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Pre-service teachers' reflections on teaching a physics lesson: How does Lesson Study and Content Representation affect pre-service teachers' potential to start developing PCK during reflections on a physics lesson

Abstract

Shulman states that deliberate reflections are needed in order for teachers to start developing their Pedagogical Content Knowledge (PCK). This is important, since a teacher who has a well-developed PCK, also has integrated knowledge of theory and practice. However, recent research has found that reflection, as used during mentoring in field practice, regularly is an obstacle to deliberate reflection. Thus, the theory-practice divide persists. This study addresses this problem by introducing Lesson Study and Content Representation as an intervention in teacher education field practice. The results of the intervention showed that the pre-service teachers reflected differently compared to the current state of practice. During the intervention, they focused more on 'Goals for instruction', 'Pupils and their learning', 'Best representation of specific content', and 'Specific assessment'. These differences in reflection might lead to pre-service teachers developing a more inter-related understanding of these focus areas as opposed to what happens in the current state of practice. This, in turn, could affect the pre-service teachers' potential to start developing their PCK. Consequently, this might give teacher educators a new way of addressing the problem of the theory-practice divide. However, further studies are needed on the quality of these differences and whether or not the intervention influences the pre-service teachers' practices in the future.

IN SEARCH OF WAYS TO BRIDGE THE THEORY-PRACTICE DIVIDE DURING FIELD PRACTICE

The theory-practice divide is a dominant theme within teacher education and the literature on reflective practice. This is because this divide hinders pre-service teachers in teacher education from making strong connections between subject-matter knowledge, pedagogical competence and real life practice (e.g. Bransford, Brown, & Cocking, 2000; NOKUT, 2006). Reflection during reflective practice is considered as a means of making this connection. However, research finds that reflection during mentoring is often an obstacle to this integration (Darling-Hammond, 2006; Sundli, 2007).

Therefore, it is apparent that teacher education needs to test out multiple ways that can possibly help pre-service teachers develop their capacity for reflection, as well as focusing on reflection in a way that promotes this integration (Harford & MacRuar, 2008). Current research gives this matter some attention (Lunde, Rundgren, & Rundgren, 2015; Nielsen, 2011, 2014; Nilsson, 2012).

This paper advocates that the theory-practice divide can be addressed if teacher education focuses on the development of pre-service teachers' Pedagogical Content Knowledge (PCK). The connection between and integration of subject-matter knowledge, pedagogical competence and real life practice is the essence of PCK (Shulman, 1986, 2015). This means that teachers who have fully developed their PCK have also bridged the theory-practice divide. Therefore, a number of current researchers view PCK as a developmental aim for teachers and use it to assess teachers' development (e.g. Henze, Van Driel, & Verloop, 2008; Loughran, Berry, & Mulhall, 2006). However, even if PCK can be viewed as a developmental aim and a framework from which to assess this integration, teacher education still needs methods and tools that can promote this development. In this respect, recent research shows that the Lesson Study method (Lewis & Tsuchida, 1999) and the Content Representation (CoRe) tool (Loughran et al., 2006) should receive special attention. Both promote deliberate reflections as a means to further the opportunities for pre-service teachers to develop their PCK. Deliberate reflection is here understood as reflections that incorporate higher-order thinking in a way that examines beliefs, goals, and practices in order to gain new or deeper understandings leading to actions that improve pupil learning (York-Barr, Sommers, Gail, & Montie, 2001). However, at present we still know little about how these deliberate reflections, as used during Lesson Study and in CoRe, can promote the pre-service teachers' development of PCK, and even less about how a combination of the two would work.

However, one recent study has looked into how the combination of Lesson Study and CoRe can possibly affect the development of pre-service teachers' PCK (Juhler, 2016). Juhler studied pre-service teachers' planning of a lesson through a time lagged design (Hartas, 2010). During the first year, the aim was to look into how two groups of pre-service teachers, together with their teacher mentors, planned a physics lesson. Field practice was conducted according to the Curriculum Regulation (Ministry of Education, 2010), depicting the current state of practice. The following year, Lesson Study was introduced as an intervention in combination with CoRe. Two new groups of pre-service teachers and their mentors were initially introduced to Lesson Study and CoRe, and they subsequently used both to plan a lesson for field practice. By comparing the two contexts, Juhler found that the teachers during the intervention had a much more even focus on all of the components that PCK consists of, according to Gess-Newsome and Leaderman. These are: 'Knowledge of Science curricula', 'Knowledge of pupils' understanding of Science', 'Knowledge of instructional strategies' and 'Knowledge of assessment'. These findings indicated that the pre-service teachers, during the intervention, had greater opportunities to develop their PCK, enabling them to start bridging the theory-practice divide.

