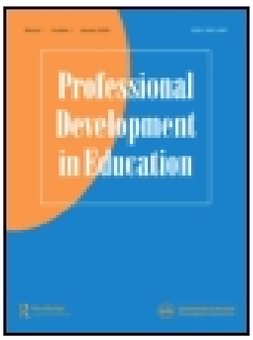

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Lesson Study: professional development (PD) for beginning and experienced teachers

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ABSTRACT

Central in this study is the professional development of beginning and experienced teachers collaborating in Lesson Study teams. Two high school teacher teams participated, a chemistry and a multidisciplinary team. Each team consisted of a beginning and an experienced teacher. Both teams went through the Lesson Study cycle twice. *What* and *from what* the beginning and experienced teachers learned, *differences* in teacher leaning and *what Lesson Study elements* contributed to this learning were studied in a qualitative multiple case study using interviews, reflective journals, and recordings . The Extended Interconnected Model for Professional Growth was used to interpret teacher learning. Our results show that two Lesson Study teams materialized in which participants shared experiences, thoughts, and ideas related to teaching and learning. Lesson Study contributed to both beginning and experienced teachers' PCK development. The combination of two phases in this professional development program proved instrumental for this PCK development: a *development phase* in which participants meet new pedagogies, discuss these in the perspective of student learning, design a lesson plan and prepare for class use. Followed by a *class enactment phase* where the designed lesson is enacted, students are observed, subsequently salient results are discussed and the lesson plan revised.

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Lesson Study; professional development; PCK; beginning teachers; Extended Interconnected Model for Professional Growth

Introduction

Beginning teachers need to grow in the school culture and system, further develop their professional identity (Pillen *et al.* 2012), and build routines for class room management and pedagogy. In the past beginning teachers mainly had to do this on their own, but now that professionally trained high school teachers for the natural sciences and mathematics are in short supply (Dutch Government 2017), and quite some beginning teachers leave the teaching profession (Den Brok *et al.* 2017), the Dutch Ministry of Education, Culture, and Science decided in 2013 to take action (Helms-Lorenz *et al.* 2013). Schools, in close collaboration with university teacher training institutions, were encouraged to set up in-school professional development programs to support beginning teachers in their professional development during their first three years of teaching. Research shows that a well-organized support program, including high-quality school mentors, positively influences beginning teachers well-being

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and teacher quality (Kelchtermans and Ballet 2002), can help beginning teachers to grow faster in the school culture and system (Helms-Lorenz *et al.* 2016) and retain them as teachers. It is supposed that Lesson Study can constitute such a professional development program.

A high school in the northeast of the Netherlands in close cooperation with the science teacher education department from our university decided to offer Lesson Study, a specific professional development model, to support beginning teachers. Lesson Study teams would be set up to facilitate collaboration between beginning and experienced teachers. These teams can form small school-based learning communities (Dudley 2013, Goei *et al.* 2015) to foster the professional development of both the beginning teachers as well as their more experienced colleagues (Luft 2001). As the focus in Lesson Study is on students and student learning we expect Lesson Study especially to contribute to teachers developing their pedagogical content knowledge (PCK) (Cerbin and Kopp 2006). In Lesson Study the *students* are observed, *not* the teacher, and therefore, participating in Lesson Study will be non-threatening for beginning teachers. Our university teacher education department had ample experience with Lesson Study involving teachers from different secondary schools (Verhoef *et al.* 2013, 2015), but not with teachers from only one school, nor with the explicit and deliberate inclusion of beginning teachers as part of a Lesson Study team. In the next section Lesson Study will be briefly described, followed by PCK and finally a model for teacher professional development.

Theoretic framework

Lesson Study

Lesson Study originated in Japan (Isoda 2007, Saito 2012). It has the characteristics of effective professional development: teachers are actively involved in both the process as the products, the focus is on content and specifically on students learning this content, it takes place over a longer time span, and there is coherence between the activities (Garet *et al.* 2001, Penuel *et al.* 2007). In Lesson Study, teachers in collaboration select a topic and plan and prepare a lesson (called a research lesson), one teacher enacts the research lesson and the others observe the students in class, and finally teachers discusses their observations (i.e., the Lesson Study cycle; see Figure 2 for the Lesson Study cycle used in this study) (Lewis *et al.* 2006, Isoda *et al.* 2007, Stepanek *et al.* 2007). During lesson preparation teachers predict how students will react to specific activities and this requires the teachers to reflect on and reassess their teaching approaches. Class enactment, during which the students are observed, of collaborative prepared lessons leads to changing insights and practices (Bakkenes *et al.* 2010). After class the observations are discussed in the light of the predicted outcome (Verhoef *et al.* 2015). These discussions and the reflection on classroom practices and student learning further stimulate teachers' professional development, and especially their PCK development (Gess-Newsome 2015).

