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# Towards an empirically substantiated professional development programme to train lead teachers to support curriculum innovation

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## ABSTRACT

The aim of this study is to establish an empirically substantiated professional development programme for teachers to become lead teachers who are able to support professional development of peers in times of curriculum innovation. The design of a professional development programme, participants' learning outcomes and their interrelatedness are described. The three main interventions in the professional development programme are: (A) a national learning community of lead teachers-in-training to participate in formal training and peer intervention; (B) regional learning communities of teachers where lead teachers-in-training practice their leadership qualities and receive feedback on their functioning as lead teachers; and (C) self-reflection to stimulate awareness of learning progress among participants. This qualitative case study reports the results of the designed programme embedded in the implementation process of a context-based chemistry curriculum in secondary education in the Netherlands. Results show that participants acquire intended learning outcomes in terms of knowledge, skills and dispositions. These learning outcomes are invoked by the combination of interventions in the professional development programme. From the results it can be concluded that the designed professional development programme has potential to train teachers to become lead teachers to support curriculum innovation.

**Abbreviations:** CIMO: Context Intervention(s) Mechanism(s) Outcomes; LT(s): Lead Teacher(s); NLC: National Learning Community; RLC: Regional Learning Community.

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## KEYWORDS

Lead teachers; professional development programme; learning outcomes

## Introduction

It has been advocated that teacher leadership is a key component in educational innovation (Frost 2012). Several authors (Howe and Stubbs 2003, Hofstein *et al.* 2004, Bulte and Seller 2011, Luft *et al.* 2014) plea for a central role for lead teachers to foster innovation in science education. Teachers are natural leaders among peers since they are familiar with teaching practice and challenges teachers encounter in their day-to-day work (Frost and Harris 2003, York-Barr and Duke 2004, Taylor *et al.* 2011, Groundwater-Smith and Mockler 2012). Lead teachers are able to support colleagues to innovate their classroom practices, for example through modelling innovative classroom practice or coaching fellow teachers in using and designing innovative teaching materials (Frost and Harris 2003, York-Barr and Duke 2004, Taylor *et al.* 2011). Doing so, lead teachers make their expertise on teaching and learning available to colleagues. For example, in a

study on lead teachers in a nationwide curriculum innovation in New Zealand, Taylor *et al.* (2011) found that peer teachers appreciate the role of lead teachers as exemplary teachers who themselves successfully changed their classroom practice. This experience lends credibility to lead teachers and encourages colleagues in their efforts to change their classroom practice.

Lead teachers are accomplished teachers who spend most of their time in the classroom and occasionally take on a leading role (Muijs and Harris 2003). However, good teachers do not automatically make good leaders as teaching and leading require substantially different qualities (Clemson-Ingram and Fessler 1997, Smylie and Mayrowetz 2009). Based on York-Barr and Duke (2004) and Taylor *et al.* (2011), (I) subject expertise, (II) ability to facilitate a learning community of teachers and (III) personal dispositions are identified as leadership qualities required for teachers to become effective leaders in times of educational innovation.

Despite recognition of the key role lead teachers can play in educational innovation, professional development programmes to train lead teachers are a relatively new area of study (Luft *et al.* 2014). It is clear that training lead teachers requires a purposefully developed programme (Smylie and Mayrowetz 2009, Luft *et al.* 2014). Empirical studies on professional development programmes to develop leadership qualities describe ongoing programmes of at least one schoolyear (Howe and Stubbs 2003, Hofstein *et al.* 2004, Luft *et al.* 2014). Hofstein *et al.* (2004) studied a year-long professional development programme for chemistry teachers to become school chemistry coordinators responsible for implementing a new chemistry curriculum in their schools. The participating teachers attended weekly full-day meetings. The content of the programme comprised development of content knowledge, pedagogical content-knowledge and leadership skills. Results of the study show that participating chemistry teachers developed the required understanding, skills and tools to implement changes. In a study on leadership development of three teachers within a large 6-year programme consisting of an initial two-week summer seminar and continuing support using 1-day, weekend or 1-week workshops and seminars, Howe and Stubbs (2003) identified four elements of their professional development programme that promoted and supported development of leadership qualities. The four elements of the programme were: creating a community of practice, opportunities to assume leadership roles, challenging tasks and mutual respect between scientists and teachers. Luft *et al.* (2014) describe how teachers developed leadership qualities by participating in a leadership programme consisting of a central summer programme, a regional school-year programme, and, over time, taking on various leadership roles. Vanblaere and Devos (2016) conducted a large scale quantitative study on links between characteristics of professional learning communities and teacher leadership. Based on teachers' self-reports, they found that reflective dialogues are important for lead teachers to become able to effect changes in education.

Thus, some evidence exists that (components of) professional development programmes link to development of leadership qualities for participating teachers. However, the results of these studies have not been directed towards mechanisms that explicitly relate a professional development programme to teachers' learning outcomes with respect to leadership qualities. The authors of these studies (Howe and Stubbs 2003, Hofstein *et al.* 2004, Luft *et al.* 2014, Vanblaere and Devos 2016) plea for explicit in-depth qualitative studies that relate components of professional development programmes to specific learning outcomes of participating teachers. Frost and Harris (2003), Mangin and Stoelinga (2010), Poekert (2012) and Snell and Swanson (2000) confirm this lack of insight into components of programmes to train lead teachers, learning outcomes of participants, and how programme components and learning outcomes are interrelated. Knowledge in this area is required to develop effective professional development programmes to train lead teachers (Baecher 2012).

The aim of this study is to establish an empirically substantiated professional development programme for teachers to become lead teachers who are able to support professional development of peers in times of educational innovation. The emphasis is on elaborating mechanisms

through which specific components of a professional development programme lead to participants' learning outcomes in terms of (I) subject expertise, (II) ability to facilitate a learning community and (III) personal dispositions.

## Design of a professional development programme to train lead teachers

To focus on interrelatedness between components of a professional development programme and participants' learning outcomes, the design of the professional development programme can be described in terms of the so-called CIMO-logic. This logic provides a template to systematically describe how professional development activities lead to intended outcomes (Deneyer *et al.* 2008). CIMO stands for Context, Intervention, Mechanism and Outcome. Table 1 provides a description of the four components of the CIMO-logic. According to this logic, design principles are described using the following structure: 'In this class of problematic Contexts, use this Intervention type to invoke these generative Mechanism(s), to deliver these Outcome(s)' (Deneyer *et al.* 2008, p. 395). Using the CIMO-logic in this design-based study creates the possibility to determine not only whether an intervention leads to a certain outcome, but also why an intervention leads to a certain outcome in a specific context (Brouwer, Brekelmans, Nieuwenhuis & Simons, 2012).

This section of the paper first describes the context, followed by predetermined outcomes of the professional development programme to train lead teachers. Next, the interventions that constitute the programme and the intended mechanisms through which the predetermined outcomes are to be achieved, are described.