Both Juhler (2016) and the current study is a part of the TasS (Teachers as Students) research project. In short, TasS focuses on the development of research within Norwegian teacher education, addressing the subjects Mathematics, Norwegian, English as a foreign language, Physical Education and Science. TasS is interested in both the investigation of pre-service teachers' learning during field practice, and how to change the learning so that it may better align with recent research recommendations. This includes looking into what kind of knowledge, competences and skills pre-service teachers develop during field practice. Both Juhler (2016) and the current study focus on Physics as a sub-set of Science, since this was the subject taught during the field practice in Science.

The current study seeks to further the goals of TasS and extend Juhler's research. This is achieved by studying the same groups of pre-service teachers and mentors, during the same circumstances, with a view to research if and how the intervention made a difference in post-lessons reflections'. Hence, the following research question is posed:

“How does the use of Lesson Study in combination with Content Representation, during a post-reflection mentoring session in Science field practice, affect pre-service teachers’ potential to start developing PCK, compared to that in the current state of practice?”

To answer this question, this article will first describe how PCK develops through deliberate reflection on action. It will then make a case for why reflection, as used in Norwegian field practice, seems to be an obstacle to, rather than an enhancement of, the development of this deliberate reflection practice. Bearing this in mind, the article will then argue that deliberate reflection can possibly emerge as a consequence of using the combination of Lesson Study and CoRe. Subsequently, an applied research design, aimed at testing this hypothesis in the context of teacher education field practice, is described. The results are subsequently presented and discussed in the light of the theory presented. Finally, a conclusion is drawn, addressing how the intervention can possibly help pre-service teachers to start developing their PCK.

DEVELOPMENT OF PCK THROUGH DELIBERATE REFLECTION ON PRACTICE

PCK develops through a process in which teachers build on and extend prior knowledge and make this connection deliberately through higher-order thinking, so that it forms PCK (Shulman, 1986, 1987). Shulman theorized that this happens through the process of ‘pedagogical reasoning and action’, for which he developed a model (Shulman, 1987, p. 15). In this model, the teacher starts with ‘comprehension’ that needs to be ‘transformed’ into ‘instruction’. After the instruction has been carried out, the process is subsequently ‘evaluated’ and ‘reflected’ upon. In turn, this leads to the development of ‘new comprehension’. In this respect, the reflective stage is especially important, since new comprehension will only be reached through this process. The reasoning is that during deliberate reflections the teacher:

“looks back at the teaching and learning that has occurred, and reconstructs, reenacts, and/or recaptures the events, the emotions, and the accomplishments. It is that set of processes through which a professional learns from experience”... “Thus we arrive at the new beginning, the expectation that through acts of teaching that are “reasoned” and “reasonable” the teacher achieves new comprehension, both of the purposes and of the subjects to be taught, and also of the students and of the processes of pedagogy themselves (Shulman, 1987, p. 19)”

PCK is thus revealed as a feature of knowledge-on-action, namely knowledge elaborated and enacted through “reflection-on-action” (Schön, 1983, 1987). Through this deliberate reflection, the aim is for pre-service teachers to realize the need for expansion or modification of their planning or repertoires for teaching a particular topic. As a consequence, they add to, reorganize, or modify their existing body of PCK for teaching that specific topic (Park & Oliver, 2008).

REFLECTIVE PRACTICE AS AN AIM AND AN OBSTACLE DURING MENTORING

Reflection as a way to improve teacher practice has a long history in mentoring and, through scholars such as Dewey (1933) and Schön (1983), it has found its way into modern educational epistemology (Zay, 1998). Handal and Lauvås’s (1987) model of ‘reflective guidance’, the one most used in Norway (Sundli, 2007), leans heavily on the notion of reflective practice - a trend also observed in many other teacher education programs (Loughran, 2002). The ideal is that the pre-service teachers’ independent reflections on teaching, coupled with the mentor’s feedback, should lead to improvement in their practical theory. Therefore, successes and failures should be elaborated, expanded and corrected; they should then be made more relevant, useful and ready to hand (Handal & Lauvås, 1987, 2000).

