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# A teacher intervention on students' higher-order learning in classroom dialogue

*How teachers learn and perform, how students engage and perceive*

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*For my granddad*

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# Table of Contents

# Abstract

Classroom dialogue is the predominant learning setting in German science and mathematics classrooms. Studies during the last 40 years have revealed that it is often a tight interaction pattern that does not necessarily foster and scaffold students' elaborations. Rather, teachers ask questions that foster students' reproduction of knowledge and provide them with short, corrective feedback. In order to change this status quo, the Dialogic Video Cycle (DVC), an evidence-based, one-year teacher professional development program (TPD) on productive classroom dialogue, was developed. The dissertation examined how the DVC would impact teachers' *learning* in the program, their *reflection* on the DVC, teachers' and students' *practice* changes in the classroom, and changes in students' *perceptions* of higher-order learning with and without considering their self-concept of ability as an individual student *precondition.* Within a longitudinal control-group design, the results revealed that teachers changed their feedback behavior and provided their students with more feedback on their learning processes. Regarding the level of questions and student answers, no significant changes were found. Individual practice changes were rather homogeneous with regard to feedback and rather heterogeneous for teachers' questioning and students' elaborations. Qualitative analysis of teacher learning within the DVC workshops showed that teachers were more open-minded with regard to feedback as a reactive teacher behavior, whereas teachers' questions as an initiative teacher behavior were seen as a vital tool for efficient navigation through lesson scripts. Although teachers faced different challenges with regard to implementing all the new knowledge provided in the TPD into their individual classrooms, their reflections on the program revealed that they appreciated the DVC mainly because of the constant community of learners and the immediate feedback on teaching routines through the video tool (Essay 1). Students perceived the changes in classroom dialogue positively with regard to their higher-order learning which is composed of situational learning processes and cognitive elaboration strategies. For both dependent variables, students reported significantly more positive perceptions at the end of the school year than the control group. An additional sub-sampling with regard to the students' self-concept of ability as a relevant student precondition revealed that the DVC was especially beneficial for students who initially had a low self-concept of ability with regard to their situational learning processes (Essay 2). In summary, the dissertation delivered results regarding systematic effects as well as on individual cases within a comprehensive investigation of the causal impact chain in TPD. Through this approach, the dissertation adds to the requested research on effective TPD, but acknowledges classrooms as individual settings for implementing new knowledge.

# 1 Research Desiderata of the Dissertation

## 1.1 Classroom Dialogue – Status Quo

In the German context, classroom dialogue is the main learning setting for mathematics (Hiebert et al., 2003) and science (Seidel & Prenzel, 2006) in secondary education. During the last four decades, classroom dialogue has mainly been put into action through the Initiation-Response-Follow-up (I-R-F) sequence (Mehan, 1979; Mercer & Dawes, 2014). The I-R-F pattern can be a learning-supportive setting when the quality of each component is assured (Chin, 2006; Dawes, 2004). Through the level of initiation and follow-up, the teacher can influence whether the I-R-F appears in an "authoritative" or "dialogic" function (Mortimer & Machado, 2000). Research has shown that often the elements of the I-R-F are rather "authoritative" causing tight interaction patterns (Howe & Abedin, 2013; Mercer & Dawes, 2014). In this context, teachers' questions, which serve as the initiation of a teacher-student interaction, have shown to be often of a closed and reproductive character. Students are then triggered for short, knowledge reproducing answers which serve as a keyword for the teacher to continue with a "secure" teaching script (Jurik, Gröschner, & Seidel, 2013). In this teaching style, subjects such as science appear as a rigid body of knowledge where there is always *the* right answer (Driver, Newton, & Osborne, 2000), and students expect to be provided with the right answer in the end anyway (Oliveira, 2010). This aspect is reinforced by the level of the teachers' feedback which is often rather "corrective" instead of "cueing" (Hattie & Timperley, 2007). In the context of mathematics, results of the TIMSS video study revealed that especially German classrooms are dominated by the described reproductive questioning approach (Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999). With such a highly routinized teaching pattern, it is rather unlikely that learning opportunities arise in which students learn how to argue and reason (Osborne, 2010), as well as develop a deep understanding and willingness to continue with a career in science, technology, engineering and mathematics (STEM) (Organisation for Economic Co-operation & Development [OECD], 2007).

Therefore, teachers are requested to provide students with fruitful learning environments that instill a positive learning attitude towards STEM. In the context of classroom dialogue, this means finding out what students think by scaffolding them in questioning their conceptions and acquiring the language to express scientific ideas by posing different perspectives to each other (Wells & Arauz, 2006). Especially, the aspect of presenting different perspectives to a problem, argument or question forms the basis for a

purposeful communication setting which allows for the term “dialogue” – meaning a minimum of two people being involved in a conversation (Howe & Abedin, 2013). Up to now, four decades of research have dealt with “classroom dialogue”, with the focus on describing the structure of dialogue patterns (70% of studies in the review of Howe & Abedin, 2013).

The main conclusions regarding the status quo on classroom dialogue are: first, the components of the I-R-F are often taught in a tight way; second, future research has to go beyond describing patterns of classroom dialogue, and rather work on its changeability. Therefore, the present dissertation investigates a teacher professional development program (TPD) on classroom dialogue called the Dialogic Video Cycle (DVC) in order to examine teachers’ practice changes as well as their learning about classroom dialogue. The DVC served as the vehicle for changing classroom dialogue in a productive way. Thus far, only a few studies have dealt with professional development programs in relation to classroom dialogue, which have mainly examined the impact of the programs through extensive case studies (“Accountable Talk,” Michaels, O’Connor, & Resnick, 2008; “CamTalk,” van de Pol & Elbers, 2013). The goal of this dissertation is to extend this line of research by implementing a longitudinal control-group study to investigate the changeability of the elements of the I-R-F in the videotaped lessons of participating teachers (Essay 1).

Besides the lack of research on the changeability of classroom dialogue, its consequences on student learning outcomes are not necessarily investigated, and if doing so, variables with regard to achievement are the center of attention (Howe & Abedin, 2013). However, the research highlights students’ perceptions of higher-order learning as relevant for students’ development of a deep and sustainable content understanding (Donovan & Bransford, 2005). Therefore, this dissertation examined in a second study whether the DVC would affect students’ higher-order learning in regard to their situational learning processes and elaboration strategies which were approached by questioning students directly after the videotaped lessons. In this context, individual students’ preconditions have to be considered due to their influential character (Corno & Snow, 1986). In the context of higher-order learning in classroom dialogue, previous studies have highlighted the self-concept of ability as important because it impacts how students engage and persist in the learning process (Helmke & van Aken, 1995; Jurik et al., 2013). From this perspective, it can be assumed that the DVC could cause different effects for different students. Therefore, a second theme in

Essay 2 was whether the DVC would affect students' higher-order learning differently when considering their math or science self-concept of ability.

## 1.2 Teacher Professional Development – Status Quo

Teacher professional development has become a growing sector due to the "alarming" results of studies such as PISA around the turn of the millennium. As a consequence, policy makers as well as educational researchers ask for a stronger focus on the quality of teachers and on the establishment of life-long learning opportunities for them (Blossfeld et al., 2015). In the same breath, more profound research on the effectiveness of TPD is claimed (Desimone, 2009; Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013; van Veen, Zwart, & Meirink, 2012). The range of offers in TPD are heterogeneous, from afternoon workshops on a wide choice of topics (Richter, Kunter, Klusmann, Lüdtke, & Baumert, 2011) to extended programs lasting for several years – mainly in the US context – where teachers are, for example, trained to become teacher-leaders in order to spread effects (e.g., Borko, 2012). Despite the empirical evidence regarding certain effective components such as *content focus, active learning, collective participation, duration* and *coherence* (Cordingley, Bell, Rundell, & Evans, 2003; Desimone, 2009; van Veen et al., 2012; Wilson, 2013), these principles of effective TPDs are not necessarily implemented in existing programs.

Within the DIALOGUE project, which embeds the present dissertation, the DVC was designed by purposefully implementing effective TPD components (Gröschner, Seidel, Kiemer, & Pehmer, 2014) and providing teachers with a mindful facilitation (Gröschner, Seidel, Pehmer, & Kiemer, 2014). To advance the field with regard to systematic and controlled research on TPD effectiveness, the DVC was compared to a rather traditional program, the Advanced Traditional Program (ATP). By doing so, it was intended to examine the rather conventional format to an evidence-based attempt. As described in Section 1.1, this was done by analyzing videotaped lessons and by capturing students' perceptions through a questionnaire after each lesson. In addition, for a comprehensive description of change processes and in order to understand the causes for changes teachers made in their practice during the TPD, results in Essay 1 were complemented by qualitative teacher statements selected from the additionally videotaped TPD workshops. For a further understanding of the DVC's role as a professional learning opportunity for teachers, qualitative excerpts of teachers' reflection interviews completed the comprehensive exploration of the program.

## 1.3 Research Questions within the Framework of the Dissertation

The following framework (Figure 1) forms the basis for five research questions of the cumulative dissertation and was derived from the above described research desiderata and the theoretical background which will be presented in the following chapter. The framework serves as an advanced organizer of the dissertation and is, therefore, presented at the end of this introductory chapter.

