

Understanding teacher learning in secondary education: The relations of teacher activities to changed beliefs about teaching and learning

Jacobiene A. Meirink^{a,*}, Paulien C. Meijer^b, Nico Verloop^a, Theo C.M. Bergen^c

^aICLON, Leiden University Graduate School of Teaching, The Netherlands

^bIVLOS School of Education, Utrecht University, The Netherlands

^cEindhoven School of Education, Technical University Eindhoven, The Netherlands

ARTICLE INFO

Article history:

Received 7 January 2007

Received in revised form 28 June 2008

Accepted 2 July 2008

Keywords:

Teacher learning

Teacher change

Beliefs about teaching and learning

Learning activities

ABSTRACT

In this study, relations between learning activities of teachers and changes in their beliefs were examined. Thirty-four teachers in Dutch secondary education were asked to complete a questionnaire regarding their beliefs about teaching and learning on two occasions. They were also asked to report on learning activities that they undertook. Teachers who had changed their beliefs in a direction congruent with the aims of recent educational reforms often reported experimentation with colleagues' teaching methods. Teachers who changed their beliefs in a direction that was not congruent with the reform often reported experimentation with alternative methods due to discontent with the effectiveness of current methods.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

Teacher learning has been given considerable attention in recent research on the practice of teaching and teacher training programs. Little is known, however, about how participation in particular activities promotes changes in beliefs on the part of teachers. Does involvement in different types of activities, for example, result in different types of belief change? The answer to this question can provide a more comprehensive understanding of how teachers learn, and thereby facilitate the design of professional development programs in the future. In addition, determination of just how particular activities undertaken in the workplace relate to specific changes in teachers' beliefs over time and how these relations can best be explained is required for successful educational reform. We therefore examined secondary schoolteachers' learning activities and explored the relation with changes in their beliefs about teaching and learning during a period of one year. Before describing the study in more detail, we will firstly elaborate on the central concepts of this study: teacher learning, beliefs, and learning activities.

1.1. Perspectives on teacher learning

In studies of teacher learning, differences exist in what, exactly, is meant by and accounted for as learning. The concepts of acquisition, construction, and participation are often used to characterize teacher learning (Cobb & Bowers, 1999; Cochran-Smith & Lytle, 1999; Hodkinson & Hodkinson, 2005; Putnam & Borko, 2000; Sfard, 1998). Teacher learning construed in terms of the concept of *acquisition* involves the mastery of new knowledge or skills, or both, by teachers in order to fill any gaps in their knowledge. This perspective on learning is often associated with 'passive reception of knowledge' and alterations or changes of knowledge and skills are considered evidence of learning. Teacher learning construed in terms of the concept of *construction* involves teachers as the "active constructors of knowledge who make sense of the world and learn by interpreting events through their existing knowledge and beliefs" (Putnam & Borko, 1997, p. 1227). Studies of learning based on this perspective often focus on the learning processes rather than on the outcomes of these processes. Often, learning is considered a continuous process without a clear ending point. Most of the literature on the professional development of teachers draws upon such a constructivist approach to learning (Hodkinson & Hodkinson, 2005). Finally, from a *participation* perspective it is argued that "learning and learning activities should not be considered separate from the context in which they take place" (Sfard, 1998, p. 6). Becoming a member of a certain community, such as a working community, counts as evidence of learning (Lave

* Corresponding author. ICLON, Leiden University, Graduate School of Teaching, P.O. Box 9555, 2300 RB Leiden, The Netherlands. Tel.: +31 71 527 3487; fax: +31 71 527 5342.

E-mail address: meirink@iclon.leidenuniv.nl (J.A. Meirink).

& Wenger, 1991). Learning is considered as an integral part of the daily work process.

Sfard (1998) argues that the choice of either an acquisition or a participation approach to learning “can have major consequences and that pluralism should lead to better research and a more satisfactory practice” (p. 10). Along these lines, Hodkinson and Hodkinson (2005) argue that a “combination of the construction and participation approach of teacher learning might be helpful in understanding and improving teacher learning” (p. 112).

In the present study, we viewed learning as an ongoing work-related process of engagement in *activities* that leads to a *change in cognition*. More specifically, we looked at *changes* in teacher beliefs. For this conceptualization of learning we used the three perspectives on learning discussed above: acquisition, construction, and participation. Firstly, we considered changes in individual teacher beliefs to correspond to the acquisition perspective in which learning outcomes take a central position. Secondly, by examining activities, we aimed to account for the construction perspective on learning. We focused primarily on individual teacher learning processes by exploring individual learning activities. Thirdly, by describing these activities in a certain context, that is, teachers' working environment, we also aimed to account for the participation perspective. Note that taking merely teachers' working environment into account is only a small part of the participation perspective. In the following sections we elaborate further on the two central concepts of our conceptualization of learning: (changes in) beliefs and learning activities.

1.2. Teacher beliefs about teaching and learning

Different concepts are employed in the literature on teacher cognition. Authors often speak of teacher knowledge and beliefs (e.g., Calderhead, 1996; Meijer, Verloop, & Beijaard, 1999; Pajares, 1992; Tillema, 1998; Van Driel, Bulte, & Verloop, 2007), teacher conceptions (e.g., Boulton-Lewis, Smith, McCrindle, Burnett, & Campbell, 2001; Kember, 1997), or teacher perspectives (Pratt, 2002). Beliefs generally refer to suppositions or commitments, and are based on evaluation and judgment (Calderhead, 1996; Pajares, 1992). Teacher conceptions and perspectives are used interchangeably and described as an interrelated set of intentions, beliefs, and actions (Pratt, 2002). In the present study, we were primarily interested in teacher beliefs about teaching and learning.

Teacher beliefs about teaching and learning can be discussed separately (Boulton-Lewis et al., 2001; Kember, 1997; Trigwell & Prosser, 1996). According to Boulton-Lewis et al., however, “teachers hold predominantly congruent beliefs about teaching and student learning” (p. 46). A commonly used distinction in the study of teachers' beliefs about teaching and learning concerns two prototypic ideologies: (1) teacher- or subject-matter-oriented beliefs, and (2) learner-oriented beliefs, i.e., beliefs focussed on supporting student learning. As the term implies, subject-matter-oriented beliefs place a strong emphasis on imparting subject matter and the reproduction of knowledge by students. Teachers are largely held responsible for the regulation of student learning processes. Also, learning is considered to be a primarily individual process. In contrast, student-oriented beliefs about teaching and learning involve teaching students how to learn, and the emphasis is on the construction of knowledge. Students are stimulated to take responsibility for their own learning processes and the regulation of these, and are also stimulated to work and learn together (see, among others, Bolhuis, 2000; Bolhuis & Voeten, 2004; Oolbekkink-Marchand, van Driel, & Verloop, 2006; Waeytens, Lens, & Vandenberghe, 2002). Subject-matter-oriented beliefs about teaching and learning are sometimes referred to as ‘traditional beliefs’, while student-oriented beliefs are sometimes referred to as ‘progressive beliefs.’ Here, however, we speak of

subject-matter- and student-oriented beliefs about teaching and learning, as the words ‘traditional’ and ‘progressive’ imply a value judgment which we prefer to avoid (Denessen, 1999).

In the context of an educational reform, teacher beliefs about teaching and learning must shift in a direction that is coherent with the aims of the reform. Given that one of the aims of a recent educational reform in upper secondary education in the Netherlands is to promote more active and self-regulated student learning, teachers are similarly expected to gradually endorse a more student-oriented approach to teaching and learning. However, teachers can also become more negative towards a student-oriented belief about teaching and learning in the context of such a reform, or even develop a stronger preference for a more subject-matter-oriented belief. In the present study, we were particularly interested in the possible associations between teacher participation in particular activities and concomitant changes in their beliefs about teaching and learning. For this reason, changes in both subject-matter-oriented and student-oriented beliefs about teaching and learning were important.