### Context

A professional development programme to train lead teachers is designed in the context of a nationwide curriculum innovation in secondary chemistry education in the Netherlands. In 2002, the Dutch Ministry of Education issued a review of the chemistry curriculum which had been in use without substantial changes since 1984. It was concluded that there was growing discrepancy between chemistry as a school subject and chemistry in science, industry and society (Van Koten *et al.* 2002). Chemistry had a negative image among secondary school students and teachers experienced an overload in the curriculum. The committee established the necessity of reform and recommended a context-based curriculum for Dutch secondary chemistry education (Driessen and Meinema 2003). The reform implies that social, experimental, theoretical and vocational contexts provide starting points for students to study chemical concepts. The professional development programme discussed in this study was established to involve chemistry teachers in this curriculum innovation. Chemistry teachers were trained as lead teacher to support peer teachers in designing teaching materials for the new context-based chemistry curriculum, and to support implementation in classroom practice.

In this context, the definitions of Luft *et al.* (2014) and Howe and Stubbs (2003) are followed to define lead teachers. Luft *et al.* (2014) describe lead teachers as teachers who exert leadership with the 'capacity and commitments to contribute beyond one's classroom' (citing Fullan and Hargreaves 1996, p. 13). According to Howe and Stubbs (2003) lead teachers 'influence others towards improved educational practices, and identify with and contribute to a community of

Table 1. CIMO-logic (adapted from Deneyer *et al.* 2008).

	Component	Explanation
C	Context	The surrounding factors and the nature of actors involved
I	Intervention	Interventions aimed at achieving predetermined outcomes
M	Mechanism(s)	Mechanisms that are triggered to achieve predetermined outcomes
O	Outcome(s)	Predetermined outcomes

teacher leaders' (citing Katzenmeyer and Moller 1996, p. 6). Howe and Stubbs describe teacher leadership as 'arising from and created by a community of people working and growing together towards common goals' (2003, p. 284). This is a view of leadership that is not managerial or administrative, but one of leadership exercised within the community of practice to which a teacher leader belongs. Lead teachers work with colleagues within their schools and beyond to introduce a new curriculum, support professional development of peers and lead the way towards educational innovation.

In this study, the term 'lead teacher-in-training' is used to refer to teachers participating in the professional development programme to become lead teachers. The term lead teachers is used for teachers that have already acquired leadership qualities by participating in the programme in previous years.

### **Outcomes**

Lead teachers-in-training need to acquire leadership qualities in the areas of (I) subject expertise, (II) ability to facilitate a learning community of teachers and (III) personal dispositions. In this study these leadership qualities are translated into specific outcomes related to the implementation of context-based chemistry education.

#### **Subject expertise**

The most important quality of lead teachers is their (I) subject expertise as it contributes to establish teachers' credibility as leaders among peers (Snell and Swanson 2000). Subject expertise consists of knowledge about their subject, that is curriculum, pedagogy, teaching and learning strategies (Snell and Swanson 2000, Frost and Harris 2003, Lieberman and Friedrich 2010), and knowledge about the reform (Remillard and Geist 2002). Lead teachers need the ability to articulate and demonstrate this expertise, and effectively share it with other teachers in order to contribute to peer teachers' professional development (Frost and Harris 2003, York-Barr and Duke 2004).

Subject expertise consists of two major aspects: (Ia) knowledge about the context-based chemistry curriculum, and (Ib) knowledge and skills related to designing context-based teaching materials. Knowledge about the context-based curriculum entails knowledge about the vision behind the curriculum, its goals and classroom implementation. Lead teachers require knowledge on these aspects to support peer teachers' professional development in this area (Remillard and Geist 2002) and to articulate and subsequently narrow the gap between peer teachers' current classroom practices and intended innovative classroom practices (Frost and Durrant 2003).

Knowledge and skills related to designing context-based teaching materials are a second aspect of lead teachers' subject expertise. Designing innovative context-based teaching materials and enacting them in classroom practice are powerful activities for teachers' professional development (Parke and Coble 1997, George and Lubben 2002, Stolk *et al.* 2009). It familiarizes teachers with the educational goals and basic principles of the new curriculum and pedagogy (Coenders 2010). This leads to teacher empowerment concerning implementation of the new curriculum (George and Lubben 2002, De Putter-Smits 2012). However, designing teaching materials is a skill not generally possessed by teachers; this skill needs to be carefully developed under the guidance of more experienced designers (Stolk *et al.* 2009, Coenders 2010). In the professional development programme, lead teachers(-in-training) fulfil the roles of expert designers to support peer teachers' professional development in this area.

#### **Ability to facilitate a learning community of peers**

A second quality of lead teachers is their (II) ability to facilitate a learning community of peers (Snell and Swanson 2000, York-Barr and Duke 2004, Taylor *et al.* 2011). To do this effectively, lead

teachers need to establish trustworthiness among peers and develop collaborative relationships to establish their authority as lead teachers (Frost and Harris 2003, York-Barr and Duke 2004).

The ability to facilitate a learning community of teachers consists of (IIa) coaching skills and (IIb) collaborative skills. Coaching skills involve supporting peer teachers, either in individual or group settings (York-Barr and Duke 2004). These skills are important for teachers' confidence to act as lead teachers and thereby ease their transition into a leading role (Muijs and Harris 2003).

Working and learning collaboratively is a primary means by which lead teachers can influence professional development of peer teachers (York-Barr and Duke 2004). Teaching is a rather solitary profession without much opportunity for collaboration with peers. Development of collaborative skills is essential for lead teachers-in-training in order to collaborate with other lead teachers-in-training in the professional development programme, and to support collaboration among peer teachers when leading professional development activities (Lieberman and Friedrich 2010).

### **Personal dispositions**

Third, a lead teacher's (III) personal dispositions determine the extent to which effective leadership can be exercised among colleagues (Frost and Harris 2003, Taylor *et al.* 2011). Lead teachers need confidence in their own knowledge and skills to lead among peers (Muijs and Harris 2003). One way to establish confidence is through experiential learning as described by Korthagen *et al.* (2001). In a cycle of action, reflection, awareness, creation of alternatives, and new action (Korthagen *et al.* 2001), teachers become conscious of their functioning as lead teachers and are enabled to monitor their own learning progress. In this way, reflection contributes to teachers' professional development to become effective lead teachers. Therefore, the outcome (III) personal dispositions consists of two aspects: (IIIa) ability to reflect on their functioning as lead teachers, and (IIIb) ability to reflect on their learning processes.

### **Interventions**

Embedded in the context of the national chemistry curriculum reform in the Netherlands, the professional development programme comprises three main components: (A) a national learning community of lead teachers-in-training, (B) regional learning communities of teachers led by lead teachers-in-training and (C) self-reflection. Each component entails planned interventions for the lead teacher-in-training. In the national learning community, lead teachers-in-training: (A1) participate in formal training on the context-based chemistry curriculum; (A2) participate in formal training on coaching techniques; and (A3) perform peer intervention with other lead teachers-in-training. In regional learning communities of teachers, lead teachers-in-training (B1) lead a learning community of peer teachers. They lead discussions about classroom practice using the context-based chemistry curriculum and they lead the process of designing context-based teaching materials. The lead teachers-in-training also (B2) receive feedback and support from a trainer or experienced lead teacher within the regional learning community. The third component is focused on self-reflection and entails the lead teachers-in-training (C1) performing self-reflection and writing reflection reports on their own learning process and functioning as a lead teacher. Table 2 provides an overview of the Interventions in the professional development programme and shows what learning outcomes are intended by the interventions.

