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The Indirect Relations between Teaching Quality and Student Outcomes: The Mediating Role of Students' Learning Processes

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Abstract

This thesis investigates the mediating role of students' learning processes in the relationship between teaching quality and student outcomes. Based on the opportunity-use model (Helmke, 2012), here, *teaching quality* is broadly the learning opportunities provided in the classroom. Meanwhile, *learning processes* are students' use of these learning opportunities. Because these constructs are very broad, the indirect relationships between their specific dimensions were empirically investigated within the scope of two publications. These are based on established models and theories, such as the model of the Three Basic Dimensions (TBD; Klieme et al., 2009) and Achievement Goal Theory (AGT; Ames, 1992). Within these publications, the mixed results for the mediating role of learning processes may have been caused by different conceptual and methodological approaches, such as the theoretical background, operationalization of the constructs, level of analyses, and study design. The third contribution undertakes a systematic review to categorize the broad constructs and unveil the complex nature of the mediating effects. The results show that both *teaching quality* and *learning processes* are heterogeneously conceptualized and operationalized in the reviewed studies. The results of these reviewed empirical studies are diverse and non-comparable. Finally, the limitations and future directions derived from the main findings of the three publications are discussed.

Zusammenfassung

In vorliegender Arbeit wird die mediierende Rolle der Lernprozesse von Schüler*innen zwischen der Unterrichtsqualität und den Lernergebnissen untersucht. Auf der Grundlage des Angebots-Nutzungs-Modells (Helmke, 2012) wird in dieser Dissertation die Unterrichtsqualität als die von der Lehrperson im Unterricht bereitgestellten Lernmöglichkeiten beschrieben, während die Lernprozesse als die Nutzung dieser Lernmöglichkeiten durch die Schüler*innen beschrieben werden. Da das Verständnis dieser Konstrukte sehr breit ist, wurden indirekte Beziehungen zwischen spezifischen Dimensionen dieser Konstrukte im Rahmen von zwei Publikationen empirisch untersucht. Diese basieren auf einigen etablierten Modellen und Theorien wie dem Modell der drei Basisdimensionen (Klieme et al., 2009) und der Zielorientierungstheorie (Ames, 1992). Die uneinheitlichen Ergebnisse zur vermittelnden Rolle von Lernprozessen in diesen Publikationen könnten durch unterschiedliche konzeptionelle und methodische Ansätze wie dem theoretischen Hintergrund, der Operationalisierung der Konstrukte, der Analyseebene und dem Design der Studien beeinflusst worden sein. Im dritten Beitrag wurde ein systematisches Review durchgeführt, um diese weit gefassten Konstrukte zu kategorisieren und das komplexe Zusammenspiel der Mediationseffekte zu beleuchten. Dieser Literaturüberblick zeigt, dass sowohl die Unterrichtsqualität als auch die Lernprozesse in den untersuchten Studien heterogen konzeptualisiert und operationalisiert werden. Die Ergebnisse der empirischen Studien waren vielfältig und nicht vergleichbar. Die Dissertation schliesst mit einem Ausblick auf zukünftige Entwicklungen und Einschränkungen, die sich aus den Hauptergebnissen der drei Publikationen dieser Dissertation ergeben.

Figures

1. Introduction

How can students learn, achieve more, and be successful in their educational life? For many decades, educational researchers, teachers, and other practitioners in education have asked this question to find effective ways for students to learn and perform better. This question is important because the ultimate purpose of education can be seen as encouraging students to use tools and methods that are helpful throughout their lives. Additionally, it aims to help students become aware of their own potential (such as competencies), improve these competencies with knowledge and practice, provide opportunities for personal and moral development, and fostering their well-being (Dewey, 2010; Kohlberg & Mayer, 1972). One of the most crucial actors in reaching educational goals are teachers as well as their *teaching behaviors*. The way teachers teach in the classroom can positively shape students' learning and achievement.