The results of the previous research, however, show the task of modifying teacher beliefs to be very difficult. Pajares (1992) concludes that “teachers' beliefs generally are not easy to change even when, based on opposing evidence, it is logical or necessary for them to do so” (p. 317). Findings of research on conceptual change suggest that motivational constructs such as goal orientation, values, efficacy beliefs, and control beliefs are mediators in the process of conceptual change (Patrick & Pintrich, 2001; Pintrich, Marx, & Boyle, 1993). Pintrich et al. also argue that prior knowledge and beliefs play a paradoxical role in conceptual change. They can impede conceptual change when students/learners possess strong alternative frameworks, and they can facilitate learning by providing a framework for understanding and judging the validity of new information. Motivational constructs such as goal orientation, values, efficacy beliefs, and control beliefs are assumed to be mediators in the process of conceptual change. From studies on teacher education programs aimed at changing student teachers' beliefs, and, therefore, conceptual change, it is known that student teachers tend to use new information to confirm and strengthen their current beliefs (Tillema, 1998). It is argued, therefore, that in order to accomplish meaningful learning and reflective enquiry for student teachers it is important to take pre-existing beliefs as a starting point to further extend their knowledge base. Tillema and Knol (1997) propose the use of a four-phased procedure to achieve belief change: (1) recognition and attention to current beliefs, (2) evaluation and investigation, (3) decision to change, and (4) reconstruction and building-up of a revised knowledge structure. Furthermore, they assume that carrying out these steps in interaction with other student teachers can be helpful. In addition, Kember (1997) found “approaches which operated over an extended period and operated within the framework of either a course or a project” (p. 272) to be particularly successful.

1.3. Teacher learning activities

In studies of Van Eekelen, Boshuizen, and Vermunt (2005), Kwakman (1999), Lohman and Woolf (2001), teachers were asked to report on activities that—in their opinion—promoted their professional development. In all three studies, a general classification of the relevant teacher activities was presented. When combined, the classification systems revealed the following five general categories of activity: doing, experimentation, reflection, learning from others without interaction, and learning from others in interaction (Bakkenes, Hoekstra, Meirink, & Zwart, 2004). In a recent publication (Meirink, Meijer, & Verloop, 2007), a more detailed classification of the activities of teachers collaborating in teams has been presented. Six teachers were interviewed after

several team meetings to explore what they learned from the collaboration with colleagues. It was found that an activity such as experimentation could be further divided into experimentation with an adjusted teaching method adopted from a colleague, experimentation with a teaching method copied directly from a colleague, experimentation with a self-invented teaching method, or experimentation with a teaching method collaboratively developed in a team meeting. The different types of experimentation were found, moreover, to lead to different reported cognitive changes, which led to the conclusion that such fine-grained classification may be critical for the study of teacher learning. In addition, it was concluded that teacher activities that promote reported changes in cognition also occur in particular sequences. For example, experimentation with a new teaching method that resulted in learning was often preceded by acquaintance with the methods of colleagues and succeeded by reflection on the results of the experimentation—either individually or in interaction with colleagues or students, or both.

1.4. The present study

In order to determine just how participation in particular activities promotes belief changes on the part of teachers, the activities of teachers in the workplace must first be mapped. In the context of the present study, the focus was on the activities of teachers who, in addition to their regular school activities, collaborated with colleagues in teams. While teachers report that they learn considerably from colleagues and, thus, from the exchange of ideas, experiences, teaching methods, and feedback (Butler, Novak Lauscher, Jarvis-Selinger, & Beckingham, 2004), the importance of such everyday collaborative activities for changes in teacher cognition is not completely apparent.

Data on the changes that occurred in secondary schoolteachers' beliefs in the context of an educational reform were gathered for the present study during the school year 2004/2005. The reform was implemented in 1998 and concerned the upper grade levels of secondary education. In these levels students from the age 15–18 years old are taught. One of the central aims of the reform concerned fostering students to learn in a more active and self-regulated manner. This provides a meaningful context to study teacher learning since considerable changes in teachers' beliefs and the behavior of the teachers were required. The teachers could no longer just teach subject matter; they now had to coach the student learning process as well. Additionally, teachers were expected to stimulate students to construct their own knowledge instead of reproducing knowledge, and to work and learn together with other students instead of learning mostly individually. Successful implementation of the educational reform requires teacher acceptance and adherence to the principles of 'active and self-regulated student learning' (Oolbekkink-Marchand et al., 2006), and thus some major belief changes on the part of the teachers. The modification of teacher beliefs is assumed to be indispensable for the successful implementation of educational reforms. However, in previous research it is shown that changing beliefs is a difficult task. The question arises how and why the beliefs of some teachers change but not of other teachers. We, therefore, formulated the following research question for this study:

- How are learning activities that teachers undertake related to changes in their beliefs with respect to the topic 'active and self-regulated student learning' during a period of one year?

Understanding the relation between teachers' engagement in learning activities and belief changes can facilitate the implementation of future educational reforms. To answer the research question we examined teachers working in a context of

collaboration in interdisciplinary teams during a period of a year, and explored the specific contributions of various daily activities to the occurrence or non-occurrence of particular belief changes in an in-depth qualitative manner.

2. Method

2.1. Participants

School principals in the western part of the Netherlands were enlisted to participate in a study on teacher learning in collaboration. Principals interested in participating in the study were asked to search for teachers in their staff who were willing to collaborate with colleagues on a project aimed at collectively thinking of ways to foster active and self-regulated student learning. Since 'fostering active and self-regulated learning' is a cross-curricular topic, teachers were required to collaborate in interdisciplinary teams. Also, one of the aims of the reform in upper secondary education was to develop assignments and projects that encourage students to integrate related subjects. As a result, teachers are required to collaborate more often with colleagues with different subject matter backgrounds. Five schools were willing to participate. In each school, one teacher team was formed in which at least teachers of two subject areas were included. In total, thirty-four experienced secondary schoolteachers were investigated over a period of one year. Table 1 presents some general characteristics of the participating teachers.

The five schools in which these teachers worked were all secondary schools for senior general secondary education or pre-university education, or both. The teams can be characterized as school-based initiatives. In order to be as responsive as possible to the educational needs of the participating teachers and schools, we made it clear that each team was free to further specify the topic of 'active and self-regulated student learning' as it wished. One of the teams, for example, chose to collaboratively consider ways to get students to reflect more on mistakes in their tests. The members of this team were not satisfied with the effectiveness of their current teaching method aimed at stimulating students to learn from their mistakes in tests. The teams all held at least five meetings during the course of the school year. All five teams began their collaboration simultaneously with the start of the study. In each team, an equal number of team meetings was attended during the school year by an experienced coach from the university who paid explicit attention to the process of collaboration in the teams. As a guideline the coach used a study team approach to monitor the process in collaboration (Tillema & van der Westhuizen, 2006). A study team approach consists of three stages: (1) reflection: raising problem awareness by explicating knowledge and beliefs, (2) study: investigation, or enquiry using different perspectives, and (3) change: generation of conceptual artifacts (pp. 54–55). These three stages

Table 1
Characteristics of participating teachers

Sex	
Male	16
Female	18
Subject matter	
Language and arts	13
Social sciences	11
Science	10
Teaching experience	
Mean	16.97
SD	8.96
Minimum	3
Maximum	34

are assumed to foster belief change. In most team meetings, teachers shared ideas and teaching methods, and discussed their experiences of experimentation with alternative methods in their own teaching practice.

2.2. Data collection

2.2.1. Questionnaire 'Beliefs about teaching and learning'

The teacher beliefs about teaching and learning were measured at both the beginning and the end of the study year (in October 2004 and October 2005). On both measurement occasions, the teachers completed a questionnaire with eight scales addressing their beliefs about teaching and learning (Table 2).

