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The Interplay of Individual Student Characteristics and Gender in Physics Classroom Interactions

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Contents

Abstract

Verbal teacher-student interactions are a core element of physics instruction. Within this context, the present dissertation focuses on the interplay between individual student characteristics, gender, and teacher statements and how those interactions predict students' learning processes in ninth-grade physics classes. In Germany, physics instruction is one of the most unpopular school subjects. Therefore, the overarching objective of this dissertation is to identify possible aspects in physics instruction that contribute to students' reluctance to enter the field of science. With regard to student characteristics, students' cognitive abilities, pre-knowledge, self-concept, and interest are integrated into five student profiles, which combine cognitive and motivational-affective characteristics. Student characteristics are increasingly being taken into account in educational research, but they are often not combined with other classroom aspects. Hence, this dissertation contributes to the lack of research in linking teacher questions and feedback to student profiles in relation to gender. Against this background, the supply-usage model is explored on the usage-level to determine how student profiles and gender predict students' *external learning activities* (verbal student engagement) (*Essay 1*). In addition, the interrelation between the supply- and usage-level is considered by investigating how student profiles, gender, and teacher statements predict students' *internal learning processes* (cognitive learning activity and intrinsic learning motivation) (*Essay 2*). The results show that student profiles differentially predict *external learning activities* (verbal student engagement) and that girls generally engage less often verbally in physics classroom talk than boys. Furthermore, interaction analyses combining student profiles with gender show that especially girls having a profile with high cognitive and motivational-affective characteristics engage more often verbally compared to the class as a whole. Moreover, the findings reveal interactions between the supply- and usage-level. Overall, deep-reasoning teacher questions and feedback positively predict students' *internal learning activities* (cognitive learning activity and intrinsic learning motivation). Additionally, student profiles differentially predict students' *internal learning activities*. Gender only predicts cognitive learning activity as girls report less cognitive learning activity than boys. In summary, the differential findings contribute to a deeper understanding of teaching and learning processes in physics classrooms and should be implemented in professional development and teacher education.

1. Introduction

International comparative studies such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) illustrated the competency deficits of German students in science (Baumert et al., 2000; Organization for Economic Co-operation and Development [OECD], 2007). After one decade of tremendous media and political attention to the German educational system, the results of PISA 2009 indicated positive developments for science. German students reached a good position in the international ranking, with still some room for improvement. Within the last 15 to 20 years, science and technology have been at the public center of attention, and science is seen as a meaningful area of activity (Rönnebeck, Schöps, Prenzel, Mildner, & Hochweber, 2010). Nevertheless, when looking at specific science subjects, physics holds the penultimate rank of the 20 most chosen study courses in Germany. With respect to gender, physics is found in the middle range for young men. Young women decide to study physics less often: physics does not appear on the top-20 list for most chosen courses for females. Within the science courses, physics is behind mathematics, chemistry, and biology (Statistisches Bundesamt, 2012). Hence, it is worth investigating physics instruction and the processes happening in classrooms by keeping gender differences and the unpopularity of physics in mind.

The present dissertation was written in the context of the video study “Teaching and Learning in Physics Instruction – A Videotape Classroom Study” (conducted at the Leibniz-Institute for Science and Mathematics Education (IPN) and therefore often referred to as the IPN video study) that focused on instructional problem areas specific to physics instruction in Germany (Dalehefte et al., 2009) and on teacher-student interactions in physics instruction. Research regarding teacher-student interactions has a long history (cf. Arnold, 1968; De Groat & Thompson, 1949; Flanders, 1970; Jackson & Lehaderne, 1967). At the moment, there are two trends regarding the investigation of teacher-student interactions: On the one hand, teacher-student interactions are explored through case studies (Turner, Meyer, Midgley, & Patrick, 2003; Turner & Patrick, 2004); on the other hand, there are analyses of instructional activities using video data, such as the TIMSS 1999 Video Study (Roth et al., 2006; Stigler, Gonzales, Kawanaka, Knoll, & Serrano, 1999) and the Pythagoras study (Klieme, Lipowsky, Rakoczy, & Ratzka, 2006; Klieme, Pauli, & Reusser, 2009). New approaches like video studies allow that “complex phenomena and events captured on video are available for analysis that can focus *ex-post facto* on various aspects of the material under investigation" (Janík, Seidel, & Najvar, 2009, p. 7).

In the current dissertation, the approach of a video study is chosen and data of the IPN video study are re-analyzed to investigate the autonomously developed research questions. This dissertation project is connected to two preliminary studies of the IPN video study. Firstly, Seidel (2006) explored the role of individual characteristics in the form of student profiles in physics instruction. With this kind of a person-centered approach, it is possible to combine multiple variables (individual student characteristics) and to examine the organization of those characteristics within a student (Lau & Roeser, 2008). The specific student profiles are described in section 2.1.1 ("Individual Student Characteristics and Their Role in Physics Instruction"). Secondly, codings of the IPN video study on teacher-student interactions, which have not been investigated in combination with student profiles, are used. The codings are explained in section 3.1.2 ("Instruments"). In the present dissertation, previous analyses are expanded as Seidel's analyses focused solely on how student profiles predict student perceptions of their classrooms. The questions of how student profiles predict students' learning processes and how those profiles interact with teacher statements remain unanswered. Consequently, genuine research questions were developed and investigated autonomously with secondary analyses in this dissertation.

The objective of this dissertation is to study the role of individual student characteristics, gender, and teacher statements for students' learning processes in physics instruction. To this end, the micro level of teaching and learning is taken into account in situations where teachers make moment-to-moment decisions (Corno & Snow, 1986; Niegemann, 2001). The pivotal consideration is to outline the current daily routine in physics classrooms regarding verbal teacher-student interactions in classroom talk. Hence, this dissertation contributes to identifying factors that inhibit students to enter the field of science and thus to diminish barriers for approaching corresponding occupations (Hannover & Kessels, 2004). This dissertation can be seen as a foundation for further interventions, such as teacher trainings with adaptive components and training of teacher behavior in classroom talk. Findings of this dissertation could be integrated into teacher education whereby teaching skills could be sharpened with regard to acknowledging individual student characteristics and gender. Therefore, from a didactical perspective, teachers' attention during classroom talk towards students' different behavior indicating their possible individual characteristics should be encouraged (Aebli, 2003).

In the following section, the theoretical background of the paper will be stated (section 2). Afterwards, the research questions are presented, followed by the presentation of the methodological approach and the results of the specific studies (section 3). Finally, a summarizing discussion will conclude this dissertation (section 4).

2. Theoretical Background

Before discussing the role of individual student characteristics and gender for verbal teacher-interactions in physics instruction, it is initially important to outline the role of those aspects in physics instruction in general (section 2.1). Subsequently, relevant aspects of verbal teacher-student interactions are explained (section 2.2). Finally, the model underlying this dissertation is described (section 2.3).

2.1 The Role of Individual Student Characteristics and Gender in Physics Instruction

2.1.1 Individual Student Characteristics and Their Role in Physics Instruction

Students' cognitive and motivational-affective characteristics are important predictors of student learning (Corno & Snow, 1986; Shuell, 1996) and are increasingly being considered in educational research (Hornstra, van der Veen, Peetsma, & Volman, 2013; Lau & Roeser, 2008; Linnenbrink-Garcia, Pugh, Koskey, & Stewart, 2012; Perry, Turner, & Meyer, 2006; Seidel, 2006; Snow, Corno, & Jackson, 1996; Wormington, Corpus, & Anderson, 2012).