### **Mechanisms**

The concept of 'mechanism' is used to link interventions in a purposefully designed (professional development) programme to intended outcomes. Deneyer *et al.* (2008, p. 395) raise the issue of causality, that is by asking through which generative mechanism(s) the intervention produces the

**Table 2.** Overview of interventions, assumed mechanisms and outcomes of the professional development programme to train lead teachers.

Interventions	Assumed mechanisms	Intended outcomes
<b>A. NATIONAL LEARNING COMMUNITY OF LEAD TEACHERS-IN-TRAINING</b>		
A1. Participate in formal training on the context-based chemistry curriculum	Through presentation of relevant information by the trainers of the NLC on the rationale, set-up and pedagogy of the context-based chemistry curriculum, LTs-in-training learn...	I.a. Knowledge about the context-based chemistry curriculum
	Through discussion of exemplary teaching materials, on the set-up, content and teaching-learning strategies and activities, LTs-in-training learn...	I.b. Knowledge and skills related to designing context-based chemistry teaching materials
A2. Participate in formal training on coaching techniques	Through presentation of relevant information by the trainers of the NLC on (peer) coaching techniques, LTs-in-training learn...	II.a. Coaching skills II.b. Collaborative skills
	Through demonstration of coaching techniques by the trainers of the NLC as role models, LTs-in-training learn...	
A3. Perform peer intervision with other lead teachers-in-training	Through using participants' experiences as leaders of a RLC as starting points for discussion and peer coaching, feelings of ownership are developed, establishing a 'need-to-know' basis fostering LTs-in-training to learn...	II.a. Coaching skills II.b. Collaborative skills
	Through peer intervision the LTs-in-training learn about others' experiences as leaders and their perspectives on the leadership role, fostering LTs-in-training to learn...	III.a. Ability to reflect on own functioning as a lead teacher III.b. Ability to reflect on own learning process
<b>B. REGIONAL LEARNING COMMUNITIES OF TEACHERS</b>		
B1. Lead the regional learning community	Through practical experience as a leader LTs-in-training experience feelings of competence and effectiveness and thereby learn...	II.a. Coaching skills II.b. Collaborative skills for working with peers
	Through sharing knowledge on the context-based curriculum with peers and leading the process of collaboratively designing teaching materials, LTs-in-training learn...	I.a. Knowledge about the context-based chemistry curriculum I.b. Knowledge and skills related to designing context-based chemistry teaching materials
B2. Receive feedback and support from a trainer or experienced lead teacher	Through visits of an experienced lead teacher or national trainer ongoing feedback, intervision and reflection on leadership activities are established, leading LTs-in-training to learn...	III.a. Ability to reflect on own functioning as a lead teacher III.b. Ability to reflect on own learning process
	Through an ongoing process of feedback, intervision and reflection on leadership activities, LTs-in-training become aware of their learning outcomes in terms of leadership qualities and can identify points of improvement, leading LTs-in-training to learn...	II.a. Coaching skills II.b. Collaborative skills for working with peers
<b>C. SELF-REFLECTION</b>		
C1. Perform self-reflection and write reflection reports	Through self-reflection, LTs-in-training become aware of their learning progress and which leadership qualities still need to be addressed, leading LTs-in-training to learn...	III.a. Ability to reflect on own functioning as a lead teacher III.b. Ability to reflect on own learning process

outcome in the given context. This is a response to earlier descriptions of 'design principles', as described by van den Akker (1999, p. 9). He developed the following format for design principles:

If you want to design <intervention X> for the <purpose/function Y> in <context Z>, then you are best advised to give <that intervention> the <characteristics A, B and C> [substantive emphasis], and to do that via <procedures K, L and M> [procedural emphasis], because of <arguments P, Q and R> .

This description emphasises the relation between Intervention and Outcome without a notion of the 'how'. Therefore Deneyer *et al.* (2008, p. 405) plea for the following description of the 'how':



Mechanisms (M) comprises the mechanism that in a certain context is triggered by the intervention. For instance, empowerment offers employees the means to contribute to some activity beyond their normal tasks or outside their normal sphere of interest, which then prompts participation and responsibility, offering the potential of long-term benefits to them and/or to their organization.

The authors come to this example of ‘mechanism’ by grounding their work in arguments from the literature. Actually, this way of reasoning resembles the earlier work of Van den Akker (1999) and Van den Akker *et al.* (2006) as it is also applied in Prins *et al.* (2011, p. 1546) when using ‘design principles’:

Design principles link *strategy components*, for example, what to do, how precisely, when in the sequence, with what tools, and how enacted; *pedagogic effects*, for example, students’ epistemic notions regarding models and modelling; and *arguments*, for example, literature on educational research, empirical findings from previous applications, and/or practical considerations.

In this study, we follow the CIMO-logic and build on the definition of Deneyer *et al.* (2008), supplemented by the last part of van den Akker’s (1999) description of a design principle: ‘because of the arguments P, Q, R’. A mechanism thus is that ‘because of the participation of a specific part of the intervention, a certain effect is established which leads to the realization of a specific part of the intended outcomes’. This assumed causality is grounded within the educational literature and includes a line of argumentation. The empirical verification of this type of causality leads to insight into whether the used arguments are valid within the context of study.

In the designed professional development programme, lead teachers-in-training are involved in two learning communities as leadership qualities are most readily fostered in learning communities (York-Barr and Duke 2004). The national learning community (A) is designed as a site for learning and regional learning communities (B) as sites for practice. In a review study on training research, Salas and Cannon-Bowers (2001, p. 481) identify four basic principles for effective training strategies:

- (1) present relevant information of concepts to be learned;
- (2) demonstrate the knowledge, skills and dispositions to be learned;
- (3) create opportunities for trainees to practice the skills and
- (4) provide feedback to trainees during and after practice.

These strategies form the basis for the assumed mechanisms that link interventions in the professional development programme to intended outcomes. Table 2 provides an overview of the interventions, assumed mechanisms and intended outcomes.

In the national learning community, lead teachers-in-training participate in formal training on the context-based chemistry curriculum (A1) to learn about the rationale, set-up and pedagogy of the new curriculum. Additionally, exemplary teaching materials are discussed. Lead teachers-in-training require knowledge on these issues in order to inform peers in the regional learning communities (Hofstein *et al.* 2004). The assumed mechanism is that by receiving relevant information and discussing teaching materials, lead teachers-in-training learn about the new curriculum and gain knowledge and skills related to designing context-based teaching materials. The lead teachers-in-training also receive formal training on (peer) coaching techniques (A2) and thereby learn knowledge and skills necessary to lead a regional learning community. This formal training corresponds to the first principle by Salas and Cannon-Bowers (2001) of being presented relevant information. Furthermore, the formal training is provided by two trainers who lead the national learning community as exemplars of how to lead a learning community, corresponding with the second principle of demonstrating the knowledge, skills and dispositions to be learned.

In line with the third principle by Salas and Cannon-Bowers (2001), lead teachers-in-training require opportunities to practice knowledge and skills they learn (Howe and Stubbs 2003, Hofstein *et al.* 2004, Luft *et al.* 2014). The regional learning communities offer sites for practice (B1) where they can share their knowledge about the new curriculum and designing teaching materials with peer teachers (Howe and Stubbs 2003). This process of knowledge sharing,



combined with collaboratively designing teaching materials with peer teachers, fosters learning of knowledge in these areas. The coaching techniques acquired in the national learning community can be applied to lead the regional learning community. The assumed mechanism is that this type of practical experience contributes to feelings of competence and effectiveness of the lead teachers-in-training (Howe and Stubbs 2003).