The questionnaire 'Beliefs about teaching and learning' was based on a previous study on teacher beliefs about teaching and learning in Dutch secondary education (Bolhuis & Voeten, 2004). In this study, three central issues of active and self-regulated learning were included in a questionnaire to examine whether teachers' beliefs were congruent with a student-oriented view of teaching and learning. The three issues pertained to (1) self-regulation of learning, (2) learning as active construction of knowledge, and (3) the social nature of learning. We further divided the issue of self-regulation of learning into cognitive and affective regulation of

learning (Vermunt & Verloop, 1999). Four of the scales concerned the student-oriented beliefs about teaching and learning currently promoted by the educational reforms. The scales labelled 'internal cognitive regulation' and 'internal affective regulation' refer to the first issue: student or self-regulation of learning. The scale 'construction of knowledge' refers to the second issue, and the scale 'collaborative learning' to the third issue. The other four scales concerned subject-matter-oriented beliefs about teaching and learning, and were labelled 'external cognitive regulation', 'external affective regulation', 'reproduction of knowledge', and 'individual learning'.

Each of the scales included both items measuring teacher beliefs about teaching and teacher beliefs about learning. The items used to measure teacher beliefs about teaching all start with "It is important that a teacher...". The items used to measure teacher beliefs about learning all start with "Students learn better when...". The teachers scored all of the items on a five-point scale (1 = totally disagree; 5 = totally agree). In Table 2, a sample item is presented along with the measures of internal consistency (Cronbach's alpha) for each of the eight scales. Given the low reliability scores for the external affective regulation scale, this scale and relevant items were omitted from further analysis.

2.3. Digital logs

Based on the work of Van Eekelen et al. (2005), we collected digital logs to examine the activities of the teachers. The teachers were asked to write down and e-mail their learning experiences, which boiled down to the provision of a description of what was learned and how it was learned. Owing to the reform context in which this study took place, the teachers were asked to report on only those experiences that related to the topic of 'active and self-regulated student learning.' In order to attain a comprehensive overview of the teachers' activities, we asked them to present their learning experiences in a story-like manner. The teachers were asked to write a log at least every six weeks, which resulted in a minimum of six digital logs for each teacher. Using digital logs gives teachers the opportunity to think carefully about meaningful learning experiences, as they have time to consider relevant aspects of their learning experiences. In interviews, teachers have to respond immediately to questions, which might impede their recollection of learning experiences. In order to support teachers in recalling their learning experiences in detail, we gave them a card illustrating the relevant aspects related to learning experiences at the start of the study (cf. Meirink et al., 2007). When a teacher was unclear about one or more of the aspects of the card, we asked clarifying questions in replies to the e-mails. In order to emphasize that all sorts of learning experiences could be reported, a variety of examples of teacher learning experiences was provided as part of the instructions on how to write a digital log. This was done to emphasize that, although the teachers were participating in a professional development program (i.e., a collaborative project), learning experiences that did not specifically relate to their collaboration in these teams could also be reported. For example an unexpected situation that occurred during teaching practice, and concerning a different topic from that discussed in the interdisciplinary team, might be reported as a learning experience as well (Zwart, Wubbels, Bergen, & Bolhuis, 2007). The aim was to gather data on the activities that the teachers themselves considered relevant to their learning; 204 digital logs were obtained for this purpose.

3. Analysis

For each teacher and for each of the seven scales separately, we examined whether the scores on the second measurement occasion

Table 2
Questionnaire 'Beliefs about teaching and learning'

Scale	Sample item	Number of items per scale	Cronbach's alpha (October 2004)	Cronbach's alpha (October 2005)
Student-oriented beliefs				
Internal cognitive regulation	Students learn better when they have to check learning progress themselves	10	.931 .824	.921 .812
Internal affective regulation	Students learn better when they gain insight into their emotions	10	.835	.801
Construction of knowledge	It's important that the teacher allows students to relate the different aspects of the subject matter themselves	9	.793	.708
Collaborative learning	It's important that the teacher stimulates students to learn from each other	7	.825	.816
Subject-matter-oriented beliefs				
External cognitive regulation	It's important that the teacher makes sure that students know exactly how to work best on an assignment	7	.892 .688	.897 .704
External affective regulation	It's important that the teacher reassures students before they take a test	8	.547	.568
Reproduction of knowledge	Students learn better when they adopt the main and side issues from the teacher	8	.855	.815
Individual learning	Students learn better when they work individually on tasks	10	.806	.853

differed significantly ($p < .05$) from those on the first measurement occasion. Significantly different scores were labelled ‘changes in beliefs congruent with’ or ‘changes in beliefs incongruent with’ the underlying aims and principles of the educational reform in Dutch upper secondary education. Significantly lower scores (closer to 1 on a five-point Likert scale) on one or more of the four student-oriented beliefs’ scales were labelled ‘incongruent with the aims of the reform’, and significantly higher scores (closer to 5 on a five-point Likert scale) on one or more of these four scales were labelled ‘congruent’ (cf. Table 2). For example, a teacher with significantly lower scores, on the second occasion, on the items of the scale ‘collaborative learning’, such as *‘It’s important that the teacher stimulates students to learn from each other’*, has changed his beliefs in a way that is not in line with the reform. Conversely, a teacher who scored significantly higher on the items of this scale was considered to have come closer to the aims of the reform in his beliefs.

Significantly lower scores on one or more of the three subject-matter-oriented beliefs were labelled ‘congruent with the aims and principles of the reform’, and significantly higher scores on one or more of these three scales were considered ‘incongruent with the reform’. For example, a teacher with scores significantly lower on the items of the scale ‘individual learning’, such as *‘Students learn better when they work individually on tasks’*, has changed his beliefs in a way that is in line with the reform. Conversely, a teacher who scored significantly higher on these items has moved further from the aims of the reform.

For the analysis of the digital logs and teacher activities, a four-phase procedure was adopted. The first step consisted of randomly selecting the logs of 10 teachers. These logs were then summarized by identifying sequences of activities reported by the teachers to result in a particular learning outcome or a so-called ‘configuration’ of activities and learning outcomes (see also Meirink et al., 2007). An example of such a configuration is presented in Fig. 1.

This configuration shows a sequence of activities consisting of noticing student behavior, asking students for an explanation, and listening to their responses during an extensive discussion. The three activities resulted in a positive feeling and an intention to think up new assignments. Since we regard teacher cognition as consisting of knowledge, beliefs, and orientations (personal goals, emotions, expectations, and attitudes) (Fenstermacher, 1994; Korthagen, 2001; Putnam & Borko, 1997), we consider feelings and intentions to be part of teacher cognition and, therefore, view new feelings and intentions as cognitive change.

In the second analytic step, the configurations identified for the 10 selected teachers were searched for more general patterns. For example, one of the teachers reported the following learning experience:

Ann, digital log number 3

My first learning experience started off during our first team meeting. Just before the meeting I had marked a test of one of my classes who had got really low grades. [...] Something had to change in that class. My first thought was: the students don’t learn, they underestimate the subject matter. [...] My goal was to control students’ homework very strictly in future and to confront them with the fact that they did not study well since I could point out in their textbooks and assignments exactly where they could have found the correct answers to the test questions. [...] During the meeting I realized that it would be worthwhile to examine first why students caught on to the subject matter so badly, because it is a rather quick conclusion to say that they just do not work hard enough. [...] In this meeting, colleagues often mentioned motivation and positive feedback as the key to activate students’ learning. I realized that this was the problem in my own teaching practice. I formed the intention to be strict about homework but mainly to compliment students in order to improve the atmosphere and work climate. So far, I do not have new grades to prove that this approach is working, but