PCK

As Lesson Study focuses on student learning it is expected that teachers will specifically develop their PCK (Shulman 1986, Van Driel *et al.* 1998, Magnusson *et al.* 1999). PCK was introduced by Shulman as 'subject matter knowledge for teaching'. Quite a number of scholars have since Shulman worked on PCK and conceptualized it in different ways, partly because of a difference in research focus (Loughran *et al.* 2004, Hashweh 2005, Park and Oliver 2008, Rollnick *et al.* 2008, Schneider and Plasman 2011, Depaepe *et al.* 2013). In Lesson Study both PCK on action (the knowledge, skills, reasons and planning, and beliefs) as well as PCK in action (teaching specific content in class) are addressed (Schön 1983). The five PCK components described by Magnusson *et al.* (1999) were adopted for this study: (1) orientations toward science teaching, (2) knowledge and beliefs about the science curriculum, (3) knowledge and beliefs about instructional strategies, (4) knowledge and beliefs about students understanding of specific topics, and (5) knowledge and beliefs about assessment. PCK is constructed in a complex process in which a teacher actively processed and integrated different knowledge bases,

topic-specific knowledge, teacher and students' beliefs, and student learning outcomes. How these different components interact is depicted in Gess-Newsome's model (2015). An expert teacher has well-formed PCK for all topics taught, developed, and shaped in classroom practice through amplifiers and filters. Beginning teachers still need to develop and expand their PCK.

Model for teacher professional development

Developing, expanding, and adapting PCK is complex and highly idiosyncratic (Clarke and Hollingsworth 2002, Borko 2004, Fullan 2007). The Extended Interconnected Model of Professional Growth (EIMPG) for teacher learning, based on the Clarke and Hollingsworth model (2002), shown in Figure 1 is used to visualize teacher PCK growth (Coenders and Terlouw 2015). The model depicts how a teachers' knowledge base (Personal Domain) grows through enactment and reflection processes between different domains: an External Domain that is not part of a teachers' daily practice, the Developed Material Domain consisting of written student learning material to be used in class, the Domain of Practice constituting class enactment, and the Domain of Consequence comprising salient student learning outcomes.

Two distinctive phases for teacher growth can be distinguished: a *development phase*, followed by a *class enactment phase*. These two phases also apply to Lesson Study as will be briefly explained below.

The *development phase* consists of the interplay between the PD, the ED, and the DMD (Figure 1). Through the External Domain the Lesson Study teachers come in contact with to them unfamiliar pedagogies and materials, and have ample opportunities to discuss how these pedagogies and materials may contribute to student learning. A number of these insights, materials, and pedagogies are finally integrated in a detailed lesson plan (Developed Material Domain).

In the *class enactment phase* reflection and enactment between the domains DP, DC, and PD transpires. Class enactment (DP) of the detailed lesson plan during which the students are observed, followed by discussion of the results (DC), is the actual proof of the pudding: did the students learn what was expected when the new materials and pedagogies were enacted. Both the *development* as well as the *class enactment* phase may lead to changes or growth in a teacher's PCK.

Literature shows that Lesson Study is effective in teacher professional development programs (Verhoef *et al.* 2015, Ermeling and Graff-Ermeling 2016, Nami *et al.* 2016), and has also been used successfully in initial teacher training programs (Bjuland and Mosvold 2015, Cajkler and Wood 2016, Leavy and Hourigan 2016). Lesson Study to support beginning and to enrich experienced teachers has not received much attention. This paper reports on such Lesson Study research.

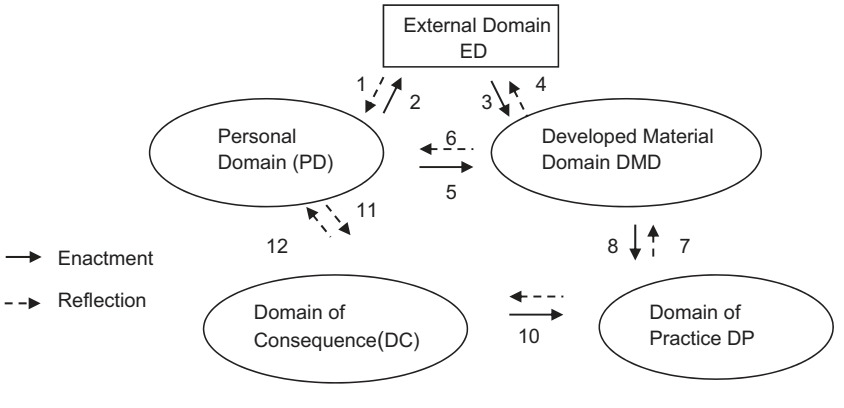

Figure 1. Extended Interconnected Model of Professional Growth (EIMPG).

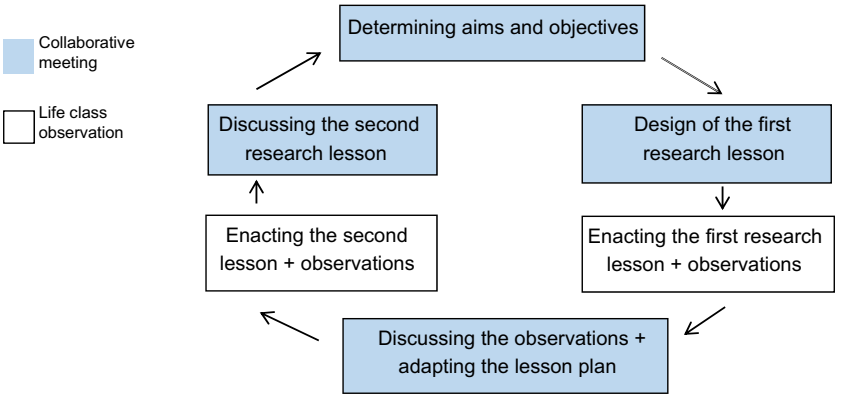

Figure 2. The Lesson Study cycle, based on Stepanek *et al.* (2007).