The fourth principle for effective training strategies, concerning feedback, is implemented in activities in both the national and regional learning communities. In the national learning community, lead teachers-in-training perform peer intervention in which situations encountered in the regional learning communities are used as the starting point for discussion (A3). The assumed mechanism is that in this way, the professional development activity responds to their needs and is connected to the activities of the lead teachers-in-training in the regional learning communities (cf Hofstein *et al.* 2004). This enhances feelings of ownership in the national learning community and thereby increases the professional development potential of the intervention activity (cf Howe and Stubbs 2003). According to Luft *et al.* (2014), discussion of leadership experiences provides lead teachers-in-training with an opportunity to address challenges they encounter in their leadership activities, and to gain insight into perspectives of other lead teachers-in-training on their leadership role. The assumption is that through these discussions, lead teachers-in-training increase their ability to reflect.

Additionally, lead teachers-in-training receive feedback and support from a trainer or an experienced lead teacher when performing their leadership activities within a regional learning community (B2). Lead teachers-in-training require ongoing support while learning to lead a learning community of peers (Howe and Stubbs 2003). The assumed mechanism is that through this ongoing support, lead teachers-in-training are continually involved in processes of feedback, intervention and reflection, thereby increasing their ability to reflect on their learning process and functioning as a lead teacher. This process is reinforced by letting lead teachers-in-training perform self-reflection and write reflection reports (C1). These interventions (B2 and C1) are aimed at making the learning of lead teachers-in-training a conscious process. The assumed mechanism is that being aware of their progress, that is acquired leadership qualities in terms of knowledge, skills and dispositions, aids lead teacher-in-training in knowing what knowledge, skills and dispositions they still need to acquire.

## Scope and research questions

To establish an empirically substantiated professional development programme for teachers to become lead teachers who are able to support professional development of peers in times of educational innovation, this study addresses two research questions. The first question is directed towards learning outcomes of lead teachers-in-training in terms of leadership qualities. The second research question is intended to reveal empirically verified mechanisms that connect interventions in the professional development programme to these learning outcomes.

The two research questions are:

- (1) What leadership qualities do lead teachers-in-training acquire in terms of:
  - ...subject expertise?
  - ...ability to facilitate a learning community?
  - ...personal dispositions?
- (2) What mechanisms are triggered by the interventions in the professional development programme to train lead teachers to contribute to participants' learning outcomes?

## Method

### Research approach

This qualitative design-based study is a case study of a professional development programme to train lead teachers during a chemistry curriculum reform in the Netherlands. The research questions are addressed through participants' self-reported learning outcomes and experiences.

### Setting

The professional development programme to train lead teachers ran for three years (2009–2012). This study focusses on six teachers that participated in the third year (2011–2012) of the programme. The programme was organized by two trainers: an expert on the new context-based chemistry curriculum, and an expert on coaching techniques. Bimonthly meetings of the national learning community were organised over the course of one schoolyear. Formal training on the context-based chemistry curriculum and coaching techniques, and intervision sessions were organised during these meetings. A schedule of the meetings is listed in [Appendix 1](#).

There were four regional learning communities led by the lead teachers-in-training. Meetings were organised every four to six weeks. Four of the lead teachers-in-training operated in duos within a regional learning community as there were only four regional learning communities and six lead teachers-in-training. [Table 3](#) shows an overview of the compositions of the regional learning communities. Two lead teachers-in-training facilitated a regional learning community independently, without guidance of an experienced lead teacher since no lead teachers were available in these regions. Four experienced lead teachers participated in community North. It was intended that lead teachers would recruit new teachers to start new regional learning communities. However, there were not enough teachers in this region willing to start new learning communities so they continued participation in community North. To allow both lead teachers-in-training to put their acquired knowledge and skills to practice, community North split into two subgroups to design teaching materials; other community activities were done collectively. In regional learning community West two lead teachers-in-training were present as well. In this community leadership was alternated between both lead teachers-in-training.

### Participants

The participants are six lead teachers-in training. They are secondary education chemistry teachers with 3 to 35 years of experience. Three out of six lead teachers-in-training (Beatrice, Ellen and Charles) participated as teachers in a regional learning community before entering the professional development programme to become a lead teacher; the other three lead teachers-in-training (Luke, James and Bob) entered the programme without previous participation in a regional learning community.

The lead teachers-in-training have a positive attitude towards educational innovation in general and the context-based chemistry curriculum in particular. They are willing to learn and take on a leading role to support peer teachers in implementing the new curriculum in classroom practice and lead a process of collaboratively designing teaching materials for the context-based curriculum.

**Table 3.** Composition of the regional learning communities.

Regional learning community	# Lead teachers-in-training	Lead teachers-in-training	# Teachers	# Lead teachers
North	2	Beatrice & Ellen	2	4
East	1	Luke	4	-
South	1	Charles	7	-
West	2	James & Bob	2	1

### Data collection

Data was collected from three sources: semi-structured interviews, a questionnaire and teachers' portfolios. Two semi-structured interviews were held with each respondent. One interview was held six months into the professional development programme; the second interview was a retrospect interview six months after completion of the programme. The interview protocols are outlined in [Appendix 2](#). All interviews were recorded and transcribed, and interview reports were sent to respondents for member checks (Miles and Huberman 1994).

A questionnaire on hindering and stimulating aspects of the professional development programme was distributed among the lead teachers-in-training two months after completion of the programme. Exemplary questions from the questionnaire are shown in [Appendix 3](#).

The third data source was portfolios of the lead teachers-in-training containing their self-reflection reports concerning their learning process and outcomes. [Table 4](#) provides an overview of the use of the data sources to answer the research questions.

### Data analysis

Qualitative data analysis was performed using a quote selection and coding strategy (Miles and Huberman 1994). Quotes relevant to answering the research questions were selected and coded using two predefined coding schemes.

To answer research question 1, coding scheme I ([Table 5](#)) was used to identify learning outcomes of the lead teachers-in-training. The scheme is based on the intended learning outcomes as described in the design of the professional development programme.

To answer research question 2, both coding scheme I ([Table 5](#)) and coding scheme II ([Table 6](#)) were used. Coding scheme II is based on the interventions in the professional development programme. It was used to identify participants' references to these interventions. Quotes coded with codes from both coding scheme I and II are used to reveal mechanisms as reported by the lead teachers-in-training as these quotes can contain information on how the lead teachers-in-training relate their self-reported learning outcomes to interventions in the professional development programme. These mechanisms are described qualitatively. [Table 7](#) provides an example of a quote coded with both coding schemes to answer research question 2.