Unfortunately, there is a long way from theory to practice. Sundli (2007) found that mentors, during their mentoring education, managed to make founded reflections on their own and their peers’ practice in primary schools. However, when they returned to practise mentoring in their respective schools, the ideals discussed and promoted through their teacher education no longer appeared to

be relevant. Instead, mentoring bore on practical preparation for action rather than on a search for better theoretical argument (Sundli, 2001, 2007). Practical preparation is understood as, for example, the means to focus on one's own actions, pedagogical strategies, classroom management and time management (Burn, Hagger, Mutton, & Everton, 2000; Gess-Newsome & Lederman, 1999; Kagan, 1992; Weiland, Akerson, Rogers, & Pongsanon, 2010). This kind of reflection does not incorporate higher-order thinking in a way that examines beliefs, goals, and practices that would lead to new or deeper understandings, which, in turn, would result in actions that would improve pupils learning. Thus, this kind of reflection does not support the pre-service teachers' development of PCK. This is one reason why teacher education needs methods and tools that can create a more deliberate reflective practice during mentoring.

DELIBERATE REFLECTIONS THROUGH LESSON STUDY AND CONTENT REPRESENTATION

Recent research has shown positive effects on the development of PCK, both through Lesson Study (i.e. Pongsanon, Akerson, & Rogers, 2011; Weiland et al., 2010) and CoRe (i.e. Nilsson & Loughran, 2011; Padilla, Ponce de León, Rembado, & Garritz, 2008; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008). As argued in Juhler (2016), Lesson Study should be combined with CoRe, since people new to Lesson Study have difficulties engaging with the method in a profound way (Fernandez, Cannon, & Chokshi, 2003), resulting in the need for a scaffolding tool. CoRe seem to be able to scaffold this process, by providing participants with an explicit way of accessing the different components of PCK (Loughran et al., 2006).

Lesson Study is described through a cycle consisting of six specific steps: First, 'goals' are defined; second, the group 'plans' the research lesson; third, they 'conduct and observe' the research lesson; fourth, they 'discuss and refine' the research lesson; fifth, they 'repeat' the research lesson; and finally, they 'disseminate' the findings. When the participants start to define their research question, which aims to focus on a specific teaching challenge, they also create a link that guides how and what to reflect on during the rest of the Lesson Study cycle. This focus is taken into the preparation of the lesson, where information from, e.g. developed teaching material and prior research (theory), helps them to reflect on how best to plan for the teaching aim, while at the same time bearing in mind the pupils and their learning. This follows into the taught lesson, where those not teaching make observations that can shed light on the problem posed in the research question. Furthermore, selected students are chosen for a short post-focus interview after the research lesson. The considerations from the planning stage, as connected to the research question, are then reflected and reasoned on. Thus, theory from the planning meets actual practice, which is reflected on through the obtained observations and interviews (evidence), as a means to make justified decisions about how best to change the lesson to better fit the research aim – thus being 'deliberate'. This process of planning, conducting/observing and discussion, is then repeated, thereby providing the opportunity to reflect on the different outcomes of the teaching approaches in the two lessons. Thus, theory meets practice based on twofold evidence, challenging the pre-service teachers to examine their beliefs, goals and practices. Thus, deliberate reflection leads to the generation of knowledge that can lead to actions enhancing pupil learning. These findings are then disseminated, so that other teachers can learn from the research (Fernandez et al., 2003; Murata & Pothén, 2011).

In Japan deliberate reflection on practice is learned through participation in Lesson Study over a period of many years (Fernández & Yoshida, 2004). Normally, an expert teacher leads the Lesson Study, ensuring depth and dedication. However, this is not the case in most contexts outside of Japan. Therefore, research has shown that teachers new to Lesson Study need help in engaging with the method in a profound way (Hart, Alston, & Murata, 2011). The tool CoRe (see Figure 1) seems to enable teachers to engage in Lesson Study in a profound way, since it is a form that in a very structured way ensures the link between the 'why' and 'what' of the content to be taught with the pupils who are to learn that content in the form of propositions (Mulhall, Berry, & Loughran, 2003). The form provides an inter-

connected structure that works as a scaffolding tool. It does so by guiding the reflections throughout the Lesson Study cycle and at the same time making the reasoning behind these reflections explicit (Loughran, Mulhall, & Berry, 2008). Thus, through filling in a CoRe form, pre-service teachers are provided with a better chance of engaging with the deliberate reflection needed during Lesson Study, and thereby with a better opportunity to start developing their PCK (Loughran et al., 2006). The Lesson Study method, combined with the form CoRe thus, works together towards an evidence-based integration of theory and practice, counteracting the theory-practice divide.