Despite their importance, achieving these educational goals is challenging, especially for teachers. This is because teaching is complex, multifaceted, and dynamic (e.g., Charalambous & Praetorius, 2020; Cohen et al., 2003). To understand the complexity of teaching, it is crucial to describe the different characteristics of teaching behaviors in the classroom. Some teaching behaviors lead to student learning and may be described as teaching quality. Here, it is important to ask, "What kinds of teaching behaviors can be thought as *teaching quality* that would lead to student learning?" Despite various definitions, some researchers describe *teaching quality* generally as moral teaching behaviors that lead to student learning, their achievement, and positive educational outcomes (e.g., Fenstermacher & Richardson, 2005). To disentangle and understand the general understanding of teaching quality and its complexity, specific dimensions of teaching quality have been described (e.g., Praetorius & Charalambous, 2018). As the goal of education is to enhance student learning in a positive and effective way,

teaching quality and *its dimensions* have been central topics for educational researchers from different disciplines, such as teaching effectiveness and motivation.

Given its high importance within teaching effectiveness research, scholars have investigated the effects of teaching quality dimensions on students' learning outcomes, such as their achievement (e.g., Fauth et al., 2014; Klieme et al., 2009; Seidel & Shavelson, 2007). However, the results of reviews and empirical studies are somewhat puzzling. Although some reviews reveal positive effects of teaching quality on student outcomes, some statistically non-significant associations are also observed (e.g., Seidel & Shavelson, 2007). Therefore, understanding the inconsistencies and gaps in this relationship is important.

One reason for the inconsistent results could be that teaching quality is a multifaceted construct that includes many dimensions and specific characteristics within many theoretical approaches and frameworks. Some theoretical frameworks are based on research on teaching effectiveness and teaching quality, whereas others are grounded in psychological research such as motivation. Motivation is an important student outcome that has been frequently investigated in teaching quality frameworks, such as the Three Basic Dimensions of teaching quality framework (TBD; e.g., Klieme et al., 2009; Lipowsky et al., 2009). Therefore, in addition to the established teaching quality frameworks (for an example list of frameworks, see Praetorius & Charalambous, 2018), considering motivation theories is important (for a list of some motivational theories, see Vu et al., 2022). In particular, the factors within motivational theories relate to student learning (Kyriakides et al., 2023; Weiner, 1990). A prominent and well-established motivational theory is the Achievement Goal Theory (AGT; Ames, 1992; Murayama & Elliot, 2009). It is one of the most relevant motivational theories for teaching quality research because within the AGT, specific teaching behaviors are defined and conceptualized to affect the relevant motivational construct. Thus, among the many theories and models in these fields, two empirical contributions of this dissertation focus on specific

and important examples of both approaches, the TBD framework (Klieme et al., 2009) and AGT (Ames, 1992; Murayama & Elliot, 2009).

TBD is a specific and prominent framework in German-speaking countries. Its three dimensions include *cognitive activation* (i.e., giving optimally challenging tasks to students and providing room for in-depth discussions), *classroom management* (i.e., preventing disruptive behaviors, communicating clear rules, and monitoring students), and *student support* (i.e., satisfying students' needs, supporting them when needed, giving them meaningful choices, and providing relevance to the tasks). Several studies have shown that these three dimensions positively affect student motivation and achievement (e.g., Fauth et al., 2014; Lipowsky et al., 2009). However, an overview of empirical studies on the TBD framework revealed that the theoretically assumed relationships of each dimension with student achievement and motivational outcomes are not always empirically supported (Praetorius et al., 2018).

While the TBD framework focuses on the important teaching quality dimensions and aims to investigate their effects on outcomes, motivational theories, particularly achievement motivation literature, attempt to understand individuals' sources of motivation and find ways to enhance them by adapting the environment according to these motivational mechanisms (e.g., Ames, 1992). A specific framework in this literature that attempts to understand the source of motivation and environment that fosters it is the AGT (Ames, 1992; Murayama & Elliot, 2009). According to AGT, individuals pursue mastery (i.e., goals focusing on understanding and learning) or performance goals (i.e., goals focusing on grades and outperforming others). Based on these, teachers' goal-related messages are described, and seen as important teaching behaviors for adapting those goals and improving student learning. Such goal-related messages are called *classroom goal structures*, whose two broad dimensions are

mastery (i.e., messages focusing on understanding and learning) and *performance goal structures* (i.e., messages focusing on grades or competing with others).