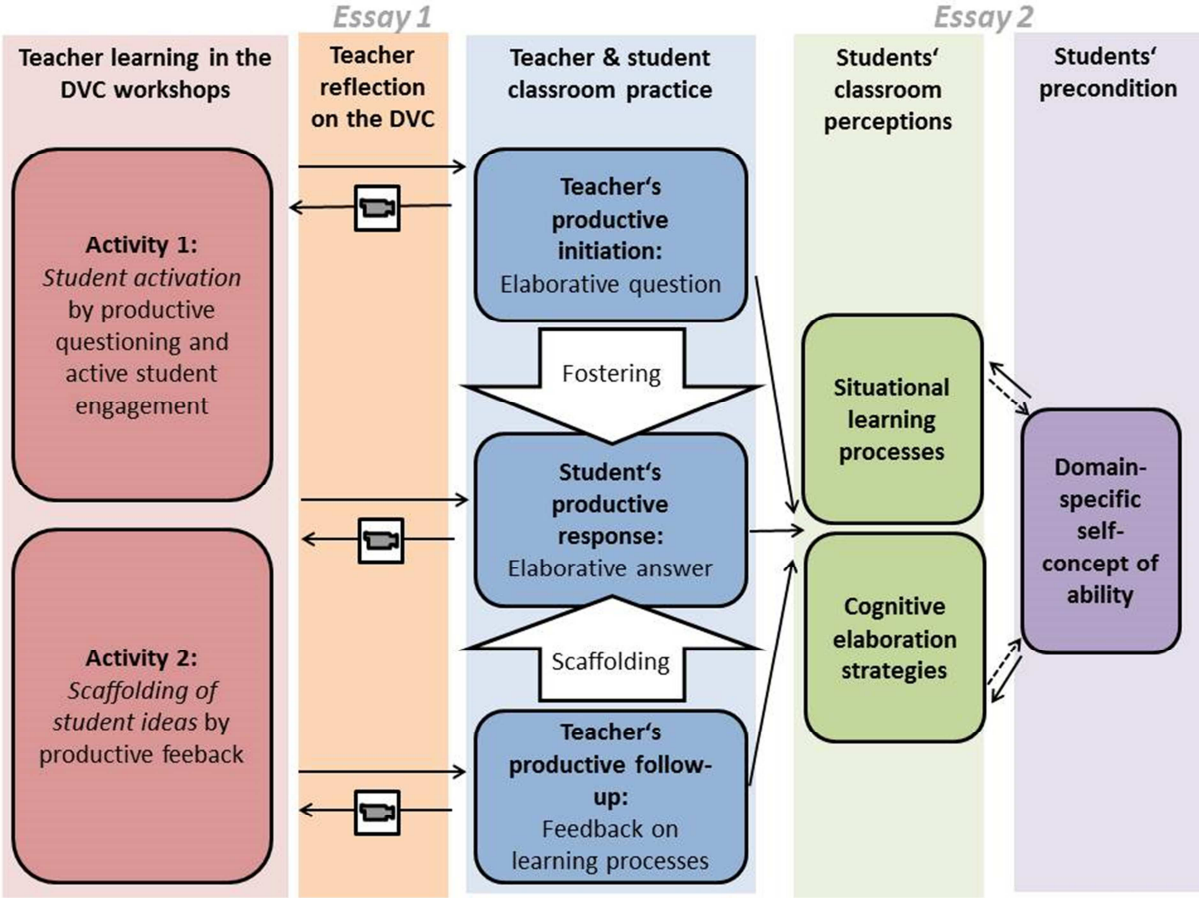


**Figure 1: Framework of the dissertation**

The dissertation aimed to comprehensively investigate the impact of the DVC on different facets within the causal chain of TPD. In this context, it is assumed that *teachers learn* in the context of two DVC activities – *student activation* and *scaffolding of student ideas* (based on Walshaw & Anthony, 2008), which influence *teacher and student classroom practice* with regard to the elements of the I-R-F. As indicated by the camera arrows, the video tool serves as the mediator between the DVC workshops and classroom practice through representative video clips of productive classroom dialogue. In between teacher learning and practice changes, *teachers reflect* within the DVC program on the role of video for professional learning. Practice changes with regard to productive classroom dialogue are assumed to influence the *students' classroom perceptions* of higher-order learning, which are

composed of perceptions of situational learning processes and perceptions of the more enduring cognitive elaboration strategies. The students' domain-specific self-concept of ability – as an influential *student precondition* – presumably impairs the impact of the DVC on students' higher-order learning perceptions.

Within the two essays, assumptions are empirically examined by the following five research questions which are asked along the five columns of the presented framework. Research questions are listed in the order they are addressed in the two essays. Detailed hypothesis regarding each research question are presented within the summary of each essay (Section 4.1 and 4.2).

**Essay 1:**

*Teacher and student classroom practice:* To what extent do the different treatments – DVC and ATP – support teachers in changing their practices in classroom dialogue?

*Teacher learning in the DVC workshops:* What teacher discussions of the DVC workshops help to illustrate the findings on teacher practice?

*Teacher reflection on the DVC:* What specific role do teachers attribute to the DVC as a professional learning opportunity based on effective components of the TPD?

**Essay 2:**

*Students' classroom perceptions:* Do students of teachers who participate in the DVC perceive positive changes in their situational learning processes and cognitive elaboration strategies in comparison to students of teachers who participated in the ATP?

*Students' precondition:* Do students with different levels in their self-concept of ability benefit differently from the DVC compared to those of the ATP in their situational learning processes and cognitive elaboration strategies?

In the following, the theoretical background is presented. In Section 2.1, literature regarding teacher and student practices in classroom dialogue is depicted. Relevant research regarding students' higher-order learning perceptions and how it is impacted by classroom dialogue and their self-concept of ability as an individual student precondition is shown in Section 2.2. Section 2.3 sums up the framework with current research on teachers' learning in professional development. After presenting the theoretical basis, the DIALOGUE project is

introduced by describing the two different TPD conditions (DVC and ATP) and their implementation (Section 3.1). In Section 3.2, the student and teacher sample is described before presenting the procedure of data collection and analysis (Section 3.3). Both essays are separately summed up in Sections 4.1 and 4.2 before being discussed corporately in Section 5.1. Finally, the educational relevance of the dissertation and future research implications are deduced from a methodological and content-based reflection.

# 2 Theoretical Background

## 2.1 Teacher and Student Practices in Productive Classroom Dialogue

### 2.1.1 Students' Productive Responses as a Source for Students' Learning

Educational research has been focusing on classroom dialogue for 40 years (Mercer & Dawes, 2014). The majority of this research has concentrated on generating empirical evidence on how dialogue between students and teachers is established in the classroom and what criteria it is required to fulfil in order to support students' learning with a maximal learning outcome (Mercer, 2008). A discrepancy still exists between the two described research foci: an extensive body of literature suggests that the main criterion of classroom dialogue is that it be learning supportive, but that its implementation in the classrooms is often still insufficient. As illustrated in Section 1.1, classroom dialogue is often put into action as a tight interaction pattern with students as keyword givers (Chin, 2006; Jurik et al., 2013; Mercer, 2008). Critically, it may be asked whether this pattern can be defined as "dialogue," in reference to Bakhtin's (1981) definition of "dialogic" as the interplay of multiple perspectives. Allowing for those multiple perspectives within classroom dialogue requires the involvement of students as equal participants in a conversation, instead of just keyword givers in a lesson script (Wells & Arauz, 2006). Such a dialogic setting provides room for scientific argumentation, the co-construction of knowledge, and a deep and critical engagement with learning content, and then it can be defined as "productive" (Alexander, 2005; Osborne, 2010). Previous research has shown that engaging students in such argumentative and interactive learning settings leads to a significant rise in students' conceptual understanding (Chi, 2009; Mercer, Wegerif, & Dawes, 1999; Resnick, Michaels, & O'Connor, 2010; Webb et al., 2014). Additionally, students' processes of reasoning show that their understanding might diverge from the teacher's expert domain knowledge. For the ongoing lesson, these disparities are particularly valuable resources in the context of students' and teachers' co-construction of knowledge (Twiner, Littelton, Coffin, & Whitelock, 2014).

### 2.1.2 Teachers' Productive Initiation and Follow-up: Fostering and Scaffolding Students' Responses

In this context, the teacher has been shown to be crucial with regard to his or her facilitation of the required "dialogic" conversation: first, the teacher takes care of activating the students to participate in the classroom dialogue; second, the teacher scaffolds the students' ideas in the conversation (Walshaw & Anthony, 2008). Strong tools for teachers'

fostering and scaffolding of students' contributions are questions and feedback. Research provides evidence that both aspects have been used ever since classroom dialogue became a focus of educational research (Mercer & Dawes, 2014), and that their "quality" varies greatly and is crucial for student learning (Chin, 2006).

The *teacher questions* tool often initiates a conversation with the aim of increasing the students' participation (Koufetta-Menicou & Scaife, 2000). In this context, its quality with regard to student learning is profound because it promotes the level of the students' answers (Chin, 2006). There is a consensus among studies on teacher questioning that a "productive question" challenges students to think profoundly, inspires their learning processes, and encourages them to use reasoning skills (Alexander, 2005; Lee & Kinzie, 2012; Wragg & Brown, 2001). Additionally, an effective teacher question can foster elaborative student responses which include explanations of the students' thoughts, and encourage students to develop their own way of expressing ideas, rather than simply memorizing facts and giving correct keywords (van Zee, Iwasyk, Kurose, Simpson, & Wild, 2001). Oliveira (2010) states that questions that allow students to give only one correct keyword lend support to students' expectations that, in case of failure, the teacher will ultimately provide them with the correct answer anyway. Oliveira (2010), therefore, emphasizes the importance of questions being *open-ended*, with multiple answer possibilities, and include *challenging* to trigger students' further exploration, and *connecting* to include students' prior knowledge. Thus, the quality of a question has an important function in classroom dialogue, influencing how students become activated and engaged in the conversation (Walshaw & Anthony, 2008).

Additionally, after activating students to participate in classroom dialogue and fostering elaborated answers, the *scaffolding of students' answers* is a second key component of productive classroom dialogue. Dawes (2004, p. 681) defines the "scaffolding" tool, in the context of classroom dialogue, as "the teacher's words support the learner's thoughts and actions." In order to support the students' thinking processes, the teacher scaffolds a student by probing ideas, words, and opinions (Dawes, 2004). Besides clear structuring of dialogue (Resnick et al., 2010), studies revealed that teacher feedback is one of the most effective tools to do so (Hattie, 2008). As described in Section 1.1, feedback is provided as the follow-up move on a students' response to the teachers question in the I-R-F pattern. Mortimer and Machado (2000) state that I-R-F is an authoritative communication pattern when the teacher's feedback is evaluative. This assumption is shared by Hattie and Timperley (2007) who categorize this form of "corrective" feedback as *feedback about the task* which provides

students only with information on the correctness of a solved task. It is claimed that this type of "corrective" feedback is most common, since most teacher questions require that students give either "right" or "wrong" answers. The problem with this type of feedback as the least effective is that students simply try to "pick the right answer," and, thus, to equip themselves with the right strategy to achieve that aim. In order to implement the I-R-F in a dialogic function, the teacher's feedback needs to provide information to the student for further extension of the response (Mortimer & Machado, 2000). This type of feedback is categorized as *feedback on the processing of the task* and has been shown to be the most effective (Hattie & Timperley, 2007). It directs students to re-think and re-use certain strategies or to ask for concrete help. It is regarded as a "cueing" type of feedback and is likely to enhance students' deep understanding of tasks. Harks, Rakoczy, Hattie, Besser, and Klieme (2014) backed this assertion, finding that process-oriented feedback that had an indirect effect on students' achievement was perceived as most useful. Another type distinguished by Hattie and Timperley (2007) is the *feedback on self-regulation*, which promotes students' self-monitoring and regulation of their learning processes. This type has been shown to influence, for example, students' perceived autonomy and self-efficacy. In this context, van den Bergh, Ros, and Beijaard (2014) investigated whether primary school teachers' attitudes towards feedback and feedback behaviors changed after a video-based intervention on feedback. The results showed that the teachers provided more confirmative and metacognitive feedback to reinforce their students' learning following the intervention. Additionally, the teachers reported finding it easier to give feedback that activated their students' thinking. These results provide a relevant piece of evidence that video-based work on a specific criterion of productive classroom dialogue can change teachers' practices and attitudes. In this context, the research group emphasizes that the interplay of one's own video excerpts and the video sequences of colleagues created a rich learning environment for teachers. They state that being videotaped while using new knowledge in the classroom is an authentic activity which encourages teachers for active participation.