Content: Age of children:	Big Idea A	Big Idea B
What do you intend the students to learn about this idea		
Why is it important for the students to know this		
What else you know about this idea (that you do not intend students to know yet)		
Difficulties/limitations connected with teaching this idea		
Knowledge about students' thinking which influences your teaching of this idea		
Other factors that influence your teaching of this idea?		
Teaching procedures (particular reasons for using these to engage with this idea)		
Specific ways of ascertaining students' understanding or confusion around this idea (include likely range of responses)		

Figure 1: CoRe Form (Loughran, Berry, & Mulhall, 2006)

RESEARCH DESIGN AND METHOD

Data collection

The data for this project focuses on Physics and is collected as a part of the aforementioned TasS project. The collection was carried out through a time-lagged design experiment (Hartas, 2010), meaning that the participants during the data collection years of 2012 and 2013 were different.

During the first year of the project (2012), two groups of pre-service Physics teachers, consisting of three and four students in each group, were observed. These two groups conducted practice as described in the National Curriculum Regulations (Ministry of Education, 2010), outlining the 'current state of practice'. This includes a mandatory 100 days of field practice spread out over four years, of which three weeks were carried out during 2012. During this period, the pre-service teachers received compulsory mentoring from a qualified mentor. The Curriculum Regulations does not offer any specific guidance to the mentor. However, the reflective model developed by Handal and Lauvås (1987) is often used (Sundli, 2007). This model focuses on reflection that mentors often stimulate by posing questions in the hope of building warranted accounts of classroom practice (Ottesen, 2007).

In 2013, the second year, an intervention was introduced which consisted of Lesson Study combined with CoRe. Two new groups of pre-service teachers, consisting of one group of three and one group of four pre-service teachers, and two new mentors, were introduced to the intervention. This was done by a Physics researcher from TasS. First, the mentors and pre-service teachers were presented with general theory about Lesson Study and CoRe. Following this, they were introduced to examples of how these instruments have been used. Finally, the presented examples were discussed in groups and then in plenary. At the end of the plenary session, they were given handouts that contained theoretical articles which explained Lesson Study and CoRe in more detail. Furthermore, they were handed a Lesson Study manual developed specifically for Norwegian teachers. This manual was produced by researchers in TasS. After the intervention, the manual was revised and published (Munthe, Helge-

vold, & Bjuland, 2015). Just prior to the intervention, two Physics researchers met with the two mentors. Together they worked through and filled in a CoRe template in detail for a given topic to ensure that the mentors had fully understood the CoRe and how to use it.

The selection of the project participants was originally intended to be carried out randomly. However, due to a small number of volunteers, the selection became one of convenience instead. The pre-service teachers in both contexts were in their twenties, mixed gender-wise, and were in their second year of teacher education. In each context, one group of teachers focused on pupils in grades 1-7 and one group on grades 5-10. Field practice groups are first divided into grade focus and then subject focus. Finally, they are randomly put together by the teacher education. Although the pre-service teachers all studied Science, they had not completed training in Physics at this point. The teaching background and experience of the participating mentors was varied. However, they all had a qualification in teacher mentoring.

The data for the current study was gathered during the post reflections, which the four different groups had together with their mentors after having taught their first lesson during field practice. Up to this stage, the current state of practice groups and the intervention groups were comparable, in the sense that they had all taught a lesson upon which they reflected. However, the goals for their reflection differed somewhat at this stage, especially since the intervention group, in addition to reflection on the lesson, also knew that they had to prepare to teach a revised version of the same lesson. The researchers from TasS were not present at this stage of the proceedings. Instead, the meetings were video-recorded by the participants themselves and then handed over to the TasS researchers. The recordings were subsequently transcribed and verified by a second researcher before starting the analysis. During the current state of practice, only a few documents were present and used during the post-reflection mentoring sessions. However, during the intervention, textbooks filled in CoRe forms and general plans for the study lesson were available and were used.

Method of analysis

The method of analysis chosen for this research was a deductive content analysis, building on the categories described in Juhler (2016). However, the original coding scheme was developed to study 'display of knowledge'. For the current research it has been adapted so that it can be used to analyze reflections instead.