Context of the study

One high school in the northeast of the Netherlands, in cooperation with our university science teacher education department, decided to use Lesson Study as part of a support program for beginning teachers in the school year 2014–2015. In order to fulfill new examination program requirements, it was the school's ambition to make their students more responsible for their own learning, to reduce explaining content by teachers and replace this by engaging their students in meaningful learning activities. This ambition is the main aim in the Lesson professional development Study approach.

In this study we worked with two Lesson Study teams. The first team consisted of a beginning and an experienced chemistry teacher plus the school mentor and a university chemistry teacher educator. The second team consisted of teachers from different subjects. Their reason to join this Lesson Study team was to improve their students' Dutch language skills by making them more active learners through three activities: reading, writing and explaining. This team comprised: an experienced biology teacher, a beginning Dutch language teacher, a beginning teacher of Spanish, an experienced economics teacher, the school mentor, and a university teacher educator. The teachers were recruited by the school mentor and participated on a voluntary basis. The school mentor, responsible for the beginning teachers' support program, was also in charge of supervision of student teachers doing their teaching practice as part of their initial teacher training program. The school mentor was a well-respected and very experienced history teacher and mentor. All research lessons were taught at upper secondary level.

The focus in this study is on two beginning and two experienced teachers who *enacted* one of the research lessons.

Both teams used the following Lesson Study cycle, shown in Figure 2:

(a) Determining aims and objectives. Making students more active participants and having them work on meaningful learning activities was agreed as the main aim. We then decided on specific research lessons: what student year, what classes, and which teaching topic. After this specific lesson objectives were discussed and approved for these specific classes.
(b) Collaborative design of the first lesson, including the pedagogy to be used and all materials necessary for the students. What and from what students would learn was hypothesized. For example, for chemistry the first topic was stoichiometric calculations. Past exam questions were selected. The teacher would only revise a conversion diagram (from mole to gram). It was anticipated that students would be able to solve the questions when they were allowed to work in groups.
(c) Class enactment of the first research lesson in which teachers observed what students were doing, how they solved problems, and what arguments they used in the discussions with their peers and the teaching teacher. What and from what students learned was established (each

teacher-observer interviewed one or two case-students during the last five minutes of the lesson (Dudley 2013)).

(d) After class discussion with a focus on what was observed. Did the students do what was envisaged during preparation and to what extend did the predicted student learning outcomes materialize? Based on these observations lesson adaptations to improve student learning were discussed, and finally the lesson was redesigned. For chemistry this resulted in the addition of a problem solving approach.
(e) Class enactment of the redesigned second research lesson and live observations (plus student interviews) in a parallel class.
(f) After class discussion and final evaluation with an emphasis on the initial aims and objectives.

Both teams went through this cycle *twice*. In the chemistry team each of the two teachers class enacted twice a jointly prepared lesson, the experienced teacher the first lesson, the beginning the revised one. In the multidisciplinary team, this was not possible as the teachers taught different subjects. The idea of teaching two consecutive lessons was retained. In the first cycle the experienced biology teacher enacted the first and the second research lesson, then, in the second cycle the beginning Dutch language teacher taught these two lessons.

Our interest was how Lesson Study would contribute to teacher professional growth, and specifically for those teachers who had enacted classes as these had personally experienced the complete Lesson Study cycles and had been involved in all preparation and discussion activities. Professional growth both in terms of *what* and *from what*. This resulted in the following research questions:

(1) What do these teachers learn in a Lesson Study team, and from what do they learn this?
(2) What are the differences in learning processes between the beginning and the experienced teachers?
(3) What elements in the Lesson Study cycle contribute most to teacher learning?

Research method

Research design

As we were interested in teacher learning, a qualitative multiple case study approach was adopted (Yin 2003). The two Lesson Study teams were considered as two separate cases as each team formulated and worked on their own specific goals. The programs of the two Lesson Study teams were conducted and closely monitored, and in the process a large amount of qualitative data in the form of video recordings and interviews were collected. The qualitative data were first transcribed verbatim and subsequently open coded to find common themes. This was followed by axial coding in order to find both *what* and *from what* the teachers learned for each of the emerged themes (Gibbs 2007).

Participants

All teacher names are fictitious. The chemistry Lesson Study team comprised a beginning (Vernon) and an experienced teacher (Eric). Vernon aged 55, had a bachelor in chemistry and had almost completed a master in chemical education. After working in the chemical industry he had switched to the teaching profession. He was in his third year of teaching. Eric had a master in chemistry plus a teacher qualification. He was 61 and a chemistry teacher for more than 15 years.

In the multidisciplinary Lesson Study team the experienced biology teacher (Toby) was 45 years of age, had a master's degree in biology plus a teacher qualification, and he had more than 15 years teaching experience. The other teacher who taught the research lessons was a beginning Dutch language teacher (Wyatt), 27 years, with a master's degree in Dutch language and a teacher qualification.

He was in his second year as a teacher. The teacher Spanish and the economics teacher did not teach research lessons themselves and were, therefore, not included in this research.

