learners (Joyce & Showers, 2002).

Clarke and Hollingsworth (2002) elaborated a model describing the growth of professional knowledge, called the Interconnected Model of Teacher Professional Growth (IMTPG). This model is presented in Figure 1. The authors distinguished four domains: a Personal Domain where teachers’ knowledge, beliefs and attitudes are located; the Domain of Practice containing all kinds of professional experimentation, including the enactment of learning material in class; the Domain of Consequence encompassing all salient outcomes of the experimentation domain; and the External Domain consisting of all sources of information or support. These four domains can influence one another through mediation processes of ‘reflection’ and ‘enactment’. ‘Enactment’ was used because the teacher needs to translate a belief or a pedagogical model before class use, which is clearly different from just ‘acting’ (2002, p. 951).
The process by which changes occur can, according to the authors, be represented by a “change sequence” consisting of “two or more domains together with the reflective or enactive links connecting these domains, where empirical data support both the occurrence of change in each domain and their causal connection” (2002, p. 958). Where the occurrence of change is more than momentary, this change is seen as professional growth and the associated change sequence is termed a “growth network”.

Figure 1. The Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002)
The context for teacher change in this study

The changes in knowledge and beliefs of two groups of chemistry teachers have been studied. The first group of three experienced chemistry teachers from different schools developed and subsequently class enacted context-based student learning material. This material had the form of a module, comprising all texts, exercises and practical and other activities for direct class use for 8 periods. To distinguish these teachers we called them teacher-developers in the rest of this paper. The second group of five teachers not involved in the development of context-based student learning material, enacted the material developed by the first three teachers in their classes. We named these teachers teacher-enactors.

This study was guided by the following questions: How can the observed changes in teacher knowledge and beliefs, both from the teacher-developers who developed and subsequently enacted innovative material in class, as well as from the teacher-enactors who only enacted the innovative materials in their classes, be interpreted and understood in terms of models for teacher learning. What are the implications of such a model for professionalization programs to prepare all chemistry teachers for context-based chemistry education?

Method

Context of the study

The three teacher-developers developed the model over a period of seven month, then used this in their classes, discussed the results and revised the module for use by other teachers. A teachers’ guide was subsequently developed. The total process took one school year.

The five teacher-enactors voluntarily enacted this module in their classes. To prepare these teachers for class use, a half-day workshop was organized in which the teacher-developers
shared their experiences with their colleagues, and in which opportunities were offered to become familiar with and practice innovative aspects from the module.

**Procedure, instruments and analysis**

Multiple case studies (Yin, 2003) have been used to portray the changes in knowledge and beliefs of these teachers. The main reason for this approach is that capturing teacher knowledge and beliefs is very complex (Pajares, 1992), and that teacher learning is seen as idiosyncratic (Clarke & Hollingsworth, 2002; Parke & Charles, 1997). In Borko’s words (2004, p. 6): “Research using the individual teacher as the unit of analysis also indicates that meaningful learning is a slow and uncertain process for teachers, (...) some teachers change more than others through participation in professional development programs”. Data were collected through interviews, questionnaires, transcribed audio recordings of network meetings (where the teachers discussed the student learning materials under development), and the developed materials were analyzed and served for triangulation. For data analysis a process of open coding, followed by axial coding, was used (Gibbs, 2007). Open coding resulted in relevant categories for changes in teacher knowledge and beliefs. Axial coding resulted in a redefinition of the categories in relation with the five previously defined PCK domains.

**Modeling teacher growth**

The Concerns Based Adoption Model as well as the Joyce and Showers’ effective training components are static models describing phases of a process. The Interconnected Model of Teacher Professional Growth is a dynamic model showing the change processes. We will therefore start with this later model. The first two models will be considered at the end of this section.
As the process teachers went through, and also the changes in knowledge and beliefs of the teacher-developers and the teacher-enactors rather varied, teachers’ growth will be described separately for these two groups. Changes in teachers’ knowledge and beliefs have been reported in detail elsewhere (Coenders, 2010). In order to develop a model for teacher growth, two aspects in which both groups of teachers changed will be reported: aspects related to the context-based approach and to cooperative learning.