The categories were originally developed from Gess-Newsome and Lederman's model (1999, p. 99) (see Figure 2) and the extended description of PCK for Science. This was further extended by using Lanning et. al.'s (2013, p. 9) descriptions, depicting a way of making sub-categories for the model. In the coding scheme that was developed, the overarching category 'Orientations to Science and teaching', was not treated as a unique one. Instead, it was coded as a part of the four main coding ca-

Figure 2: Components of PCK for Science (Gess-Newsome & Lederman, 1999, p.99)

tegies: ‘Knowledge of Science Curricula’, ‘Knowledge of Pupils’ Understanding of Science’, ‘Knowledge of Instructional Strategies’ and ‘Knowledge of Assessment’. Each of these main categories was then divided into four sub-coding categories (A1-4, B1-4, C1-4 and D1-4). The final coding scheme for the current study is represented in Table 1: ‘Coding matrix for main and sub coding categories’.

Table 1: Coding matrix for main and sub-coding categories

Main coding categories	Sub Coding Categories
A - Reflections on displayed knowledge for curriculum in Physics	A1. Reflections on goals for instruction
	A2. Reflections on national, state, and or local standards
	A3. Reflections on resources and content of textbooks (i.e., specific knowledge of things included in curricular materials)
	A4. Reflections on scope and sequencing of physics topics
B - Reflections on displayed knowledge of pupils’ understandings within Physics	B1. Reflections on prior knowledge
	B2. Reflections on motivators, difficulties
	B3. Reflections on misconceptions (i.e. random mistakes, alternative conceptions, intuitive ideas, misconceptions)
	B4. Reflections on strategies pupils use to approach, solve and understand a concept or problem
C - Reflections on displayed knowledge of instructional strategies for Physics	C1. Reflections on student behavior and ability that could influence teachers’ way of instructing
	C2. Reflections on best representations and actions to use for specific content (i.e. specific models or ways of presenting an idea)
	C3. Reflections on specific activities, measures and materials to use for physics content
	C4. Reflections on organization and sequencing of instruction for specific content
D - Reflections on displayed knowledge of assessment for Physics	D1. Reflections on the purposes and reasons for assessment
	D2. Reflections on different and best strategies for assessment
	D3. Reflections on the specifically used assessment method and results from it
	D4. Reflections on hypotheses about pupils’ thought patterns, enacted thought patterns and teacher responses
Other	Data that clearly does not fit into any of the four main categories.

During the coding process, the following criteria were used. First, one of the four main categories was chosen from ‘Table 1: Coding matrix for main and sub-coding categories’, followed by the appropriate sub-category. Then whole segments of utterances, and in a few cases single sentences, were coded into that sub-category. The whole document was coded. Pauses due to interruptions and other occurrences clearly not related to the pre-supervision were coded in the category ‘Other’. The coding for the current state of practice and the intervention was done equally, even though the aim for the reflections differed somewhat.

To enable a comparison between transcripts of different lengths, one transcript was counted as 100 %. The findings thus rely on the percent coverage of coded text to a given category, counted on a word basis for each individual transcript. The main categories consist of the aggregated percentages from the sub-categories, namely that the percentage in main category A is the sum of A1, A2, A3 and A4. The coding process was carried out using NVivo (2014), which automatically calculates the percentages for each category, using the criteria described above. In order to be able to discuss changes between the current state of practice and the intervention groups, the profiles of each groups were compared. The two groups from the current state of practice showed similar profiles of focus during their reflections, as did the two groups from the intervention. Finally, pie charts depicting the general tendencies from the current state of practice and the intervention were developed for main and sub-codes, thus making them easily comparable so that interpretation could be carried out.

RESULTS AND DISCUSSION - COMPARISON OF POST-REFLECTION SESSIONS BETWEEN THE CURRENT STATE OF PRACTICE AND THE INTERVENTION

The following presents findings from the first post-reflection session, comparing two groups of pre-service teachers conducting field practice according to the National Curriculum Regulations (Ministry of Education, 2010), and two groups of pre-service teachers using the Lesson Study method in combination with CoRe during field practice. The results have first been divided into four main categories depicting the main tendencies (see Figure 3). Thereafter, each main category has been divided into four sub-categories, depicting tendency changes within each main category (see Tables 2 – 5). This way of presenting the findings is identical to that of Juhler (2016), which is done so that the results from the planning of the lesson can be compared with those of the post-reflections.

Main category results

In the following, the results are presented from the research on the four main categories within 'Table 1: Coding matrix for main and sub-coding categories'.

Figure 3: Percentage division of the four main categories within PCK for Science

As seen in the current state of practice, the main focus is on category 'C', leaving only a short time for consideration of the three other main categories. The same main focus is found in the Intervention, although here the other three main areas are 20 per cent larger in comparison, which is especially on account of category 'D' and somewhat of category 'B'.