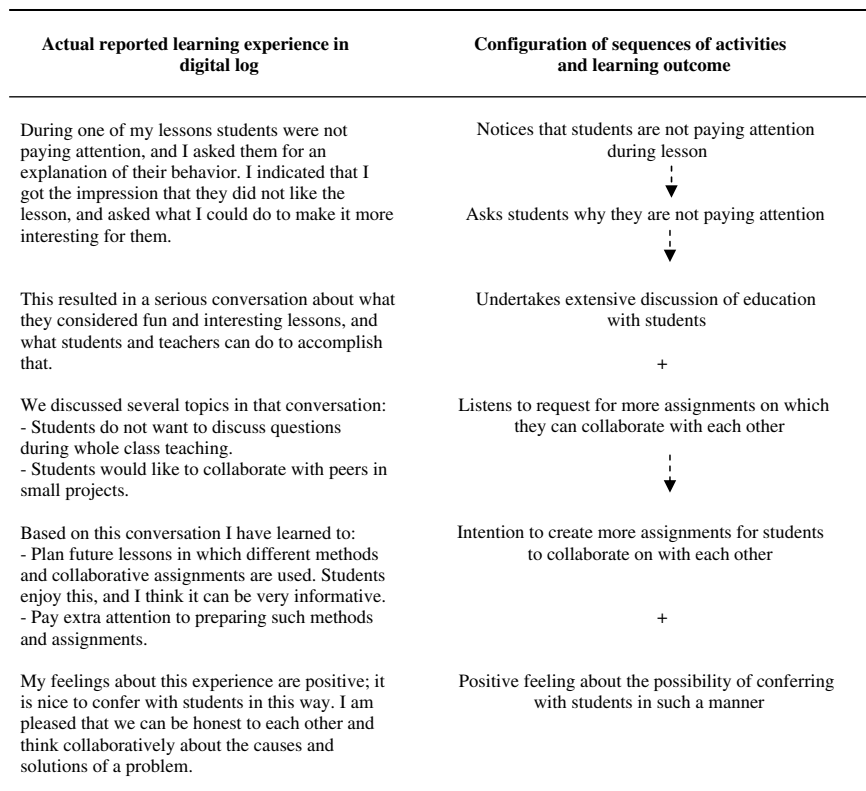


Fig. 1. Example of a configuration of teacher activities plus outcome.

the atmosphere has improved and I notice that students are indeed more motivated when they receive a compliment. Actually, I knew this for years, but the consultation with colleagues has opened my eyes and stimulated me to use this knowledge in my teaching practice.

In this example the teacher reports having learned in a team meeting by listening to colleagues' experiences with teaching methods that foster active and self-regulated learning. After listening to these colleagues, the teacher decides to experiment with the same method in her own practice, and evaluates her experimentation. This experimentation and evaluation result in a rediscovered idea of how to motivate students. Another teacher reported the following in one of her digital logs:

Susan, digital log number 1

[...] This year I wasn't very pleased with my own method of controlling students' homework. I want students to do their homework as asked, but I don't want to use punishment exercises. I would rather motivate them to do their homework in a different manner. In the second term of this school year, I started off with a different method. I got the idea by visiting schools in France and observing a teacher at one school. This teacher pulled out a number out of a bag at the start of each lesson and asked the student whose number on the student list corresponded to this number, to write his or her homework on the blackboard. [...] I don't control students' homework anymore, but I let chance decide which student has to write down his or her answer to a homework assignment on the blackboard. [...] Students think it is important to have their homework in order when it is their turn to present it, and I can give them a compliment for their efforts. Students appear to be more motivated when I use this 'chance method' than when I checked their homework. This surprises me, but it is a pleasant surprise.

In this example, the teacher reports having learned by observing a colleague during an assignment for an in-service training course. As a result of this observation she decides to try the colleague's method in her own classes, and evaluates the positive and negative aspects of the method. Based on the experimentation and evaluation, the teacher reports having acquired a new idea of student learning.

In both examples the general pattern can be characterized as follows: acquaintance with colleagues' methods in a professional development context, experimentation in own teaching practice, and evaluation of experimentation. This sequence in learning activities, however, resulted in different learning outcomes: a rediscovered idea and a new idea of how students can be motivated to work in a more active and self-regulated way.

In the third analytic step, we examined the reported learning experiences by separating sequences of activities from learning outcomes. In the 60 digital logs of the 10 selected teachers, we found 12 similar sequences of activities.

In the final analytic step, the 12 initial sequences of activities were used to analyze the remaining 144 digital logs of the other 24 teachers in our study. Digital logs with a sequence of activities similar to one of the 12 original sequences were coded using the corresponding number. A total of 18 digital logs could not be coded using one of the 12 original sequences. These 18 logs contained 3 sequences that resembled each other across logs; these sequences were, therefore, added to the 12 original sequences of activities. Seven sequences of activities appeared to be specific to only one teacher and were, therefore, not included in the remainder of the analysis. In the end, this procedure resulted in a list of 15 sequences of activities.

Three researchers were involved in the interpretation and classification of the learning experiences reported in the digital logs. In addition, a research assistant was involved in the coding of the digital logs; this was to see if a person who was not familiar with the data could reliably apply the same codes as the first researcher. A total of 50 digital logs were coded by the research assistant, which resulted in an inter-rater reliability of .77 (Cohen's kappa).

4. Results

We first present the questionnaire results for the teachers' beliefs about teaching and learning, followed by the results of the analysis of the digital logs. Finally, we present our interpretation to explain the observed relations between changed teacher beliefs about teaching and learning and learning activities.

4.1. Changes in teacher beliefs about teaching and learning

Factor analyses were conducted to determine if teacher beliefs about teaching could be distinguished from teacher beliefs about learning. In line with the results of previous research by Boulton-Lewis et al. (2001), the different teacher beliefs did not load on separate factors and were, therefore, not distinguished in the remainder of the analysis. Of the 34 teachers participating in the study, 21 were found to produce significantly different scores on one or more of the teacher beliefs about teaching and learning scales after a period of one year. In Table 3, information on the direction of the changes in the student-oriented and subject-matter-oriented teacher beliefs about teaching and learning is presented.

As can be seen, the largest group (13) consists of teachers who did not have significantly different subject-matter- or student-oriented beliefs after one year and participation in an interdisciplinary team. Changes that were congruent with the aims of the relevant reform occurred more frequently than changes that were not congruent with the aims of the reform. For the student-oriented teacher beliefs about teaching and learning, the frequencies of changes that were congruent and those of changes that were incongruent with the aims of the reform were almost equal. For the

Table 3
Numbers of teachers with congruent, incongruent, or no changes in beliefs about teaching and learning

		Student-oriented beliefs			Total number of teachers
		Number of teachers with changes congruent with the aims of the reform	Number of teachers with no changes	Number of teachers with changes incongruent with the aims of the reform	
Subject-matter-oriented beliefs	Number of teachers with changes congruent with the aims of the reform	5	5	1	11
	Number of teachers with no changes	3	13	6	22
	Number of teachers with changes incongruent with the aims of the reform	1	0	0	1
	Total number of teachers	9	18	7	34

subject-matter-oriented teacher beliefs about teaching and learning, however, changes that were congruent with the aims of the reform were found to occur more often than changes that were not congruent with the aims of the reform.

4.2. Teacher activities

The procedure used to analyze the digital logs resulted in a list of 15 sequences of activities, which are described in Table 4.

In sequences 1–3, 5, and 6, colleagues are explicitly involved in the learning activities of the teachers. Sequences 7–14 represent various individual learning experiences during actual teaching