This dissertation connects to the empirical evidence by examining whether the DVC, as another video-based TPD on productive classroom dialogue which includes videotaping during the implementation of new knowledge, supports teachers in changing their questioning and feedback behavior in order to facilitate elaborative student answers (Essay 1).

## 2.2 Students' Perceptions of Higher-Order Learning

In accordance with the current paradigm in educational research, teachers provide students with learning opportunities that they can ideally use to achieve maximum success regarding the construction of knowledge and learning outcomes (Klieme & Rakoczy, 2008). As stated in Section 2.1, it is therefore relevant to ask in the context of classroom dialogue how teachers can use conversation to facilitate student learning. Besides observing students' responses as an external learning activity, it is relevant to ask how students use classroom dialogue for their internal learning activities. In this context, the present study concentrates on students' higher-order learning as an important outcome variable, which thus far has seldom been considered, although it is a particularly relevant precondition to allow for students' understanding of learning content (Donovan & Bransford, 2005).

Higher-order learning can be characterized by *situational learning processes* that focus on the question of how students perceive their learning in a current lesson, and *cognitive elaboration strategies* that determine the students' use of certain strategies to support their learning in a more habitual and constant way (Vermunt & Verloop, 2000).

### 2.2.1 The Interplay of Classroom Dialogue and Students' Higher-Order Learning

The procedures of processing, elaborating, and organizing are basically characterized as the essential *situational* elements of higher-order learning (Collins, Brown, & Newman, 1989; de Corte, Verschaffel, Entwistle, & van Merriënboer, 2003; Donovan & Bransford, 2005). *Processing* describes whether a student is able to follow and process the lesson, which is important in order to participate in a conversation. *Elaborating* mirrors the way students are activated and how their prior knowledge is integrated. The third situational element of higher-order learning, *organizing*, asks how well the student can structure and organize the gained knowledge. It can be assumed that all situational elements, *processing*, *elaborating* and *organizing*, are supported by productive classroom dialogue. The teacher's questions that allow for the students' elaborated answers, as well as feedback that supports students in re-thinking their responses, can be expected to positively influence the situational elements of higher-order learning. This assumption has not been tested empirically and is, therefore, investigated in the presented dissertation (Essay 2).

Beyond situational learning processes, cognitive elaboration strategies are relevant for higher-order learning (Weinstein & Mayer, 1986). Cognitive learning strategies, of which elaboration strategies are a part, are assumed to be more enduring (Vermunt, 1996), and are

intentionally used by learners (Zimmerman & Martinez-Pons, 1990). In the context of productive classroom dialogue, in which students are verbally challenged to offer explanations and evidence (Duschl & Osborne, 2002), cognitive elaboration strategies are regarded as the students' intentional use of strategies to connect existing knowledge to previous knowledge, and then using the knowledge in a new context (Weinstein & Mayer, 1986). When teachers in a TPD on classroom dialogue learn about the importance of fostering and scaffolding students' elaboration the role of cognitive elaboration strategies and changes in students' perceptions of them over a period of time should be considered (Essay 2).

### 2.2.2 Students' Domain-specific Self-concept of Ability as an Influential Precondition

Besides the teacher's impact on student learning (Hattie, 2008), a consensus in educational research is that students' individual preconditions influence how students become engaged in learning (Corno & Snow, 1986). In this context, the self-concept of ability is considered an important student characteristic (Bandura, 1986; Marsh & Martin, 2011). Shavelson, Hubner, and Stanton (1976) characterize self-concept of ability as a person's perception of himself, which is influenced by experiences in the person's environment. This definition is internationally shared in educational research (Bong & Skaalvik, 2003; Retelsdorf, Köller, & Möller, 2014). Jurik et al. (2013) have shown that students with a low self-concept of ability tend to be disengaged from classroom dialogue, even when their previous knowledge is high. Furthermore, students' self-concept of ability has consequences for higher-order learning, since it influences how students initiate and persist in learning processes such as elaborating and organizing learning content (Helmke & van Aken, 1995; Wigfield & Karpathian, 1991). This is consistent with Bandura's (1986) line of reasoning that the self, as a regulator of behavior, activates strategies that induce lower or higher performance.

Studies have shown that a domain-specific context of self-concept provides a much more precise picture than asking students for their general academic self-concept of ability (e.g., Marsh & Hattie, 1996; Marsh, Lüdtke, Trautwein, & Morin, 2009; Shavelson et al., 1976). Because the present study focuses on the context of science and mathematics education and the importance of considering domain-specific self-concept of ability, it also focuses on math or science self-concept of ability, depending on the teacher's chosen subject in their TPD.

In accordance with the given literature, the domain-specific self-concept of ability seems to be an important differential and influential aspect on students' higher-order learning,

and therefore a relevant indicator for investigating the effectiveness of a TPD on classroom dialogue (Essay 2).

## 2.3 Teachers' Learning and Reflection in Professional Development about Productive Classroom Dialogue

As illustrated in the previous sections, enhancing classroom dialogue is one key to giving students opportunities to develop a deeper understanding of STEM learning content and to have a positive learning experience which, in the final analysis, might lead to career choices in the highly demanded STEM fields. Therefore, this study aimed to develop an effective TPD that would have an impact on students' higher-order learning. Since TPD is not necessarily connected to teachers' needs in their daily routines (Richter et al., 2011) and empirical evidence regarding the effectiveness of TPDs is still rare (Osborne et al., 2013), the DIALOGUE project, in which the present dissertation is embedded, aimed to develop a TPD which is based on empirical evidence regarding effective TPDs (Borko, 2004; Desimone, 2009; Wilson, 2013), as well as address classroom dialogue as a predominant topic of teachers' daily routines (Kunter et al., 2006; Seidel & Prenzel, 2006).

### 2.3.1 Effective Components of Teacher Professional Development

In conceptualising such a program, we considered evidence of research on effective TPDs by implementing Desimone's (2009) components: *content focus, active learning, collective participation, duration,* and *coherence*. In this context, Vescio, Ross, and Alyson (2008) stated that carefully designed TPDs were more likely to positively influence changes in teachers' practices.

Specifically, such a program should give teachers the chance to *actively* improve their practical knowledge and to experience opportunities to transfer concrete classroom dialogue activities to daily teaching practice. This active learning process should be encouraged by the *collective participation* of teachers in a trustworthy community of learners (van Es, 2012). The *duration* and *coherence* components formed the structural basis for the TPD by giving teachers the chance to learn within a coherent concept over the period of an academic year. Such constant TPDs are still uncommon in the German context (Richter et al., 2011). By providing teachers with concrete and coherent activities on the *content* of classroom dialogue, the DVC was conceptualized along Walshaw and Anthony's (2008) activities 1 (student activation) and 2 (scaffolding students' ideas). Both activities were enriched by the body of literature presented in Section 2.1.

### 2.3.2 Video – A Tool in Effective Teacher Professional Development

Research has shown that changes in teacher learning are more likely if teachers recognize improvement in their students' learning resulting from their newly implemented practices (Guskey, 2002; Opfer, Pedder, & Lavicza, 2011). A promising tool to make such changes in practice visible and reflect on them is video (e.g., Borko, Jacobs, Eiteljorg, & Pittman, 2008). Video excerpts can illustrate a rich pool of (new) teaching techniques and allow teachers to better understand their students' thinking by watching colleagues' videos (Sherin & Han, 2004). Video allows for connections to teachers' daily routines and opportunities for active and collaborative learning, both of which are important aspects of successful TPDs (Opfer et al., 2011; van Veen et al., 2012), and which have been proven to be effective (Borko et al., 2008; Goldman, Pea, Barron, & Denny, 2007; Santagata, 2009; Sherin & van Es, 2009; Zhang, Lundeberg, Koehler, & Eberhardt, 2011). Additionally, it gives teachers the ability to watch themselves from a distance, outside of the situation of acting in a complex classroom setting. Thus, it is regarded as a cultural tool for mediating interactions between the classroom and TPD workshop contexts (Tripp & Rich, 2012).

Besides generating evidence regarding teachers' practice changes and students' learning outcomes, the dissertation seeks to further understand how teachers learn in an evidence-based program, such as the DVC, and reflect on the role of video and their professional needs, which have been acknowledged as important sources to improve TPD creation (Mansour, Heba, Alshamrani, & Aldahmash, 2014). Therefore, the videotaped TPD workshops as well as the teachers' reflections on the newly designed program seemed to be another valuable data sources and were, therefore, qualitatively examined in Essay 1.

# 3 Project Context – DIALOGUE

As described above, the dissertation was conducted within the DIALOGUE[1] project which integrated the two illustrated current research strands, *classroom dialogue* and *teacher professional development*. Along with its standalone framework, the dissertation focused on the impact of the DVC on teachers' learning, reflections, and practices, as well as students' practices, perceptions and the impact of preconditions.

## 3.1 Research Design

In order to expand the perspective of research regarding effective TPD, the DVC as a program (which explicitly refers to effective components) was compared to a rather traditional approach of TPD (Richter et al., 2011). We called the second program the 'advanced traditional program' (ATP) because of a continuous parameter: participating teachers took part in a set of common workshops on classroom communication and additionally met in "roundtables" with the facilitator of the DVC. Along this conceptualization, teachers who participated in the DVC served as the intervention group (IG), teachers of the ATP as a control group (CG). Both programs are described in more detail in the following and are illustrated in Figure 2.

### 3.1.1 The Dialogic Video Cycle (DVC)

The IG teachers participated in a TPD with two iterations of the DVC, with each cycle including three workshops and one video recording of the teachers' lessons. The central topic of the year-long intervention was "productive classroom dialogue." As mentioned above, Walshaw and Anthony's (2008) activities 1 and 2 served as the basis for each cycle. In Workshop 1, the teachers first received input on productive classroom dialogue from the facilitator and learned about the importance of scaffolding students' ideas and activating students to engage in the learning processes. The teachers learned, for example, about the importance of asking open-ended questions, which allow students to elaborate on their knowledge and, therefore, engage in the learning process. Additionally, they received input on the importance of scaffolding students' elaborations by using the feedback tool. After receiving theoretical input, the teachers were asked to adapt concrete facets of student activation and scaffolding into a lesson plan that each of them had brought to the workshop. The teachers were then videotaped by the research team while they taught the lesson they had revised in the workshop. The facilitator chose video excerpts on the basis of the criteria of

[1] funded by a research grant from the German Research Foundation (SE 1397/5-1)

productive classroom dialogue – the elements that the teachers had identified at the beginning of the DVC – and prepared them as a basis for teacher reflections in Workshops 2 and 3 (Gröschner et al., 2014b).

Workshop 2 of each cycle focused on student activation and clarifying discourse participation rights (activity 1), whereas Workshop 3 focused on scaffolding student ideas and feedback (activity 2). In both workshops, participating teachers watched selected clips, clarified questions about productive classroom dialogue, and jointly reflected on their experiences. In Workshop 2, teachers concentrated on reflecting on those teaching routines that activate students to engage in the learning process, whereas Workshop 3 focused on scaffolding students' learning. Again, teachers reflected on, for example, the importance of fostering students' productive engagement in classroom dialogue, as well as scaffolding their students' learning processes by, for example, productive feedback. The facilitator posed guiding questions to support the teachers' reflections (e.g., which teacher strategies to promote student activation are discernible in the video clip?). The second iteration of the DVC followed the same course of action.