**Teacher-developers growth**

In an iterative and cyclic process under supervision of a coach, the teacher-developers, whom we will call Pete, Lisa and Ed, developed student learning material in a time frame of seven months. In this period, nine network sessions have taken place, where all participants met to discuss progress. In between the sessions there was e-mail contact. These teacher-developers thereafter enacted the material in their classes.

We will summarize how Pete, Lisa and Ed changed during the development phase and the class enactment phase with respect to the context-based approach and to cooperative learning.

**Context-based approach.** During the development phase all three teachers learned how to develop learning material starting from a context in which students explored concepts using multiple activities. Ed said that he had to rediscover the content. All three had made modifications to the jointly developed module to suit personal preferences. After development of the material Pete and Lisa were still anxious about class enactment.

In class, all three teacher-developers experienced the potential of the context-based approach. They assessed the context as motivating. The main problem encountered was that students had difficulties getting the concepts clear and not automatically linked up concepts nor connected these to previously learned concepts. The teacher-developers called for explicit attention for this
in the material. Pete for example wanted to incorporate concept maps for this, and Lisa asked to
reserve class time to let students make a summary and a concept list. The teacher-developers
experienced that learning material needs to have different kinds of activities for students to
explore the context and get the concepts clear. They also experienced that the quality of the
material is important. Assignments should be challenging but feasible, and the wording is
important. If not, teachers have to spent substantial time explaining the meaning.
Pete and Lisa said to need time to get used to the different teacher role they had in class. This
shows that building up teaching routines is important.
Their views on what is more important, context or concept also changed through class enactment.
Before class enactment Pete considered the context as more important than the concepts but class
use made him change this view. Lisa and Ed judged concepts more important than the context,
but class enactment made both change their view.

Cooperative learning. During the writing phase all three teacher-developers acquired knowledge
and skills with respect to the why and how of cooperative learning. Group size and roles were
discussed and possible roles for this context were identified and defined. The use of T-cards to
get grip on cooperation skills and how to teach these to students was discussed using examples.
The advantages and disadvantages of a group logbook to monitor students’ learning were
discussed and an exemplary group logbook was developed.
In class, Ed grouped his students, but did not use the cooperative elements like group roles, a
group logbook or T-cards. He therefore learned little regarding cooperative learning. Lisa and
Pete did implement cooperative learning in their classes. Both were positive about the use of
group roles and especially about the use of the group logbook. They learned that marking or
providing feedback in these logbooks stimulated student reflection on what they had done the
previous period. Lisa also used the T-cards and was positive about this as it helped her students to acquire and use cooperative skills. Lisa and Pete said that both their students and they themselves had to get used to cooperative learning.

**Teacher-enactors growth**

Five teachers, called Ann, Art, Iris, Hank and Gene, enacted the developed module in their classes. Except Iris, all made adaptations to the module before class use.

*Context-based approach.* Ann made the inquiry assignments less open and was still not happy as she proposed to revert to a recipe kind of practicals. Art made substantial changes to the module and as a result of this did not learn much with respect to context-based chemistry. Iris was initially skeptical about the renewal as she said to be “suspicious towards this chemistry renewal” and “so I thought let me join the tryout of the learning material and see how it looks afterwards”. She learned very little, and did not see how context-concept chemistry contributed to student learning. Hank only learned that it is also important to teach skills. Gene learned that context-based chemistry leads to different learning as students cover fewer concepts, but they understood the concepts better.

*Cooperative learning.* Ann used cooperative learning elements like groups of more than two students, group roles and experienced that marking the group logbook had a positive impact on student learning. Art did not use unfamiliar aspects and therefore did not learn anything on cooperative learning. Iris used elements but in a diluted form. For example student groups used the logbook and she browsed regularly through some of them without giving feedback to the students. As a result she learned little. Hank did learn to use cooperative learning: he used group roles and the logbook and provided written feedback after each period. Gene used cooperative groups and
the logbook, but he did not give feedback in these logbooks, something he said that he would certainly do next time.