Table 4
List of learning activity sequences

Sequence code	Description of general learning activity sequence	Frequency
1	Acquaintance with teaching methods or ideas of colleagues in the context of a professional development program (e.g., observation, discussion) → experimentation with teaching methods of colleagues → evaluation of alternative teaching methods	24
2	Acquaintance with teaching methods or ideas of colleagues during spontaneous interaction with colleagues (e.g., observation, discussion) → experimentation with teaching methods of colleagues → evaluation of alternative teaching methods	11
3	Dissatisfaction with current methods → request for feedback from colleagues → experimentation with an adjusted form of one's own teaching methods → evaluation of adjusted teaching methods	12
4	Encountering difficulties with own learning process → relating difficulties to student learning difficulties → consideration of explanations and solutions for own learning difficulties and student learning difficulties	9
5	Acquaintance with the beliefs of colleagues via reading or listening → reflection on and evaluation of explanations for these (negative) beliefs	6
6	Collective dissatisfaction with level of knowledge, skills, or attitudes of students → collective or individual formulation and experimentation with alternative teaching methods → evaluation of alternative teaching methods	10
7	Individual dissatisfaction with level of knowledge, skills, or attitudes of students and the effects of current teaching methods → individual formulation and experimentation with alternative teaching methods → evaluation of alternative teaching methods	43
8	Formulation of alternative teaching methods due to illness or time constraints → experimentation with alternative teaching methods → evaluation of alternative teaching methods	5
9	Selection of standard assignment for students → observation and evaluation of students doing the assignment → evaluation of the assignment	37
10	Inquiry into student desires regarding lesson content → experimentation with an alternative teaching method → evaluation of the alternative teaching method	13
11	Observation of students → surprise at a particular student attitude	5
12	Confrontation with an unexpected situation (e.g., students making fun of the teacher or a student crying in class) → reaction to the situation → evaluation of own reaction (either reflexive or conscious) to the unexpected situation	12
13	Grading of tests and detection of disappointing results → search for explanations for the disappointing results → consideration of whether the teacher, the students, or perhaps both may be responsible for disappointing test results	3
14	Reflection on own teaching methods and behaviors at the end of the school year → experimentation with new teaching behaviors → evaluation of new teaching behaviors	3
15	Writing and re-reading of own digital logs → detection of own special points of interest for improved teaching practice → consideration of ways to adjust own teaching practices	4

practice. Sequences 4 and 15 can be characterized as learning through awareness of one's own learning process.

4.3. Exploration of changed teacher beliefs in relation to their learning activities

In order to explore the relations between the learning activities reported by the teachers and changes in their beliefs about teaching and learning, the following calculations for the student- and subject-matter-oriented beliefs of the teachers were performed separately. The frequencies of the 15 sequences of learning activities reported in the digital logs of those teachers with (1) a change of beliefs congruent with the aims of the reform, (2) no change of beliefs, or (3) a change of beliefs incongruent with the aims of the reform were calculated. Given the initially unequal frequencies of changes in the student- and subject-matter-oriented beliefs of the teachers, the relative frequencies of the 15 sequences for the different categories of teachers' belief changes were calculated. For example, for the 9 teachers with a change of student-oriented beliefs congruent with the aims of the reform, the number of reported learning experiences that could be characterized with sequence number 1 ($n = 11$) was divided by the total number of reported learning experiences of that group of teachers ($n = 47$) and presented in percentages ($11/47 = .234 = 23.4\%$). The 18 teachers who did not change their student-oriented beliefs reported 8 learning experiences that were labelled with sequence number 1. When this number of learning experiences was divided by the total number of reported learning experiences of this group ($8/110 = .073 = 7.3\%$), a lower relative frequency resulted. Finally, the 7 teachers with a change in student-oriented beliefs incongruent with the aims of the reform reported 5 learning experiences with label sequence number 1, which resulted in a relative percentage of 12.5% ($5/40 = .125$).

The relative frequencies were then compared to determine which types of activity sequences were most noteworthy (i.e., had a high percentage) for the 3 categories of teachers' belief changes (i.e., teachers showing congruent changes, incongruent changes, or no change in their beliefs about teaching and learning). A difference of more than 5% between the relative frequencies for the 3 categories of teachers' belief changes was considered noteworthy. With regard to the previous example, it can be concluded that learning experiences with sequence number 1 are more related to changes in student-oriented beliefs congruent with the aims of the reform. The relative percentage of 23.4% is noteworthy higher compared to the percentages in which learning experiences with sequence number 1 were reported by teachers with no changes in student-oriented beliefs and teachers with changes in student-oriented beliefs incongruent with the aims of the reform (7.3% and 12.5%). Note that the comparison of the relative frequencies must be regarded as exploratory; it did not aim for determining significantly different frequencies.

Since we measured both student-oriented and subject-matter-oriented beliefs, the relative frequencies were compared for each set of beliefs separately. An incongruent change in the subject-matter-oriented beliefs about teaching and learning was found to occur for only one teacher, which made comparison of the relative frequencies with a group of such teachers impossible.

Inspection of the relative frequencies of the different activity sequences showed that those sequences with a frequency that was less than 19 were not specific to a particular group of teachers. The relative frequencies of those three activity sequences with the highest frequencies of occurrence are presented in Table 5.

As can be seen from Table 5, noteworthy differences in the relative frequencies of activity sequences 1, 7, and 9 were detected for differences in changes in student-oriented beliefs. Sequence 1 reflects learning experiences in which teachers reported

Table 5
Relative frequencies of activity sequences 1, 7, and 9 according to changes in student- and subject-matter-oriented beliefs about teaching and learning

Beliefs about teaching and learning	Changes (frequency)	Sequence of activities code		
		1 (n = 24)	7 (n = 43)	9 (n = 37)
Student-oriented beliefs	Teachers with changes congruent with the aims of the reform (9)	23.4%	12.8%	14.9%
	Teacher with no changes (18)	7.3%	20.9%	22.7%
	Teachers with changes incongruent with the aims of the reform (7)	12.5%	35.0%	12.5%
Subject-matter-oriented beliefs	Teachers with changes congruent with the aims of the reform (11)	12.3%	24.6%	15.8%
	Teachers with no changes (22)	12.1%	20.7%	20.0%

experimentation (or an intention to experiment) with alternative teaching methods that they discovered through interaction with colleagues in a professional development setting (cf. Table 4). This sequence of learning activities was found to occur relatively more often in the digital logs of teachers who produced a higher score for student-oriented beliefs about teaching and learning in October 2005 than in October 2004. Activity sequence 7 reflects learning experiences in which teachers experimented with alternative teaching methods owing to dissatisfaction with the students' level of knowledge, skills, or attitudes, or the effectiveness of the methods otherwise used. This activity sequence was found to occur relatively more often for those teachers who produced lower student-oriented belief scores in 2005 than in 2004. Activity sequence 9 reflects teachers learning through observation of students during an assignment that was part of the standard curriculum, and showed the highest relative frequency for teachers who did not change their student-oriented beliefs after a period of one year and participation in an interdisciplinary team. No noteworthy differences in the relative frequencies of activity sequences 1, 7, and 9 were found to occur for the different groups of teachers when their subject-matter-oriented beliefs about teaching and learning were examined over time. That is, the relative frequencies of the activity sequences did not differ to a noteworthy extent for those teachers with beliefs that changed in a manner that was congruent with the aims of the reform or those teachers who showed no changes in their subject-matter-oriented beliefs after a period of one year.

In sum, it can be concluded that activity sequences 1, 7, and 9 related differently to the changes (or lack of change), particularly in the student-oriented beliefs of the teachers. The question remains to be answered why activity sequence 7 occurred more often for teachers showing a change of student-oriented beliefs incongruent with the aims of the educational reform, while activity sequence 1 occurred more often for teachers showing a change congruent with the aims of the educational reform. Similarly, it is unclear why some teachers did not change their beliefs about teaching and learning despite collaboration in an interdisciplinary team and the report of sequence 9 activities. These questions are addressed in the following sections, where we report examination of the nature and topics of the reported learning activities in greater detail and closer examination of the initial teacher belief scores.

4.4. Differences in the nature and topics of the learning activities

Closer inspection of the teachers' learning experiences showed the reported activities to differ sometimes with regard to whether or not they were undertaken with the intention of learning from the

activities. For example, learning through experimentation with a new teaching method, the observation of students during such a lesson, and subsequent evaluation of the new method is very different from learning through observation of students working on a standard assignment. The former learning experience includes the explicit intention to change one's teaching practices whereas the latter learning experience can be characterized as largely spontaneous.

Darling-Hammond, Hammerness, Grossman, Rust, and Shulman (2005) have further observed that "although much research has focused on the processes of teacher learning, evidence suggests that *what* teachers learn matters at least as much as *how* they learn" (p. 395). For example, teachers can experiment with a new method that gives students greater responsibility for their own learning, or with a new method that involves taking greater control of student learning. While the nature of the activity itself is basically the same, the focus or topic of the activity is very different.

