

Science Teaching Through the Lenses of Students: Lower Secondary School



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Introduction

While various researchers have argued that teacher quality is one of the most important influences on student learning (Hattie 2009; Nilsson and Loughran 2012), there is limited consensus about what that teacher knowledge looks like in action. As a way of making different components of teacher knowledge explicit to teacher educators, Shulman (1986, 1987) introduced the concept of pedagogical content knowledge (PCK). Since then, researchers have investigated and developed the concept of PCK as a possible way to describe the professional knowledge of teaching to better meet students' learning needs. Loughran et al. (2004) proposed a reflective tool called content representation (CoRe) in order to unpack the embedded components in PCK. With the help of explicit prompts to reflect on when planning, teachers can use CoRe to reveal the tacit parts of PCK (Loughran et al. 2004; Nilsson and Loughran 2012). Eames et al. (2011) found that the tool helped both novice and experienced teachers to develop their PCK while working together. The teachers became more sensitive to students' needs (Eames et al. 2011).

Cross and Lepareur (2015) investigated the connection between PCK and students' growing understanding in physics and highlighted that there is not a linear connection between PCK and student learning, but rather that PCK must be understood in relation to the complicated and multifaceted context in which teaching is conducted. Teaching and learning is best seen as a communicative process in which the concept of didactic contract could be a way to improve understanding of the complexity of teaching and learning. Cross and Lepareur (2015) argued for the need to understand more about how the concept could be taken into account in the PCK model.

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One model that is suitable for explaining the connections between student outcome and teachers' PCK in action is the model of consensus (Fig. 1, Gess-Newsome 2015). This model offers explanatory power for researchers and a way to understand the complexity of teaching. It is a model of teacher professional knowledge and skill, including PCK, and influences classroom practice and student outcome.

The model takes student outcome into account as a facilitator for teacher learning. Teacher affect is recognized as a component of amplifiers and filters. The model describes teacher professional knowledge and skill (TPK & S) and illustrates schematically how the theoretical knowledge is translated into practice (Fig. 1). The model includes something described as amplifiers and filters. Both teachers and students are transmitters and recipients in a context where expectations, preconceived opinions, self-esteem, and prerequisites act as filters and amplifiers. This, in turn, affects how teachers' professional knowledge is shaped in action and how it will be perceived by students in the current classroom practice. It also affects how the teacher's professional knowledge will develop. In the model, PCK is described both as knowledge used in the planning and implementation of subject-specific teaching and as a skill or ability used while teaching takes place. The consensus model introduces a perspective that includes both a theoretical and experience-based knowledge in PCK and the ability to translate this knowledge into practice. The model provides the possibility to investigate PCK in a classroom context while teaching. The student's perspective is included in the model as both the student's results and classroom events, which can give the teacher new signals or new knowledge that affects both the teacher's topic-specific area and the professional knowledge and skill (Gess-Newsome 2015). It was announced during the ESERA-2017 Conference that the model is undergoing further development. Papers from the conference describe how the world's PCK researchers continue to emphasize the need to further pay attention to the students' knowledge development and to link this to research on teachers' PCK (Berry et al. 2017).

From a sociocultural perspective, teachers' professional development also lies in the learning process. Vygotsky and Cole (1978) used the Russian term *Obuchenie* to explain that the teaching process has a dialectic relationship between teaching and learning. To be able to teach, you must know about how the student learns. To be able to learn, you have to teach the meaning and communicate what you learned to the teacher.

The present study seeks to examine how teachers' PCK is expressed in a science teaching practice, from both teacher and student perspectives. As such, the aim is to make the action parts of PCK more visible for teachers and students. The study aims to investigate the fields in which teachers' understanding of how students understand the teaching can be important and, in so doing, contribute to the area of professional development. The research questions for the study are the following: How do teachers describe and reflect their PCK in action while teaching physics and how do teachers reflect when reading students thoughts about which of the teachers' actions students find facilitate their learning? This chapter focuses on the second question, regarding how teachers respond to students' reflections about actions of teaching.