### 3.1.2 Advanced Traditional Program (ATP)

The teachers participating in the ATP chose a set of workshops that the research team had identified as focusing on productive classroom dialogue and that were offered by the local TPD institute. Furthermore, to establish a social community among the participants, the teachers met twice in roundtables provided by the same facilitator as in the IG to share their experiences in the different courses they had previously visited. The teachers were encouraged to exchange ideas regarding how they had experienced the central aspects of productive classroom dialogue. Due to the lack of video as a central intervention tool, the teachers neither reflected on their own teaching routines nor actively learned by watching their own or others' teaching.

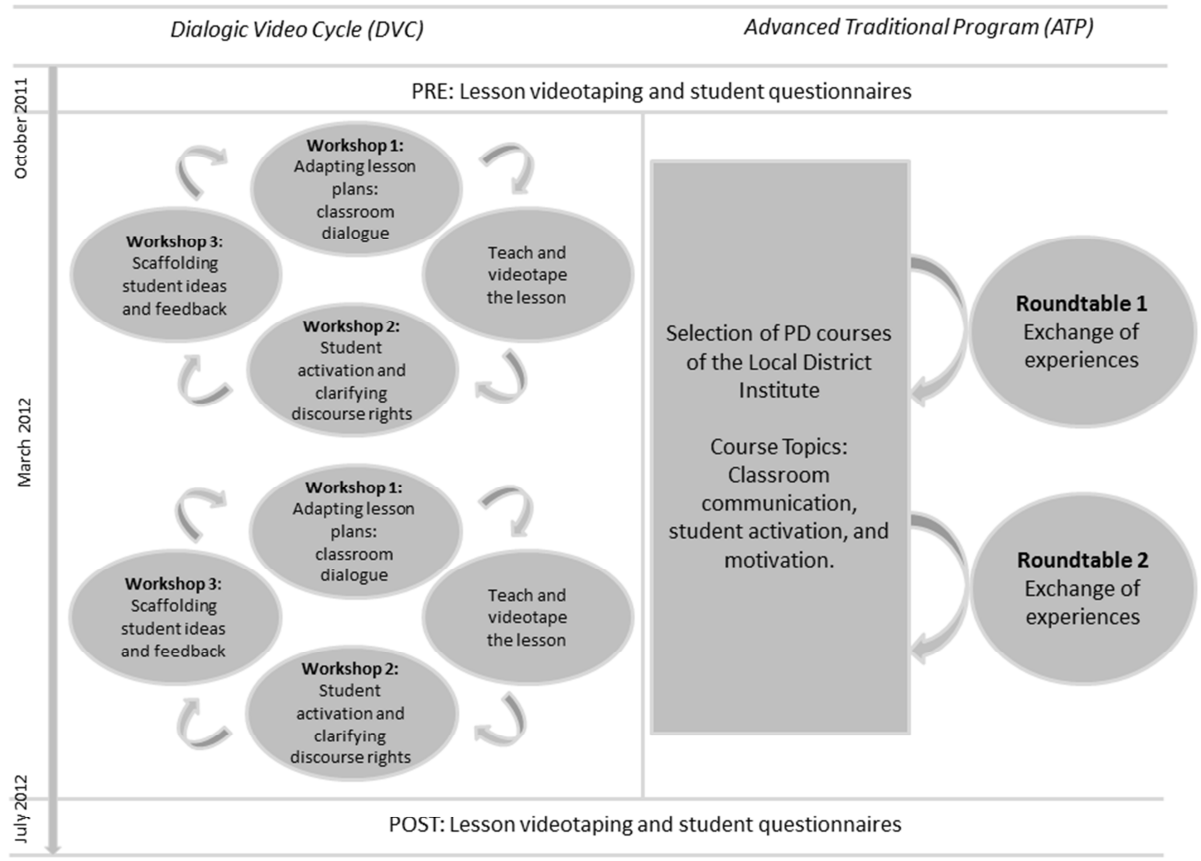


**Figure 2: Overview of TPD offerings**

### 3.1.3 Treatment Implementation

To examine the extent to which the two different treatments provided options for professional teacher learning, a feasibility study was implemented (Gröschner et al., 2014a). Two independent, trained coders rated the videotaped DVC workshops and the roundtables with regard to the implementation of effective components. The raters agreed that a pedagogical focus (i.e., on classroom dialogue), comparable duration (22 h), and coherence were fully implemented in both programs. Opportunities for collective participation and exchange were fully observed in the DVC, but were also observed (to a smaller extent) in the roundtables. Active learning and reflection of teaching practice were only observed in the DVC workshops. Moreover, aspects of concrete lesson planning and video-based reflection were only implemented in the DVC workshops (Gröschner et al., 2014a). The feasibility study served as an important requirement to ensure that both programs varied systematically (for variation overview see Table 1). Detailed findings are further described in Gröschner et al., 2014a, which served as an important suppositional publication for the dissertation.

**Table 1: Treatment implementation**

| Component of effective TPD | DVC | ATP |
|---|---|---|
| *Content focus* | + | + |
| *Duration (22 h)* | + | + |
| *Coherence* | + | + |
| *Collective participation and exchange* | + | 0 |
| *Active learning and reflection* | + | - |
| *Lesson planning* | + | - |
| *Video-based reflection* | + | - |

Note: + fully implemented; 0 partly implemented; - not implemented

## 3.2 Sample

### 3.2.1 Focus of Essay 1: Teacher sample

The teacher sample was recruited through an announcement at the local TPD institute and the university correspondence school network. Teachers chose whether to participate in the DVC (IG) or the ATP (CG). In the first meeting, the teachers were briefed on the two different programs. They knew the programs would have the same duration and content, but would differ according to whether or not the video would be used as a tool for reflecting on one's own classroom dialogue practice, or as a committed group of practitioners who would meet regularly in workshops to plan and reflect on their individual practices. This procedure allowed teachers who were reluctant to participate in a video-based TPD to avoid it (Fishman, Marx, Best, & Tal, 2003). The teachers did not know which program would serve as the intervention or control condition. Six teachers opted for the DVC and four teachers chose the ATP. The teachers in both groups did not differ ($U$ = 7.00, $z$ = −1.14, $p$ = .25) in their motivation to learn about productive classroom dialogue (four-point Likert scale) during their participation in the DVC ($M$ = 3.51, $SD$ = .47; $M_{Rank}$ = 4.67) or the ATP ($M$ = 3.81, $SD$ = .38; $M_{Rank}$ = 6.75). Furthermore, to prevent any effects from systematic variation in teachers' characteristics, teachers in both the IG and CG were compared beforehand. The teachers in both groups did not significantly differ in either age or teaching experience. No significant differences were found in gender or the chosen subject (either math or science) for the TPD between the IG and the CG (see Table 2).

**Table 2: Teacher sample**

| | IG ($n$ = 6) | | | CG ($n$ = 4) | | | Mann-Whitney Test | | |
|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *Mean Rank* | *M* | *SD* | *Mean Rank* | *U* | *z* | *p* |
| Age [years] | 39.5 | 5.43 | 6.25 | 36.5 | 6.03 | 4.38 | 7.5 | −.97 | .33 |
| Teaching Experience [years] | 4.67 | 2.94 | 4.50 | 7.13 | 2.52 | 7.00 | 6.0 | −1.30 | .20 |
| | | | | | | | Chi square | | |
| | *n* | *n [%]* | | *n* | *n [%]* | | $\chi$ | *df* | *p* |
| Gender | | | | | | | .08 | 1 | .78 |
| *Male* | 2 | .33 | | 1 | .25 | | | | |
| *Female* | 4 | .66 | | 3 | .75 | | | | |
| Subject for TPD | | | | | | | .63 | 1 | .43 |
| *Math* | 3 | .50 | | 1 | .25 | | | | |
| *Science* | 3 | .50 | | 3 | .75 | | | | |

To better understand how teachers transferred their new knowledge regarding students' higher-order learning within classroom dialogue to their individual classrooms (Buczynski & Hansen, 2010; Van den Bergh, Ros, & Beijaard, 2015; Vescio et al., 2008), individual practice changes as well as qualitative excerpts of individual participants were analysed. Therefore, Table 3 gives an overview of individual teachers' characteristics:

**Table 3: Individual teachers' characteristics**

| Teacher pseudonym | PD program | Age [years] | Gender | Teaching experience [years] | Subject in the PD* | Secondary level** |
|---|---|---|---|---|---|---|
| Sarah | IG | 39 | F | 10 | Math | High |
| Marc | IG | 45 | M | 4 | Math | Low |
| Laura | IG | 33 | F | 2 | Physics | Low |
| Caroline | IG | 44 | F | 5 | Physics | High |
| Lucy | IG | 33 | F | 2 | Math | High |
| Thomas | IG | 43 | M | 5 | Math | Low |
| Peter | CG | 43 | M | 10 | Physics | High |
| Susan | CG | 30 | F | 4 | Math | High |
| Helena | CG | 33 | F | 7 | Biology | High |
| Karin | CG | 40 | F | 8 | Physics | High |

Note: *Lower and higher secondary teachers in Germany usually study and teach two subjects. Due to international contextualization, throughout the dissertation it is referred to "Science" for the subjects "Physics" and "Biology"; **In Bavaria (Southern Germany), students are tracked after primary education according to their achievement level

### 3.2.2 Focus of Essay 2: Student sample

Because the teachers were free to choose one of the two TPD conditions, the numbers of students in the IG and the CG differed (IG: $n_{teachers}$ = 6, $n_{students}$ = 136; CG: $n_{teachers}$ = 4, $n_{students}$ = 90). The two student groups differed slightly in age ($t$ (224) = 5.20, $p$ = .00, $d$ = .71)

and gender ($\chi$ = 8.94, *df* = 1, *p* = .00); thus, both variables were accounted for as covariates in the analysis regarding students' perceptions of situational learning processes and cognitive elaboration strategies. To prevent any potential problems with internal validity, both groups were checked for pre-test differences in both dependent variables. Pre-test differences could not be determined for either situational learning processes, *t* (193.16) = −1.48, *p* = .14, nor for cognitive elaboration strategies, *t* (203) = .25, *p* = .80 (see Table 4).

For the second research question in Essay 2, the median for students' domain-specific self-concept of ability when entering the study was identified ($m_{\text{initial level}}$ = 2.02). Along this median, students were grouped into low and high initial self-concept of ability. Gender and age served as covariates to offset the significant differences between the IG and the CG groups in both initial levels (see Table 4). Again, tests for systematic differences in the pre-test measurements for both dependent variables were applied. For students who initially had a high self-concept of ability, no group differences in either situational learning processes (*t* (79.59) = −.46, *p* = .65) or cognitive elaboration strategies (*t* (87) = −.04, *p* = .97) could be detected. For students who initially had a low self-concept of ability (see Table 4), a difference appeared in the situational learning processes (*t* (112) = −1.96, *p* = .05, *d* = .38), but not in the cognitive elaboration strategies (*t* (114) = .14, *p* = .88).