In Table 5, it can be seen that activity sequence 1 occurred relatively more often for teachers who changed their student-oriented beliefs in a direction that was congruent with the aims of the educational reform than for teachers who did not change their student-oriented beliefs or who changed them in a direction that was not congruent with the aims of the educational reform. Experimentation with the methods of a colleague is a typical sequence 1 activity, and was usually preceded by familiarization with the teaching methods and ideas of colleagues (e.g., through observation, discussion, or brainstorming) and reflection upon one's own teaching methods. The latter two activities took place either in the teams or in interaction with colleagues outside the team. In both cases, however, the sequence of activities was undertaken with the intention of changing teaching practices. The topic of the activities also always concerned the fostering of more active and self-regulated student learning, which is clearly congruent with the aims of the relevant educational reform.

The results in Table 5 further showed activity sequence 7 to relate to teacher beliefs that changed in a direction that was *not* congruent with the aims of the educational reform. Activity sequence 7 starts with individual dissatisfaction, which can be seen to prompt experimentation with alternative teaching methods and confirmation of one's initial assumptions (see Table 4).

Comparison of activity sequences 1 and 7 shows the impetus for learning in sequence 1 to be interaction with colleagues, while the impetus for learning in sequence 7 is individual consideration (i.e., dissatisfaction). The two activity sequences are, however, very similar in nature: they both include intentional experimentation with an alternative teaching method. However, the topic of the learning experiences represented by activity sequence 7 clearly differs from the topic of the learning experiences represented by activity sequence 1. In the case of activity sequence 7, for example, the teachers see that students cannot (yet) be held responsible for their own learning and, therefore, decide to take greater control of the student learning process and experiment with teaching methods along these lines. In the case of activity sequence 1, alternatively, the teachers see that the methods of colleagues produce more active and self-regulated student learning and they, therefore, experiment with these methods.

Finally, the results presented in Table 5 show that activity sequence 9 occurred most often for teachers who did not change their student-oriented beliefs about teaching and learning. Inspection of the activities constituting this sequence in Table 4 shows that the relevant activities clearly differ in nature from the activities constituting sequences 1 and 7. In sequence 9, the teachers learned from spontaneous observation of students during standard assignments. In other words, there was no explicit a priori intention to learn, as there was in activity sequences 1 and 7.

In sum, teachers can engage in activities of a similar nature but show different patterns of change in their student-oriented beliefs.

This outcome can better be understood when the topics of the learning activities are examined. Teachers showing changes in beliefs that are largely congruent with the aims of the educational reform can be seen to have experimented with teaching methods that give students greater responsibility for their own learning. Conversely, teachers showing changes in beliefs incongruent with the aims of the educational reform can be seen to have experimented with teaching methods that more strongly regulate student learning. The differences between teachers who changed their student-oriented beliefs and those who did not change their beliefs can conceivably be explained by the fact that the former group of teachers specifically intended to learn from the reported activities while the latter group did not.

4.5. Differences in initial teacher beliefs about teaching and learning

In order to better understand the differences between the teachers with respect to the changes in their beliefs about teaching and learning, their initial scores on the questionnaire 'Beliefs about teaching and learning' were examined in greater detail. In Table 6, the initial means, standard deviations, minimum scores, and maximum scores along a five-point scale are displayed in relation to the different patterns of change in the student- and subject-matter-oriented beliefs of the teachers.

As can be seen, the initial mean and maximum scores for teachers who later changed their student-oriented beliefs in a manner that was congruent with the aims of the reform were lower than the initial mean and maximum scores for teachers who later changed their student-oriented beliefs in a manner that was incongruent with the aims of the reform. This means that to some extent ceiling effects may have occurred for the second group of teachers. The results presented in Table 6 further show that the mean and maximum scores for teachers with subject-oriented beliefs that changed in a manner congruent with the educational reform were higher at the start of the study than the scores for teachers showing no such changes. The scores of the first group are, therefore, more likely to decline after a year than the scores of the second group.

In Table 7, a schematic overview is given for the results presented above with regard to the differences in the changes in teacher beliefs in conjunction with the nature and topics of the reported learning experiences and initial teacher beliefs.

5. Conclusions and discussion

The relations between teacher learning activities and the patterns of change in teacher beliefs with respect to the topic 'active and self-regulated learning' in upper secondary education were explored. Below, the most important results are first

Table 6
Initial means, standard deviations, minimum scores, and maximum scores for different patterns of change in student- and subject-matter-oriented beliefs about teaching and learning (October 2004)

Changes in beliefs about teaching and learning		Mean	SD	Minimum	Maximum
Student-oriented beliefs	Teachers with change congruent with the aims of the reform	3.83	.26	3.42	4.28
	Teachers with no change	4.26	.41	3.56	4.98
	Teachers with change incongruent with the aims of the reform	4.27	.34	3.85	4.74
Subject-matter-oriented beliefs	Teachers with change congruent with the aims of the reform	3.11	.75	2.32	4.54
	Teachers with no change	2.86	.32	2.19	3.53

Table 7
Characterization of activity sequences and belief changes in terms of nature and topic of learning experiences and initial belief scores

	Activity sequences in relation to pattern of change in student-oriented beliefs		
	Activity sequence 1 & congruent belief changes	Activity sequence 7 & incongruent belief changes	Activity sequence 9 & no belief changes
Nature of the learning experience			
Intentional	✓	✓	
Unintentional			✓
Topic of the learning experience			
Teacher regulation		✓	
Student regulation	✓		✓
Initial teacher belief scores			
Average	✓		
High		✓	✓

summarized; the implications of the results are then discussed. We conclude with some comments on the data collection methods employed and some suggestions for future research on teacher learning.

The present results show that 16 teachers clearly changed their student-oriented beliefs and 12 teachers clearly changed their subject-matter-oriented beliefs. The changes in teachers' student- and subject-oriented beliefs could be divided into (1) changes that were congruent with the aims of the reform and (2) changes that were not congruent with the aims of the reform. This finding is in line with the findings of Tillema and Knol (1997), who also found that student teachers changed their beliefs as a result of two different teacher education programs, but not consistently in one direction. Changes incongruent with the aims of the reforms are particularly remarkable in light of the context in which the teachers in this study were examined: all of the teachers participated in a project that involved participation in an interdisciplinary team and the objective of fostering more active and self-regulated student learning.

How can the finding be explained that some teachers changed their beliefs in a manner congruent with the idea of fostering more active and self-regulated student learning, while other teachers did not? What learning activities were undertaken by some of the teachers but not by others? And in what way do teachers whose beliefs changed in a manner congruent with the educational reform differ from teachers whose beliefs did not change in a manner congruent with the aims of the reform? In order to answer these questions, we first analyzed the learning activities reported by the teachers in their digital logs. We described teachers' learning experiences in sequences of activities instead of separate activities; as a result, a more detailed view of how teachers learn in the workplace was attained. For future studies on teacher learning, therefore, we suggest focusing on sequences of activities rather than on separate activities.

As depicted in Table 5, the relative frequencies of the activity sequences with the highest frequency of occurrence clearly differed for the different patterns of change in beliefs. For the

subject-matter-oriented beliefs of the teachers, no noteworthy differences in the relative frequencies of the activity sequences were detected. For the student-oriented beliefs of the teachers, however, some noteworthy differences in the relative frequencies of activity sequences 1, 7, and 9 were found. Activity sequence 1 occurred relatively more often for teachers with student-oriented beliefs that changed in a manner congruent with the aims of the reform. Activity sequence 7 occurred relatively more often for teachers with student-oriented beliefs that changed in a manner incongruent with the aims of the reform. Finally, activity sequence 9 occurred relatively more often for teachers who showed no changes in their student-oriented beliefs about teaching and learning.

The exact nature and topics of the learning experiences reported by the teachers were examined in greater detail in order to further interpret the observed differences in the relations between teacher learning activities and patterns of change in the teacher beliefs about teaching and learning. In addition, possible differences in their initial belief scores were now taken into consideration.