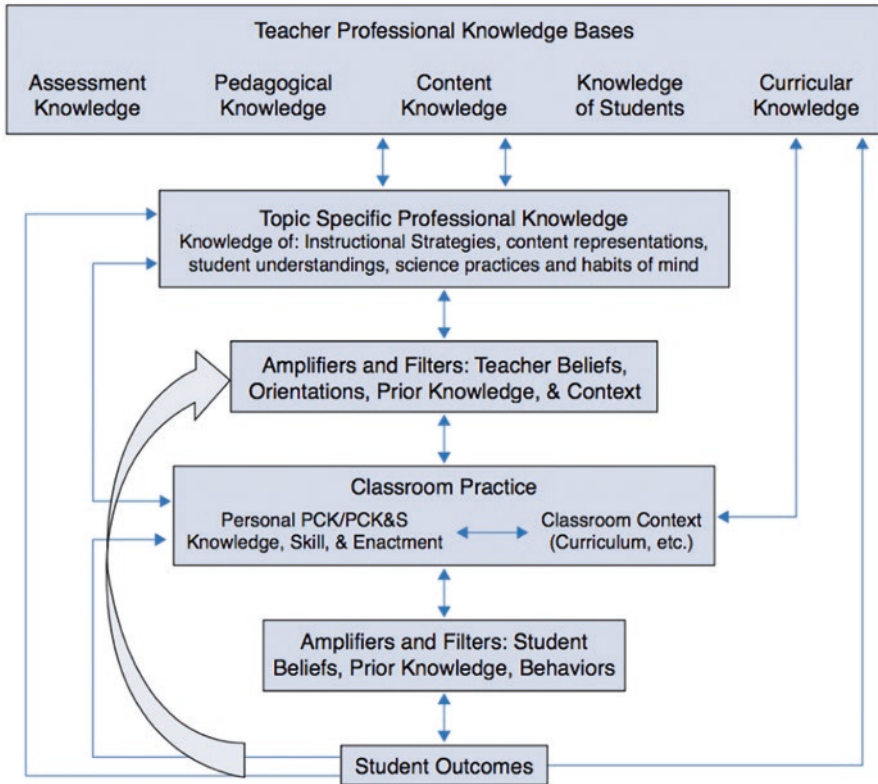


Fig. 1 Model of consensus (Gess-Newsome 2015). The model visualizes teacher professional knowledge and skill, including PCK and its influences on classroom practice and student outcomes. This model was used as a tool for analysis of the data in the study

Method

This is a qualitative case study of three teachers’ physics lessons in grades 7–8 in a lower secondary school in Sweden (Cohen et al. 2011). The teachers were all experienced and served as head teachers at their schools. The teachers were informed about the study, the design (Fig. 2), and the extent of their participation, and they all participated voluntarily. The parents of the students gave written consent for their child to participate in the study. The study included several analytical units in its design. These units included sound recordings, video-recorded classroom observations, teachers’ protocols (CoRe), as well as students’ results, interviews, and reflected conversations stimulated from video films in video clubs (Johnson and Cotterman 2015; Sherin and Han 2004; Sherin and van Es 2009; van Es 2014; van Es and Sherin 2010). Since the transcribed conversations from the video clubs were the primary sources of data, the video club research method is described further below.

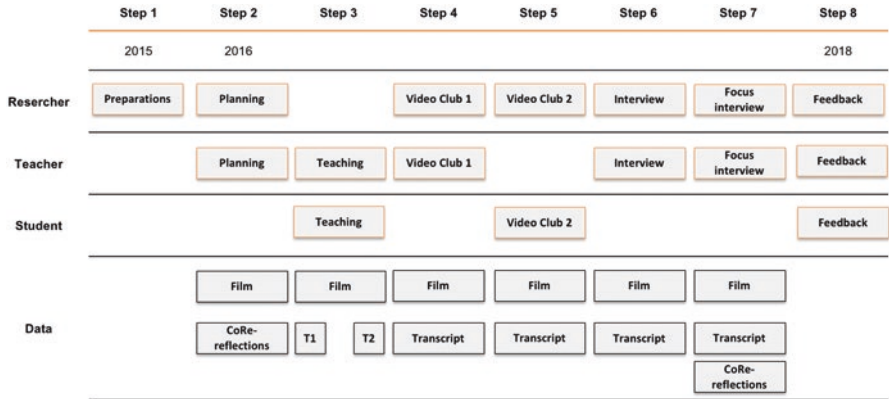


Fig. 2 Illustration of the research design. The horizontal rows describe the logistics of the study, and the vertical columns show the different steps the activities, who attended in them, and what data it generated

Research Design

The design and logistics of the study are visualized in Fig. 2 and are referred to in the text as the research design of the study.

Video Club

The concept of video club was previously used in educational research studies (Nilsson and Elm 2017; Johnson and Cotterman 2015; Sherin and Han 2004; Sherin and van Es 2009; van Es 2014; van Es and Sherin 2010). In a video club, filmed sequences from the environment, in this case three lessons in physics, are used as a basis for group reflection. The participants investigate the subject matter. Video club as a method has been described mainly as a way for teachers to develop professionally. During lessons, the teacher is often highly motivated to act and interact with students, while teachers in a video club are more able to reflect and describe what happened during the lesson. In a video club, teachers have the opportunity to give words to some tacit knowledge (Sherin and Han 2004). In the present study, both teachers and students attended the video clubs (Fig. 2). The focus was on how teacher actions in the classroom facilitate students’ learning.