**Extending the Interconnected Model of Teacher professional Growth**

Comparison of teacher-developers’ learning with teacher-enactors’ learning shows that the *development phase* contributed substantially to the changes in teacher knowledge, beliefs and attitudes. This led to the conclusion that the *development phase*, followed by the *class enactment phase* was instrumental for teacher-developers growth.

To accommodate the fact that the learning material ‘under construction’ substantially contributed to teacher growth, the Clark and Hollingsworth IMTPG model is extended with one extra domain, the Developed Material Domain. This EIMTPG model is shown in Figure 2. In this new model two phases can be distinguished: a *development phase* and a *class enactment phase*.

![Figure 2. Extended Interconnected Model of Teacher Professional Growth (EIMTPG)](image)

Teacher learning in the *development phase* will take place though interaction of this Personal Domain and two other domains, the External Domain and the Developed Material Domain.
Teacher knowledge and beliefs are located in the Personal Domain. The External Domain comprised: a) documents about context-based chemistry, for example from the National Steering Committee that initiated this reform, b) experiences from one teacher-developer served as learning opportunities and mirrors for the others, c) specific literature, for example on cooperative learning, d) network discourse about the learning materials ‘under construction’ in the different stages and its influence on student learning, e) expertise from the coach.

During the class enactment phase, experiences in the Domain of Practice can lead to salient student learning outcomes (Domain of Consequence) and this in turn will influence the Personal Domain. The interaction between the domains occurs either through enactment or reflection.

Reflection on the External Domain influences the knowledge in the Personal Domain (Figure 2, arrow 1). Exchanged experiences during network sessions catalyzed reflection on own practices. A teacher-developer, who shared experiences about learning activities, materials or instructional methods and the resulting student learning outcomes, was given a mirror through the questions the other network members posed. For the other teacher-developers these experiences form a framework through which they assessed their own practices. This kind of exchanging experiences is powerful as they are about real class practices. Discourse at network meetings had a similar effect. Discussions ranged from coming to grasp with context-based chemistry to possible chemical reactions with food additives.

Enactment from the Personal Domain (Figure 2, arrow 2) can be portrayed as follows: teacher-developers had to become aware of personal teaching practice experiences interesting enough to share with the others. Each teacher-developer not just had to select and share these experiences, but had to translate these in such a way as to become accessible for the others. During discourse
at network sessions a similar enactment process was required: a teacher-developer had to get his own framework clear to be able to contribute.

Analogous interactions in the form of reflection or enactment occurred between the other domains of Figure 2 (the arrows 3 t/m 12).

**Modeling teacher-developers’ growth**

The following examples for Pete, Lisa and Ed’s learning in the areas of a context-based approach and cooperative learning will illustrate how interactions between domains may lead to changes in teacher knowledge and beliefs.

**Pete.** In the extended model of Figure 2, the changes in beliefs with respect to context-based chemistry is visualized by the following sequence. Pete’s personal domain (PD) in addition to the context-based approach from the National Steering Committee (ED) was in a discourse process at network meetings translated into learning material (DMD) (arrows 1, 2, 3, 4), resulting in a module based on an appealing context for students. Pete however still had doubts about what students are to learn and about his own role in it (arrows 5, 6). Class experiences (DP) were positive in motivational terms (arrows 7, 8) but student concept learning was considered insufficient (DC) (arrows 9, 10), and this influenced Pete’s beliefs (PD) as he expressed that he now considered concepts more important than the context (arrows 11, 12). Experiences in class in fact determined how Pete finally perceived context-based issues.

The changes in knowledge and beliefs regarding cooperative learning can be described with the following sequence. Pete (PD) had not used cooperative learning earlier, but wanted to try this and literature about cooperative learning was studied (ED) (arrows 1, 2). After long discussions at the network meetings, cooperative learning was included in the learning material (DMD) (arrows 3, 4). This did not conflict with his beliefs (arrows 5, 6). Through the development of the
learning material Pete learned the why and how of cooperative learning, and he therefore decided to enact it in his classes. The subsequent class enactment (DP) (arrows, 7, 8) and the learning results (DC) (arrows 9, 10) proved that it worked well. This influenced his personal domain (PD) in the sense that his knowledge and belief of cooperative learning was confirmed (arrows 11, 12).