An inter-rater reliability check was performed in four steps by the three authors. First, the first author selected relevant quotes from the data. The second and third author checked the data of one lead teacher-in-training to assess whether all relevant quotes were selected. There was agreement on the selected quotes. The second step entailed discussion of coding schemes I and II and the corresponding codebooks to enhance consistent interpretation of codes among the

**Table 4.** Data sources used to answer research question 1 and 2.

	Interview I	Interview II	Questionnaire	Portfolio
Research question 1	x	x	x	x
Research question 2	x	x	x	

**Table 5.** Coding scheme I.

Code	Quotes concerning:
Subject expertise	Learning outcomes related to... ...the new context-based chemistry curriculum ...designing teaching materials
Ability to facilitate a learning community	Learning outcomes related to ...coaching skills ...collaborative skills
Personal dispositions	Learning outcomes related to ...reflective skills

**Table 6.** Coding scheme II.

Code	Quotes concerning:
A. National learning community of lead teachers-in-training	Activities in the national learning community related to...
A1. Participate in formal training on the context-based chemistry curriculum	...learning about the new context-based curriculum
A2. Participate in formal training on coaching	...learning coaching skills
A3. Perform peer intervision with other lead teachers-in-training	...exchanging experiences and discussing the role of lead teacher in a regional learning community
B. Regional learning community of teachers	Activities in the regional learning community related to...
B1. Lead the regional learning community	... leading a regional learning community in general
B1a. Lead design process	...specifically leading the process of designing teaching materials for the new curriculum
B1b. Lead discussions on classroom practice	...specifically leading discussions on classroom use of the new curriculum
B2. Receive feedback and support from a trainer or experienced lead teacher	...receiving feedback from a trainer or experienced lead teacher
C. Self-reflection	Activities related to...
C1. Perform self-reflection and write reflection reports	...reflecting on own learning process and learning outcomes

**Table 7.** Example of a quote to answer RQ 2.

Quote [Beatrice, interview II]	Codes	Mechanism
<i>I learned a lot from coaching a teacher who still had a lot to learn. (...) Without the professional development programme I would have done that very differently, with less successful results I think. To have somebody to share your knowledge with and to be able to immediately practice the things you have learned, that is really nice. That way you can see what works and what doesn't work (...) That was very pleasant.</i>	Intervention – B1 Outcome – Ability to facilitate a learning community Intervention – B1 Outcome – Ability to facilitate a learning community	Through immediately applying coaching techniques learned in the NLC to coach a peer teacher in the RLC, Beatrice's learned coaching skills are reinforced.

three coders. Subsequently, all authors coded the data of one lead teacher-in-training. The coding was discussed, which led to refinements of the codebooks. Third, the quotes of the remaining five teachers were coded by the first author and one of the other authors. The inter-rater reliability was 67%. All coded quotations were discussed until consensus was reached on the coding. The last step entailed discussion of the results of the coding process per lead teacher-in-training to reach consensus on the interpretation of the data and ensuing results. The authors answered research questions 1 and 2 per lead teacher-in-training based on the performed data analysis. This was followed by discussion of the results by all authors until consensus was reached.

## Results

### Research question 1

The lead teachers-in-training report learning outcomes that are in agreement with the intended learning outcomes, complemented with additional learning outcomes that were not anticipated in the design of the programme. Table 8 shows an overview of reported learning outcomes.

### Subject expertise

All lead teachers-in-training report learning outcomes concerning (I.a.) knowledge about the context-based chemistry curriculum. Despite considerable learning in this area, James and Bob were not satisfied with this aspect of the programme. In contrast to the other lead teachers-in-training, they were not involved in a regional learning community before entering the professional development

**Table 8.** Overview of reported learning outcomes of lead teachers-in-training.

	Intended outcomes	Additional outcomes
<b>SUBJECT EXPERTISE</b>		
I.a. Knowledge about the context-based chemistry curriculum	X	
I.b. Knowledge and skills related to designing context-based chemistry teaching materials	X	
I.c. <i>Changed perspective on teaching and learning in classroom practice</i>		X
<b>ABILITY TO FACILITATE A LEARNING COMMUNITY</b>		
II.a. Coaching skills	X	
II.b. Collaborative skills	X	
<b>PERSONAL DISPOSITIONS</b>		
III.a. Ability to reflect on own functioning as a lead teacher	X	
III.b. Ability to reflect on own learning process	X	
III.c. <i>Increased work attitude</i>		X
III.d. <i>Explicating personal views</i>		X

programme. Therefore, they were unfamiliar with the new context-based chemistry curriculum upon participation in the programme and they expressed that more time should have been allocated to learn about the new curriculum at the start of the programme.

Furthermore, the lead teachers-in-training gain (I.b.) knowledge and skills related to designing teaching materials. By designing teaching materials for the new chemistry curriculum, they gain increased understanding of its content and pedagogy. However, four lead teachers-in-training (Beatrice, Luke, James and Bob) tended to become overly involved in designing teaching materials, thereby losing sight of their primary role in the regional learning communities which was to support professional development of peer teachers.

A third learning outcome concerning subject expertise reported by the lead teachers-in-training is (I.c.) a changed perspective on teaching and learning in classroom practice. This learning outcome was not anticipated in the design of the programme, but was spontaneously reported by James and Ellen. By learning about and using the new curriculum in classroom practice, Ellen reports changes in her role as a teacher from 'instructor' to 'coach' of her students. This changes the teaching and learning within her classroom from teacher-led to student-led education.

### **Ability to facilitate a learning community**

Gaining (II.a.) coaching skills is a learning outcome reported by all lead teachers-in-training. They report ability to analyse and manage interactions and activities within their regional learning communities. Besides coaching skills for leading a community of peers, Ellen, James, Bob and Luke also report increased ability to coach individual teachers, either colleagues at their school or student teachers, in implementing the context-based chemistry curriculum.

Increases in (II.b.) collaborative skills reported by the lead teachers-in-training are mainly related to role and task division within a learning community. By leading a regional learning community, all lead teachers-in-training learn about their own role as a leader in relation to the participating teachers. They learn to activate the teachers in their community and to stimulate active involvement of all participants in group discussions and collaborative tasks, for example designing teaching materials.

James and Bob, who co-led regional learning community West, report the importance of a clear division of tasks between them and the experienced lead teacher in the community. Lack of clarity on this point resulted in 'three captains on one ship', which led to confusion among community members and thereby disturbed the learning processes of both lead teachers-in-training.

### *Personal dispositions*

Concerning personal dispositions, James, Beatrice and Ellen report increased (III.a.) ability to reflect on their own functioning as a lead teacher of a regional learning community. In their reflections, they move from descriptive reflection focused on their own actions to more critical reflection focused on consequences of their actions (Hatton and Smith 1995) as leaders for participating teachers in their regional learning communities.

Designing teaching materials for the context-based chemistry curriculum was one of the main activities in the regional learning communities as the participants enjoyed working on this task. However, the lead teachers-in-training tended to forget that designing teaching materials was a means to an end, namely teacher professional development concerning the use of the new curriculum, not an end in itself. By focussing too strongly on the product of design instead of the process of designing, learning opportunities for participating teachers were decreased. In the course of the programme, James, Charles and Beatrice became aware of this issue due to their critical reflection on their role as a lead teacher. They regained focus on the primary purpose of the regional learning communities and adjusted their leadership strategies accordingly.