Several studies have described teaching quality from the perspective of AGT by focusing on mastery and performance-oriented teaching behaviors (i.e., task, authority, recognition, grouping, evaluation, time) within the TARGET model (see also Bardach et al., 2021; Bergsmann et al., 2013a; 2013b). Considering the aforementioned definitions of teaching quality mentioned and the general levels of teaching behavior within the TARGET model, classroom goal structures can be seen as specific aspects of teaching quality. Many empirical studies have shown that classroom goal structures play a major role in affecting students' academic achievement goals, and are related to student achievement and motivation (e.g., Meece et al., 2006; Wolters, 2004). However, a synthesis of studies conducted with middle and secondary school students revealed that most relationships between *performance goal structures* and student achievement were not positive. Additionally, *mastery goal structures* were mostly positively linked to student achievement; however, no associations were found in some cases (Givens Rolland, 2012).

These two theoretical approaches clearly imply inconsistent associations between teaching quality and students' academic outcomes, particularly student achievement. Then, the reasons for inconsistent findings can be derived by considering the results of studies using these theoretical approaches. One important explanation is the different mechanisms underlying these aspects of teaching quality and student outcomes. Although these direct effects have been investigated, the underlying processes (students' learning processes) between teaching quality and student outcomes, such as motivation or achievement, have not yet been fully understood.

The idea of underlying mechanisms is rooted in the constructivist perspective of learning. According to this perspective, learners actively construct knowledge and build meaning themselves. It is assumed that teaching does not directly affect student achievement, but does

so through students' learning processes (e.g., Vygotsky, 1978; Seidel, 2014). Based on this idea, within the German-speaking research community, the opportunity-use model was developed (*Angebots-Nutzungs Modell*; Helmke, 2012; Seidel, 2014). This model focuses on the idea that teaching behaviors are viewed as opportunities for students. When students use these opportunities created and provided in the classroom, they are assumed to achieve better and be successful through their *use of learning opportunities* (students' learning processes). In this dissertation, students' learning processes are considered a broad construct based on different theoretical backgrounds, and are described as students' *behavioral, motivational, emotional, cognitive, and metacognitive* learning experiences in a learning environment. Considering the importance of the constructivist perspective and mediation assumption in this research field, this dissertation aims to empirically investigate the indirect relationships between, teaching quality, students' learning processes, and student outcomes by focusing on the specific dimensions of these constructs and systematically reviewing relevant empirical studies.

In the following sections, the theoretical background and state of research in teaching quality and learning processes are presented first (Chapter 2). Next, the aims of the dissertation (Chapter 3) and its three contributions are presented (Chapter 4). Finally, the results of the contributions are discussed broadly and the implications for research and practice, limitations, and future research directions are outlined (Chapter 5).

2. Theoretical Background

Here, the current state of research (Section 2.1) as well as empirical findings and research gaps (Section 2.2) are presented. To conceptualize the constructs, teaching quality (Section 2.1.1), student outcomes (Section 2.1.2), learning processes, and their mediating roles (Section 2.1.3) are described based on the established theories and models. Finally, the empirical findings and gaps regarding the link between teaching quality and student outcomes (Section 2.2.1), and the mediating role of learning processes (Section 2.2.2) are introduced.

2.1. Conceptualizations of the constructs

2.1.1. Teaching quality

Educational research explores the specific characteristics of a learning environment and teaching behaviors that positively affect student outcomes, such as student achievement and motivation (Opdenakker, 2023; Zitzmann et al., 2021). Due to their importance, the characteristics of teaching behaviors have been described in various domains. One domain is *teaching quality research*, and relatedly, teaching effectiveness research, which explores what high-quality teaching is and how teaching can be effective for student learning (e.g., Seidel & Shavelson, 2007). In this domain, teaching is understood as a classroom construct (e.g., Marsh et al., 2012). Another domain is *motivation research*, which describes the characteristics of teaching from the perspective of student motivation and often considers the perception of teaching as an individual construct. While understanding teaching and teaching effectiveness, motivation research is particularly important because motivation is often seen as an antecedent of student learning, achievement, and development (Opdenakker, 2023; Vu et al., 2022). Additionally, most teaching quality frameworks and empirical studies based on these frameworks consider motivation as an important student outcome (e.g., Fauth et al., 2019, Klieme et al., 2009).

These two educational research domains have advanced independently of each other; indeed, descriptions of teaching quality in these domains typically differ (Opdenakker, 2023). However, some commonalities exist. For example, both domains describe characteristics of high-quality teaching (Opdenakker, 2023). To better understand these differences and commonalities, this dissertation adopts an exploratory approach based on the theoretical approaches from these two research domains.