Instruments for data collection

As we were interested in effects of specific Lesson Study elements on teacher learning, data were collected from each element: the preparatory meetings were video recorded (each meeting was between 90 and 150 min), the enacted lessons (50 min) were video recorded with one camera directed toward the whole class and one directed toward a group of randomly selected students, and the after class discussions were also video recorded (between 75 and 120 min).

Teachers who enacted research lessons (each cycle two teachers) were requested to fill in a reflective journal. However, these were far from complete but could still be used. Teachers said that filling in was too laborious. Each of these four teachers was interviewed (between 75 and 120 min) at the end of the second cycle using a semi-structured interview guide. After the opening question ('what did Lesson Study bring you') the focus was on what was discussed in the collaborative meetings and on what was enacted in class.

For each of these four teachers the following data sources were present: the individual interview, the reflective journal, transcripts of the collaborative meetings: the preparatory meetings (2x), the after class discussions and redesign (2x), and the final meetings (2x). The interview and the reflective journal constituted the primary data sources, the preparatory meetings, and after class discussions were used for validation.

The class enactment video recordings were used in the Lesson Study process to feed the after class discussions, and to validate teacher statements about class enactment.

Data analysis

The interviews and the video recordings from all meetings were transcribed verbatim and then coded using Atlas.ti. In a first round, the teacher interviews and the reflective journals were open coded to determine 'what is learned'. The resulting codes were in a second round collapsed into a number of themes. For the chemistry teachers this resulted in four themes: teacher role, group work, teaching order, and topic-specific issues. The codes from the multidisciplinary team could be grouped into the themes: teacher role, teaching approach, and topic-specific issues. The teacher statements on 'what is learned' and 'from what is it learned' for these themes were then transferred to a word table, for each teacher one table per theme. When a teacher said to have learned a specific aspect we wanted to see where in the Lesson Study process this aspect was discussed. The video transcripts were therefore analyzed and coded, and the passages that showed the discussion were transferred to the relevant word table in a column called 'where in the Lesson Study process present'.

Coding thus resulted in thematic tables for each teacher, four for the chemistry team as there were four themes, and three for the multidisciplinary team. Each table had three columns with the following lay out:

What is learned	From what is it learned	Where in the LS process present?	
Interview and reflective journal	Interview and reflective journal	1st cycle	2nd cycle

The first author completed these tables and the second author checked the tables against the transcripts. As the tables would take too much space, a number of teacher statements and passages from the discussion from these tables will be presented in the results section.

Results

We will present the results for the chemistry teachers first, followed by the teachers from the multidisciplinary team. In each section we start with a concise description of the preparatory meetings before

turning to teacher learning on the emerged themes. The last paragraph of the results section is about what elements in the Lesson Study cycle most contribute to teacher learning.

Chemistry teachers

The aims and objectives of this Lesson Study team were making students more active participants in class.

First cycle

The topic was stoichiometric calculations as this was considered difficult for students. Both teachers had explained students the content and handed out a diagram showing conversions from gram to mole, number of particles, and volume. The preparation of the first research lesson resulted in an approach in which students would, after a brief revision of the conversion diagram by the teacher, work on selected past exam questions. The teacher would move around to coach and assist students.

Second cycle

More student autonomy and student groups working on 'open' assignments were central. As both teachers soon were to start a new chapter (heat of reaction) it was decided to focus in the research lessons on this topic. Discussions resulted in an approach in which student groups would first experimentally determine the heat of combustion of candle wax. The experimental results would in the next period be used to explore the relevant content (calculations, enthalpy diagrams, activation energy). Additional worksheets for the experiment were developed to ensure that the student groups could continue working without teacher intervention, and to demonstrate the class observers what the students were doing. The research lesson was the lesson immediately following the experiment lesson and would start collecting the experimental results of all groups on the black board. After a brief discussion of these results and clarification of possible difficulties, student pairs were to work on exercises to explore the theory themselves.

Because of the time-tables, Eric taught the first research lesson, Vernon the second in both cycles.

Experienced chemistry teacher Eric

(a) *Teacher role*. Eric realized that his way of teaching very much centered around him and that he had a tendency of *explaining* content instead of *engaging* students in learning activities: 'I think that students indeed should be more responsible for their own learning process, but I get the creeps as they are not yet used to it' (interview). 'This means that a situation of student inactivity arises, and then I panic as a teacher and revert to working in a plenary class. So I think the problem lies more with me than with the students, or maybe with both' (interview). During the preparation for the second cycle after he agreed to develop a worksheet for the experiment Eric said: 'No, they (the students) now get carte blanche, no introduction on heat of reaction, measuring is knowing'. In the interview Eric admitted that students can do much on their own. This however requires that 'I have to prepare the lesson from begin to end very detailed, I knew this but when students work on their own this is even more important'.

(b) *Group work*. Group work was not a common strategy for Eric. Working in pairs was quite normal but he never used larger groups. When the use of larger groups was discussed Eric regularly asked how it would work out in practice: 'How do you see this, there are 21 students in this class, and they always work in groups of two when doing practical work' (preparation meeting). It was then agreed to work with groups of three or four students. After class enactment he noticed that it could be done: 'they had composed their own groups, finalized their experiment and compared the results where they had to try and explain their different measurements' (after class discussion).