Activity sequence 1 was found to have the highest relative frequency of occurrence for teachers with student-oriented beliefs that changed in a manner congruent with the aims of the educational reform. Through exposure to the teaching methods of colleagues, and methods that could be seen to foster more active and self-regulated student learning in particular, these teachers were prompted to experiment with the methods on their own. In general, the teachers greatly valued the opportunity to experiment with new methods, became more positive about efforts to promote more active and self-regulated student learning, and changed their student-oriented beliefs about teaching and learning accordingly. Although beliefs are often found to be difficult to change (Pajares, 1992), we found that collaboration with colleagues led to such changes: the exchange of experiences and methods clearly promoted experimentation with the methods of colleagues. Positive experiences of the adoption of new methods to foster more active and self-regulated student learning then led to changes in the beliefs about teaching and learning held by the teachers or—in other words—to the changes required for successful implementation of an educational reform. This finding confirms the results of previous research showing collaboration between teachers to constitute a powerful learning environment (Butler et al., 2004; Grossman, Wineburg, & Woolworth, 2001; Putnam & Borko, 2000; Shank, 2006). This finding contributes to a more comprehensive understanding of how exactly teacher learning takes place in collaboration. In many studies on teacher collaboration, it was assumed that the exchange of ideas, experiences, teaching methods, and feedback fosters learning. Based on the findings of this study it might be argued that merely exchanging teaching methods may not be sufficient to result in belief changes. We found that teachers learn by exchanging ideas, experiences, and teaching methods with colleagues in combination with experimentation in their own practice with alternative methods, and deliberate evaluation of this experimentation.

Activity sequence 7 was found to have a relatively high frequency of occurrence for teachers with student-oriented beliefs that changed in a manner that was not congruent with the aims of the relevant educational reform. The information presented in Table 5 also shows that the teacher learning activities in sequence 7 related differently to the changes in the student-oriented beliefs of the teachers than the activities in sequence 1. Closer examination of the specific topics addressed in activity sequence 7 showed that these teachers experimented mostly with methods aimed at strong regulation of the student learning process, and that such experiments were highly valued. As a result of negative experiences of allowing students greater autonomy, these teachers considered students (so far) incapable of taking responsibility for their own

learning, and had lower student-oriented belief scores in October 2005 than in October 2004.

The results in Table 5 also show that teachers with student-oriented beliefs that changed in a manner congruent with the aims of the reform also reported learning experiences involving activity sequence 7, but to a far lesser extent than did teachers with student-oriented beliefs that changed in a manner incongruent with the aims of the reform. The question, then, is what prompted these teachers to change their student-oriented beliefs about teaching and learning in a manner nevertheless congruent with the aims of the reform? More detailed examination of the topics in the learning experiences reported by the teachers showed that these teachers in particular experimented with teaching methods that nevertheless gave students greater responsibility for their own learning. On the basis of their negative experiences of allowing students greater autonomy, these teachers reasoned that the students simply did not have enough experience of working and learning in a more active and independent manner, and, therefore, experimented with new methods and assignments specifically intended to give students greater responsibility for their own learning.

Finally, the results in Table 7 show that, in contrast to the results for activity sequences 1 and 7, activity sequence 9 involves no explicit intention to learn. The absence of such an a priori intention to learn may explain, in turn, the lack of changes in the student-oriented beliefs of the teachers.

Another important conclusion on the basis of the results of this study is that patterns of change in the beliefs of teachers should always be considered with respect to their initial beliefs. The lack of change in the beliefs of some teachers was explained by teachers' pre-existing beliefs. We demonstrated that these teachers possessed strong student-oriented beliefs which may have impeded belief change (Pintrich et al., 1993). Also, changes congruent and incongruent with the aims of the reform were detected, but a value judgment was not assigned to these two types of change. Viewed from the perspective of policymakers, however, changes that are not in agreement with the aims of a reform may be valued negatively. By taking the initial scores of the teachers in the present study into account, we hope to have made it clear that incongruent changes need not necessarily be interpreted negatively, and thereby to have made the nature of the incongruent changes more comprehensible.

We referred in Section 1 to the work of Sfard (1998) and Hodkinson and Hodkinson (2005), who have argued that (teacher) learning should be approached in terms of combinations of the acquisition, construction, and participation perspective. To understand teacher learning, information should be called upon from (1) an acquisition perspective, where learning is described in terms of individual learning outcomes (changes in cognition), (2) a construction perspective, where learning is regarded as an ongoing process of constructing knowledge, and (3) a participation perspective, where learning is understood in terms of participation in (workplace) activities. In the present study, we aimed to meet this requirement with the inclusion of information on changes in teacher beliefs about teaching and learning, and on teachers' engagement in learning activities in their working environment, and by examining just how belief changes relate to teachers' work-related learning activities over time. Two instruments that differ with regard to the level of information measured were used for this purpose. Whereas the teacher learning activities were measured at a situation-specific level, the changes in the teachers' beliefs about teaching and learning were measured at a more general level. The relations between the reported learning activities and observed changes in the teacher beliefs were computed as the relative frequencies of occurrence for different sequences of activities according to the different types of observed change in beliefs. The

results of such an analysis do not reveal causal relations, even though the teachers were asked to report on learning experiences which they considered most relevant to their own learning regarding the topic of active and self-regulated learning. Information about teacher learning activities was collected using the reports of 6 learning experiences of each teacher. Given that teachers may learn everyday from their teaching experiences, changes in their beliefs about teaching and learning may also be better understood and more fully explained when their daily activities are also examined in greater detail.

In this study, we related belief changes to teachers' learning experiences and corresponding activities that occurred during a period of one year. Although this study focuses mainly on the nature of belief changes and teachers' activities which applies for teachers in general, only upper secondary schoolteachers were included. In future research it would be worthwhile to examine the relation between teachers' belief changes and activities in other grade levels as well. Furthermore, based on the findings of previous studies on conceptual change, it can be argued that motivational factors such as goal orientation, interest, and efficacy beliefs are intermediate factors in the process of conceptual change (Patrick & Pintrich, 2001). It would be interesting to examine teachers' goal orientation in relation to changes in beliefs. This orientation can be divided into a mastery orientation and a performance orientation (Patrick & Pintrich, 2001). Teachers with a mastery orientation towards learning are likely to think deeply about new ideas or situations they have been confronted with, in order to attain a comprehensive understanding. On the contrary, teachers with a performance orientation are likely to be extrinsically motivated. For the experienced teachers in this study, such an orientation might imply that they change their teaching practices in order to meet the expectations of others, such as school management teams. Applied to belief changes found in this study, teachers who did not change their beliefs might be mainly performance oriented, whereas teachers who did change their beliefs might have been mastery oriented. However, the majority of reported learning experiences included evaluations of experiences in which the teachers, for example, reflected on their experiments with alternative methods and sought possible underlying principles and explanations of why a method did or did not work. Such deliberate evaluation of situations and experiences may be interpreted as mastery oriented rather than performance oriented. For future research on experienced teachers' belief changes, we suggest examining the influence of motivational factors on learning activities in more detail.

In addition to including motivational factors in future research on teacher learning, it would also be useful to include school organization factors, such as (teachers' perceptions of) the support provided by principals and school management teams to teachers in implementing educational reforms and in teachers' professional development (Geijsel, Slegers, van den Berg, & Kelchtermans, 2001). Teachers who feel supported in their professional development may be more inclined to look for opportunities and situations which are helpful in their own development than teachers who do not feel supported. For this study we had only general information on school organizational factors; for example, all 5 schools were secondary schools for senior general secondary education or pre-university education, or both, and in all 5 schools the teachers were facilitated in their participation in the teams. Also, the participating teachers who changed their beliefs worked in different schools. Consequently, it is difficult to relate teacher learning to school organizational factors. Teachers working in the same school can have different views on their school organizations, and it would, therefore, be interesting to include data on teachers' individual perceptions on school organizational factors in future studies. This might provide insight into differences in individual teacher learning within a school organization.