Teaching quality is viewed as one of the most important social factors affecting student learning (e.g., Muijs et al., 2014; Seidel & Shavelson, 2007). Because of its importance in the field of educational sciences and to understand its features, researchers have defined and conceptualized teaching quality by considering its different facets. Sometimes, it has been defined as a teaching characteristic that positively influences learning outcomes, which has mainly included student achievement or performance (Praetorius et al., 2017; Seidel & Shavelson, 2007). Another definition is a content-focused social process that is co-constructed by teachers and students (e.g., Praetorius et al., 2018; Thommen et al., 2021), and is in line with normative beliefs and values (Berliner, 2005; Fenstermacher & Richardson, 2005). Finally, in another description, teaching is argued to be a complex construct that demonstrates interactions between students, teachers, and subjects (Bell, 2020; Cohen et al., 2003). Clearly, teaching quality is seen as a complex and broad concept, and defining it is difficult (Berliner, 2005; Cohen et al., 2003).

To empirically examine this intricate construct, models and frameworks have been developed in teaching quality research to capture its core aspects, characterizing teaching quality using groups of separate and specific dimensions (for a review, see Praetorius & Charalambous, 2018). One such framework is the TBD framework (Klieme et al., 2009). It is a well-established teaching quality framework, particularly in German-speaking countries, and distinguishes three dimensions: *classroom management* (i.e., clarity of rules, monitoring,

withitness, effective transitions, efficient prevention, and handling of disruptions), *cognitive activation* (i.e., providing optimally challenging tasks, practicing discourse, and stimulating participation in deep classroom discussions), and *student support* (i.e., supporting students' need for autonomy, competence, and relatedness).

Given multiple frameworks and models, some researchers have compared, analyzed, and synthesized them. The MAIN-TEACH model is the result of one such synthesis of teaching quality frameworks (Charalambous & Praetorious, 2020). This model proposes seven dimensions of teaching quality: supporting practice, selecting and addressing content- and subject-specific methods, cognitive activation, formative assessment, classroom and time management, support for active engagement, socio-emotional support, and differentiation and adaptation (for each dimension's description, see Charalambous & Praetorius, 2020). Thus, teaching quality is a multifaceted construct that covers various dimensions and understanding what constitutes it is crucial.

In addition to the established frameworks and models in teaching quality research that identify the distinct characteristics of teaching practices (Charalambous & Praetorius, 2020), other domains, such as motivation research, assume that certain teaching behaviors can positively affect student outcomes. Empirical studies in motivation research have described teaching quality based on motivational theories (e.g., Bergsmann et al., 2013a; 2013b; Capon-Sieber et al., 2022; León et al., 2017, 2019; Ruiz-Alfonso & León, 2017; Theis et al., 2020). One well-established theory of achievement motivation is the AGT (Ames, 1992; Murayama & Elliot, 2009). Within AGT, the well-grounded TARGET model identifies teaching behaviors that help foster students' achievement goals, particularly mastery goals, and other motivational outcomes (Ames, 1992; Clinkenbeard, 2012). Specifically, the model describes and distinguishes six dimensions of teaching behaviors: *task* (designing tasks that include some reasonable and optimal challenge for students, are rich in variety, and help students' to think

about their learning), *authority* (involving students to develop their skills in decision making processes and deciding with students how to proceed in the classroom), *recognition* (recognizing student effort for learning to improve), *grouping* (establishing heterogeneous and flexible grouping), *evaluation* (focusing on improvement, mastery, and progress by giving constructive feedback), and *time* (giving opportunities students to improve, and providing flexible and sufficient time for their individual studies) (Ames, 1992; Bergsmann et al., 2013a). These six dimensions share some common characteristics with the dimensions described by teaching quality frameworks (see for example, the MAIN-TEACH model; Charalambous & Praetorious, 2020). This highlights the connection between *teaching quality* and *motivation research*.

According to the AGT, these six mastery- and performance-oriented teaching behaviors can help students pursue their achievement goals. Derived from the concept of mastery (i.e., goals focusing on learning and understanding) and performance goals (i.e., goals focusing on performance and normative success), Ames (1992) categorized these six relevant teaching practices based on two broad categories of *classroom goal structures*: *mastery* (i.e., teachers' goal-related messages focusing on learning, improvement, and understanding) and *performance goal structures* (i.e., teachers' goal-related messages focusing on competing with others or performing better). Such specific teaching behaviors, within the TARGET model, can provide underlying messages related to students' achievement goals. For example, within the *task* dimension, teachers can prepare tasks that can foster students' thinking about their own learning and understanding (i.e., mastery goal structure). Meanwhile, announcing exam results in the classroom can focus on the performance of the students and provide a message that the students should perform better in the future (i.e., performance goal structure). Because of their influential nature in teaching, classroom goal structures are considered global instructional

approaches, and important elements for students' achievement goals and functioning (Daumiller et al., 2022).