(c) *Teaching order.* Eric initially wanted to firmly hold on to the textbook. Finally he agreed to reverse the teaching order from the textbook and experienced that doing this opened new ways to discuss experimental results and connect this with content. In the interview he said: 'First students do the experiment and then I explain the theory is possible. I have continued to use this approach afterward in other classes. I had double periods and I let first do the experiment and then we discussed the paragraph and the experimental results'.

(d) *Topic-specific issues.* Eric had taught his students a specific approach for problem solving: 'I find it very important, that you highlight for yourselves what you think are important data to solve an exercise' (preparation meeting). However, class enactment showed Eric that students either did not do this at all, or highlighted almost the entire text. 'It was very enlightening for me, this was my learning moment. It (problem solving) is not as easy as it looks, students need a number of steps they understand in order to solve an exercise' (after class discussion). So Eric realized that the guidance he had given his students was insufficient.

Beginning chemistry teacher Vernon

(a) *Teacher role*. Vernon's normal practice was to explain the content as he said 'I have the tendency of reverting to the explain mode' (interview) although he realized that 'Time and again I am amazed about how little students pick up from plenary class explanations. So students need to be more active, need to explore more themselves' (interview). In the after class discussion after the first cycle he noticed 'I now give students more freedom to sort out stuff themselves, I want to give them more responsibilities'.

He noticed that he has to unlearn his tendency of explaining students the content and answering questions instead of posing probing questions to determine where students get stuck. He said that in his other class after the second cycle when students were struggling with the questions on heat of reaction, he inserted questions for the students to scaffold their learning process as an alternative to explaining the content.

(b) *Group work.* He never let students work in larger groups than two but now noticed that: 'Working in larger groups than pair's is quite feasible' (interview). But he was also critical about the student group size used during the practical and formulated a workable alternative: 'With the practical work in the second cycle groups of four are too large as we have long laboratory tables and students sit in a row. Some students have no role in the discussions' (after class discussion). He therefore said: 'Three would be possible and next time I will use groups of two or three'.

(c) *Teaching order.* Changing the sequence of events (explaining content and experimentation) effectively did lead to student learning and was appreciated by a large number of students: 'First having students do an experiment and then letting them explore the content starting from their experimental results worked fine' (interview). According to Vernon the result is better understanding: 'Because students did the experiment first, they had more time manipulating the concepts and therefore grasped the theory much better' (after class discussion).

(d) *Topic-specific issues*. When Vernon thought that all students had answered a question he automatically started to explain the answer in a plenary class session, as did his colleague. In the after class discussion the effectiveness of this strategy was discussed and alternatives surfaced. For example, to only assist and explain content to groups that have a problem with it, and not to involve the entire class. In the interview Vernon said about this: 'When students master it (a specific exercise) there is no need to go over it and explain it again in a plenary'. Here, Vernon formulated a fundamental insight for class differentiation.

In summary the main aspects learned:

	Eric	Vernon
	Experienced teacher	Beginning teacher
Teacher role	Less explaining, more engaging students is activities	Students need to explore themselves, less explaining
Group work	Group work is possible	Groups of three students is effective
Teaching order	Experiment first, then explanation is effective	Experiment first leads to better understanding
Topic-specific issues	Students need problem solving guidance	Class differentiation possible

Biology and Dutch language teachers

The aims and objectives of this Lesson Study team were to improve students' language skills by making them more active learners through reading, writing, and explaining. In this Lesson Study team, with teachers from different disciplines, it was not possible to have one teacher within one cycle teach the first research lesson and another one teach the second. Therefore, the experienced biology teacher Toby taught both research lessons in the *first* cycle and the beginning Dutch language teacher Wyatt taught both classes in the *second* cycle.

First cycle

The team agreed to focus on making students more active learners in biology class by letting them do activities (reading, writing, explaining) and giving them more responsibilities for their learning. That is, give students time to work in groups on assignments and only explain content to student groups who have specific questions. The teacher would, therefore, spent less time in plenary setting explaining content or exercises and more on assisting student groups who had difficulties with activities. During preparation we discussed how this could be done in this biology class with the specific topic (immune system and cell apoptosis). In the exercises students were referred to specific pages from an information book and would solve the questions in pairs.

Second cycle

In the second cycle the focus would be on students actively cooperating around different article styles in the Dutch language lessons. Students have to be able to explain why a text is seen as an argumentation, a consideration or an account. Therefore, after a very brief repetition by the teacher on differences between these articles styles, students would in the first lesson read an article and decide based on arguments what the style is. They were then to discuss their answer with their neighbor and especially try to convince one another based on their arguments.

In the second lesson two shorter texts were used. One student from the pair had to start with one text and the neighbor with the other text. After the teacher had given a signal the students would swop the texts. Then the pairs were to decide, based on their arguments, what style each text was.

Experienced biology teacher Toby

(a) *Teacher role.* Toby, an experienced teacher with more than 15 years of experience, used a very traditional approach: in his first lesson he only explained content and students mainly listened, in his second lesson he had students do some assignments themselves. During lesson preparation his focus was on the content, not on the pedagogy: 'The notion that I need to spent more time on determining what the essential aspects of the content are and what meaningful student activities fit in, I think that I too often ignored this' (interview). After his lessons he stated it in the following way: 'I need to focus more on student activities as this is nicer for myself, for the students and there is more learning outcome' (after class discussion). Realizing this however does not automatically bring about change: 'I am happy about the awareness, but not yet about how this changed my practice' (interview). And a few minutes later he reiterated: 'I became aware of this aspect but it is not yet part of my normal teaching repertoire' (interview).