All lead teachers-in-training (except Bob) report becoming (III.b.) able to reflect on their own learning process. Through descriptive reflection focused on their own professional development (Hatton and Smith 1995), they learn to explicate what they have learned in the programme and what aspects of their leadership development still need to progress. Reflecting on their own learning is a new activity for the lead teachers-in-training that most of them do not enjoy at first. However, in retrospect they consider it to be a valuable activity. In the course of the professional development programme, the lead teachers-in-training started to recognise that performing self-reflection and writing self-reflection reports were not intended to be held accountable for their progress, but to increase their own awareness of their learning processes and outcomes. James reports (III.c.) an increased work attitude. This learning outcome was not anticipated in the design of the professional development programme. James reports increased enthusiasm and passion for teaching, collaborating with peers, and designing new teaching materials.

Another unanticipated learning outcome, reported by James, Charles and Luke, is (III.d.) learning to explicate their views concerning the new curriculum, teaching materials and chemistry education in general. They are not used to doing this and find it interesting to discuss these issues with peers. They learn that other teachers have views different from their own. The lead teachers-in-training learn to be open towards other perspectives and learn to provide substantive arguments for their own perspective.

### *General*

Despite considerable learning by all lead teachers-in-training, James, Luke, Beatrice and Ellen do not consider themselves to be fully qualified lead teachers after participating in the 1-year professional development programme. They do not feel competent and confident enough as lead teachers to independently lead a regional learning community without support of an experienced lead teacher or trainer. These lead teachers-in-training would like more opportunities to practice their leadership qualities, especially to increase (II) their ability to facilitate a learning community.

Additionally, there seems to be a lack of awareness among the lead teachers-in-training of their role in the implementation of the new context-based chemistry curriculum. They are aware that they should support the professional development of teachers in their regional learning communities, but this does not seem to be their main concern. The lead teachers-in-training are mainly concerned with their own learning to become lead teachers.

These two issues seem to be related, as teachers first need to feel competent and confident in their role as lead teachers before they can actually take on a leading role. This is in line with the Concerns-Based Adoption Model (Hall and Hord 2006) that describes how teachers, when implementing an innovation, tend to focus on their own concerns first, before they can focus

on student learning. The teachers in the professional development programme focus on their own learning first, before they can focus on professional development of peer teachers.

### **Research question 2**

The mechanisms invoked by the interventions in the professional development programme, as experienced by the lead teachers-in-training, are described in [Table 9](#). Results show that the lead teachers-in-training perceive the interventions in the programme to invoke mechanisms that lead to intended and additional learning outcomes. The mechanisms described by the participants indicate a strong interrelatedness between the three main interventions in the programme: (A) the national learning community, (B) the regional learning communities and (C) self-reflection.

The lead teachers-in-training describe, for example, that they need subject expertise that is obtained during formal training in the national learning community to provide substantive content for processes in the regional learning community, and vice versa: by sharing and applying their expertise in the regional learning community, knowledge and skills obtained during formal training are consolidated. The same interrelatedness applies to knowledge and skills to facilitate a learning community of teachers. Performing self-reflection supports lead teachers-in-training in explicating their own learning processes and outcomes, thereby reinforcing their professional development as invoked by activities in the national and regional learning communities.

When compared to the intended learning outcomes of the interventions in the national learning community, participants' experiences show a similar pattern. The lead teachers-in-training report gaining leadership qualities in terms of (I) subject expertise, (II) ability to facilitate a learning community and (III) personal dispositions by participating in the national learning community (A). They do not explicitly mention (I.b) knowledge and skills related to designing teaching materials, (II.b) collaborative skills and (III.b) ability to reflect on their own learning process. This lack of mentioning does not necessarily mean they did not acquire these leadership qualities by participating in the national learning community. This could mean that the learning of these qualities was not as intensely experienced in this community as it was in the regional learning communities (B).

Compared to the assumed mechanisms in [Table 2](#), the experienced mechanisms in [Table 9](#) show a richer pattern with stronger interrelations between interventions and achieved outcomes. For example, experienced mechanisms from interventions in the national learning community have comparable descriptions compared to the assumed mechanisms in the design of the professional development programme. However, the experienced mechanisms are more precise. For example, the initial mechanism in relation to (A3), performing peer intervention with other lead teachers-in-training, refers to the participants' own experiences and needs. The experienced mechanisms mention 'intense discussions of situations' or even 'difficult situations' and 'collective reflection'.

The descriptions of the mechanism in relation to intervention (B1), leading a regional learning community, also have a higher level of detail than the assumed mechanisms described in [Table 2](#). For example, the assumed mechanism is described in terms of 'practical experiences'. The experienced mechanisms reveal what was experienced by the lead teachers-in-training: collaboratively designing context-based materials and ongoing (deep) discussion, for example on quality of materials, suitability for classroom practice, teaching approaches and vision on chemistry education. All these intermediate activities trigger learning outcomes in terms of subject expertise.

Leading a regional learning community (B1) also contributed to achieved learning outcomes in terms of (II.a) coaching skills and (II.b) collaborative skills. The lead teachers-in-training specify that the general skills learned in the national learning community become more articulate by practicing them as leaders of a regional learning community. They learn to think about which coaching techniques work for them and which do not, to distinguish between means and ends in community activities, to discuss difficult issues, and to be aware of role and task divisions in a learning community. Difficulties experienced in (B1) leading a regional learning community and



**Table 9.** Interventions, experienced mechanisms, achieved outcomes.

Interventions	Experienced mechanisms	Achieved outcomes
<b>A. National learning community of lead teachers-in-training</b>		
A1. Participate in formal training on the context-based chemistry curriculum	Through active engagement with the new curriculum, a lead teacher-in-training learns about the principles, didactics and classroom implementation of the new curriculum, and develops a personal vision on the new curriculum. Consolidation of these learning outcomes is obtained by implementing the new curriculum in classroom practice, and by sharing and applying this knowledge in the RLC.	I.a. Knowledge about the context-based chemistry curriculum
A2. Participate in formal training on coaching techniques	Through active learning about coaching, a lead teacher-in-training gains skills in managing group processes and coaching individual teachers, which aid a lead teacher-in-training in leading a community of teachers.	II.a. Coaching skills
	Through active learning about coaching, a lead teachers-in-training becomes aware of the importance of the learning processes of teachers in the RLC over producing teaching materials for the new curriculum.	III.a. Ability to reflect on own functioning as a lead teacher
A3. Perform peer intervention with other lead teachers-in-training	Through exchanging experiences and ideas with other lead teachers-in-training, a lead teachers-in-training develops a personal vision on the new curriculum.	I.a. Knowledge about the context-based chemistry curriculum
	Through intense discussions of situations occurring in the RLC's, a lead teacher-in-training gains skills to analyse and manage group processes, and learns how to handle (difficult) situations in a learning community of peers.	II.a. Coaching skills
	Through collective reflection on the functioning of the RLC, a lead teacher-in-training becomes aware of the importance of the learning processes of teachers in the RLC over producing teaching materials for the new curriculum.	III.a. Ability to reflect on own functioning as a lead teacher
<b>B. Regional learning communities of teachers</b>		
B1. Lead the regional learning community	Through deep discussions about the new curriculum in the RLC or with individual community members, and through classroom visits to community members, a lead teacher-in-training expands his/her personal perspective on the new context-based chemistry curriculum and on its use in classroom practice.	I.a. Knowledge about the context-based chemistry curriculum
	Through collaboratively designing teaching materials in the RLC, a lead teacher-in-training leads ongoing discussions about the content and pedagogy of the context-based chemistry curriculum, thereby applying newly gained knowledge about the context-based chemistry curriculum, which reinforces this knowledge.	I.a. Knowledge about the context-based chemistry curriculum
	Through collaboratively designing teaching materials and ongoing discussions about quality of teaching materials in the RLC, a lead teacher-in-training gains increased knowledge and skills to design context-based chemistry teaching materials and learns what makes materials (un)suitable for use in classroom practice.	I.b. Knowledge and skills related to designing context-based chemistry teaching materials
	Through experience with using the context-based chemistry curriculum in classroom practice and through discussions with peers about chemistry education and the new curriculum, a lead teacher-in-training gains new perspectives on teaching and learning chemistry.	I.c. <i>Changed perspective on teaching and learning in classroom practice</i>

*(Continued)*

Table 9. (Continued).