**Table 4: Student sample**

| | IG | | | CG | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Chi square | | | |
| | *n* | *n [%]* | | *n* | *n [%]* | | $\chi$ | *df* | *p* | |
| Gender [female] | | | | | | | | | | |
| *Whole sample* | 54 | .40 | | 54 | .60 | | 8.94* | 1 | .00 | |
| *Low initial level* | 34 | .49 | | 32 | .68 | | 4.03* | 1 | .05 | |
| *High initial level* | 15 | .27 | | 18 | .55 | | 6.86* | 1 | .01 | |
| | | | | | | | *t*-Test | | | |
| | *n* | *M* | *SD* | *n* | *M* | *SD* | *t* | *df* | *p* | *d* |
| Age | | | | | | | | | | |
| *Whole sample* | 136 | 15.41 | .98 | 90 | 16.07 | .85 | 5.20* | 224 | .00 | .71 |
| *Low initial level* | 69 | 15.48 | 1.00 | 47 | 16.28 | .85 | 4.45* | 114 | .00 | .86 |
| *High initial level* | 56 | 15.27 | .90 | 33 | 15.79 | .78 | 2.75* | 87 | .01 | .61 |
| Pre $_{\text{Sit. learning processes}}$ | | | | | | | | | | |
| *Whole sample* | | 1.96 | .45 | | 2.05 | .35 | -1.48 | 193.16 | .14 | |
| *Low initial level* | | 1.79 | .39 | | 1.96 | .48 | -1.96 | 112 | .05 | .38 |
| *High initial level* | | 2.14 | .45 | | 2.18 | .34 | -.46 | 79.59 | .65 | |
| Pre $_{\text{Cog. elab. strategies}}$ | | | | | | | | | | |
| *Whole sample* | | 1.40 | .62 | | 1.36 | .55 | .25 | 203 | .80 | |
| *Low initial level* | | 1.28 | .53 | | 1.24 | .53 | .14 | 114 | .88 | |
| *High initial level* | | 1.53 | .69 | | 1.54 | .53 | - .04 | 87 | .97 | |

Note: * $p \leq .05$

## 3.3 Data collection and analysis

Data collection took place in the school year 2011/2012. As color-coded in Figure 3, different data served as sources to examine the five research questions along the framework within the two essays.

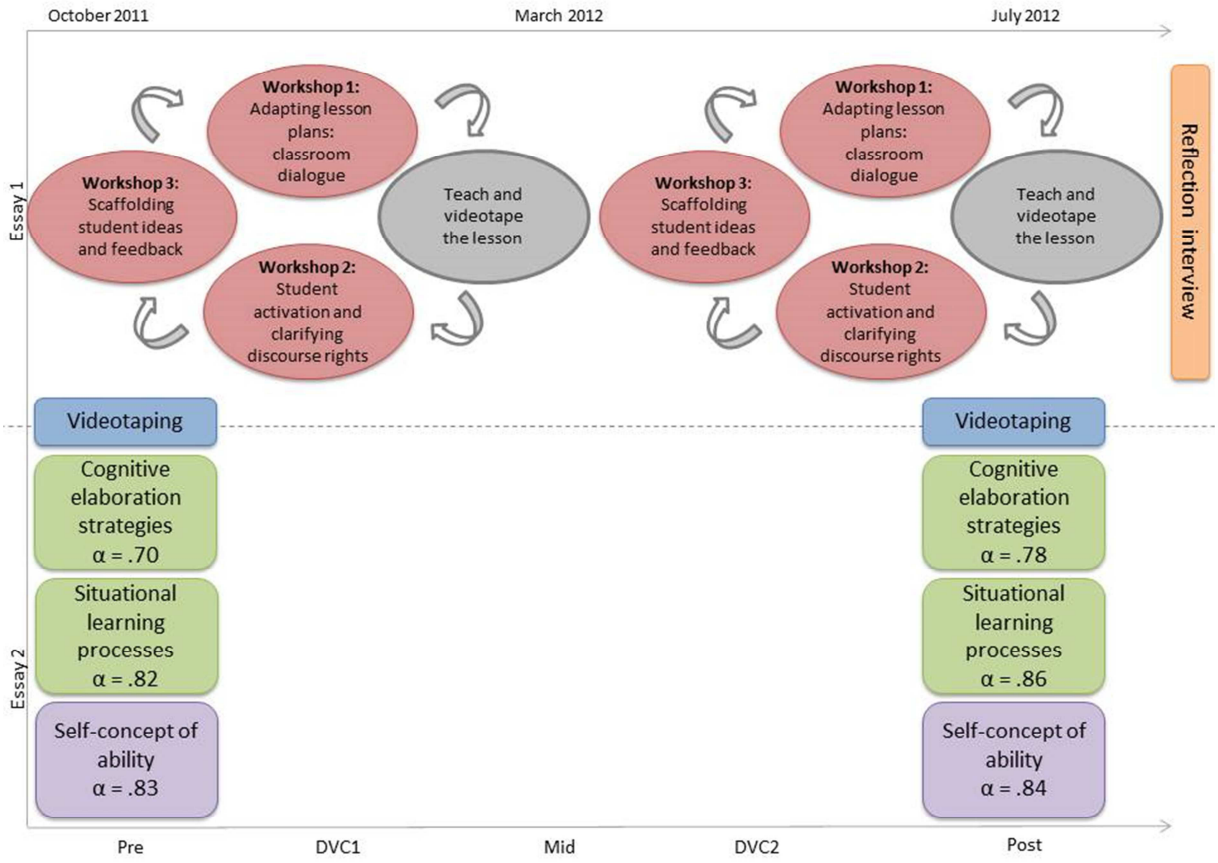


**Figure 3: Overview of data collection (color-coded according to the framework)**

### 3.3.1 Essay 1

***Data collection***

Also illustrated in Figure 3, data regarding teacher and student practices were obtained by videotaping the IG and the CG teachers' lessons at the beginning (pre) and the end (post) of the school year. For an additional illustration of teacher learning, which was the second focus of Essay 1, workshops of both iterations of the DVC were filmed. Regarding teacher reflection on the DVC as a professional learning opportunity, the IG teachers were videotaped at the end of the study for a short interview.

***Data analysis***

All video codings related to teachers' classroom practices were determined by five independent raters using the Videograph software (Rimmele, 2002). The raters were trained using video material that came from the same study but was excluded from the final data analysis. To examine research question (a) and (b), all videos of classroom lessons were first sub-divided into speaker turns (i.e., teacher, student, and no speaker) based on the event-sampling method (Bakeman, 1997). Low-inference coding systems were then developed by applying disjunct categories (see Table 5) based on previous video studies (Seidel, Prenzel, Duit, & Lehrke, 2003) and the literature review, which allowed for the analysis of elements of productive classroom dialogue, as they related to teachers' questioning and feedback and student answers (Pehmer, Kiemer, & Gröschner, 2014). Therefore, each instance of a teacher talking (i.e., teacher talking turn) was first coded in terms of whether the teacher was providing feedback or asking a question, independent of the instance's level. Subsequently, each teacher question was coded in relation to its level of fostering, and each teacher feedback was coded based on its level of scaffolding. According to this same procedure, each instance of a student talking was coded based on the level of the student answer. The described procedure of coding pre-set talking turns according to the levels of the questions, answers and feedback allowed for the quantification of a qualitative video analysis (Schümer, 1999). Since the study focused particularly on classroom dialogue, only talking units in classroom dialogue were considered in the first study's analysis. Both kappa and direct consensus calculations reached satisfactory levels and are presented in Table 5.

All video codings presented in Table 5 were aggregated on the class level. The absolute data were then translated into relative data. This procedure allowed for comparing variations in the total times of the recorded lessons and to calculate, for example, the number of teacher questions in relation to the total number of teacher statements. For the teacher statements, data analysis using frequencies were performed. For the students' statements, however, it was focused on the length of the statements in order to examine their elaborations. Therefore, the durations of student statements were used in the data analysis.

For research question (a) of each component of the I-R-F, and with regard to the sample size of teachers, non-parametric variance analyses for longitudinal comparisons of the two groups were applied in *R* (R Core Team, 2013), using relative data at the cognitive level of teacher questions and student answers, as well as at the level of teacher feedback. To

facilitate deeper insight into individual changes in teaching practice (b), the relative data for each IG teacher pre- and post-intervention were illustrated using descriptive curves.

To select illustrative comments that underlie the findings (research question (c)), the videotaped IG workshops ($n$ = 6, each approximately 2 h) were screened, and relevant statements addressing aspects of teacher questioning and feedback, as well as student elaborations, in classroom dialogue were transcribed.

To provide further insights into the DVC's role as a professional learning opportunity related to effective components of TPD (research question (d)), teachers' reflection interviews were further screened with a focus on the teachers' implementations of gained knowledge and on the discursive tools applied to the DVC, the role of video, and the exchange among teacher colleagues.

**Table 5: Video codings regarding teacher and student classroom practice**

| Element of TPD program | Unit of analysis* | Categories | Example | Cohen's Kappa** | Direct consensus [%] |
|---|---|---|---|---|---|
| **Preliminary work** | | | | | |
| Speaker turn | --- | • teacher<br>• student<br>• no one/other | | | 98.1*** |
| Classroom setting | T & S | • classroom discourse****<br>• group/partner/single student work | | | 85.7*** |
| **Activity 1** | | | | | |
| I: Productive initiation: Level of teacher question | T (frequency) | • No question | | .79 | 89.7 |
| | | • Fostering reproduction of knowledge | "What was the mathematical sentence of last lesson starting with a C?" | | |
| | | • Fostering elaboration of knowledge | "How can you manage to increase the picture on the screen?"<br>"What is the explanation for your finding?" | | |
| R: Productive response: Level of student response | S (duration) | • Reproduction of knowledge | "Sentence of Cavaleiri" | .68 | 79.9 |
| | | • Elaboration of knowledge | "First of all I labeled the diagram, next I drew the curve. The numbers I got from the table" | | |
| **Activity 2** | | | | | |
| F: Productive follow-up: Level of teacher feedback | T (frequency) | • No feedback | | .68 | 82.2 |
| | | • Feedback on task | "Yes", "No", "Right", "Wrong" | | |
| | | • Feedback on learning processes | "Think again, what does the 4 and the 2 tell us." | | |
| | | • Feedback on self-regulation | "I know that in the test you will be able to manage the task." | | |

* T = Teacher statement; S = Student statement. ** 784 units of analysis. *** Only direct consensus can be reported because each rater set up own speaker turns to validate whether all raters would agree on the same amount of talking units in a video; for Kappa calculations video material with pre-set speaker turns by one person is needed. **** Only elements of setting "classroom discourse" are included in the analysis

### 3.3.2 Essay 2

***Data collection***

As illustrated in Figure 3, data for Essay 2 were collected in the same lesson as the videotaping by student questionnaires. This procedure allowed for the connection of both studies.