Preparing lessons this way requires extra effort and time, but he was confident as he noticed: 'That I can still develop myself' (interview).

(b) *Teaching approach.* 'My focus till now was on the content, not so much on pedagogy and teaching approach. Now that I am aware of what I do I need to concentrate more on the essence, on what meaningful student activities can be used and on the aims and objectives of these activities' (interview). The Lesson Study cycle helped Toby, as after his second lesson he noticed: 'In the second research lesson I had a number of assignments, including the one on apoptosis, in which students were actively engaged with the content. I think I have delivered two totally different lessons' (interview). Because his students valued his second lesson much higher, he was also convinced that this was more effective.

(c) *Specific issues.* Differentiation was discussed during lesson preparation. Ways to organize differentiation were discussed. Toby said: 'Differentiation is important because the difference between students is substantial. I have in this class bright students and students who might just pass at the end of the year' (interview). Apparently Toby realizes this, but his practice still needs to change.

Beginning Dutch language teacher Wyatt

(a) *Teacher role.* Wyatt realized that the *what* (scan-read the text and write down three elements) and the *how* (use your elements in the discussion with your neighbor) aspects need to be explained. 'I learned that instruction is very important for the way students engage in certain assignments, and for introducing specific strategies' (interview). 'Because of the discussion after the first lesson my second lesson was much better' (interview). 'My instruction should be so clear that students will do what you want and know how to approach it' (after class discussion).

(b) *Teaching approach.* 'I have learned that I sometimes too easy thought that students know or master something. I never payed attention to how students should collaborate, but now that I know that my instruction is important, I am also able to give better instruction for specific collaborative tasks' (interview).

(c) *Specific issues.* Jointly as a Lesson Study team preparing a lesson was an eye opener for Wyatt and he then realized that this could also be worthwhile doing with his other Dutch language colleagues: 'So I thought that it might be worthwhile to prepare lessons with my colleague Dutch language teachers because we don't do this now. We do swap texts but what we do with these texts in class is something each of us decides on his own' (interview).

'The pedagogical aspect, using two texts and then exchange these after about 10 min, and then to ask students to discuss their answers was nice to do, and I am going to do this more often' (after class discussion). 'It is a very important skill (for students), giving and receiving feedback, and explain and discuss the why question' (interview).

In summary the main aspects learned:

	Toby	Wyatt
	Experienced teacher	Beginning teacher
Teacher role	More focus on student' activities, less explaining content	My instruction needs to be clear
Teaching approach	Student engagement through assignments	How to collaborate needs to be taught
Specific issues	Class differentiation important	Collaborative lesson preparation is effective

What elements in the Lesson Study cycle contribute most to teacher learning?

Eric said that for him 'the most important factor are my students' reactions and opinions'.

Vernon mentioned in the interview that 'I have learned most from lesson preparation, as alternative routes were debated', but also wanted the proof of the pudding in class and explicitly said to have benefitted observing students.

Toby said to have benefited from his student comments through the observers after his research lessons: 'because of the observers in class you also get extra feedback from students'. The collaborative lesson preparation made it possible for him to prepare and enact his second lesson differently.

Wyatt was very explicit about the Lesson Study elements: 'Jointly preparing a lesson was for me an enrichment although in first instant I did not like it that my idea was discharged. Finally the lesson design was very successful'. 'But I think that both the observations and the class enactment can be very instructive'. 'The (lesson) preparation has helped me. Class enactment also. But especially the discussions after class and the video recordings of my own lessons. It opened my eyes for what can be improved?'

Summarizing: all teachers said to have learned specific aspects during collaborative lesson preparation, during class enactment, in the after lesson discussions, and also while observing students in classes of another teacher.

Conclusion and discussion

Three research questions guided this study: (1) What do the teachers learn in a Lesson Study team, and from what do they learn this? (2) What are the differences in learning processes between the beginning and the experienced teachers? (3) What elements in the Lesson Study cycle contribute most to teacher learning?

In the following section the answers to these questions will be discussed.

Teacher learning in a Lesson Study team

The main aim of this professional development Lesson Study endeavor was to make students more responsible for their own learning. The results show that all four teachers did acquire knowledge and insights with respect to specific PCK components:

- On their own role as a teacher: engage students in meaningful learning activities and focus less on explaining the content. Lesson preparation means selecting and designing these meaningful activities.
- With respect to the instructional strategies: students collaborating in groups in which they need to discuss assignments, explain content to group members and agree on answers.
- In relation to students' understanding. For example, changing the teaching order influenced student engagement but also their understanding of the concepts as they spent more time grappling with the content. In their role as observers the teachers noticed how students work, what problems they meet, and how they try to solve these. Teachers also noticed differences in pace and in understanding, and this led to the notion of class differentiation. All four teachers appreciated their students' opinions and all used the student feedback.