Interventions	Experienced mechanisms	Achieved outcomes
	Through leading a RLC, a lead teacher-in-training gains practical experience in using acquired coaching techniques. Through this experience, the lead teacher-in-training learns what coaching techniques do (not) work for him/her, what leadership style he/she prefers, and thereby learns to effectively and efficiently lead collaborative actions and interactions within the RLC. Noticing progress in the professional development of peer teachers motivates a lead teacher-in-training to actively lead a RLC.	II.a. Coaching skills
	Through confrontation with a twofold aim in the RLC (professional development of teachers and designing teaching materials), a lead teacher-in-training learns to shift focus in community meetings. In this learning process, a lead teacher-in-training learns that a too strong focus on the product of design instead of the process of designing disturbs the learning process of himself/herself and community members.	II.a. Coaching skills
	Through communication issues in the RLC in between meetings, a lead teacher-in-training learns about the importance of ongoing communication to keep the collaborative processes going.	II.b. Collaborative skills
	Through dominance of an experienced lead teacher in the RLC, the learning process of a lead teacher-in-training is disturbed. Through this experience, a lead teacher-in-training learns to establish and value a clear division of roles and tasks within the RLC.	II.b. Collaborative skills
	Through collaboration with peers in the RLC on designing teaching materials, a lead teacher-in-training gains practical experience with collaborative skills.	II.b. Collaborative skills
	Through experienced difficulties in collaboratively designing teaching materials and subsequent discussions about it with the members of the RLC, a lead teacher-in-training learns to reflect on actions and interactions in the RLC and his/her own role in it.	III.a. Ability to reflect on own functioning as a lead teacher
	Through collaboratively designing teaching materials in the RLC, a lead teacher-in-training receives feedback on his/her design work. Through this experience, he/she learns to cope with feedback.	III.b. Ability to reflect on own learning process
	Through deep discussions in the RLC on designing and using context-based chemistry teaching materials, a lead teacher-in-training is forced to reflect on his/her personal views on teaching and learning chemistry and learns to explicate his/her views in discussions with peers. Through confrontations with alternative views on teaching and learning, a lead teacher-in-training learns to take an open stance towards these alternative views.	III.d. <i>Explicating personal views</i>
B2. Receive feedback and support from a trainer or experienced lead teacher	Through feedback on his/her functioning, a lead teacher-in-training learns what he/she is (not) doing well as a leader of a RLC.	II.a. Coaching skills
	Through feedback on his/her functioning, a lead teacher-in-training becomes aware of his/her role in collaborative processes in the RLC.	II.b. Collaborative skills
	Through feedback on his/her functioning and on reflection reports, a lead teacher-in-training learns to reflect on his/her role as a leader of a RLC.	III.a. Ability to reflect on own functioning as a lead teacher

(Continued)

Table 9. (Continued).

Interventions	Experienced mechanisms	Achieved outcomes
	Through feedback on his/her functioning and on reflection reports, a lead teacher-in-training learns to reflect on his/her learning process and outcomes.	III.b. Ability to reflect on own learning process
	Through the example set by an experienced lead teacher, a lead teacher-in-training learns to take a critical stance, and to encourage dedication and enthusiasm within the RLC.	III.c. <i>Increased work attitude</i>
C. Self-reflection		
C1. Perform self-reflection and write reflection reports	By performing self-reflection, a lead teacher-in-training becomes aware of what does (not) work for him/her in leading a RLC.	II.a. Coaching skills
	By performing self-reflection, writing reflection reports and receiving feedback on these reports, a lead teacher-in-training learns to reflect on his/her actions and role as leader of a RLC.	III.a. Ability to reflect on own functioning as a lead teacher
	By performing self-reflection on their personal role in the process of designing teaching materials in the RLC, a lead teacher-in-training becomes aware of the importance of participating teachers' professional development over designing teaching materials.	III.a. Ability to reflect on own functioning as a lead teacher
	By performing self-reflection, writing reflection reports and receiving feedback on these reports, a lead teacher-in-training learns to reflect on his/her personal learning process and outcomes.	III.b. Ability to reflect on own learning process
	By performing self-reflection, writing reflection reports and receiving feedback on these reports, a lead teacher-in-training learns to explicate personal views on teaching and learning and to be receptive of other teachers' views.	III.d. <i>Explicating personal views</i>

subsequent discussions about these issues with other members of the regional learning community, are related to learning outcomes in terms of reflection abilities.

The experienced mechanisms from interventions (B2), receive feedback and support, and (C1), perform self-reflection, align with the assumed mechanisms in the design of the professional development programme, but again they provide more detail and are therefore more precise. The assumed mechanism is that lead teachers-in-training become aware of their learning progress through self-reflection and thereby increase their ability to reflect. The experienced mechanisms show, for example, that writing reflection reports is essential as this offers an opportunity to receive feedback on their own reflection, increasing their learning outcomes concerning abilities to reflect.

## Conclusions and discussion

The aim of this study is to establish an empirically substantiated professional development programme for teachers to become lead teachers in order to support professional development of peers in times of curriculum innovation. An essential part of this study is to reveal what interventions in the professional development programme relate to what learning outcomes and through what mechanisms.

With respect to research question 1, it can be concluded that lead teachers-in-training have acquired the intended learning outcomes. However, most teachers do not feel empowered enough to independently lead a learning community of peers after the training. Participants were accomplished chemistry teachers, but unfamiliar with taking on a leading role in a community

of peers. Because of this unfamiliarity, they felt one year of training to be insufficient to become competent and confident lead teachers.

With respect to research question 2, results show that the professional development programme is a holistic programme where the sum of the interventions results in stronger learning outcomes than the separate parts. From the experienced mechanisms, it can be inferred that the separate interventions will most likely not achieve the learning outcomes as invoked by the combined interventions. The number of mechanisms reported by the lead teachers-in-training reveal that intervention (B1), leading a regional learning community, was perceived to be the most intense learning experience. However, this learning experience is strongly related to the other interventions in the programme and would not be as successful without them. The lead teachers-in-training need the formal training in the national learning community to become able to lead and provide substantive content in the regional learning community. Peer intervention, ongoing feedback and support, and self-reflection are essential to reinforce and consolidate learning experiences of the lead teachers-in-training from the formal training and their leadership of a regional community. Therefore, coherence and reinforcement between the interventions in the programme are important conditions for success.