Video club is suitable for qualitative case studies, such as the present study, where the object of interest is what a teacher does in a classroom and how students and teachers reflect on this. However, the method needs to be supplemented with additional data, such as interviews or observation notes that can contribute to a deeper understanding of the data (Jensen and Winitzky 2002). An opportunity for triangulation of data increases the possibility that interpretations become more

trustworthy; hence more sources provide greater opportunity to highlight the investigated phenomena from several angles (Bryman and Nilsson 2002).

The teachers reflected on their PCK collaboratively, with the help of the conceptual tool CoRe before teaching (step 2, Fig. 2). They taught three different aspects of physics – the energy principle, magnetism, and support surfaces – in three different classes. The lessons were video-recorded with two cameras in the classroom (step 3). The teachers and the researcher met three times in the video club to watch three video-recorded lessons (step 4). Students in each class were asked to join the researcher in similar video clubs to watch and talk about the lesson they had participated in. Six to eight students in each class were willing to contribute in the video clubs (step 5). The films were used in a video-stimulated recall interview (video club) where the participants stopped the film when they found some important teacher action they wanted to discuss, pinpoint, or criticize. The video clubs were filmed and later transcribed using Transana, a tool for transcription and analysis (Thorsteinsson and Page 2009). Before the next step, the students' transcriptions were presented to the teachers. After their reading, the teachers were interviewed (step 6) in a semi-structured way (Cohen et al. 2011). The final step in the data collection was a focus group interview (step 7) with the three teachers together (Cohen et al. 2011). All interviews were transcribed, and the transcriptions from the video clubs and interviews were the primary data for this study. As such, the data were analyzed to find how teachers identify and reflect on their PCK in action. The data also shows how the students find the teaching to facilitate their learning and how teachers reflect on information from students regarding their views on the teachers' teaching. This chapter only presents parts of the study; the focus is on how teachers reflect on their actions in a classroom based on the data from students' reflections in video club 2. Data from steps 5–8 were used to answer the following question: How do teachers reflect their teaching when listening to the students' opinions about which teacher actions in classroom facilitate their learning?

Analysis

The study's process of analysis (step 8) had a hermeneutical and iterative approach where the data were analyzed with a qualitative content analysis method (Gadamer et al. 2004). In the hermeneutical tradition, interpretation is used as the main research method. The analysis was conducted in three phases, with the first phase using data from video club 1, the second phase using data from video club 2, and the third phase using data from the teacher interviews. The three phases of analysis enabled the triangulation of data from various sources. Gess-Newsome's (2015) "Consensus model of PCK" (Fig. 1) was used both as a methodological and a theoretical framework in order to reflect the teachers' perception and interpretations of how to transform PCK into action. The second research question is about how teachers reflect on their students' perceptions of the teacher's actions in teaching. It is the second question that the present chapter focuses on.

Results

How do teachers reflect on their teaching when listening to students' opinions about which teacher actions in classroom facilitate their learning? Two key themes in the results highlight important aspects:

- The importance of reflection for professional development
- The importance of developing knowledge about students' knowledge and understanding

The Importance of Reflection for Professional Development

Teachers take advantage of hearing students reflect on teaching and also benefit from participating in a video club with colleagues. They say that these conversations with colleagues contribute to their own development by giving them the opportunity to stop and reflect on the teaching that has been completed. They consider both the conversations with colleagues and getting to know students' reflections on teaching as meaningful. Teachers express that these affect them in ways that probably lead to professional development:

I think this gives me a lot; not only what the students say, but also our meetings in video clubs, where we could stop and reflect for a moment. You talk a lot about the importance of developing your content knowledge, but I don't think that is where I need to develop; instead, I need to be more responsive to the students. (Quote from teacher 3)

Teachers highlight that differences between teachers and students' reflections are interesting. Students' reflections contribute to a new perspective for teachers. Teachers notice that, in their collegial conversations, they talk about didactic aspects that they actually already know are good. They are looking for actions that they know, according to the research, facilitate student learning:

In some way, we slip into things that we already know are good. Do you see what I mean? We know it's good to reinforce, we know it's good with concepts. (Quote from teacher 2)

In their reflections, teachers express the benefit of the students' slightly different perspective on the teacher's actions. Unlike teachers, the students are not affected by educational literature and, according to the teachers, seem to be more based on their own individual perspective. To some extent, teachers are surprised that the students think so much about what the teacher does:

... they see a lot more from their own perspective. I look more at goal achievement from a class perspective. It's really interesting with students who, in a serious way, have reviewed a lesson. (Quote from teacher 2)

The fact that colleagues are talking to each other in video clubs partly helps teachers leave their own perspective by taking part in a critical and developed reasoning from colleagues. On the other hand, the teachers discuss that there are limita-

tions in conversations between colleagues because colleagues have, to some extent, the same understanding of what, according to current research, are constructive ways of teaching in the teacher's professional context. The students' reflections enable other and new perspectives. Teachers expressed amazement and interest in the students' knowledge about teacher's actions. The students' metacognitive ability is highlighted in the result in this theme of the study:

They think about teaching, they are meta-reflecting about teaching. Not topic-specific content, but how the teacher does and doesn't. They think about why and why not. (Quote from teacher 3)

When students' voices become visible, like in this study, by the teachers reading the students' thoughts about teacher's actions in classroom, it gives the teacher new views on aspects other than those they are looking for. These perspectives help teachers to leave their own ideas of how good teaching is expressed and to see their professional practice from the student's perspective. The students' examination of the teaching adds something that the teachers are interested in and that will help teachers incorporate new knowledge into future teaching. The results show that the students' perspectives can help create a new understanding of how teachers' actions contribute to students' learning in science. The results raise awareness about aspects that the teachers have not noticed before, to such an extent that students know more about the teachers' actions and what lies behind them.

The Importance of Developing Knowledge About Students' Knowledge and Understanding

As stated in the theme above, teachers experience the meaning of listening to students' descriptions about teachers' actions in teaching. The results show that teachers see students in a new way, to some extent. It seems like they had not previously noted that students have similar knowledge of teaching as their own colleagues. Once they did notice, however, they expressed thoughts about the possibility that students' comments could be used to develop teaching:

I have also thought about interviewing students and that it is a source of excitement if you want to develop professionally. (Quote from teacher 1)

The results show that teachers see new opportunities for professional development by involving students in the teaching itself. The teachers have not previously thought that students have so much to say about the teacher's teaching. This could indicate that teachers have mostly focused on teaching from a teacher's perspective and that they in collegial conversations get the opportunity to reflect on how teaching affects students' learning. Through various forms of assessment, teachers examine how students understand and what they have learned and adjust their teaching based on both formative and summative assessments of students' understanding. The results illustrate that the teachers, by listening to the students' comments on

actions of teaching, get ideas that they could involve students in new ways, for example, by interviewing them about the actions in the teaching. Through students' reflections on teaching, teachers can use students like experts in teaching. Teachers believe that they may be more interested in asking students about the teaching to supplement their own knowledge of students' learning. The results show that students' reflections on teaching could lead teachers to view another perspective that concerns the teacher's actions but from the perspective of the students. Since teachers benefit from learning about how students learn, this information from students will further contribute to teachers' didactic skills. When teachers find out how students reflect on the teacher's actions, there is reason to believe that teachers accommodate an additional dimension of feedback that can develop their teaching.

The results also suggest that the view of teachers' actions differs between students. Some of the teachers noticed that students have different ways of expressing themselves; some have a lot to say and some students less.

Teachers reflected on questions about whether students' awareness of the teacher's actions may be related to how well the students utilize the teaching in science. The teachers problematized students' different understanding of science teaching and reflected on how that would affect students' learning:

I think it's about metacognitive ability. It is far from all students who think in those ways. The teacher is the teacher and students don't question the teaching, if it is right or wrong or appropriate or not. This category of students is more likely to put the blame on themselves when they fail in class, while those who are metacognitively aware certainly can question some actions from us teachers. (Quote from teacher 3)

The results show that, to some extent, the teachers mean that they can get a view of pupils' metacognitive ability by learning about pupils' reflections about teaching. They mean that students' thoughts about themselves as students and whether they can assimilate the teaching should reasonably be linked to their ability to reflect on the teaching. On the other hand, the teachers' description can also be interpreted as meaning that students with a good ability to describe the teacher's actions may question their learning opportunities if they do not believe that the teacher's actions favor them. According to teachers, this category of student would be more likely to place the responsibility outside themselves. This could have a negative effect if communication with the teacher is not constructive and, in such a case, could lead to a changed action that is more likely to facilitate the student's learning. The teachers believe that there is positive link between the student's awareness of the teacher's action and a beneficial learning for the student. The results also show that teachers believe that there may be a negative link between students with less awareness of the teacher's actions and their learning and a risk of blaming themselves for the lack of learning. Students who put the entire blame on themselves risk consolidating an image of themselves as negative, and instead of considering whether teaching benefits them, they think it is their own fault that they do not learn. When teachers gain access to different students' reflections, they receive important information about how students respond to the teaching and, thus, new knowledge from the source that students can offer. This knowledge from students can be translated into the teachers'

teaching practice. In conversation with students about the teacher's teaching, teachers and students come closer to one another.