Looking at Magnusson *et al.*'s (1999) components it surfaces that the four teachers learned regarding three of the four components: orientation toward teaching, instructional strategies, and students' understanding of specific topics. For this teacher learning to take place, all elements in Gess-Newsome's model of professional knowledge and beliefs (2015) involved in PCK development were required, including the amplifiers and filters such as teachers and students beliefs and prior knowledge.

Although all four teachers did acquire PCK knowledge and beliefs, this study shows once again that teacher learning is idiosyncratic (Borko 2004).

Differences in learning processes between experienced and beginning teachers

Our results also show that especially the experienced teachers not only need to learn PCK, but for this to take place have to unlearn teaching repertoire. Especially for the experienced biology teacher

Toby and the chemistry teacher Eric this was far from easy. Their way of lesson preparation had to change and this required more time. But most challenging was their changed role in class: they had to take care not to revert to their habit of explaining the content. Changing practice for them seems more complicated than for the beginning teachers.

Lesson Study elements that contribute most to teacher learning

Each Lesson Study element (see Figure 2) engenders specific teacher learning, this is in line with previous research (Cerbin and Kopp 2006, Dudley 2013, Nami *et al*. 2016). During the collaborative lesson design the Lesson Study team members discuss their PCK and this creates awareness for all involved. Especially the experienced teachers contribute as years of practice results in more PCK knowledge, beliefs and skills with respect to teaching and learning a specific topic (Van Driel *et al*. 1998). The school mentor and the university teacher educator broaden the lesson design with alternative approaches, pedagogies and materials, through research papers or specific student learning material. The designed lesson plans contain some of these new elements. Even though practicalities and 'how-to-do-advice' are part of the discussion, the newly acquired PCK is fragile as teachers are still anxious about students' reactions and the learning outcomes (Clarke and Hollingsworth 2002).

The ultimate proof of the pudding is how students experience the lessons. Observations during class enactment reveal how students perceive the lessons and what they learn. The after class discussions, with the focus on salient learning results, expose the relation between teacher instruction, student activities, and student learning.

All teachers say to have learned specific aspects in each of the Lesson Study elements (Stepanek *et al*. 2007), but particularly the *combination* of elements is seen as powerful. This is in line with previous research into teacher professional development and with the Extended Interconnected Model for Professional Growth (Figure 1). A *development phase* followed by a *class enactment phase* are instrumental (Coenders and Terlouw 2015). For example, initially Eric did not want to change the teaching order from the student text book, but eventually agreed and included it in the lesson plan. Class enactment showed that it worked well. Vernon did see the advantage of having student groups of four cooperatively do practical work, but noticed in class that because of the lab tables this was difficult and concluded that groups of three are possible, but not four. Toby prepared his lessons differently from what he used to do, with more emphasis on student activities, yet in class reverted to explaining the students and used the activities only during plenary explanations. After teaching his first research lesson Wyatt realized that his instruction had to be more explicit, so his second lesson was prepared with more specific instruction, even on how students were supposed to cooperate. After enactment of this lesson accordingly he noticed the difference. These examples show that these teachers had to go through both the *development phase* as well as the *class enactment phase*. Or in Lesson Study terms: going through complete Lesson Study cycles finally results in teachers realizing and internalizing new PCK knowledge and beliefs.

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References

Bakkenes, I., Vermunt, J.D., and Wubbels, T., 2010. Teacher learning in the context of educational innovation: learning activities and learning outcomes of experienced teachers. *Learning and Instruction*, 20 (6), 533–548.