Finally, the digital logs contain information not only on the learning-related activities of the teachers but also on the learning-related outcomes of such activities. It is, therefore, possible that a new or confirmed idea about student learning or the decision to use a particular method more frequently, for example, may also relate differently and significantly to the observed changes in teacher beliefs. Teachers who report mainly intentions to change their teaching methods or confirmation of their ideas regarding student learning in their digital logs, for instance, are not likely to change their more general beliefs about teaching and learning. Teachers who report new insights regarding student learning in their digital logs, in contrast, may be predisposed to change their general beliefs about teaching and learning as well. Examination of such situation-specific changes in cognition, therefore, constitutes a promising direction for the study of teacher learning.

Despite the limitations, this study has contributed to a more detailed understanding of teacher learning in secondary education by using different complementary data collection methods.

Acknowledgements

The authors would like to thank Inge Bakkenes, Annemarieke Hoekstra, and Rosanne Zwart for their collaboration on this project and particularly for their help with the construction of the data collection methods. We would also like to thank Ben Smit for his help on the analyses of the digital logs.

Finally, we would like to thank two anonymous reviewers for their very helpful comments on an earlier version of this article.

This research was funded by The Netherlands Organization for Scientific Research (NWO) (Project no. 411-01-251).

References

- Bakkenes, I., Hoekstra, A., Meirink, J., & Zwart, R. (2004, June). *Leren van docenten in de beroepspraktijk [Teacher learning at the workplace]*. Paper presented at the annual meeting of the Dutch Educational Research Association (VOR), Utrecht, The Netherlands.
- Bolhuis, S. (2000). *Naar zelfstandig leren: wat doen en denken docenten? [Towards self-directed learning: What do teachers do and think?]* Leuven/Apeldoorn: Garant.
- Bolhuis, S., & Voeten, M. J. M. (2004). Teachers' beliefs about student learning and own learning. *Teachers and Teaching: Theory and Practice*, 10, 77–98.
- Boulton-Lewis, G. M., Smith, D. J. H., McCrindle, A. R., Burnett, P. C., & Campbell, K. J. (2001). Secondary teachers' beliefs about teaching and learning. *Learning and Instruction*, 11, 35–51.
- Butler, D. L., Novak Lauscher, H., Jarvis-Selinger, S., & Beckingham, B. (2004). Collaboration and self-regulation in teachers' professional development. *Teaching and Teacher Education*, 20, 435–455.
- Calderhead, J. (1996). Teachers: beliefs and knowledge. In D. Berliner, & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 709–725). New York: Simon and Schuster Macmillan.
- Cobb, P., & Bowers, J. (1999). Cognitive and situated learning perspectives in theory and practice. *Educational Researcher*, 28(2), 4–15.
- Cochran-Smith, M., & Lytle, S. L. (1999). Relationships of knowledge and practice: teacher learning in communities. *Review of Research in Education*, 24, 249–305.
- Darling-Hammond, L., Hammerness, K., Grossman, P., Rust, F., & Shulman, L. (2005). The design of teacher education programs. In L. Darling-Hammond, & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 390–441). San Francisco: Jossey-Bass.
- Denessen, E. J. P. G. (1999). *Opvattingen over onderwijs: leerstof- en leerlinggerichtheid in Nederland [Beliefs about education: Subject matter and student orientations in the Netherlands]*. Doctoral dissertation. Garant, Leuven.
- Fenstermacher, G. (1994). The knower and the known: the nature of knowledge in research on teaching. *Review of Research in Education*, 20, 3–56.
- Geijsel, F., Slegers, P., van den Berg, R., & Kelchtermans, G. (2001). Conditions fostering the implementation of large-scale innovation programs in schools: teachers' perspectives. *Educational Administration Quarterly*, 37, 130–166.
- Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record*, 103, 942–1012.
- Hodkinson, H., & Hodkinson, P. (2005). Improving schoolteachers' workplace learning. *Research Papers in Education*, 20, 109–131.
- Kember, D. (1997). A reconceptualisation of the research into university academics' beliefs about teaching. *Learning and Instruction*, 7, 255–275.
- Korthagen, F. A. J. (2001). *Linking practice and theory: The pedagogy of realistic teacher education*. Mahwah: Lawrence Erlbaum Associates.

- Kwakman, C. H. E. (1999). *Leren van docenten tijdens de beroepsloopbaan; Studies naar professionaliteit op de werkplek in het voortgezet onderwijs [Teacher learning during the professional career: Studies of professionalism at the workplace in secondary education]*. Unpublished doctoral dissertation, University of Nijmegen, The Netherlands.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
- Lohman, M. C., & Woolf, N. H. (2001). Self-initiated learning activities of experienced public school teachers: methods, sources, and relevant organizational influences. *Teachers and Teaching: Theory and Practice*, 7, 59–74.
- Meijer, P. C., Verloop, N., & Beijjaard, D. (1999). Exploring language teachers' practical knowledge about teaching reading comprehension. *Teaching and Teacher Education*, 15, 59–84.
- Meirink, J. A., Meijer, P. C., & Verloop, N. (2007). A closer look at teachers' individual learning in collaborative settings. *Teachers and Teaching: Theory and Practice*, 13, 145–164.
- Oolbekkink-Marchand, H. W., van Driel, J., & Verloop, N. (2006). Secondary and university teachers' perspectives on self-regulated learning. In F. Oser, F. Achterhagen, & U. Renold (Eds.), *Competence oriented teacher training: Old research demands and new pathways* (pp. 219–236). Rotterdam: Sense Publishers.
- Pajares, M. F. (1992). Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research*, 62, 307–332.
- Patrick, H., & Pintrich, P. R. (2001). Conceptual change in teachers' intuitive conceptions of learning, motivation and instruction: the role of motivational and epistemological beliefs. In B. Torff, & R. J. Sternberg (Eds.), *Understanding and teaching the intuitive mind: Student and teacher learning* (pp. 117–143). Mahwah: Lawrence Erlbaum.
- Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: the role of motivational beliefs and classroom contextual factor in the process of conceptual change. *Review of Educational Research*, 63, 167–199.
- Pratt, D. D. (2002). Good teaching: one size fits all? *New Directions for Adult and Continuing Education*, 93, 5–15.
- Putnam, R. T., & Borko, H. (1997). Teacher learning: implications of new views of cognition. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers and teaching* (pp. 1223–1296). Dordrecht: Kluwer Academic Publishers.
- Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, 29(1), 4–15.
- Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, 27(2), 4–13.
- Shank, M. J. (2006). Teacher storytelling: a means for creating and learning within a collaborative space. *Teaching and Teacher Education*, 22, 711–721.
- Tillema, H., & van der Westhuizen, G. J. (2006). Knowledge construction in collaborative enquiry among teachers. *Teachers and Teaching: Theory and Practice*, 12, 51–67.
- Tillema, H. H. (1998). Stability and change in student teachers' beliefs about teaching. *Teachers and Teaching: Theory and Practice*, 4, 217–228.
- Tillema, H. H., & Knol, W. E. (1997). Promoting student teacher learning through conceptual change or direct instruction. *Teaching and Teacher Education*, 13, 579–595.
- Trigwell, K., & Prosser, M. (1996). Changing approaches to teaching: a relational perspective. *Studies in Higher Education*, 21, 275–285.
- Van Driel, J. H., Bulte, A. M. W., & Verloop, N. (2007). The relationships between teachers' general beliefs about teaching and learning and their domain specific curricular beliefs. *Learning and Instruction*, 17, 156–171.
- Van Eekelen, I. M., Boshuizen, H. P. A., & Vermunt, J. D. (2005). Self-regulation in higher education teacher learning. *Higher Education*, 50, 447–472.
- Vermunt, J. D., & Verloop, N. (1999). Congruence and friction between learning and teaching. *Learning and Instruction*, 9, 257–280.
- Waeytens, K., Lens, W., & Vandenberghe, R. (2002). Learning to learn: teachers' beliefs about their supporting role. *Learning and Instruction*, 12, 305–322.
- Zwart, R. C., Wubbels, T., Bergen, T. C. M., & Bolhuis, S. (2007). Experienced teacher learning within the context of reciprocal peer coaching. *Teachers and Teaching: Theory and Practice*, 13, 165–187.