Considering the nature of teaching and definition of teaching quality given above, several researchers unsurprisingly describe teaching quality by referring to classroom structures (or *goal structures*) within the TARGET model (e.g., Bardach et al., 2021; Bergsmann et al., 2013a; 2013b; Daumiller et al., 2023; Lüftenegger et al., 2015). This is because these teaching practices focus on improving students' goals towards learning. For example, mastery goal structures describe specific teaching behaviors, such as providing constructive feedback to create a positive motivational climate that focuses on learning and improvement (e.g., Ames, 1992; Bardach et al., 2020a; 2020b). In this dissertation, the general levels of these teaching practices, namely mastery and performance goal structures, are deemed important aspects of teaching quality based on the definition of classroom goal structures. Their conceptualizations, on a more general level, may facilitate clearer theoretical considerations within the AGT (Daumiller et al., 2022).

Regarding the two theoretical frameworks (TBD and AGT), teaching quality is understood broadly. Moreover, to date, most studies have examined the relationships between teaching and learning based on certain research traditions, such as *teaching quality research* or *motivation research*. A systematic understanding of teaching quality, especially in studies investigating mediation, is lacking. Considering the theories of achievement motivation (e.g., AGT) and theoretical models (e.g., TBD) in teaching quality research, and the exploration of the descriptions of teaching quality with a systematic review, this dissertation aims to understand what constitutes teaching quality by having a more inclusive and broader perspective. This is useful and important because a broader view can help in identifying the similarities and differences between teaching quality dimensions based on different theoretical strands.

In the first contribution, *classroom goal structures* (i.e., teachers' goal-related messages) are investigated and they are seen as teaching quality within the AGT. In the second contribution, teaching quality corresponds to the three basic dimensions of teaching quality (i.e., *cognitive activation, classroom management, and student support*) described within the TBD framework. In the third contribution, a systematic review identifies which theoretical framework empirical studies are based on, and how they describe, conceptualize, and operationalize teaching quality while investigating its indirect effects on student outcomes. For this, the MAIN-TEACH model was used to categorize the teaching quality dimensions (Charalambous & Praetorius, 2020). To explore the theoretical background on which the studies focus, the systematic review adopted a broader view instead of focusing on only one theoretical perspective on teaching quality. The synthesis of the three contributions can inform future theoretical and empirical works on teaching quality on a broader level.

2.1.2. Student outcomes

Within the two theoretical strands of *teaching quality* and *motivation research*, teaching quality is assumed to positively affect student outcomes. Some theories focus on improving achievement outcomes, some examine non-cognitive outcomes (e.g., student development, well-being, and motivation in the classroom), while others emphasize both cognitive and non-cognitive outcomes (Oppdenakker, 2023).

Within *teaching quality research*, the aim is to increase student success and performance related to the learning content as well as students' outcomes which are closely related to academic achievement outcomes. Therefore, student outcomes are categorized as cognitive and non-cognitive outcomes (see Praetorius & Charalambous, 2023; Seidel & Shavelson, 2007). Cognitive outcomes refer to student achievement or performance, whereas non-cognitive outcomes mostly refer to students' motivational characteristics as well as metacognitive and psychomotor outcomes.

To include both cognitive and non-cognitive outcomes in teaching quality research, particularly within the TBD framework, achievement and motivation are considered the most important educational outcomes (Klieme et al., 2009). In studies based on the TBD framework, student achievement is typically represented by grades or standardized tests in specific subjects, whereas student motivation is typically represented by self-reported interest or self-efficacy (e.g., Fauth et al., 2014; 2019; Herbert et al., 2022; Klieme et al., 2009). Researchers have investigated cognitive and non-cognitive outcomes, such as student achievement and interest, to understand the unique role of teaching quality on each outcome (e.g., Fauth et al., 2014; 2019; Herbert et al., 2022).