Bjuland, R. and Mosvold, R., 2015. Lesson Study in teacher education: learning from a challenging case. *Teaching and Teacher Education*, 52, 83–90.
Borko, H., 2004. Professional development and teacher learning: mapping the terrain. *Educational Researcher*, 33 (8), 3–15.
Cajkler, W. and Wood, P., 2016. Adapting 'lesson study' to investigate classroom pedagogy in initial teacher education: what student-teachers think. *Cambridge Journal of Education*, 46 (1), 1–18.
Cerbin, W. and Kopp, B., 2006. Lesson Study as a model for building pedagogical knowledge and improving teaching. *International Journal of Teaching and Learning in Higher Education*, 18 (3), 250–257.
Clarke, D. and Hollingsworth, H., 2002. Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18 (8), 947–967.
Coenders, F. and Terlouw, C., 2015. A model for in-service teacher learning in the context of an innovation. *Journal of Science Teacher Education*, 26 (5), 451–470.
Den Brok, P., Wubbels, T. and van Tartwijk, J., 2017. Exploring beginning teachers' attrition in the Netherlands. *Teachers and Teaching*, 23 (8), 881–895.
Depaepe, F., Verschaffel, L., and Kelchtermans, G., 2013. Pedagogical content knowledge: a systematic review of the way in which the concept has pervaded mathematics educational research. *Teaching and Teacher Education*, 34, 12–25.
Dudley, P., 2013. Teacher learning in Lesson Study: what interaction-level discourse analysis revealed about how teachers utilized imagination, tacit knowledge of teaching and fresh evidence of pupils learning, to develop practice knowledge and so enhance their pupils' learning. *Teaching and Teacher Education*, 34, 107–121.
Dutch Government, 2017. Teacher shortage secondary education. Available from: https://www.rijksoverheid.nl/onderwerpen/werken-in-het-onderwijs/aanpak-tekort-aan-leraren/lerarentekort-voortgezet-onderwijs
Ermeling, B.A. and Graff-Ermeling, G., 2016. *Teaching better, igniting and sustaining instructional improvement*. Thousand Oaks, CA: Corwin.
Fullan, M.G., 2007. *The new meaning of educational change*. 4th ed. New York: Teachers College Press.
Garet, M.S., *et al.*, 2001. What makes professional development effective? Results From a national sample of teachers. *American Educational Research Journal*, 38 (4), 915–945.
Gess-Newsome, J., 2015. A model of teacher professional knowledge and skill including PCK. *In*: A. Berry, P. Friedrichsen, and L. John, eds. *Re-examining pedagogical content knowledge in science education*. London: Routledge, 28–42.
Gibbs, J.R., 2007. *Analyzing qualitative data*. London: SAGE.
Goei, S.L., *et al.*, 2015. Een Lesson Study team als een professionele leergemeenschap (A Lesson Study team as a professional learning community). *Tijdschrift voor lerarenopleiders*, 36 (4), 83–90.
Hashweh, M.Z., 2005. Teacher pedagogical constructions: a reconfiguration of pedagogical content knowledge. *Teachers and Teaching*, 11 (3), 273–292.
Helms-Lorenz, M., Slof, B., and van de Grift, W., 2013. First year effects of induction arrangements on beginning teachers' psychological processes. *European Journal of Psychology of Education*, 28 (4), 1265–1287.
Helms-Lorenz, M., van de Grift, W. and Maulana, R., 2016. Longitudinal effects of induction on teaching skills and attrition rates of beginning teachers. *School Effectiveness and School Improvement*, 27 (2), 178–204.
Isoda, M., 2007. A brief history in mathematics Lesson Study in Japan. *In:* M. Isoda, Y. Ohara, and T. Miyakawa, eds. *Japanese Lesson Study in mathematics* NJ: World Scientific.
Isoda, M., *et al.*, 2007. *Japanese Lesson Study in mathematics: its impact, diversity and potential for educational improvement*. Singapore: World Scientific Publishing Co., Pte. Ltd.
Kelchtermans, G. and Ballet, K., 2002. The micropolitics of teacher induction: a narrative-biographical study on teacher socialisation. *Teaching and Teacher Education*, 18, 105–120.
Leavy, A.M. and Hourigan, M., 2016. Using Lesson Study to support knowledge development in initial teacher education: insights from early number classrooms. *Teaching and Teacher Education*, 57, 161–175.
Lewis, C., Perry, R., and Murata, A., 2006. How should research contribute to instructional improvement? The case of Lesson Study. *Educational Researcher*, 35 (3), 3–14.
Loughran, J., Mulhall, P., and Berry, A., 2004. In search of pedagogical content knowledge in science: developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, 41 (4), 370–391.
Luft, J.A., 2001. Changing inquiry practices and beliefs: the impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers. *International Journal of Science Education*, 23 (5), 517–534.
Magnusson, S., Krajcik, J., and Borko, H., 1999. Nature, sources, and development of pedagogical content knowledge for science teaching. *In*: J. Gess-Newsome and N.G. Lederman, eds. *Examining pedagogical content knowledge*. Dordrecht: Kluwer Academic Publishers, 95–132.
Nami, F., Marandi, S.S., and Sotoudehnama, E., 2016. CALL teacher professional growth through Lesson Study practice: an investigation into EFL teachers' perceptions. *Computer Assisted Language Learning*, 29 (4), 658–682.
Park, S. and Oliver, J., 2008. Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in Science Education*, 38 (3), 261–284.
Penuel, W., et al., 2007. What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal*, 44 (4), 921–958.

Pillen, M., Beijard, D. and Den Brok, P., 2012. Profiles and change in beginning teachers' professional identity tensions. *Teaching and Teacher Education*, 34, 87–93.
Rollnick, M., et al., 2008. The place of subject matter knowledge in pedagogical content knowledge: a case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education*, 30 (10), 1365–1387.
Saito, E., 2012. Key issues of Lesson Study in Japan and the United States: a literature review. *Professional Development in Education*, 38 (5), 777–789.
Schneider, R.M. and Plasman, K., 2011. Science teacher learning progressions: a review of science teachers' pedagogical content knowledge development. *Review of Educational Research*, 81 (4), 530–565.
Schön, D., 1983. *The reflective practitioner: how professionals think in action*. London: Temple Smith.
Shulman, L.S., 1986. Those who understand, knowledge growth in teaching. *Educational Researcher*, 14 (2), 4–14.
Stepanek, J., Appel, G., Leong, M. T., & Mitchell, M. (2007). *Leading Lesson Study: a practical guide for teachers and facilitators*. Thousand Oaks, CA: Corwin Press.
Van Driel, J.H., Verloop, N., and De Vos, W., 1998. Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, 35 (6), 673–695.
Verhoef, N.C., *et al.*, 2015. Professional development through Lesson Study: teaching the derivative using GeoGebra. *Professional Development in Education*, 41 (1), 109–126.
Verhoef, N., *et al.*, 2013. The complexities of Lesson Study in a European situation. *International Journal of Science and Mathematics Education*, 12 (4), 1–23.
Yin, R.K., 2003. *Case study research, design and methods*. 3rd ed. London: Sage.