Regarding cognitive characteristics, prior knowledge is an important student variable for learning and commonly had positive effects on students' performance in previous studies (Dochy, de Rijdt, & Dyck, 2002; Dochy, Segers, & Buehl, 1999). In general, prior knowledge explained between 30 and 60% of variance in performance (Dochy et al., 1999). With regard to motivational characteristics, a high intrinsic motivation, in contrast to a high extrinsic motivation affects cognitive processing and achievement positively (Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). Previous studies already combined cognitive and motivational-affective characteristics by characterizing different groups of students (Lau & Roeser, 2008) and indicated the importance of high motivational characteristics, particularly for girls (Linnenbrink-Garcia et al., 2012).

This dissertation focuses particularly on students' individual cognitive and motivational-affective characteristics in physics instruction. In this school subject, Seidel

(2006) identified five student profiles of cognitive (general cognitive abilities, physics pre-knowledge) and motivational-affective (interest in physics, self-concept of ability) characteristics. As this dissertation refers to these student profiles identified by Seidel (2006), they will be described in more detail. Table 1 presents an overview of the student profiles:

Table 1

Overview of Student Profiles

Student profiles	**Cognitive abilities**	**Physics knowledge**	**Interest**	**Self-concept**
“strong”	+	+	+	+
“uninterested”	+	o	-	o
“underestimating”	+	+	o	-
“overestimating”	-	o	+	+
“struggling”	-	-	-	-

Note. + = high; o = intermediate; - = low (Seidel, 2006).

First, students with a “strong” profile showed high values for cognitive and motivational-affective characteristics. Second, those profiled as “uninterested” exhibited a high general cognitive ability but a low to medium level of physics pre-knowledge combined with a low level of interest and an intermediate level of self-concept of ability. Third, students labeled as “underestimating” their ability also exhibited a high general cognitive ability and a high level of pre-knowledge but had an intermediate level of interest and a very low self-concept of ability. Fourth, students with low general cognitive abilities, an intermediate level of physics pre-knowledge, and high values for motivational-affective characteristics were labeled as being in danger of “overestimating” their abilities. Finally, those profiled as “struggling” showed low values for general cognitive ability, intermediate to low pre-knowledge of physics, and low values for cognitive and motivational-affective characteristics. In the study, students with a “strong” or “overestimating” profile experienced their science classroom as more supportive than their classmates with “uninterested,” “underestimating,” and “struggling” profiles. As students’ characteristics in physics instruction seem to affect the way they perceive their learning environment, it also appears important to study the extent to which the different perceptions are observable in students' learning processes. The present dissertation expands Seidel's study by investigating how student characteristics predict students' learning processes.

2.1.2 Gender and Its Role in Physics Instruction

Besides students' individual cognitive and motivational-affective characteristics, the role of gender is important in physics instruction. Looking at boys' and girls' average score for science achievement, PISA 2006 indicated no significant differences for the majority of the participating countries. However, the subscales showed differences: In all OECD countries (except Turkey), boys significantly outperformed girls in the content area "physical systems," i.e., physics and chemistry (OECD, 2007). Furthermore, in another study, girls reported less interest than boys and found physics instruction less motivating than boys (Hoffmann, 2002). Hoffmann (2002) also revealed that interest-oriented physics lessons combined with part-time, single-sex teaching had positive effects on girls' cognitive and motivational characteristics. In general, students in such classes scored significantly higher than students of the control classes on a final achievement test. In addition, the difference in interest in physics instruction between girls and boys diminished in the experimental classes and was no longer significant by the end of the school year. In contrast, this difference increased in the control classes (Häussler, Hoffmann, Langeheine, Rost, & Sievers, 1998). Summarizing previous results, gender seems to particularly affect students' learning processes in physics instruction.

Few studies have investigated students' cognitive and motivational-affective characteristics in combination with gender. Linnenbrink-Garcia and colleagues (2012), for instance, connected cognitive and motivational characteristics and showed that boys and girls undergo persistent conceptual change when they have high interest and academic self-efficacy in combination with at least moderate levels of basic prior knowledge in biology. Additionally, motivational factors were especially important for girls to achieve conceptual change (Linnenbrink-Garcia et al., 2012). Häussler and colleagues (1998) also connected cognitive and motivational-affective characteristics with gender in physics instruction and revealed that boys in particular exhibit a profile with high grades and a high self-concept of ability.

However, the role of teacher statements in verbal teacher-student interactions was not taken into account in these studies. Therefore, this dissertation contributes to existing research by combining student characteristics, gender, *and* teacher statements for predicting students' learning processes in physics instruction. Before describing the students' learning processes in physics instruction, the key element of physics instruction and the role of teacher behavior during classroom talk for student' learning processes are delineated.

2.2 Verbal Teacher-Student Interactions in Physics Instruction

Classroom talk is the most prevalent component of physics instruction in Germany (Kobarg et al., 2011). Teacher-student interactions, thus, form the basis of communication in physics instruction. Against this background, teacher-student interactions are investigated in the context of classroom talk in this dissertation. During classroom talk teachers are very active compared to students (Roth et al., 2006) and dominate classroom talk up to 80% of the time. Hence, students have few opportunities to engage verbally in classroom talk. In physics instruction, students mainly provide keywords for subsequent conversation. Interactions between teachers and students are narrowly focused with few opportunities for verbal student engagement (Seidel & Prenzel, 2006; Seidel et al., 2007). Previous studies showed that verbal student engagement in classroom talk promotes student learning (Bargh & Schul, 1980; Pauli & Lipowsky, 2007; Webb & Farivar, 1994). Therefore, teacher behavior in classroom talk plays an important role in student learning.

2.2.1 Teacher Behavior in Classroom Talk

Teachers can affect students' learning and motivation through statements (Craig, 2013). Regarding teacher behavior during classroom talk this dissertation concentrates on teacher statements in terms of teacher questions and feedback.

The term *teacher question* refers to questions being addressed to students in the classroom. A teacher's questioning style influences the opportunities for student verbal engagement (Cazden, 2001). Seidel and colleagues (2007) revealed that teacher questions are generally on a low cognitive level in physics instruction. Asking low cognitive level questions, such as reproductive questions (Galton, Hargreaves, Comber, Wall, & Pell, 1999), limits students' opportunities to engage verbally and to be cognitively active. In contrast, deep-reasoning questions that provide students with the opportunity to think on their own influence student learning positively (Erdogan & Campbell, 2008; Hiebert & Wearne, 1993; Michaels & O'Connor, 2012; Oliveira, 2010; Redfield & Rousseau, 1981). However, this kind of question does not arise very often during classroom talk (Lee & Kinzie, 2012; Lipowsky, Rakoczy, Pauli, & Klieme, 2007; Wimer, Ridenour, Thomas, & Place, 2001). As previous research indicated that deep-reasoning questions are meaningful for student learning but seldom occur, this dissertation focuses on that type of question.

Teacher feedback describes reactions to student statements with short, factual, constructive, and supportive information that lead to increased effort to solve challenging tasks or achieve goals (Timperley, 2013). Feedback influences student learning and achievement (Hattie & Timperley, 2007). Studies regarding teacher feedback generally have found that feedback does not occur frequently (Voerman, Meijer, Korthagen, & Simons, 2012). In physics instruction, for instance, teacher feedback also rarely occurred and included short and simple, constructive and content-related, and supportive statements (Seidel et al., 2007). With regard to the type of feedback statements, positive feedback enhances the probability that students return to or continue with an activity and report higher interest in the activity (Deci, Koestner, & Ryan, 1999). Supportive teacher feedback can also generate further questions that lead to deeper thinking and engage students to be more cognitively active (Chin, 2006).