Similar to teaching quality frameworks, some motivational theories also focus on outcomes such as student achievement, motivation, as well as well-being (e.g., AGT and self-determination theory (SDT)). Furthermore, motivational theories such as SDT (Ryan & Deci,

2017) and empirical studies use indicators of well-being such as vitality (e.g., Capon-Sieber et al., 2022), life satisfaction (e.g., Leversen et al., 2012), and flow experience (e.g., Brown & Ryan, 2004; Schüler et al., 2013) to assess outcomes. Thus, within these frameworks of teaching quality and *motivation research,* student achievement, motivation, and well-being are assumed to be positively affected by teaching quality.

Student outcomes constitute a diverse range of constructs such as achievement, motivation, and well-being. This dissertation includes some of these indicators. In the first contribution, indicators of well-being and optimal educational experiences, such as flow, vitality, and educational satisfaction in general as well as in specific courses, are assessed. In the second contribution, students' achievements and interests in mathematics are assessed. Third, a systematic review explored the studies that have investigated student achievement as an outcome. Achievement, motivation, and well-being are closely connected, beneficial for students, and important for successfully achieving educational goals (Morinaj & Tascher, 2022). The variety of outcomes assessed in this dissertation can help in comparing the results for certain outcomes by identifying similarities and differences. Ultimately, this variety can help identify new research areas to connect student outcomes stemming from different theoretical strands while examining the indirect link between teaching quality and student outcomes.

2.1.3. The mediating role of students' learning processes

Learning processes (or *learning activities*) are a broad concept used in the fields of educational psychology and educational research, and many conceptualizations of learning processes exist. To understand this broad construct, categorizing these conceptualizations is important. In her dissertation, Huber (2017) categorized students' learning processes into *external* and *internal* learning processes. Whereas *external learning processes* are observable behaviors, such as discussions, completing worksheets, and doing homework, *internal learning processes* are categorized as cognitive and motivational learning processes. *Internal learning processes* are considered to be more essential for student outcomes because scholars argue that it is not external processes that are connected with students' learning outcomes, but how students make meaning of and engage with the activity matter (Graham & Golan, 1991; Chi, 2009; Huber, 2017). This idea of engagement is explained by internal learning processes that function during external learning processes and are assumed to lead to learning. This dissertation focuses on *internal learning processes*, which can be broadly defined as students' *behavioral, cognitive, metacognitive, emotional, and motivational* experiences during learning which affect student outcomes.

The mediating role of learning processes has become a pivotal assumption in recent decades, as the constructivist perspective is key in teaching and learning (Vygotsky, 1978). Within *teaching quality research*, particularly in German-speaking countries, one influential model explaining the mediating role of learning processes is the opportunity-use model (*Angebots-Nutzungs-Modell*; see Helmke, 2012). The model assumes an indirect impact, where teaching behaviors or learning opportunities do not influence student outcomes directly but instead through *students' use of learning opportunities*. In this model, Helmke (2012) categorized students' use of learning opportunities (or learning processes) based on whether learning occurred during regular instruction times or outside the classroom. Within this model,

scholars have mentioned many other dimensions of learning processes, such as emotions and homework (e.g., Klieme et al., 2009; Lipowsky, 2006; Seidel, 2014). Thus, being comprehensive and inclusive, the model supports the assumption of mediating role of learning processes.