Current educational literature revealed a lack of in-depth qualitative studies that relate interventions in professional development programmes to train lead teachers to specific learning outcomes of participants (c.f. Howe and Stubbs 2003, Hofstein *et al.* 2004, York-Barr and Duke 2004, Luft *et al.* 2014, Vanblaere and Devos 2016). Our study provides insights into the functioning of the different components of a professional development programme, which so far was insufficiently available (Snell and Swanson 2000, Frost and Harris 2003, Mangin and Stoelinga 2010, Poekert 2012). The CIMO-logic as established by Deneyer *et al.* (2008), is a suitable structure to describe a professional development programme and its outcomes since it captures the coherence between all parts of a programme: between interventions and outcomes, but also between interventions, through mechanisms.

By using the CIMO-logic, assumed mechanisms underlying the design of the professional development programme were made explicit, enabling subsequent empirical validation of these mechanisms. Knowledge on mechanisms is essential to reveal what interventions are effective to achieve intended learning outcomes. By establishing empirical validation of mechanisms, this study provides a valuable contribution to the field of professional development of lead teachers since knowledge in this area can contribute to the set-up of effective professional development programmes.

### **Interventions**

The results of this study show that there are points for improvement concerning the interventions in the designed professional development programme. First, a one-year training programme is insufficient according to four out of six lead teachers-in-training. This is in line with previous studies on teacher leadership development advocating the necessity of training programmes of at least one year (Howe and Stubbs 2003, Hofstein *et al.* 2004, Luft *et al.* 2014). A point for improvement would therefore be to extend the training period. This would allow more time for formal training and practice, and thereby increase lead teachers-in-training's feelings of empowerment to independently take on leadership of a learning community of teachers. An extended training period and increased feelings of empowerment to lead could also overcome lead teachers-in-training's preoccupation with their own learning and help them gain a stronger focus on the professional development of peers and implementation of the new curriculum. This shift in focus would strengthen the role of the lead teachers-in-training in the process of curriculum innovation as it would allow for increased professional development of peers and subsequent implementation in classroom practice.

A second point for improvement can be found in the composition of the regional learning communities. In two of four regional learning communities, there were two lead teachers-in-training in the same community. This limited participants' opportunities to practice their leadership qualities and therefore hindered their learning processes. All lead teachers-in-training need their own learning community to lead in order to have sufficient opportunity to practice their leadership qualities and become competent and confident lead teachers.

### **Mechanisms**

The experienced mechanisms are in line with assumed mechanisms as described in the design of the programme, but they contain more detail and therefore provide a richer picture of the contributions of the interventions to participants' learning outcomes. Interrelatedness between the interventions in the professional development programme also becomes clear from the described mechanisms. Descriptions of experienced mechanism therefore provide valuable information. Without these descriptions of mechanisms, no insights in coherence between the interventions and learning outcomes, or between interventions, would become apparent.

### **Outcomes**

The lead teachers-in-training relate more learning outcomes to the interventions than was anticipated in the design, both unexpected learning outcomes and intended outcomes related to other interventions.

A point for improvement would be to only allow teachers to participate in the professional development programme who are already familiar with the new curriculum. Lead teachers need this familiarity to be able to effectively share knowledge on the curriculum innovation with peers in the regional learning communities (Frost and Harris 2003, York-Barr and Duke 2004) and to establish credibility among peers (Snell and Swanson 2000). Without this familiarity, lead teachers-in-training struggle too much with the new curriculum themselves to be able to support professional developments of others in this area. Knowledge of the new curriculum or educational innovation should therefore not be an intended learning outcome of the professional development programme, but a prerequisite for participating teachers.

A limitation of this study is its small scale with six teachers in one context. More field testing of the designed programme in different contexts and on larger scales is necessary to increase insight in the mechanisms and outcomes invoked by the interventions in the professional development programme. Additionally, this study is based on self-report of participants. This proved to be a suitable strategy to gain insight into experienced mechanisms and achieved outcomes as personal experiences are necessary to gain insight into these issues. However, use of other instruments could strengthen findings by complementing participants' insider-perspectives with outsider observations. For example, through observations of meetings of the national and regional learning communities or group discussions among lead teachers-in-training. These could provide valuable triangulation opportunities to view the professional development programme and its outcomes from multiple perspectives.

The deployment of lead teachers to provide professional development for peer teachers in learning communities is a promising strategy for large-scale implementation of curriculum innovations. Instead of providing a professional development programme for all teachers to learn about an innovation, a professional development programme for a limited group of teachers can be provided. By training teachers to become lead teachers who are able to provide professional development activities for peers, this strategy has potential for exponential growth and subsequently reach (potentially) more teachers.

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## Appendices

### Appendix 1. Schedule of national learning community meetings in the professional development programme to train lead teachers

Date	Activity
September 2011	Meeting 1: – Organizational issues – Introduction to making a personal portfolio for final assessment – Formal training: • Organizing meetings for a regional learning community
November 2011	Meeting 2: – Formal training: • Context-based chemistry – Exchange of experiences among participants
January 2012	Meeting 3: – Formal training • Coaching • Recruiting new teachers for regional learning communities – Exchange of experiences among participants
March 2012	Meeting 4: – Exchange of experiences among participants • Progress in regional learning communities • Progress in professional development to become a lead teacher • Progress with recruiting new teachers for regional learning communities
April 2012	Meeting 5: – Exchange of experiences among participants • Progress in regional learning communities • Progress in professional development to become a lead teacher • Progress with recruiting new teachers for regional learning communities
June 2012	Meeting 6: – Regional learning communities present designed teaching materials – Starting new regional learning communities in the next year – Final assessments

### Appendix 2 Protocols for semi-structured interviews with lead teachers-in-training

#### Protocol interview I

1. What were your drivers to participate in the professional development trajectory and to become a lead teacher?
2. What do you want to accomplish as a lead teacher for context-based chemistry?
3. What role do you want to take on in the new context-based chemistry curriculum?
4. According to you, what are necessary developments in chemistry education?
5. What are you currently doing within the national and regional learning community and what do you plan to do after this year of training?
6. What do you expect to learn in the professional development trajectory to become a lead teacher?
7. What do you expect to learn from
  - a. Other lead teachers-in-training?
  - b. Experienced lead teachers?
  - c. The two experts in the national learning community?

#### Protocol interview II

1. What did you learn during participation in the professional development trajectory to become a lead teacher?
  - a. What learning outcome do you consider most important?
2. What were drivers to continue professional development to become a lead teacher after completing stage 1 of the trajectory as a competent context-based teacher and designer?
3. Did you experience hindering or stimulating factors during the professional development trajectory to become a lead teacher?
4. Which aspects of the professional development trajectory did you experience as stimulating professional development?
5. Which aspects of the professional development trajectory did you experience as hindering professional development?
6. In retrospect, would you again choose to participate in this trajectory?

### Appendix 3 Exemplary questions from questionnaire for lead teachers-in-training

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1. Do you consider the national learning community for lead teachers a hindering or stimulating aspect of the professional development trajectory?

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- Hindering
- Somewhat hindering
- Somewhat stimulating
- Stimulating

Please illustrate your answer.

2. Do you consider designing teaching materials a hindering or stimulating aspect of the professional development trajectory?

- Hindering
- Somewhat hindering
- Somewhat stimulating
- Stimulating

Please illustrate your answer.

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