*Math or science self-concept of ability (students' precondition):* Since the TPD intervention was focused on productive classroom dialogue in mathematics and science teaching, math or science self-concept of ability was measured. The scale used for this study was originally developed for the PISA study and included three items (e.g., "In mathematics/science I am a fast learner") scoring on a four-point Likert scale (Ramm et al., 2006). At both the pre- and post-test, the scale showed a good reliability of $\alpha_{pre}$ = .83 and $\alpha_{post}$ = .84.

*Situational learning processes (students' perceptions):* Students were asked about their situational learning processes during instruction directly after a lesson with their teacher. The instrument included 14 items and were scored on a four-point Likert scale (Seidel, Prenzel, & Kobarg, 2005). The larger number of items was due to the multifaceted character of situational learning processes and comprised items reflecting basic processing ("I was able to follow the lesson the whole time"), elaborating ("I had a lot of ideas concerning the topic"), and organizing ("I was aware what was more or less important"). The scale had good reliability at both the pre- and post-tests ($\alpha_{pre}$ = .82 and $\alpha_{post}$ = .85).

*Cognitive elaboration strategies (students' perceptions):* To examine more stable and enduring aspects of higher-order learning, students were asked what kind of cognitive elaboration strategies they applied during instructions. The cognitive elaboration strategy scale included five items (e.g., "I try to understand new things better by connecting them to things I already know") that were rated on a four-point Likert scale (Ramm et al., 2006), the reliability of which was satisfactory ($\alpha_{pre}$ = .70, $\alpha_{post}$ = .78).

***Data analysis***

In order to determine changes in the students' perceived higher-order learning, differences were calculated from post- to pre-test scores (Δ post/pre-processes, Δ post/pre-strategies). The two different scores served as dependent variables for analysis of covariance (ANCOVA) with a differentiating factor between treatment groups (IG and CG). Student

gender and age served as covariates (see Section 3.2.1). The significance level for all analyses was $p \leq .05$.

# 4 Contributions of the Two Studies to the Dissertation Objectives

## 4.1 Fostering and Scaffolding Student Engagement in Productive Classroom Dialogue: Teachers' Practice Changes and Reflections in Light of Teacher Professional Development (Essay 1)

Essay 1 was submitted to the journal, *Learning, Culture and Social Interactions*, and accepted for publication in May 2015. Conception, preparation, analysis, and the publication-based presentation were fulfilled in the context of this dissertation and implemented in Essay 1 (80%). The originating process, the preparation, and the presentation of the essay were advised by both co-authors (Alexander Gröschner 15%; Tina Seidel 5%).

Pehmer, A.-K., Gröschner, A., & Seidel, T. (2015). Fostering and scaffolding student engagement in productive classroom dialogue: Teachers' practice changes and reflections in light of teacher professional development. *Learning, Culture and Social Interactions.*

As stated within the research desiderata, classroom dialogue is an extensively investigated learning setting with regard to its structure (Howe & Abedin, 2013), but seldom with regard to its changeability. The DVC aimed to support teachers in changing their questioning and feedback to foster and scaffold students' elaborations. With regard to the investigation of its impact, it was therefore a major aim to examine changes in teacher and student classroom practices. Vescio et al. (2008) state in this context that purposefully designed programs are more likely to positively impact teachers' classroom practices. The DVC was designed by implementing concrete components of effective TPD (Desimone, 2009). Especially, a constant community of learners whereby a longer duration forms an important basis is emphasized as relevant for successful teacher learning (van Es, 2012). Still, there is no consensus regarding the optimal length of a successful TPD (Lauer, Christopher, Firpo-Triplett, & Buchting, 2014), but promising approaches have worked with teachers throughout a longer – partly extensive – period (Borko, 2004). The DVC with its duration of 22 hours within one academic year served as a new approach in the German context where TPD often takes place in a single afternoon's workshop setting (Richter et al., 2011). Also video-based feedback on concrete, teaching techniques has shown to support teachers (Santagata, 2009; Sherin & van Es, 2009) and is, therefore, assumed to be a tool that fosters teacher learning within the DVC.

Other TPDs in the context of classroom dialogue, such as “Accountable Talk” (Michaels et al., 2008) which equip teachers with concrete talk moves, report successful knowledge transfer to teachers’ classroom practices, but emphasize the energy teachers constantly needed to apply in order to establish the new dialogic setting. They emphasize that both the teacher and the students have to get used to new forms of communication which is not always the case. Such findings are backed by other literature which emphasizes that teachers might face challenges and individual barriers to their learning (Molinari & Mameli, 2013), as well as the individuality of classrooms for the implementation of new knowledge (van den Bergh et al., 2014). In order to better understand these barriers, teachers’ individual attitudes towards TPD can provide valuable insights and help to understand their individual needs (Mansour et al., 2014).

Therefore, the first study of this dissertation aimed to expand the field of research on classroom dialogue with regard to its changeability. To the field of research on effective TPDs, the present study adds by examining changes in teachers’ practices both by a systematic approach (comparison of DVC which served as IG and ATP which served as CG), but also individual analyses. For a comprehensive picture of the DVC’s impact, the study throws light on teachers’ learning within the DVC and their reflection on the program with regard to its potential for professional teacher learning. Concretely, the following research questions and hypotheses were derived from the presented body of literature and are to be embedded in the first three columns of the overall framework of the dissertation.

The study addressed four research questions. Research questions (a) through (c) were formulated in a general manner and were explored separately for each component of the I-R-F pattern.

*(a) Aggregated practice analysis: To what extent do the different treatments (i.e., DVC and ATP) support teachers in changing their practices in classroom dialogue?*

Hypothesis 1a Level of teacher questions (I): It was conjectured that the DVC provided more learning opportunities than the ATP and therefore support IG teachers better in changing relative frequency of questions that foster the elaboration of knowledge.

Hypothesis 2a Level of student responses (R): Accordingly, it was hypothesized that the relative duration of students’ elaborations of knowledge increases in the IG.

Hypothesis 3a Level of teacher feedback (F): We expected changes in the IG teachers' relative frequency of feedback on learning processes and feedback on self-regulation to increase, whereas relative frequency of feedback on tasks was expected to drop.

*(b) Individual practice analysis: How does the individual practice of each teacher in the IG change throughout the academic year?*

Hypotheses 1b–3b: Due to each classroom being a very unique context, it is hypothesized that different teachers implement components of classroom dialogue (I, R, F) differently.

*(c) Teacher learning analysis: What teacher discussions from the DVC workshops help to illustrate the findings on teacher practice?*

Since (c) and also (d) provide in-depth knowledge on teacher learning in the DVC, both research questions are more exploratory; therefore, no hypotheses were formulated.

*(d) Reflection analysis: What specific role do teachers attribute to the DVC as a professional learning opportunity based on effective components of TPD?*

Results were generated through the video-coding procedure and screening of the DVC workshops and teacher reflection interviews as described in Section 3.3.1.

Contrary to hypotheses 1a and 2a, the non-parametric ANOVA showed that teachers in the IG ($n$ = 6) neither significantly changed their questions to a level which fosters students' elaborations, nor did their students elaborate more on their knowledge. The CG ($n$ = 4) teachers showed a decrease in both aspects. Furthermore, the CG teachers asked fewer questions to foster students' elaborations; accordingly, there were fewer student elaborations at the end of the school year. In keeping with hypothesis 3a, the IG teachers showed significant changes regarding their level of feedback. Teachers in the IG, thus, provided their students with significantly more feedback on learning processes and self-regulation at the end of the academic year. In contrast, the CG group members stagnated at the level at which they entered the ATP.

The findings related to research question (b) confirmed the hypothesis that teachers' changes in practice seem to differ for individual teachers. At the level of teacher questions and student answers, a rather heterogeneous change for the six participating teachers was shown. Three teachers positively developed their questioning behaviours, whereas three teachers showed a decrease in their practice during the academic year. Students' development

was according to the individual classes: teachers who positively changed their questioning triggered their students for more elaborations and vice versa. In contrast, changes related to the level of feedback were more homogeneous and changed, except for one teacher, in similar ways towards more feedback on learning processes and self-regulation.

The extracted discussions (for detailed excerpts see 5.1.3, 5.2.3, and 5.3.3 of Essay 1 in Supplement A) revealed a kind of uncertainty whether questions are a tool for activating students and if opening up questions for students' elaborations means moving away from a controlled lesson script. With regard to student elaborations, the qualitative teacher discussion revealed that rich student elaborations are not yet part of learning environments, but that teachers see the need for it. The last excerpt gave an insight that teachers considered feedback a relevant guiding tool for students' engagement in deep thinking processes.

In their reflection interviews (for detailed excerpts see 5.4 of Essay 1 in Supplement A), teachers highlighted the community of learners as appreciating, encouraging, and inspiring. Additionally, they emphasized the role of immediate feedback about their teaching practice – which was possible through the use of video – as essential for their professional learning.

To sum up, the first study revealed knowledge about the impact of an evidence-based TPD with regard to changes in classroom practices, teachers' learning, and teachers' reflections:

- ✓ On an aggregated level, the DVC – compared to the ATP – showed to be effective with regard to teachers changing their scaffolding behavior by providing more feedback on students' learning processes and self-regulation in classroom dialogue.
- ✓ Analysis of individual practice changes revealed that the implementation of new knowledge about classroom dialogue in the classroom varies for individual participants.
- ✓ Qualitative excerpts of teachers' learning in the TPD as well as reflections on the TPD provide an informative insight into teachers' constraints and needs and should, therefore, be considered for the conceptualization of future TPD offers.

## 4.2 How Teacher Professional Development regarding Productive Classroom Dialogue Affects Students' Higher-Order Learning (Essay 2)

Essay 2 was submitted to the journal, *Teaching and Teacher Education*, and published in April 2015. Conception, preparation, analysis, and the publication-based presentation were fulfilled in the context of this dissertation and implemented in Essay 2 (75%). The originating process, the preparation, and the presentation of the essay were advised by both co-authors (Alexander Gröschner 15%; Tina Seidel 10%).