Sub-category results

In this section the 'sub-categories results' from Table 1, are used to shed light on shifts within the main category results, expanding and providing different perspectives on these findings.

Reflections on displayed knowledge for curriculum in Physics

When comparing the current state of practice and the intervention main category 'Reflections on displayed knowledge for curriculum in physics', the impression is that these both receive little attention and that they do not differ much, as a closer reveals.

Table 2: Reflections on displayed knowledge for curriculum in Physics

Main category A: Reflections on displayed knowledge for curriculum in Physics	Current state of practice 3,4%	Intervention 4,4 %
A1. Reflections on goals for instruction	2,4%	3,6%
A2. Reflections on national, state, and or local standards	1,0%	0,1%
A3. Reflections on resources and content of textbooks (i.e., specific knowledge of things included in curricular materials)	0,0%	0,7%
A4. Reflections on scope and sequencing of Physics topics	0,0%	0,0%

In both the current state of practice and in the intervention group/situation, the main focus is on 'A1'. However, in the intervention greater emphasis is placed on this subject. The current state of practice also has some focus on 'A2', which covers an episode discussing the relevance of the subject during exams, a topic which is nearly non-existent in the intervention. The intervention, on the other hand, discusses 'A3', emphasizing a problematic chapter they have used in the book, a topic which does not exist in the current state of practice. Both the current state of practice and intervention have not discussed the last subject, 'A4'.

Reflections on displayed knowledge of pupils' understandings within Physics

Generally, the focus on 'reflections on displayed knowledge of pupils' understanding within Physics' is somewhat greater in the intervention (3,8%) than in the current state of practice (0,4%).

Table 3: Reflections on displayed knowledge of pupils' understandings within Physics

Main category B: Reflections on displayed knowledge of pupils' understandings within Physics	Current state of practice 0,4%	Intervention 3,8%
B1. Reflections on prior knowledge	0,4%	0,1%
B2. Reflections on motivators, difficulties	0,0%	1,6%
B3. Reflections on misconceptions (i.e. random mistakes, alternative conceptions, intuitive ideas, misconceptions)	0,0%	1,4%
B4. Reflections on strategies pupils use to approach, solve and understand a concept or problem	0,0%	0,7%

During the current state of practice, this category was nearly non-existent, only represented by one short conversation about 'B1'. Prior knowledge was not considered during the intervention, although the intervention does emphasize the three other categories: 'B2', 'B3' and 'B4'.

Reflections on displayed knowledge of instructional strategies for Physics

Generally, there was a considerable difference between the current state of practice and the intervention in this respect. The percentage spent on the main category 'Reflections on displayed knowledge of instructional strategies for Physics' was 22% lower during the intervention than during the current state of practice.

Table 4: Reflections on displayed knowledge of instructional strategies for Physics

Main category C: Reflections on displayed knowledge of instructional strategies for Physics	Current state of practice 92%	Intervention 70%
C1. Reflections on student behavior and ability that could influence teachers' way of instructing	7,4%	5,8%
C2. Reflections on best representations and actions to use for specific content (i.e. specific models or ways of presenting an idea)	7,3%	31,4%
C3. Reflections on specific activities, measures and materials to used for physics content	20,4%	19,8%
C4. Reflections on organization and sequencing of instruction for specific content	56,8%	12,9%

The sub-categories show a picture of how this difference occurred. Most of the time during the current state of practice was spent on 'C4'. In contrast, this theme was 44% smaller during the intervention, where the main focus was instead on 'C2'. The category 'C1' differed slightly between current state of practice and the intervention, being of less concern during the intervention. The second biggest category, 'C3', is more or less the same size in both contexts.

Reflections on displayed knowledge of assessment for physics

The category 'Reflections on displayed knowledge of assessment for physics' as five times greater in the intervention than in the current state of practice, thereby showing a much greater focus on this category during the intervention.

Table 5: Reflections on displayed knowledge of assessment for Physics

Main category D: Reflections on displayed knowledge of assessment for Physics	Current state of practice 4,2%	Intervention 21,9%
D1. Reflections on the purposes and reasons for assessment	0,0%	0,0%
D2. Reflections on differed and best strategies for assessment	0,0%	0,2%
D3. Reflections on the specifically used assessment method and results from it	4,2%	21,6%
D4. Reflections on hypotheses about pupils' thought patterns, enacted thought patterns and teacher responses	0,0%	0,0%

A closer study of the data reveals a specific trend. Both the current state of practice and the intervention almost solely emphasize the category 'D3'. In both instances, they totally leave out reflections around 'D1' and 'D4'. The category 'D2' was left out during the current state of practice and only mentioned in a very short conversation during the intervention.