Lisa. Lisa’s learning concerning context-based chemistry started at the network meetings (ED), where the materials and also the ‘how-to-do’ aspects for class enactment were discussed (arrows 1, 2, 3, 4). The developed module (DMD) was for her instrumental for reflection (arrows 5, 6) as she wondered how students were going to react to it. Class enactment (DP) (arrows 7, 8) and the resulting learning outcome (DC) (arrows 9, 10) confirmed the value of the context-based approach, though Lisa was not happy about the concept learning that occurred. She could however indicate how to improve this aspect in future (arrows 11, 12).

Literature and the discussions during the network meetings (ED) on what instructional strategies to include in the learning material provided ideas for cooperative learning and these were included in the learning material (DMD) (arrows 1, 2, 3, 4). Class enactment (DP) (arrows 7, 8) was positive, and Lisa was happy about the process for student learning (DC) (arrows 9, 10). This resulted in theoretical and practical knowledge and skills on cooperative learning (PD) (arrows 11, 12).

Ed. Ed’s growth with respect to context-based education can be described through the following sequence in the model. He had outspoken beliefs (PD) about what students had to learn and how this could be achieved. Network discourse (ED) hardly influenced these beliefs (arrows 1, 2). He advocated the use of a context in the material (DMD) (arrows 3, 4) as he wanted students to start from the concrete. Ed and his students perceived class enactment (DP) positively (arrows 7, 8).
and the student learning results (DC) were as expected (arrows 9, 10) which strengthened his initial beliefs (arrows 11, 12).

Regarding cooperative learning a similar sequence unfolded, but with an unexpected turn. Ed (PD) wanted students to be active learners and perceived his role in class as coach and facilitator of Socratic conversations. He wanted students to work on their own, not in cooperative groups. Network discourse and specific literature (ED) (arrows 1, 2) resulted in incorporation of cooperative learning, including the use of a group logbook and student group roles, in the material (DMD) (arrows 3, 4). Before class enactment Ed however decided not to use cooperative learning, his personal belief (PD) resulted in changes in the instructional strategies advocated in the material (DMD) (arrows 5, 6). Class enactment (DC), of the adapted material, and learning results (DC) were positive, confirming Ed’s initial beliefs (arrows 7, 8, 9, 10, 11, 12).

Clarke and Hollingsworth (2002) distinguished so called “change sequences” consisting of “two or more domains together with the reflective or enactive links connecting these domains, where empirical data support both the occurrence of change in each domain and their causal connection” (p. 958), and “growth networks” when a change is more than momentary. This last is seen as professional growth. Our data in relation to the last two phases from the process, the development phase and the class enactment phase support the argumentation that the changes during the development phase can be seen as “change sequences”. The class enactment phase leads to “growth networks” for specific aspects of teacher-developers’ knowledge and beliefs.
**Modeling teacher-enactors’ growth**

In terms of the EIMTPG model, the External Domain for this group of teachers was very limited: as there were no network sessions the documents from the national steering committee were not discussed, teaching experiences were not exchanged, no ‘materials under construction’ were discussed, and no specific literature was consulted, except the teachers’ guide supporting the learning material. This resulted in the teacher-enactors making personal adaptations to the learning material (DMD) (Figure 2, arrows 5, 6) even before class use. Because these teacher-enactors did not have a clear picture of context-based chemistry, they did not use the materials in class (DC) as intended by the teacher-developers, resulting in disappointing student learning results (DC) and few changes in the teacher-enactors’ knowledge and beliefs. Actually these teacher-enactors did not use the opportunity to bring their knowledge and beliefs in line with the renewal, but they adapted the material to suit their knowledge and beliefs.

The stages of concern teachers go through in times of an innovation from the Concerns Based Adoption Model are all addressed in the EIMTPG model. For the teacher-developers the first three phases, initiation, adoption and part of implementation are addressed in the *development phase*, the rest of implementation and incorporation in the *class enactment phase*. Because the teacher-enactors did not go through a development phase it is clear that they miss out on initiation, adoption and part of implementation.