Pehmer, A.-K., Gröschner, A., & Seidel, T. (2015). How teacher professional development regarding classroom dialogue affects students' higher-order learning. *Teaching and Teacher Education*, 47, 108-119. http://dx.doi.org/10.1016/j.tate.2014.12.007

The overall goal of TPD is to improve student learning. Therefore, when investigating the effectiveness of TPD, student learning outcomes should be considered (Desimone, 2009). Thus far, systematic approaches regarding TPD effectiveness also with regard to a program's impact on students' learning are either rare or null findings are reported (Osborne et al., 2013). Besides observable, external learning activities such as students' responses, internal learning activities are another outcome variable which should be considered. In the context of classroom dialogue, it was claimed that studies mostly investigate the impact of classroom dialogue on student achievement (Howe & Abedin, 2013). Students' positive perceptions of higher-order learning are relevant for developing a deep and sustainable understanding of content (Donovan & Bransford, 2005). Higher-order learning is composed of *situational learning processes* which capture students' situational processing, elaborating, and organizing of knowledge (e.g., de Corte et al., 2003) and *cognitive elaboration strategies* which are more enduring and stable (Vermunt & Verloop, 2000). From a theoretical perspective, but not yet investigated, it can be assumed that productive classroom dialogue which fosters and scaffolds students' elaborations impacts both facets of higher-order learning. Through, for example, teacher feedback on learning processes, a positive impact on students' organization of knowledge could be expected as through scaffolding learners are supported in the reorganization of their knowledge (Dawes, 2004). Therefore, the second study of the dissertation explored, again in a systematic longitudinal control-group design, how the DVC would impact students' situational learning processes and cognitive elaboration strategies. When investigating the impact of a program such as the DVC, differing effects regarding the perceptions of higher-order learning should be assumed for students with different preconditions as they are known to be highly influential (Corno & Snow, 1986). A program

such as the DVC in which teachers concretely work on their own teaching practice within one class with whom they participated in the study might have a different impact on students' with differing preconditions. In the context of classroom dialogue, students' self-concept of ability has been shown to be relevant with regard to the students' engagement and persistence in the learning process (Jurik et al., 2013). Therefore, the additional aim of the second study was to investigate the expected differential effects for student sub-samples (low and high self-concept of ability)

Concretely, the following research questions and hypotheses were deduced from the presented body of literature and investigate the fourth and fifth column of the framework of the dissertation. Numbering of the hypotheses differs from the original numbering in Essay 2 (Supplement B) to allow for coherent numbering within this dissertation.

*4. Do students of teachers who participate in a video-based intervention (IG) on classroom dialogue perceive positive changes in their situational learning processes and cognitive elaboration strategies in comparison to students of teachers in a CG?*

Hypothesis 4: It was expected that students of teachers in the IG to benefit from the intervention and show positive developments in their perceived situational learning processes and cognitive elaboration strategies. Positive changes were expected because of their teachers' participation in the DVC, which provided learning and reflection opportunities on components of teaching that activate and scaffold students' higher-order learning. For students of teachers in the CG, no changes were assumed between pre- and post-tests because their teachers took part in a program that provided exchange rather than active learning and reflection opportunities.

*5. Do students with different levels in their self-concept of ability benefit differently from video-based intervention (IG) compared to those in the CG in their situational learning processes and cognitive elaboration strategies?*

Hypothesis 5: Different effects for students with a low and high self-concept of ability were assumed. Students with a low self-concept of ability were predicted to profit most from the intervention on situational learning processes (hypothesis 5a). Students with a high self-concept of ability already possess strong situational learning processes due to their known favorable learning engagement and persistence, but were predicted to profit from more enduring and intentional use of cognitive elaboration strategies (hypothesis 5b). As in research question 4, no changes were predicted for the CG.

Both the IG ($n$ = 126) and the CG ($n$ = 90) student samples (for detailed sample descriptions, see 3.3.2) were investigated by a four-point Likert scale on their situational learning processes (scale based on Seidel et al., 2005), cognitive elaboration strategies (scale based on Ramm et al., 2006) and math or science self-concept of ability depending on the subject the class participated with (scale based on Ramm et al., 2006). Questioning of students happened in the same lesson as the videotaping. As described in Section 3.3.2, post-pre differences of situational learning processes and cognitive elaboration strategies served as dependent variables for each ANCOVA, applying treatment (IG and CG) as the differential factor. Gender and age served as covariates due to significant differences for both treatment groups (see Table 4). Regarding the fifth research question, the same procedure was applied for sub-samples of students with low vs. high initial levels of their self-concept of ability. Sub-samples were generated along the median $m$ = 2.02.

Results regarding research question 4 (see also Figure 4) revealed that students benefited significantly from the DVC in both their situational learning processes and cognitive elaboration strategies (hypothesis 4 was confirmed). Students' perceived situational learning processes stayed at a medium to positive level throughout the one-year intervention, whereas the levels of students in the CG decreased. The IG students' perceptions of cognitive elaboration strategies improved, while students in the CG again reported slightly worsening perceptions at the end of the school year.

An investigation of research question 5 showed that IG students who entered the study with a low self-concept of ability significantly improved their situational learning processes (hypothesis 5a confirmed). The DVC was also positively connected to the use of cognitive elaboration strategies in students who reported a high self-concept of ability level. Here, IG students tended to show an increase in their perceptions (hypothesis 5b partly confirmed).

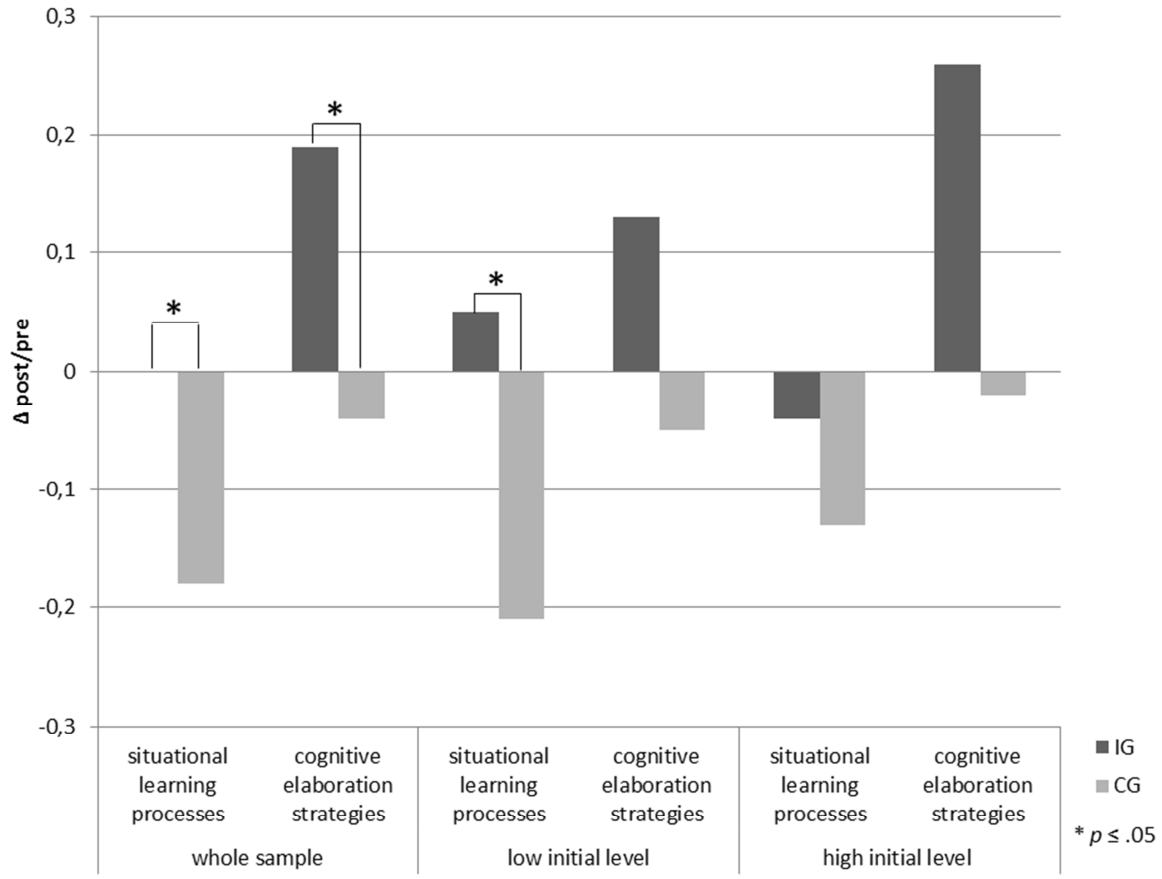


**Figure 4: Changes of students' perceived higher-order learning**

To sum up, the second study complemented the dissertation with regard to students' perceived learning outcomes:

- ✓ As a consequence of their teachers' participation in the DVC, IG students improved their higher-order learning.
- ✓ More specifically, the DVC showed to be particularly beneficial for students with a lower self-concept of ability.
- ✓ Therefore, teachers' participation in TPD based on effective teaching components and addressing relevant aspects of teachers' daily routines, such as classroom dialogue, can be an important tool in supporting student learning in STEM subjects.

# 5 Discussion

## 5.1 Discussion of Central Results

Based on the research desiderata stated in Sections 1.1 and 1.2, the dissertation aimed to contribute to the field of research on classroom dialogue as well as effective teacher professional development (TPD). Along with the framework presented in Section 1.3, it intended to examine how the Dialogic Video Cycle (DVC) as a TPD which considered both research streams, *classroom dialogue* and *effective TPD,* impacted the different elements of a causal chain in TPD (Desimone, 2009): *teachers' learning in the DVC workshops, teachers' and students' changes in classroom practices* and *students' classroom perceptions* of their higher-order learning. To acknowledge potential differential effects with regard to *students' preconditions,* these were considered by means of their math or science self-concept of ability when investigating treatment effects. *The teachers' reflections of the DVC,* as a professional learning opportunity, were integrated as a mediating column between the teachers' learning and practices.

Regarding the five columns of the framework, the data sources were investigated based on the following intentions: first, it aimed to contribute to the demand for more research on TPD effectiveness (e.g., Osborne et al., 2013) by examining treatment effects on teachers' *practices* and students' *perceptions*. This was approached by comparing the DVC to a second treatment, the advanced traditional program (ATP). Second, teachers' learning, reflection, and practice changes need to be acknowledged as individual processes (e.g., Vescio et al., 2008), whereby individual teacher data regarding theses aspects were additionally examined.

With regard to the systematic intention, the dissertation examined how the two different treatments supported teachers in changing their practices regarding classroom dialogue. In this context, the levels of the teachers' questions and feedback, as well as the students' responses, were examined due to their relevance in classroom dialogue (Chin, 2006) and their assumed impact on students' higher-order learning. The longitudinal intervention-control group comparison revealed that the IG teachers were able to change their scaffolding behavior in favor of more feedback on students' learning processes and self-regulation (confirmation of hypothesis 3a). Against hypotheses 1a and 2a, no systematic changes of teachers' questioning and students' responses were found.

Given the partly contradictory results for the aggregated teacher sample and the acknowledgment of classrooms as individual implementation settings (van den Bergh et al., 2014), the need for further individual analysis of teacher practices as well as a qualitative examination of teachers' learning in the workshops arose.

The analysis of teachers' individual practices revealed that teachers showed a rather heterogeneous entry level as well as development with regard to their questioning behavior. The students' level of responses behaved very accordingly, which again shows the triggering character of teachers' questions for students' answers (Wragg & Brown, 2001). The DVC supported only half of the teachers in positively changing those two elements of productive classroom dialogue. In contrast, teachers entered the study with a rather homogeneous feedback behavior and also showed comparable development regarding this element of productive classroom dialogue.