DISCUSSION

I will first discuss the main category findings to show differences between the current state of practice and the intervention. Second, I will consider the sub-category findings, using these to expand the perspectives found in the main category results. Third, I will point out some limitations of the study. Finally, I will draw conclusions about the implications of the results.

The main category results from the current state of practice show that they first and foremost reflect on *C: Instructional strategies for Physics* (92 %), leaving only a short time for consideration of the three other main categories. The same main focus is found during the intervention (70%), although it is 22% smaller here. This shift in focus is especially on account of *D: Assessment for Physics* (21%), but also *B: Knowledge of pupils' understanding* (3,8%). These difference shows a trend moving away from a focus on one's own actions, classroom and time management, as previously found in (e.g. Burn et al., 2000; Gess-Newsome & Lederman, 1999; Weiland et al., 2010), toward a more learner-centered focus. These findings are supported by prior studies of both Lesson Study and CoRe (Fernández & Yoshida, 2004; Nilsson & Loughran, 2011).

The descriptions of Lesson Study and CoRe might provide an understanding for this change. For instance, the increased focus on the 'Assessment' category may reasonably be attributed to the direct focus of Lesson Study on the observation of pupils while teaching, coupled with post-focus interviews with pupils. In addition, it is also a main concern which has been filled into the CoRe. Findings from the planning stage also show greater attention to this category (Juhler, 2016). More focus on assessment naturally leads to talk about the 'pupils' understandings', since this is what the pre-service teachers are assessing. This, in turn, also leads to the need for an extended understanding of 'curriculum'. Both 'pupils' understanding' and 'curriculum' are represented in the CoRe's main prompts, as well as being an embedded part of the Lesson Study method. Furthermore, 'pupils' understanding' also received increased focus during the planning stage (Juhler, 2016). These main findings point to the creation of a more reflective and integrated practice, surpassing basic survival concerns (Kagan, 1992), which may start to counteract the theory-practice divide (e.g. Bransford et al., 2000).

The *Curriculum sub-categories A1-4* was a small category (3,4%) during the current state of practice and 4,4% during the intervention. Most focus in both cases was on *A1: Goals for instruction*. However, the focus during the intervention (3,6%) was somewhat greater than in the current state of practice (2,4%). The secondary focus for the current state of practice was on *A2: National standards* (1,0 %), whereas for the intervention it was on *A3: Resources and textbooks* (0,7%). The category *A4: Scope and sequencing*, has been left out in both cases. The findings show a larger focus on 'goals' and 'resources' during the intervention, instead of on national standards. This emphasizes a more learner-centered approach: 'What do we want the pupils to learn?' and 'With which 'resources'? instead of 'What do the 'government' want the pupils to learn?' However, since it was nevertheless a small category, it only somewhat started to counteract what research normally finds, namely that disciplinary content during mentoring is downplayed (e.g. Bradbury & Koballa, 2007). This finding is somewhat surprising since focus on 'goals' during the intervention planning stage was 9,2%, namely 5,4 times bigger than that of the current state of practice (Juhler, 2016). One of the reasons for this might be that the pre-service teachers at this stage, due to the Lesson Study format, had a good deal of focus on the assessment category, thus downplaying talk about the actual goals.

When considering *Pupils understanding sub-categories B1-4*, one finds that these are 9,5 times greater during the intervention (3,8%) than in the current state of practice (0,4%), a tendency also found during the planning stage (Juhler, 2016). Even though it is a fairly small category, it nevertheless emphasizes a greater focus on the learners and their understanding during the intervention. This stands out in particular, since the only focus manifested during the current state of practice was on *B1, prior knowledge* (0,4%). The intervention, on the other hand, focused on *B2: Reflections* and motivation (1,6%), *B3: Misconceptions* (1,4%) and *B4: Strategies pupils use* (0,7%). This shows a difference

from 'what the pupils have learned in prior lessons', which one can read directly out of the written teaching plans, to a much more complex and reflective intervention focus on the learners and their understanding of Physics. This focus gives the pre-service teachers a chance to start blending both their theoretically-acquired knowledge from teacher education about 'motivators', 'misconceptions' and 'strategies', with their own experiences from the taught lesson, something not found in regular practice (Sundli, 2007). This difference has arguably come around because of the raised awareness on assessment and student understanding in Lesson Study (Fernández & Yoshida, 2004), but also as a consequence of the pedagogical prompts in the CoRe (Loughran et al., 2006).