Previous research has shown differential effects of different types of teacher questions and feedback on student learning and motivation. In physics instruction, teachers seldom ask deep-reasoning questions and mostly provide short feedback (Seidel et al., 2007). However, challenging teacher questions and feedback are crucial aspects of classroom talk and are meaningful for student learning (Chin, 2006; Erdogan & Campbell, 2008; Hattie & Timperley, 2007; Hiebert & Wearne, 1993; Voerman et al., 2012; Wells & Arauz, 2006). As teacher statements affect students' learning processes, it is important to consider the specific aspects of those learning processes.

2.2.2 Students' Individual Learning Processes in Classroom Talk

The present dissertation describes students' learning processes as *external* and *internal learning activities* (Aebli, 2003; Renkl, 2009). *External learning activities* express the students' observable behavior and comprise the quantity and quality of *verbal student engagement* by measures of student utterances. In detail, the quantity of verbal student engagement comprises *frequency* and *duration* of student statements. In connection to this, the frequency of students' statements is counted and the amount of time in which students contribute verbally to classroom talk is measured. The quality of verbal student engagement refers to the *type* and *function* of students' statements. The *type* of statements includes giving *answers* and asking *questions*. The *function* of students' statements comprises the terms *keyword giver* and *equal conversational partner*. If students just provide keywords for the following conversation and do not express their own opinion, they act as stooges. If students are given the opportunity to influence the flow of the conversation and can express their own opinion, they act as an equal conversational partner.

In contrast to students' observable behavior, their *external learning activities,* students also engage in *internal learning activities* (Renkl, 2009). It is also important to investigate *internal learning activities,* as previous studies have shown that the same observable behavior in learning environments does not necessarily lead to the same knowledge acquisition (Fischer & Mandl, 2005). In the present dissertation, *internal learning activities* include *cognitive learning activity* and *intrinsic learning motivation*. *Cognitive learning activity* describes "the kind of activity that really promotes meaningful learning . . . (e.g., selecting, organizing, and integrating knowledge)" (Mayer, 2004, p. 17). If a teacher states that students' answers are "right" or "wrong" and also prompts students to evaluate the validity of their solutions for themselves, cognitive learning activity may be evoked (Baumert et al., 2010). This dissertation refers to student cognitive activities as processing information in teacher-student interactions, such as deep elaborations and organizing processes (Seidel, 2003). *Intrinsic learning motivation* describes the quality of motivation during the process of learning and is characterized by "doing of an activity for its inherent satisfactions rather than for some separable consequence" (Ryan & Deci, 2000, p. 56). Intrinsically motivated students enjoy learning and want to learn more about the content.

As classroom talk is the core element of physics instruction, it is worthwhile to investigate how teachers and students verbally engage in teacher-student interactions and how students' individual learning processes are affected by those interactions. Moreover, it is important to focus on students' individual characteristics and gender, as there are meaningful differences between each single student that influence their *external* and *internal learning activities*.

Previous studies have revealed the importance of teacher statements on student learning and motivation. Therefore, the present dissertation examines how teacher questions and feedback in particular predict *cognitive learning activity* and *intrinsic learning motivation*. By exploring these interrelations, this dissertation contributes to the lack of research in connecting teacher questions and feedback to student characteristics and gender. In the next section, the model underlying this dissertation illustrates how the interplay between the specific aspects is investigated in detail.

2.3 Model of the Dissertation

The model of the present dissertation is based on a supply-usage model (Fend, 2002; Helmke, 2006; Pauli & Reusser, 2006) that evolved from the process-product paradigm (Dunkin & Biddle, 1974). The process-product paradigm often viewed student achievement as a direct consequence of teacher behavior in the classroom (Brophy & Good, 1986). Differing from that line of research, in the extended process-product model, school achievement is not seen as a direct "product" but rather as a result of the students' usage of the instructional supply, which is offered by the teacher (Pauli & Reusser, 2006). The quality of supply depends on teachers' characteristics (e.g., gender, teaching experience), teacher behavior (e.g., quality of instruction, quantity of learning opportunities), and classroom context (e.g., class size, heterogeneity), the context of school and subject, and on characteristics of the educational system (Brühwiler & Blatchford, 2011; Pauli & Reusser, 2006). The usage of the supply depends on individual student characteristics (cognitive, motivational, emotional), individual learning processes (e.g., learning activities, attention), and learning environments (e.g., language spoken at home, peers, media) (Brühwiler & Blatchford, 2011; Pauli & Reusser, 2006). Hence, learning in school depends on how teachers are able to provide an optimal learning supply and to support their students to use this supply effectively (Pauli & Reusser, 2006).

The present dissertation did not investigate the entire conceptual framework but focused on selected variables at the two levels of teachers and students (see Figure 1). Figure 1 summarizes and integrates the research questions of this dissertation into one model. On the usage-level it is explored how students' individual characteristics and gender predict their individual learning processes (*external learning activities* and *internal learning activities*). In addition to the role of students' individual characteristics and gender for their learning processes, this dissertation concentrates on teacher behavior on the supply-level. Specifically, the role of teacher statements and their interplay with student characteristics for students' *internal learning activities* (cognitive learning activity, intrinsic learning motivation) is explored.