Joyce and Showers’ effective training components are for the teacher-developers integrated in the EIMTPG model. The teacher-enactors however had very limited time to familiarize with the rationale, the demonstration and practice, and had no support during teaching.
Conclusion and discussion

Developing student learning material and subsequent class enactment leads to changes in knowledge and beliefs of the teacher-developers. Only class enactment of this learning material hardly leads to changes in knowledge and beliefs. The combination of two cycles, the development of student learning material followed by class enactment, proved instrumental for teacher learning. This process can be described through the EIMTPG model.

The first cycle, the interactions between the Personal Domain, the External Domain and the Developed Material Domain, in this extended model shows that the development of learning material allows for multiple cycles of presentation and reflection on knowledge (Penuel, Fishman, Yamaguchi, & Gallagher, 2007), in which teachers get to understand the goals of the renewal (Pintó, 2005) and in which their knowledge and beliefs are taken as starting points (F. Coenders, Terlouw, & Dijkstra, 2008). The teacher-developers make their PCK explicit through reflection about their practices (Bindernagel & Eilks, 2009). The iterative and cyclic process of developing material and discourse about this material leads to new knowledge and beliefs. Several “change sequences” are established in this process.

Two other advantages of this first cycle can be distinguished. Firstly, discourse at network meetings facilitates implementation by seeking ‘how-to-do’ advice, also with respect to new teaching approaches. Secondly, the ‘teacher as developer’ process narrows the gap between the ideal and the operational curriculum (Van den Akker, 1998).

The second cycle in this extended model, the interactions between the Domain of Practice, Domain of Consequence and the Personal Domain, shows the consequences of enacting the material in class. Three different kinds of results may surface: (a) a student learning result hoped for by the teacher-developers does occur; (b) a learning result hoped for does not materialize;
and (c) a not anticipated learning result is seen. When a student learning result was anticipated and indeed does take place, teachers’ knowledge and beliefs will be reinforced, and this will lead to a “growth network” for given aspects of teacher knowledge. When a student learning result was anticipated but does not materialize a cognitive conflict arises. Teachers may revert to their previous’ knowledge and beliefs, but it is also possible that the teachers can explain why the anticipated learning does not take place and can indicate how the materials can be adapted to repair this. This will also lead to lasting new knowledge and beliefs, in other words to “growth networks”. When a not anticipated learning result does take place, teachers will try to attribute this to specific elements in the material or to the learning process, which may lead to “change sequences” or to “growth networks”.

To develop the EIMTPG, two extremes have been studied. On the one hand the teacher-developers who developed student learning material from scratch, that was based on context-based chemistry, and thereafter enacted this in class. These teachers did acquire new knowledge and beliefs. Unfortunately the process is costly in terms of invested time and therefore not suitable to professionalize large numbers of teachers. The second group, the teacher-enactors who merely class enacted the learning material, learned little about the innovation.

Both cycles, a development phase followed by a class enactment phase are important. But the question that needs to be answered is how much development activities a teacher must do to come to a sufficient form of professionalization, in other words how must the development phase look like. Would it be sufficient when teachers redeveloped existing learning material in a group of teachers with a coach instead of starting from scratch?
The first seeds of changes in knowledge and beliefs are planted in the External Domain. What components should this External Domain consist of in order to provide sufficient new ideas, practical advice and tools to develop innovative student learning materials? Is it sufficient when the External Domain consists of elements like: a) opportunities to exchange experiences and ideas between the participating teachers in order to catalyze reflection, b) opportunities to familiarize with new content and new pedagogies, c) opportunities for discourse on draft materials and how student learning is anticipated, d) sufficient time? And how should the development process look like to both have sufficient time for the development of the material and to allow the teachers to learn concurrently how this material can be enacted in class? What is the optimum number of meetings in what time frame? Future research needs to clarify this.
References


Coenders, F. (2010). *Teachers' professional growth during the development and class enactment of context-based chemistry student learning material*. Doctoral Thesis University of Twente, Enschede.