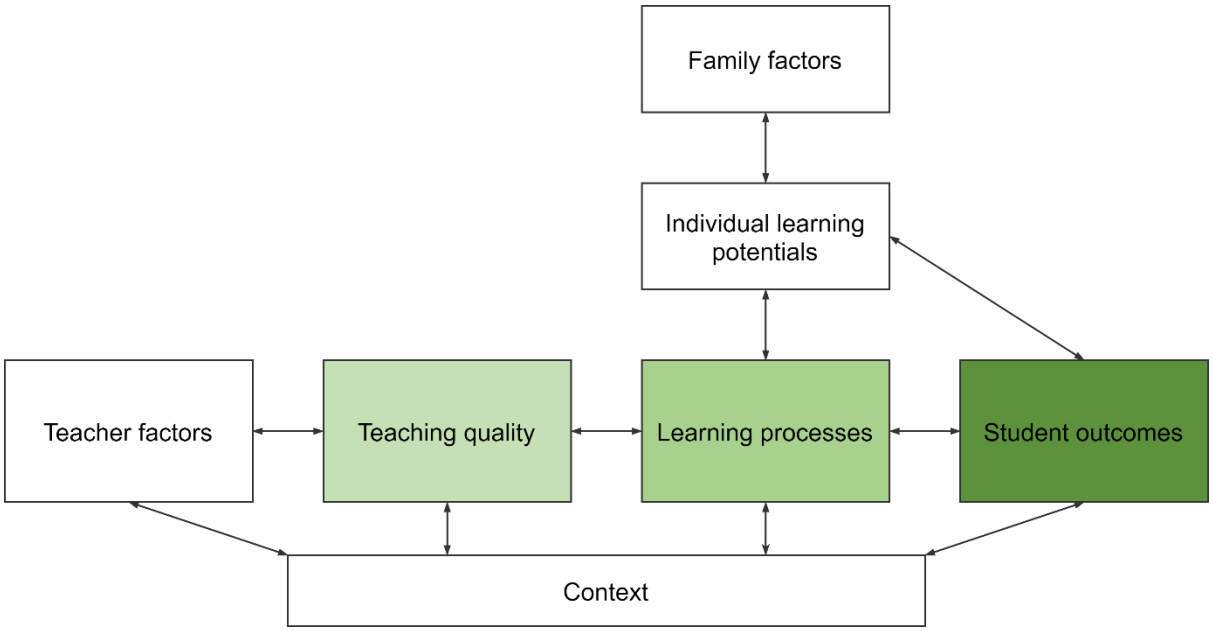

Figure 1. The opportunity-use model (adapted and simplified from Helmke, 2012; Seidel, 2014; Vieluf et al., 2020)

The constructivist understanding has become the state-of-the-art in educational research and has been incorporated into various models of teaching quality. Based on the opportunity-use model, the TBD model (Klieme et al., 2009) connects the three dimensions of teaching quality to achievement and motivation outcomes with three mediators representing students' learning processes (or students' use of learning opportunities): *time-on-task, depth of processing,* and *satisfaction of the three basic psychological needs*. Specifically, classroom management is assumed to affect student achievement through depth of processing (i.e., high-level thinking), time-on-task (i.e., time spent engaged in learning), and need satisfaction (i.e., needs for autonomy, competence, and relatedness). Cognitive activation affects student achievement through depth of processing, while student support affects student motivation

through need satisfaction (Klieme & Rakoczy, 2008; Klieme et al., 2009; Praetorius et al., 2018). The TBD model includes need satisfaction as a mediator based on SDT (Deci & Ryan, 2000). According to SDT, the three basic psychological needs are seen as psychological mediating mechanisms between teaching behaviors and student outcomes, such as motivation and well-being (Connell & Welborn, 1991; Deci et al., 1991; Skinner et al., 2009). This emphasizes the important connection between *teaching quality* and *motivation research*.

Many theories on achievement motivation describe learning processes, and propose mediating mechanisms between teaching quality and student outcomes. One model that takes an integrative and comprehensive view of these mechanisms is the self-system model of motivational development (SSMMD; Skinner et al., 2009). This model assumes that teaching, or more generally, the classroom environment first affects the *self* and then *action*, which in turn affects student outcomes. *Self* is described as a motivational system consisting of values, beliefs, perceptions, and attitudes, whereas *action* is described as engagement-related aspects such as self-regulation and cognition. Thus, *action* is assumed to be directed by motivational processes (*self*). *Self* and *action*, in turn, are assumed to affect student outcomes, such as well-being, academic achievement, and adjustment. In the third contribution of this dissertation, SSMMD was used to categorize students' learning processes, which were empirically investigated as mediators in the reviewed studies.

In summary, learning processes are broad and conceptualized differently in the literature depending on the theoretical background they are based on. The term 'learning processes' contains a diverse set of variables, including both specific constructs such as *basic psychological needs* and multifaceted constructs, such as *student engagement* which are seen as important determinants of students' achievement and adaptive functioning. Furthermore, the mediating role of learning processes has been assumed in various theoretical models. This dissertation takes a broader view to answer the research question by focusing on different

theoretical approaches. This broad view is important and useful because it can increase the possibility of treating and investigating these constructs by considering several theoretical assumptions. The inclusion of a variety of theoretical assumptions might help in better understanding "the piece of reality" in teaching and learning (see Prediger et al., 2008). This might open new opportunities for integrating different strands while investigating mediation in empirical educational research.