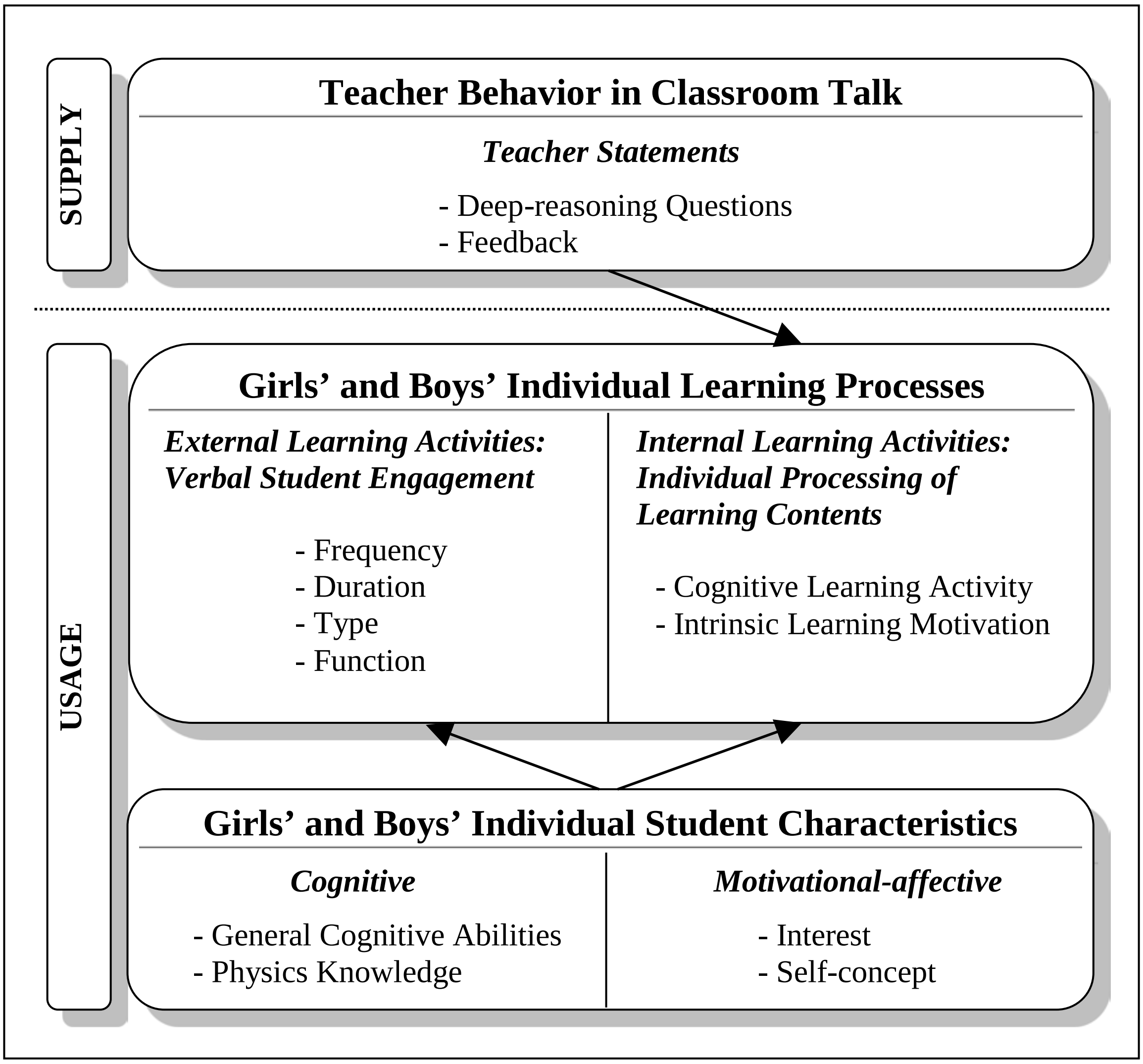

Figure 1. Supply-usage model of the present dissertation.

Considering the sparse research combining individual cognitive and motivational-affective characteristics and gender, this dissertation contributes to the lack of research in combining these aspects in physics instruction. The model of this dissertation includes not only students' *external learning activities* (observable behavior in the form of verbal student engagement) but also students' *internal learning activities* (individual processing of learning contents) and considers the question of how students' learning processes can be predicted by their individual characteristics, gender, and teacher statements. Therefore, both levels of the supply-usage model and their interplay are taken into account. Moreover, this dissertation expands previous research by bringing teacher questions and feedback together with student characteristics and gender when predicting *internal learning activities*. In general, previous studies mostly investigated classroom processes from a single perspective. This dissertation goes beyond former studies as differentiated interactions between important classroom aspects are considered; this method enables a deeper view to reach a more detailed picture of physics classrooms. In the following section, the specific research questions of this dissertation are presented. The research questions originate from genuinely own research interest.

3. Research Questions

The objective of this dissertation is to investigate the role of individual student characteristics and gender in verbal teacher-student interactions in physics instruction in light of the outlined supply-usage model. Two research questions were addressed. More detailed research questions and hypotheses are delineated when introducing the specific studies (sections 3.2 and 3.3).

1. How do student profiles and gender predict students' *external learning activities* (verbal student engagement) in physics instruction? *(Essay 1)*

It was expected that student profiles differently predict verbal student engagement (Hypothesis 1a). With respect to gender, it was assumed that girls would engage less verbally than boys (Hypothesis 1b).

2. How do teacher statements (deep-reasoning questions, feedback), student profiles, and gender predict students' *internal learning activities* (individual processing of learning contents) in physics instruction? *(Essay 2)*

It was hypothesized that teacher statements would predict students' *internal learning activities* positively (Hypothesis 2a). Considering student profiles and gender, differential results for students' *internal learning activities* were expected (Hypothesis 2b).

This publication-based dissertation is grounded in two essays in accord with the two research questions. *Essay 1* was published in February 2013 in the journal *Learning and Instruction*. *Essay 2* was submitted to the journal *Learning and Individual Differences* and was accepted for publication in January 2014. The publications can be found in the supplement and will be summarized (sections 3.2 and 3.3) after the presentation of the methodological approach (section 3.1). The short presentation of the essays gives an overview of results of this dissertation, which are subsequently discussed as a whole.

3.1 Methodological Approach

In the present dissertation, secondary analyses of the IPN video study were conducted. “*Video study* represents a complex methodological approach, which enables the employing of a number of various strategies, methods, or techniques for generating, collecting, and analyzing *video data*, i.e. audiovisual data grounded in rich situational contexts” (Janík et al., 2009, p. 7). Previous video studies such as the TIMSS video study (Roth et al., 2006) and the Learner Perspective Study – LPS (Clarke, Emanuelsson, Jablonka, & Mok, 2006) have contributed to establishing the strength of video as a methodological design within the educational sciences (Klette, 2009). The IPN video study aimed at transferring video codes describing classroom practices on the surface level from mathematics to science teaching. Moreover, a goal was to add in-depth video analyses to teaching and learning components (Janík et al., 2009).

In general, video studies allow researchers to record, combine, and analyze repeatable different aspects in the classrooms (Klette, 2009; Reusser & Pauli, 2010). Despite the merits of video studies, the video data set challenges for the researchers due to the different and enormous volume of data (Klette, 2009). Considering the huge workload involved with video studies, secondary analyses of the video data are worth conducting to contribute to and to expand previous research.

3.1.1 Sample and Design

The IPN video study investigated physics teaching and learning in 82 randomly selected high and intermediate ninth-grade classes in German and Swiss schools. The design of the IPN video study was subdivided into three measuring points. In a pre-test, students’ cognitive and motivational-affective characteristics were tested at the beginning of the 2002/2003 school year (measuring point 1; MP 1). Completed student questionnaires and tests were examined by Seidel (2006) to identify the student profiles (see section 2.1.1).

Four months after the pre-test at measuring point 2 (MP 2), a physics teaching unit (two introductory lessons on either the concept of force or reflection and refraction) was videotaped. After the teaching unit was recorded, a questionnaire on students’ internal learning activities during the teaching unit was administered. The topics to be videotaped were determined, and the video recordings were based on standardized procedures. The final sample included 161 lessons (98% of the lesson sample) of 82 classes (100% of the class sample). The software Videograph (Rimmele, 2009) was used to transcribe statements, identify analysis units, and apply video analysis instruments. Student profiles of measuring point 1 were matched with the video data. Thereby, in 72% of the cases, student statements could be linked to the corresponding individual student profile. Teacher and student statements served as units of analysis.