A considerable difference can be found when looking into *Instructional strategies sub-categories C1-4*, which was generally 22% smaller during the intervention, a tendency also found during the planning stage (Juhler, 2016). Here the main focus for the current state of practice was on *C4: Organization and sequencing* (56,8%) and secondly on *C3: Specific activities* (20,4 %). These categories mostly focus on what the teacher did and in which order, in addition to it being either good or bad. However during the intervention the main focus is on *C2: Best representations* (31,4%) with a secondary focus on *C3: Specific activities* (19,8%). This shows that the pre-service teachers wanted to improve the activities used during the study lesson, which is a basis for talking about the activities themselves. There is thus a difference in focus from concerns on general management and survival, which is also normally found in earlier research (e.g. Bradbury & Koballa, 2007), to a focus on how best to use teaching activities in the pursuit of pupil learning. The main reason for this difference can arguably be found in the use of Lesson Study, since the same but revised lesson is to be taught once again to another class (Fernández & Yoshida, 2004). However, the CoRe also focuses on the best activity to be used in combination with the learning aims (Loughran et al., 2006).

When considering *Assessment sub-categories D1-4*, the results show more than a five-times positive difference between the current state of practice (4,2%) and the intervention (21,9%). This was also a trend found during the planning stage (Juhler, 2016). Interestingly enough, in both cases the whole focus was directed towards *D3: Specific assessment methods*, with the minor exception of the intervention having 0,2% in *D2: Best strategies*. In this case, the pre-service teachers were talking about what they should have assessed and why that would have been better. These findings show that assessment of and for pupils' learning has become a greater part of the intervention, which can arguably be attributed to Lesson Study. Lesson Study especially emphasizes assessment through the focus on answering a research question, which is carried out through systematic observation (Fernández & Yoshida, 2004). However, this leaves out reflections about *D1: Purposes and reasons* and *D2: Best strategies* and *D4: Pupils thought patterns*. This does not match the results from the planning, where the intervention differed positively in having a focus on all four sub-categories of 'Assessment' (Juhler, 2016). It is especially surprising that the intervention did not focus on *D4: Pupils' thought patterns*, since this is a main focus in the CoRe as well as a focus in Lesson Study (Fernández & Yoshida, 2004; Loughran et al., 2006). Furthermore, the research shows that discussions about the reasoning behind assessment and the link to which strategy would be the best to use during assessment, is not considered in the current state of practice nor the intervention.

However, one needs to be cautious about the results due to the limitations of this research. The results mainly rely on information from the reflection stage, calculated on a percentage basis. Therefore, one can only say something about the proportion of focus, but not anything about the thinking behind it. Second, the data is from a relatively small sample within a specific setting, thereby making it hard to generalize. However, that is not to say that the findings cannot be relevant to other settings. The issue of transference is further aided by the fact that a comparison within the two settings shows similar patterns. Furthermore, findings shown are similar to findings from both Lesson Study and CoRe research.

CONCLUSION

The main findings show that the use of Lesson Study in combination with CoRe during field practice in teacher education can indeed affect the pre-service teachers' potential to start developing PCK. This combination seems to help the pre-service teachers to some extent to focus more on the pupils and their learning. During the reflective stage of the intervention, the pre-service teachers in this study had more focus on goals for instruction, the pupils and their understanding, best representation of specific content, and much more focus on specific assessment, as compared to in the current state of practice. In doing so, the pre-service teachers could start to reflect differently about the connection between subject-matter knowledge, pedagogical competence and real-life practice, making these more inter-related. The same focus has also been found during the planning of the lesson (Juhler, 2016), as well as being reported from other researchers studying the effects of Lesson Study (e.g. Weiland et al., 2010) and CoRe (e.g. Nilsson & Loughran, 2011), making the results of this study more plausible.

These findings suggest that the focus for further research should be on the reasons behind these differences, since they have thus far not been uncovered. More research is especially needed to establish how this shift in focus permeates the cycle of learning through the planning, conducting and reflecting on a lesson during field practice. Special attention should be given to uncovering the reasons behind the altered focus on the learning goals, the learners and their understanding and assessment. One problem is whether or not Lesson Study and CoRe actually influenced the pre-service teachers' notion of teaching, or whether they simply changed their focus because the structure of the intervention required them to do so.

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