Discussion and Conclusions

Developing professional knowledge of teaching is a complex process. As Loughran et al. (2004) indicated, teachers need systematic tools to better capture and analyze their own teaching practice. As the present study has indicated, using students' eyes and letting them reflect on their teachers' actions provide a deeper insight into the dialectic relation between a teachers' teaching and the students' learning that Vygotsky and Cole (1978) felt was essential to teaching quality. This result could be an acknowledgement of what Cross and Lepareur (2015) described as a need to make teaching more visible to students and pinpoint the importance of explicit methods for teachers to do that. The result implies that the design of the study could be a way to facilitate what Cross and Lepareur (2015) called for, namely, understanding PCK in action within the complex context where it is conducted.

One conclusion in the study is that teachers who are given the opportunity to reflect on which teaching actions benefit students' learning believe that they get a deeper view of and understanding of students. As in other studies (Eames et al. 2011), teachers became more sensitive to student needs. Conversations between colleagues, on the other hand, tend to get stuck in known patterns, where conversations about different students and how they respond to the teaching receive a lot of focus. Using filmed lessons and strict questions about teacher actions helps teachers focus on their own actions in classroom and reflect about how the actions benefit or do not benefit different students (Sherin and Han 2004).

A further step in the design of this study is where students study lessons in the same way as teachers and where teachers get to know students' thoughts about the teacher's teaching. The teacher receives feedback from students on his or her teaching, which has probably not been received before. Student feedback helps the teacher view their teaching from a new perspective, and it also enables teachers to see the student in a slightly different way. Like Hattie (2009); Nilsson and Loughran (2012) mentioned, there is little consensus about what teacher knowledge looks like in action. It is most likely that students can help visualize that knowledge by putting the teachers' expressed PCK into words. Worth noting is the power a teacher has relative to the students regarding issues such as grade assessment and the possible concerns students can have to express themselves. The students are, in a way, in a state of dependence toward the teacher. This point needs to be considered and weighed into the benefit of the method.

The teachers noticed different levels of awareness from different students, and from that point of view, they reflect on how this knowledge helps them to do more specific prompts in a classroom. It corresponds to the need to understand how students learn, which could be a way for teachers to better teach a variety of students. Similarly, it gives students the opportunity to reflect on teachers' prompts, which

could be a facilitator for their own learning. This may help students' metacognitive awareness to grow, when they are stimulated to put teachers' actions as facilitators for learning into words. In a way, this could meet the need that Cross and Lepareur (2015) formulated as a need for teachers and students to make the didactical contract visible. This point of students' metacognitive awareness would be of great interest for future studies.

This study has not pinpointed any special teacher action as the best action to facilitate student learning in science, as there seems to be weak consensus from students on that point. However, there is some agreement that the way this study is conducted seems to be a way to unpack and understand how the teachers' PCK is expressed in action in a classroom and how it is understood by students. In this case, both students and teachers agree that reflection in video clubs is a way to better understand teaching and learning and the way teaching affects both students' learning in science and teachers' learning about science teaching.

Summary of Conclusions

- The design of the study could be a way to connect PCK to practice.
- Video-recorded lessons help teachers see themselves from a student perspective.
- The design of the study can be a model for school development in practice.
- Teachers believe that they benefit from hearing pupils' reflections on their teaching.
- Students' metacognitive ability can be extended with the help of video clubs.

ESERA Conference 2017

The questions and discussion that arose after my presentation at the ESERA 2017 conference focused on how to understand teachers' reflections and the potential difficulty in interpreting them in a correct way due to different background, orientation, and prior knowledge. This problem is acknowledged in the current study. The argument stresses why it is not possible to provide evidence, in this study, about which teacher action(s) are recognized as the better ones. Rather, the contribution of this study is the process of learning about how students can understand teacher actions. Also of great interest to the audience was the way that students' minds were involved in the study. It seemed like there was agreement about the problem that students are often left "outside" even if they are the subject of teaching. In that way, students can be very important for making teaching understandable to teachers. Students are often neglected when teaching is discussed or developed, but they were involved to the highest extent in the present study. The working method provides opportunities to involve students in a meaningful way.

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