In the post-test at measuring point 3 (MP 3), students were asked again about their cognitive and motivational-affective characteristics. In this dissertation, research questions were developed autonomously and the existing video and questionnaire data of measuring points 1 and 2 were used for analyses. In both essays, the analyses were conducted with the sample of students of the IPN video study. As PISA 2009 also still identifies students on different levels of proficiency and reveals that boys perform better than girls in German science classes (OECD, 2010), the data of the IPN video study are still relevant for answering the research questions of this dissertation. Figure 2 illustrates which measuring points of the IPN video study are taken into account in the present dissertation:

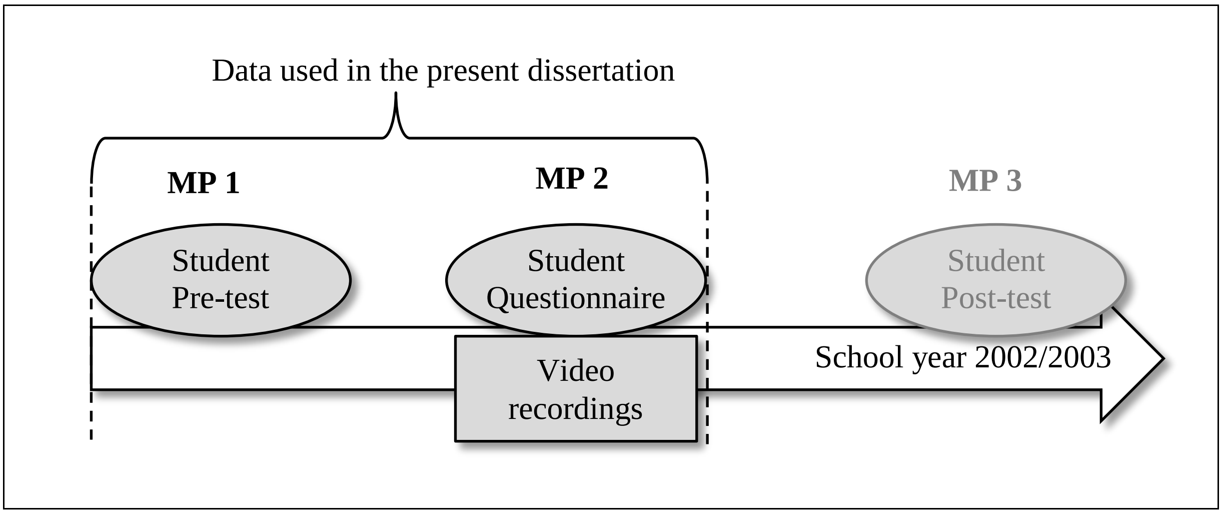

Figure 2. Design of the IPN video study and the present dissertation.

3.1.2 Instruments

Both essays take student profiles and gender into account (see section 2.1). The first essay (section 3.2) investigates how student profiles and gender predict student verbal engagement. In so doing, the following codings of the IPN video study were used. The video analysis (Kobarg & Seidel, 2005) was based on three categories: 1) *frequency and duration* of student engagement, 2) *type*, and 3) *function* of student engagement. Student statements in classroom talk served as the unit of analysis. For *frequency and duration* of verbal student engagement, each student statement was coded and the frequency of student engagement was enumerated. Moreover, time (in seconds) of verbal student engagement in classroom talk was calculated for each student. The *type* of student statements comprised both student questions and student answers. Answers were reactions to the teacher's or a classmate's questions. The inter-rater reliability ($\kappa = .61$; inter-rater percentage agreement: 79%) was considered acceptable (Landis & Koch, 1977). The *function* of student statements included two categories: keyword giver and equal conversational partner. An interaction role was characterized as a stooge statement (keyword giver) when the correct answer was given to a teacher's prompt, thus supporting the teacher's line of thought; in these situations, the student did not express a personal opinion. When the student could contribute his or her own ideas and thus influenced the course of the verbal interaction with the teacher, the statement was categorized as equal conversational partner. The inter-rater reliability ($\kappa = .67$; inter-rater percentage agreement: 82%) was acceptable (Landis & Koch, 1977).

In the second essay (section 3.3), the codings of teacher statements regarding *deep-reasoning questions* and *feedback* were used. A teacher question was coded as *deep-reasoning* when it stimulated the students to think independently and required deep cognitive processes. Facts that were not yet known had to be explained. An example of a deep-reasoning question is "What pre-requisites must a car fulfill to be able to protect the driver in an accident?" The inter-rater reliability of $\kappa = .67$ (inter-rate percentage agreement: 83%) was acceptable (Landis & Koch, 1977). A teacher's statement was characterized as *feedback* when it contained simple and short statements, such as "yes," "no," or "that's right," factual and constructive statements (example: "Yes, that's right, but you have to re-think the structure."), or positive and supportive statements, such as "you formulated that well." Therefore, feedback included any positive and supportive statements regarding a student's response. The inter-rater reliability of κ = .88 (inter-rate percentage agreement: 96%) was good (Landis & Koch, 1977).

To examine the role of teacher statements for students' learning processes, student questionnaire data were taken into account and combined with the video codings. The scale for *cognitive learning activity* included 10 items that were rated on a four-point Likert scale with the categories 1 (*I do not agree*), 2 (*I partly agree*), 3 (*I mainly agree*), and 4 (*I do agree*) (Seidel, 2003). An example item is as follows: "During the last two lessons, I explained the content in my own words." The mean value of the scale was used in the statistical analyses (M = 2.52; SD = 0.58; α = .81). The scale for *intrinsic learning motivation* comprised three items also rated on the four-point Likert scale between *I do not agree* and *I do agree*. For example, the students were given the following statement: "During the past two lessons, I joyfully participated." For the statistical analyses, the mean value was used (M = 2.40; SD = 0.87; α = .87).

3.1.3 Data Analysis

To answer both research questions, two-level hierarchical models were applied with the software Mplus 6.11 (Muthén & Muthén, 1998-2011). For both questions, several models were introduced by inserting different predictors and interactions between the predictors. In the first essay, two models were used. The first model (M1) comprised student profiles and gender as predictors of verbal student engagement. In the second model, the interactions between student profiles and gender were additionally investigated. Analyses for the second essay included three models. In the first model (M1), teacher deep-reasoning questions and teacher feedback were respectively used as predictors. In the second model (M2), student profiles and gender served as predictors of cognitive learning activity and intrinsic learning motivation. The third model (M3) comprised deep-reasoning questions or feedback, gender, student profiles, and the interactions between those variables as predictors. Hereafter, the results are presented according to the two research questions, which were derived from genuinely own research interest.

3.2 How Individual Student Characteristics and Gender Predict Students' External Learning Activities in Physics Instruction (Essay 1)

Conception, preparation, analysis, and publication-based presentation were fulfilled in the context of this dissertation and were implemented in essay 1. Both co-authors advised the origination process, the preparation, and the presentation of the essay. The essay was submitted to the journal *Learning and Instruction* and was published in February 2013.

Jurik, V., Gröschner, A., & Seidel, T. (2013). How student characteristics affect girls' and boys' verbal classroom engagement in physics instruction. *Learning and Instruction, 23,* 33–42. doi: 10.1016/j.learninstruc.2012.09.002

With regard to the outlined supply-usage model (section 2.3), essay 1 focused on the usage-level. It was investigated how student characteristics and gender predict students' *external learning activities* (verbal student engagement) in physics instruction. The codings of Seidel's (2006) student profiles ("strong," "uninterested," "underestimating," "overestimating," and "struggling," see section 2.1.1) were used in this dissertation and served as independent variables along with gender. Verbal student engagement included *frequency*, *duration*, *type* (questions and answers), and *function* (keyword giver and equal conversational partner) of student statements and served as the dependent variable. The following two research questions were addressed:

(1) How are girls and boys represented in profiles of cognitive and motivational-affective student characteristics? It was expected that more boys than girls would be assigned to a "strong" student profile and that a greater proportion of girls would show an "underestimating" profile.