For further explanation of these results, the additional qualitative analysis of teacher discussions during the workshops revealed that teachers are confronted with different challenges with regard to the instructional practices in productive classroom dialogue. Questions which foster students' elaborations mean that teachers enter a "field of unexpected responses," whereas giving feedback in a different way can be declined as a "field of controllable responses" because it involves a reaction directly from the teacher. It seems that teachers, therefore, felt more comfortable in changing this element of classroom dialogue. Student elaborations are seen as important, but hard to establish.

Integrating the systematic and individual findings regarding teachers' practices and learning could reveal that feedback as a *controllable*, *reactive* teacher behavior was changeable, whereas questions as an *initiative* teacher behavior that causes *unexpected* student behavior was not. Van den Bergh et al. (2014) report similar positive findings with regard to teachers' feedback after participating in a video-based intervention. They conclude that intensive work within a community of learners and, therefore, the interplay between one's own and colleagues' videos illustrating teaching practices, supported teachers with regard to their practice changes. The DVC as a program which had implemented comparable features (Gröschner et al., 2014a) supported teachers in a similar way. Whereas their program was primarily focused on feedback, the DVC addressed all elements of classroom dialogue. Therefore, the teachers might have been confronted with too many different aspects and seemed to have picked *feedback* as the rationale for change. Osborne et al. (2013) state in this context, "professional learning is not just a case of developing a new skill but also one of

developing a deeper understanding of the theoretical rationale of any practice" (p. 338). Here, the qualitative excerpt regarding teacher questioning – for which no significant changes could be revealed – gave an insight that one illustrated teacher was lacking a deep understanding with regard to the role of questions as an activating tool. Through the other teacher's statement, it became clear that the teachers see questions as a vital tool for efficiently navigating through lesson scripts. The qualitative excerpt showed that the implementation of new knowledge in the individual classroom, even from a purposefully designed TPD, can face barriers due to a lack of awareness of certain instructional practices (Molinari & Mameli, 2013). Especially with the complex tool of questioning, which can cause completely new teacher-student interactions (Mercer, 2010), teachers faced challenges. Therefore, teachers might need stronger support regarding this facilitation element of classroom dialogue, an aspect which will be discussed later on implications for future TPD (Section 5.3)

After examining that a lack of awareness of certain instructional qualities may partly have led to the results regarding classroom practices, the dissertation sought to further understand teachers' attitudes towards the program as they might also hinder knowledge implementation (Mansour et al., 2014; Vermunt & Endedijk, 2011). The results of the teachers' reflections provided knowledge that the DVC with its purposefully implemented learning community and video tool for immediate feedback was appreciated by the teachers, independent from their practice development. These findings are coherent with the literature which emphasizes a trustworthy and constant community of learners as an important condition in TPD (van Es, 2012). The results also reveal that teachers seek TPDs that are connected to their daily routine, and which provide feedback on their own and others' teaching techniques (Guskey, 2002).

After discussing the findings regarding the observable video data, the dissertation aimed to investigate the DVC – again based on the systematic purpose – with regard to students' higher-order learning. Assumptions that the DVC would positively affect students' perceptions could be supported by the revealed findings. In comparison to the CG students, the IG students' situational learning processes could be kept on a positive level throughout the academic year. Their cognitive elaboration strategies significantly improved, while the CG students' elaboration strategies dropped (confirmation of hypothesis 4). Additionally, differential effects of the DVC could be shown for students with a differing math or science self-concept of ability. Here, the DVC was especially beneficial for students with a low self-concept of ability with regard to their situational learning processes (confirmation of

hypothesis 5a). Students with a high self-concept of ability reported their cognitive elaboration strategies at an increased level at the end of the academic year, but with no significant difference for CG students (hypothesis 5b partly confirmed).

As discussed for study 1, teachers significantly changed their scaffolding behavior by means of more feedback on student learning processes and self-regulation which was perceived by their students. It is emphasized in the body of literature that the teachers' facilitation strategies of classroom dialogue influence students' educational outcomes (Mercer & Littleton, 2007; Snell & Lefstein, 2011). Especially, feedback has shown to be one of the most influential instructional practices (Hattie & Timperley, 2007). Through more information regarding their learning processes and self-regulation, students were seemingly able to stabilize their situational learning processes and increase their cognitive elaboration strategies. Particularly, students with a lower self-concept of ability could benefit from these changes with regard to their situational learning.

As stated before, the changeability of classroom dialogue has seldom been investigated (Howe & Abedin, 2013) and only a small number of studies have examined the impact of TPD on student learning outcomes (Vescio et al., 2008). Therefore, the findings of the second study add to these fields of research in multiple ways: first, feedback changes in classroom dialogue are perceived by students by means of higher-order learning. Consequently, second, students' higher-order learning is a construct to be considered when investigating the impact of TPD. And third, the investigation of differential effects with regard to students' self-concept of ability provided valuable insights into possible various effects of a TPD treatment.

With its findings generated by rather systematic approaches, as well as (partly qualitative) results for individual teachers, the dissertation could show that teachers' practices are changeable, but not for every component of classroom dialogue; at least, not at the same time. The observed changes are nevertheless perceived by students with regard to their higher-order learning and are especially beneficial for students with a low self-concept of ability. Teachers' learning faces some challenges, although the DVC itself is appreciated as a fruitful professional learning opportunity. After reflecting on these results from a methodological perspective and providing limitations of the two studies, the educational relevance of the dissertation for TPD as well as for research on TPD is deduced.

## 5.2 Methodological Reflections and Limitations

The comprehensive examination of TPD with regard to its impact on teachers' learning, reflection, practice, students' perceptions, and the consideration of preconditions is still rare in the German context (Richter et al., 2011), as well as internationally (Osborne et al., 2013). The presented mixed-method approach allowed for generating valuable knowledge on how a carefully designed program can support teachers in their learning processes and practice changes in order to support students' higher-order learning. In this context, it is acknowledged that carefully designed TPDs are more likely to positively influence changes in teachers' practices (Vescio et al., 2008). The ATP as a rather traditional TPD approach, but comparable to the DVC with regard to duration and content focus, could neither cause any positive practice changes nor prevent students from perception decreases. This longitudinal control-group approach was a new attempt, which has thus far been seldom applied in the context of TPD, especially with regard to classroom dialogue where rich case studies are pivotal (Michaels et al., 2008; Van de Pol & Elbers, 2013), but was required in order to deliver clear evidence on TPD effectiveness. The individual analyses and qualitative excerpts allowed for detecting barriers such a program faces and, therefore, conclusions can be drawn for future TPD offers.

The dissertation has limitations which serve, in addition to the findings, as an important basis for future research. Both studies were based on a small sample size and some participating teachers already showed "above average" practices (e.g., 50 % student elaborations) within the German context (Jurik et al., 2013). Moreover, practice analyses were based on frequency and duration; therefore, no conclusions can be drawn about the individual interactional patterns or timing of, for example, teacher feedback on the learning processes. Hattie and Timperley (2007) stated that, besides the level of feedback, the timing and student perceptions of particular kinds of feedback are also relevant. Additionally, teacher practice changes were measured in the learning setting of "classroom dialogue" and do not deliver any information on other talking formats, such as small group dialogue. The presented qualitative data only serve as illustrations for teacher learning and reflection and, therefore, cannot be over generalized.

## 5.3 Educational Relevance and Implications for Future Research

Findings of the dissertation are of educational relevance both from a practical and research perspective: first, taking empirical evidence into account when designing TPDs should be a stronger concern. The DVC as such a program could positively impact (some)

practice changes (especially in regard to feedback), students' higher-order learning, and teachers' positive attitude towards the program. Results regarding the CG reveal that besides the implementation in newly designed programs, research also needs to investigate existing TPDs with regard to effective components and their impact on classroom practices and student learning outcomes. Such efforts are needed in order to understand how existing programs within the landscape of TPD (do not necessarily) impact students.

Second, a comprehensive mixed-method exploration helped to understand how such a program affects students and teachers, but also to further throw light on possible barriers for knowledge implementation in the classroom. Within future research efforts, therefore, instruments must be developed and applied that aim to measure teachers' awareness of instructional practices in the context of classroom dialogue. Additionally, interview data before and after participating in the DVC seem to be promising to better understand teachers' attitudes towards the program as a professional learning opportunity. This approach seeks to generate more knowledge of why some components are observably implemented in the classroom, while others are not. From a practical perspective, such data at the beginning of a TPD can also help the facilitator to support the individual teacher's needs in the program.

Third, some components the teachers learned about were more difficult to implement than others. In order to break routines which have often been established over a long period of time, future TPD efforts should, therefore, distinguish between instructional practices which teachers can implement easily and those which need a longer time to establish. Also, changing all facets of classroom dialogue at the same time was understandably challenging for teachers. Therefore, future DVC efforts will concentrate on one topic at a time in order to give teachers the chance to develop a deep understanding of certain instructional practices and their consequences for student learning. With regard to research implications, this procedure will also allow for more refined conclusions of how changes regarding certain components influence students' learning perceptions. Furthermore, future efforts also aim to improve the video-coding procedure in order to capture teacher-student interactions more precisely, thereby also allowing from this methodological perspective a more concrete picture regarding the interplay of changes in classroom dialogue and students perceptions.

The fourth implication and directly connected to the previous statement concerns students' perceptions, which should be considered in research regarding the impact of TPD. Here, moving away from only achievement as an outcome variable can provide knowledge regarding students' reluctance for career choices in STEM. It can help to understand what

instructional practices teachers need to change in order to positively impact learning perceptions in the mentioned subjects. In the context of classroom dialogue, students' perceptions of the teachers' fostering and scaffolding tools in classroom dialogue can provide another valuable insight. Therefore, within future research, an instrument will be developed that captures students' perceptions of feedback and questioning.

Finally, with regard to differential effects, especially, students with lower preconditions were shown to benefit from the intervention. Future research on TPD, therefore, should consider that such treatments not only impact individual classrooms differently, but also individual students.

From the dissertation, it can be concluded that the field of research on TPD is still in an initial stage, but that well-designed studies can throw light on the effects of TPD, the barriers it faces, and the teachers' needs. By implementing careful research designs which apply initial measuring of classroom practices as well as students' perceptions and preconditions, causal conclusions can be drawn regarding effective TPD. Additionally, initial data provide TPD facilitators with concrete information on instructional practices and teachers' needs, and therefore allow for an individual adaption of these throughout the program. Such programs have the potential to support teachers' in changing classroom routines in order to meet the societal challenge of encouraging more young people to choose a career in a STEM field.

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# Appendix

Supplement A:

Pehmer, A.-K., Gröschner, A., & Seidel, T. (2015). Fostering and scaffolding student engagement in productive classroom dialogue: Teachers' practice changes and reflections in light of teacher professional development. *Learning, Culture and Social Interactions.*

Supplement B:

Pehmer, A.-K., Gröschner, A., & Seidel, T. (2015). How teacher professional development regarding classroom dialogue affects students' higher-order learning. *Teaching and Teacher Education, 47*, 108-119. http://dx.doi.org/10.1016/j.tate.2014.12.007