(2) How do girls and boys with different profiles engage verbally in physics classrooms with respect to the frequency, duration, type, and function of student statements? It was hypothesized that verbal engagement in physics can be predicted by student profiles and gender. More specifically, it was expected that girls and boys with a "strong" profile would engage more often verbally and longer (frequency, duration), give more answers and ask more questions (type), and act more often as keyword givers and equal conversational partners (function) than students with a "struggling" profile.

Furthermore, it was assumed that boys with a “strong” profile would reveal higher values for the three aspects than girls with a “strong” profile.

Due to missing data, one class could not be included, and the sample comprised N = 1378 students (46% girls, 54% boys; in average 15-year-olds; range 14-16) from 81 ninth-grade high school physics classes in Germany and the German-speaking part of Switzerland. Student profiles were identified at the beginning of the school year, and classroom talk was videotaped four months later. The results are structured corresponding to the two research questions:

(1) More boys than girls fit into “strong” and “overestimating” student profiles. More girls were found in the “uninterested,” “underestimating,” and “struggling” profile group.

(2) The findings of the multilevel regression analyses revealed that the student profiles predicted verbal student engagement for girls and boys. Students with a “strong” profile engaged statistically significantly more often and longer in classroom talk compared to the classroom mean. Additionally, students with a “strong” profile gave more answers and acted more often as keyword givers and equal conversational partners. In contrast, students with a “struggling” profile engaged statistically significantly less often and for shorter periods of time in classroom talk. Students with a “struggling” profile gave fewer answers and acted less often as keyword givers. Students with an “underestimating” profile engaged shorter in classroom talk compared to the classroom mean. The “overestimating” student profile never predicted verbal student engagement.

Gender also predicted verbal student engagement. In general, girls engaged less often and for shorter amounts of time in classroom talk than boys. They gave fewer answers and acted less often as keyword givers and equal conversational partners. However, in more detail, different results appeared with respect to specific student profiles; significant interaction terms were found which indicated “strong” girls had higher verbal engagement regarding frequency, duration, and student answers compared to “strong” boys. No significant interactions were identified regarding the function of verbal student engagement. Furthermore, girls with a “struggling” profile provided fewer answers than boys with a “struggling” profile. For the other student profiles, no significant interactions were found.

To sum up, the results demonstrate that students’ individual cognitive and motivational-affective characteristics and gender affect their verbal engagement in classroom talk. The investigation of teaching-learning processes in classrooms can be complemented through the classification of students into distinct profile groups. Moreover, the findings emphasize the importance of taking gender into account as well.

3.3 How Individual Student Characteristics, Gender, and Teacher Statements Predict Students' Internal Learning Activities in Physics Instruction (Essay 2)

Conception, preparation, analysis, and publication-based presentation were also fulfilled in the context of this dissertation and were implemented in essay 2. Both co-authors advised the origination process, the preparation, and the presentation of the essay. The essay was submitted to the journal *Learning and Individual Differences* and was accepted in January 2014.

Jurik, V., Gröschner, A., & Seidel, T. (2014). Predicting students' cognitive learning activity and intrinsic learning motivation: How powerful are teacher statements, student characteristics, and gender? *Learning and Individual Differences, 32*, 132-139. doi: 10.1016/j.lindif.2014.01.005

Essay 2 explored the interrelation between the supply- and usage-level of the outlined supply-usage model (section 2.3). The interplay between teacher statements on the supply-level and individual student characteristics and gender on the usage-level was investigated. Specifically, the focus was on how those aspects predict *internal learning activities* (individual processing of learning contents) in physics instruction. Individual processing of learning contents comprised *cognitive learning activity* and *intrinsic learning motivation*. These variables served as the dependent variables. Again, Seidel's (2006) codings of the student profiles were used and joined gender as the independent variables. To expand the previous results, the following three research questions were addressed:

(1) Do deep-reasoning teacher questions and teacher feedback predict cognitive learning activity and intrinsic learning motivation? It was hypothesized that deep-reasoning teacher questions and feedback predict students' cognitive learning activity and intrinsic learning motivation positively.

(2) How do student profiles and gender predict cognitive learning activity and intrinsic learning motivation? It was assumed that students with a "strong" profile would

report higher cognitive learning activity and intrinsic learning motivation than students with a "struggling" profile. Referring to gender, it was expected that boys would report higher cognitive learning activity and intrinsic learning motivation.

(3) Are there interactions among teacher statements, student profiles, and gender that predict cognitive learning activity and intrinsic learning motivation? According to previous research, interactions among teacher statements, student profiles, and gender were expected to reveal advantageous results, especially for girls with a "strong" profile.

In this study, the sample included N = 1335 students (46% girls; 54% boys; in average 15-year-olds; range 14-16) and 79 teachers from 79 ninth-grade high school physics classes in Germany and Switzerland. Missing questionnaire data led to different sample sizes between both essays. Student profiles were identified at the beginning of the school year, and classroom talk was videotaped four months later. The results are presented in correspondence to the three research questions:

(1) The results revealed that deep-reasoning teacher questions and feedback significantly predicted both students' cognitive learning activity and intrinsic learning motivation positively.

(2) Student profiles predicted both cognitive learning activity and intrinsic learning motivation. The "strong" student profile predicted "strong" students' cognitive learning activity and intrinsic learning motivation positively. Students with a "strong" profile showed higher cognitive learning activity and intrinsic learning motivation compared to the classroom mean. The "underestimating" profile predicted cognitive learning activity and intrinsic learning motivation negatively. Students with an "underestimating" profile reported significantly lower cognitive learning activity and intrinsic learning motivation compared to the classroom mean. In contrast, students with an "overestimating" profile exhibited significantly higher values for cognitive learning activity and intrinsic learning motivation. The "struggling" profile predicted cognitive learning activity and motivation significantly negatively. Gender predicted only cognitive learning activity. Girls reported lower cognitive learning activity than boys.

(3) Regarding interaction effects between teacher statements, student profiles, and gender, a significant interaction term was found for the "underestimating" student profile and deep-reasoning teacher questions for cognitive learning activity. Students with an "underestimating" profile in classrooms where the teacher asked more deep-reasoning questions showed a higher value for cognitive learning activity compared to the classroom mean. Moreover, only the interaction between the "struggling" profile and gender showed

significant results for cognitive learning activity and intrinsic learning motivation. In both models for deep-reasoning questions and feedback, girls with the “struggling” profile showed lower values for cognitive learning activity and intrinsic learning motivation than boys with the “struggling” profile. There was no significant interaction term for teacher statements and gender.

In summary, the findings emphasize that students’ individual cognitive and motivational-affective characteristics and gender do not only predict students’ external learning activities. Individual student characteristics and gender also affect students’ internal learning activities. Additionally, the results demonstrate the positive influences of teachers’ deep-reasoning questions and feedback on student learning and motivation.

4. Discussion

Based on the theoretical background regarding the role of individual student characteristics, gender, and teacher statements in classroom talk in physics instruction, the following discussion reflects the results of this dissertation. Firstly, the central results of this dissertation are discussed together (section 4.1). After that, the methodology is reflected (section 4.2) followed by implications of the dissertation (section 4.3). To conclude, the limitations of this dissertation are pointed out with possible research questions that could be investigated in future research (section 4.4).

4.1 Overview and Discussion of Central Results

This dissertation deals with teaching and learning processes occurring in physics instruction. It is intended to provide insight into the role of individual student characteristics, gender, and teacher behavior for classroom processes to implement that knowledge in further research, interventions, and teacher education. Hence, an overarching goal of this dissertation is to improve the teaching daily routine in physics instruction and to adapt it to the specific needs of the individual students by taking the individual characteristics of each girl and boy into account.

The findings of this dissertation regarding the usage-level of the model revealed that student profiles and gender predict *external learning activities* (verbal student engagement). Student profiles differently predict verbal student engagement (confirmation of hypothesis 1a), and girls engage verbally less often than boys (confirmation of hypothesis 1b), which is congruent with the assumptions and previous research. Moreover, the results of this dissertation revealed interactions between the supply- and usage-level. Teacher statements, student profiles, and gender predict *internal learning activities.* Teacher questions and feedback predict cognitive learning activity and intrinsic learning motivation positively (confirmation of hypothesis 2a), and student profiles predict cognitive learning activity and intrinsic learning motivation differently. Gender only predicts cognitive learning activity (partial confirmation of hypothesis 2b).

Beyond these results, the interactions between teacher statements, student profiles, and gender expand previous research and provide a more differentiated pattern for physics instruction: The combination of student profiles and gender showed that the few “strong” girls were highly verbally engaged in classroom talk. These results indicate that student profiles mediate gender differences and are a pivotal factor for verbal engagement in physics instruction. Additionally, girls with a "struggling" profile in particular showed low verbal engagement and cognitive learning activity. Furthermore, "underestimating" students' cognitive learning activity seems to be supported by classrooms where the teacher asks more deep-reasoning questions.

Altogether, the findings of this dissertation demonstrate that interactions between teacher statements, student profiles, and gender are valuable predictors of students' learning processes in physics instruction. Moreover, the results contribute to gain a deeper and more detailed insight into the teaching and learning processes in physics instruction. Considering these interactions, the present dissertation reveals that it is not sufficient to investigate student profiles and gender separately as there are not fixed groups of *the* "strong" students or *the* girls. There are rather varying nuances in physics classrooms that should be considered. Hence, the present dissertation could be seen as an impulse to reflect about common stereotypes. In addition, it could be shown that many students' capabilities in physics classrooms are unappreciated. Students with an "underestimating" profile exhibit a high potential in physics instruction but are in danger of being neglected as they do not show their abilities and do not believe in their own competencies. Consequently, teachers should in particular take the "underestimating" student profile into account, as this dissertation also revealed that those students in particular benefit from deep-reasoning teacher questions. More differentiated aspects should be integrated into teacher education to meet the needs of all single learners and to use the existing but not obvious visible potentials.

4.2 Methodological Reflections

The method of video analysis of classrooms enables researchers to identify teaching and learning conditions in classrooms in a valid way (Brophy, 2004). The IPN video study used a multi-method by combining video analyses with further sources of information, such as students' learning processes (by means of student questionnaires), which turned out to be useful for exploring the connection between teaching and learning (Seidel et al., 2009). Therefore, the IPN video study data allow observable behavior to be linked with internal processes. This connection makes it possible to acquire deeper knowledge regarding teacher-student interactions. The design of this video study is unique as a longitudinal assessment was used to investigate the short-term effects of students' individual characteristics on students' learning processes four months later. Furthermore, the topics treated in the instructional units were kept constant, ensuring a comparison of teaching approaches across classrooms. The instructional units had the same topic and the same position in the lesson context. In addition, the sample was large enough to run hierarchical linear models (Seidel et al., 2009). Nevertheless, video studies in general and video-based research in combination with questionnaires are very complex and time-consuming undertakings. Consequently, it is still valuable to continue to analyze data of the IPN video study, which took place in the school year 2002/2003. Moreover, there is only a small body of educational research regarding the combination of student profiles and gender, and there are still different proficiency levels of students and differences between girls and boys in science classes (OECD, 2010). Hence, it is valuable to continue to use these data for complex analyses that integrate teacher statements, student profiles, and gender for predicting students' *external* and *internal learning activities*.

4.3 Implications

From a theoretical point of view the results of this dissertation replicate findings of previous studies regarding teacher-student interactions by revealing positive influences of teachers' deep-reasoning questions and feedback on student learning and motivation (Hattie & Timperley, 2007; Hiebert & Wearne, 1993; Kluger & DeNisi, 1996; Oliveira, 2010; Redfield & Rousseau, 1981; Voerman et al., 2012). Student learning and motivation could be fostered if students received deep-reasoning questions and feedback. Additionally, previous research indicated that individual student characteristics and gender play a role in student learning (Häussler et al., 1998; Linnenbrink-Garcia et al., 2012), which could be confirmed by the results of this dissertation.

Furthermore, teachers report less conflict and more closeness in teacher-student relationships when interacting with students showing a high level of academic performance (Nurmi, 2012) and interact especially with high-achieving ("strong") students (Brophy & Good, 1974). However, the equal distribution of verbal interactions across different ability groups leads to the compensation for differences in achievement (Einsiedler & Treinies, 1997). In such "difference compensating" classes (Einsiedler & Treinies, 1997, p. 349), teachers provide supplementary help to low-achieving students. In contrast, teachers of “difference increasing” classes (Einsiedler & Treinies, 1997) predominantly interact with high-achieving students. Hence, the findings indicate that the teachers’ behavior in the present sample seems to be “difference increasing” rather than “difference compensating” as more students with a “strong” profile were engaged in verbal teacher-student interactions.

Seidel (2006) revealed that integrating cognitive and motivational-affective characteristics is useful for identifying profiles that affect teacher-student interactions. This dissertation expands the applicability of student profiles to students’ *external* and *internal learning activities*. Beyond the combination of cognitive and motivational-affective characteristics, this dissertation extends previous research by focusing on the interrelation between different aspects, such as teacher statements, individual student characteristics, and gender. The considered aspects show a nuanced picture for predicting *external* and *internal learning activities.* Therefore, this dissertation contributes to existing research that focused on students’ cognitive and motivational-affective characteristics without taking gender *and* teacher statements into account (Lau & Roeser, 2008; Linnenbrink-Garcia et al., 2012).

From a practical point of view, the results indicate a didactical need for action in physics classrooms. Especially students with a “strong” or “overestimating” profile are verbally engaged and report higher cognitive learning activity and intrinsic learning motivation compared to the “underestimating” and “struggling” profile students. With respect to gender, girls engage verbally less often and show a lower cognitive learning activity than boys. Due to the teachers’ “difference increasing” behavior (Einsiedler & Treinies, 1997), students with an “underestimating” and a “struggling” profile and girls have fewer opportunities to formulate their thoughts and ideas. This could be a possible reason for reporting less cognitive learning activity. Such differences may be compensated for if students with “underestimating” and “struggling” profiles and girls were engaged more often in classroom talk. Consequently, from a didactical perspective, teachers are encouraged to involve all students in classroom processes independent of the student profiles and gender. As students’ active participation might also depend on students’ decisions to participate, teachers should provide different opportunities for student verbal engagement and make participation rights clear as well as facilitate students’ decisions to engage in communication (Mercer & Howe, 2012). If teachers take students’ profiles into account when asking questions, they could, for instance, start by calling on weaker students. By allowing students with higher characteristics to answer the questions subsequently, it is quite likely that each new answer will contain a new element. Additionally, teachers should seek to call on quiet students as well to prevent this quiet behavior from persisting during instruction (Aebli, 2003). Therefore, teachers should be sensitive to the characteristics of their students and take student profiles and gender into account when verbally interacting with students. In addition to including all students, teachers should also focus on their statements during classroom talk and, for instance, emphasize the positive aspects of each student answer in their feedback (Aebli, 2003).

With regard to implementing the consequences of the findings in classrooms, the results of this dissertation could be integrated into teacher education and professional development, such as teaching competency trainings with adaptive components (Vogt & Rogalla, 2009). Recognizing and considering girls' and boys' differences in the teaching processes could be very helpful for teachers to adapt their teaching to the individual needs of students. In particular, students with an "underestimating" and "struggling" profile should be involved in classroom talk. A current DFG research project (Seidel & Prenzel, 2011) already used the specific student profiles (Seidel, 2006) by developing standardized interaction situations for pre-service teachers. These teachers interacted with actors showing the specific student profiles, and the exercise was videotaped. A feasible training program in teacher education could also include such standardized and videotaped interaction situations. Videos of the situation could be watched and discussed afterwards, and (pre-service) teachers could learn strategies to interact with the specific student profiles by taking the different characteristics of each single student into account.

Moreover, if teachers would be aware of their students' individual cognitive and motivational-affective characteristics, new instructional designs could be integrated. A possible format could be peer learning in which groups of student learning partners are composed of different profiles (Linn & Hsi, 2000). Integrating such aspects into physics instruction might be helpful to increase the popularity of this school subject and to shift the perspective more to the learners. Previous research already showed that physics instruction oriented to the students' interests instead of the traditional physics curriculum leads to significantly better learning achievements and results in the positive development of the physics-related self-concept, particularly among girls (Häussler & Hoffmann, 2000; Hoffmann, 2002).

Furthermore, teachers should pay attention to the type of question (Erdogan & Campbell, 2008; Hiebert & Wearne, 1993; Lee & Kinzie, 2012; Lipowsky et al., 2007; Michaels & O'Connor, 2012; Oliveira, 2010; Redfield & Rousseau, 1981; Wimer et al.,

2001) and provide feedback to the students (Chin, 2006; Deci et al., 1999; Hattie & Timperley, 2007; Voerman et al., 2012). While the low self-concept of the "underestimating" profile appears unfavorable to their *external* and *internal learning activities*, students with such a profile do have high cognitive characteristics. However, this group of students needs positive feedback to increase their self-concept; as previous studies have stressed a particularly strong relation between positive verbal feedback and academic self-concept (Chen, Thompson, Kromrey, & Chang, 2011). Hence, interventions with respect to teachers' behavior in classroom talk are of great importance (Mercer, Wegerif, & Dawes, 1999; Michaels & O'Connor, 2012; Seidel, 2010).

4.4 Limitations and Further Research Questions

This dissertation revealed specific results with regard only to physics instruction. Therefore, future research could focus on other science subjects, such as biology and chemistry, and explore the role of student characteristics and teacher statements for teacher-student interactions in these subjects. For instance, Linnenbrink-Garcia and colleagues (2012) already combined cognitive and motivational characteristics and gender in biology, but they did not study how these factors influence teacher-student interactions. Moreover, additional emphasis should be given to the different school domains. Expanding the domain-specific perspective would provide opportunities to study the role of student profiles for teacher-student interactions in different areas. Within this context, it could be explored whether identified student profiles in physics instruction can also be found in other domains, such as languages, and whether the identified student profiles also predict *external* and *internal learning activities* in other domains. A comparison of student profiles between different domains could expand the results of this dissertation. A possible research question could be whether students with a specific student profile, such as the "strong" profile, also exhibit the same student profile in another domain. This research question is the topic of an ongoing DFG research project, which investigates student profiles in language arts and mathematics instruction (Seidel, 2012).

Another topic for further research questions is how student profiles develop over their school careers. With the investigation of the development of student profiles it may be possible to identify teaching factors that are beneficial to the progress of individual student characteristics. In addition to the usage-level with its emphasis on students, it would also be interesting to study the supply-level to determine the extent to which teachers differ regarding their behavior in teacher-student interactions across different grades.

This dissertation concentrates on the high and intermediate school tracks. As there are several school tracks in the German educational system, future research could also focus on a comparison of the distribution of student profiles between different school tracks, as previous research has shown that tracking influences students' self-concept (Trautwein, Lüdtke, Köller, Marsh, & Baumert, 2006). It would also be possible to explore the transition from primary to secondary education in the German school system and how student profiles predict the transition processes. Furthermore, the way teachers are influenced by student profiles when making transition decisions from primary to secondary education could be explored. Former studies have already indicated that teachers' recommendations given at the transition from primary to secondary education are partly influenced by students' socio-economic background (Ditton, Krüsken, & Schauenberg, 2005). Students from low socio-economic backgrounds are evaluated less positively compared to students from higher socio-economic descent (Boone & Van Houtte, 2013).

As this dissertation did not investigate whether teachers knew what kind of students were sitting in front of them, another interesting aspect would be to ask teachers about their knowledge regarding their individual students. An expanded perspective could include comparing the teachers' assessments of the students' profiles with the actual student profiles and how teachers' expectations predict their behavior, which is also planned in the ongoing DFG research project (Seidel, 2012). Additionally, the reasons for teachers' behavior in specific teacher-student interactions could be studied. For this purpose, a possible approach to complement the quantitative methods is the use of qualitative methods, such as interviews and thinking-aloud-studies. Case studies would give more detailed information about teacher-student interactions in the classroom and would be helpful to determine if teachers are aware of students' individual characteristics and have specific strategies when interacting with them. Videos of their own teaching could be presented to the teachers and then discussed. This approach has already shown that teachers reflect their teaching and learn new ways to understand teaching and learning when watching their own classrooms on video (Sherin & Han, 2004). As previously mentioned, this dissertation can be seen as a foundation for further teacher trainings of professional development and teacher education to advance teaching in heterogeneous classrooms. Teacher professional development already uses video for teacher learning and professional development (Borko, Jacobs, Eiteljorg, & Pittman, 2006; Krammer & Reusser, 2005; Seago, 2004; Sherin & Han, 2004) with a specific emphasis on classroom talk (Seidel, 2010). Other interventions focus on how adaptive teaching competency can be fostered through coaching (Vogt & Rogalla, 2009). The findings of this dissertation could be integrated into professional development by complementing previous interventions with the expanded knowledge. If students' individual characteristics are considered when examining teacher-student interactions in physics classrooms, then there is a chance to compensate for competency deficits of German students, as "The success of education depends on adapting teaching to individual differences among learners" (Corno & Snow, 1986, p. 605). The investigation of teaching and learning and the development of interventions would benefit from awareness of this specific issue. This could help to advance the current teaching practices in physics classrooms, hopefully resulting in a greater popularity of this school subject and smaller gender differences in performance.

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Appendix

Supplement A:

Jurik, V., Gröschner, A., & Seidel, T. (2013). How student characteristics affect girls' and boys' verbal classroom engagement in physics instruction. *Learning and Instruction, 23*, 33–42. doi: 10.1016/j.learninstruc.2012.09.002

Supplement B:

Jurik, V., Gröschner, A., & Seidel, T. (2014). Predicting students' cognitive learning activity and intrinsic learning motivation: How powerful are teacher statements, student characteristics, and gender? *Learning and Individual Differences, 32*, 132-139. doi: 10.1016/j.lindif.2014.01.005