The two empirical contributions of this dissertation aim to investigate the mediating effects of learning processes in the relationship between teaching quality and student outcomes by focusing on their specific dimensions. In the third contribution, the systematic review aims to explore how empirical studies conceptualize and operationalize these constructs, and synthesize their findings. Taking this exploratory approach and the variety of different theoretical backgrounds, conceptualizations, and operationalizations can help us in understanding whether specific patterns exist in the results.

2.2. Empirical findings and research gaps

2.2.1. The relationships between teaching quality and student outcomes

While teaching quality is assessed based on a variety of dimensions and operationalizations, meta-analyses and reviews have revealed varying associations between teaching and student outcomes. For example, Seidel and Shavelson's (2007) meta-analysis examined the effects of teaching on motivational-affective, cognitive, and learning process outcomes. The results showed that, although domain-specific activities had the greatest effect on student outcomes, the effects of the other dimensions varied. According to Muijs et al.'s (2014) review, the impact of teaching quality on students' non-cognitive outcomes, such as motivation and engagement, ranged from non-significant to moderate. In another systematic review, Wang et al. (2020) found that overall quality of teaching (i.e., instructional support, classroom organization and management, and socio-emotional support) had small-to-medium positive relationships with engagement, motivation, social competence, and academic achievement.

Further, the associations have been investigated within specific theoretical frameworks, such as the TBD and AGT. Although scholars widely accepted and assumed the constructivist notion, within the TBD framework (Klieme et al., 2009), studies empirically examined the direct effects of student support, cognitive activation, and classroom management on student outcomes, such as achievement and motivation, and found inconsistent results both supporting the positive direct effects of teaching quality (e.g., Baumert et al., 2010; Decristan et al., 2015; Lipowsky et al., 2009) and those indicating no significant direct effects (e.g., Blömeke et al., 2016; Ergönenç et al., 2014). The inconsistent results became more evident when empirical studies based on the TBD framework were conducted. Studies that investigated these relationships longitudinally in multilevel models revealed inconsistent results regarding the

assumed effects of each dimension (student support, classroom management, and cognitive activation) on student motivation and achievement (Praetorius et al., 2018).

Recent studies have investigated these direct associations (e.g., Fauth et al., 2019; Herbert et al., 2022; Senden et al., 2023). In line with the assumptions of the TBD framework, Fauth et al. (2019) showed that both classroom management and cognitive activation are positively linked with elementary students' science achievement, whereas student support is positively associated with students' interest in science. Senden et al. (2023) showed that classroom management was positively linked with student achievement in both fifth and nine grades; however, for cognitive activation and student support, this positive link was only found in ninth grade. Herbert et al. (2022) investigated these relationships across education systems and found that the effects differed between countries. They found no statistically significant effects of student support on student achievement across educational systems, except in Colombia; disruptions (an aspect of classroom management) were positively linked with student learning only in England and Mexico; and cognitive activation was positively related to student learning only in Colombia and Japan. Besides the overview by Praetorius et al. (2018), the findings of the recent studies confirm the inconsistencies of the results of these direct relationships. These results warrant further investigation to reconsider and investigate the assumptions of the TBD model.

In addition to teaching quality frameworks, such as the TBD framework, and motivational theories, such as the AGT, inconsistent associations were found. Similar to the TBD framework, *classroom goal structures* based on AGT are assumed to be important determinants of student outcomes (Murayama & Elliot, 2009; Urdan, 2004). However, *mastery goal structures* are viewed to be more reliable positive correlates of motivation than *performance goal structures* (Michou et al., 2013; Murayama & Elliot, 2009). However, empirical evidence for student outcomes is less clear than theoretical assumptions. A review

and meta-analysis of studies conducted with middle school students showed that *mastery goal structures* were frequently positively linked with sixth grade students' motivation and achievement; however, this link was not always found for seventh grades. By contrast, the link between *performance goal structures* and achievement was negative in sixth grade, whereas no link was found in older grades (Givens Rolland, 2012). The links between *classroom goal structures* and student outcomes, such as grade, self-efficacy, and stress for school performance, have also been investigated, and distinct results were found for mastery and performance goal structures (e.g., García-Moya et al., 2023; Gutman, 2006; Kaplan et al., 2002). These results also underline the fact that direct links between classroom goal structures and those student outcomes have not always been found empirically. This highlights the need for further research to examine the association between classroom goal structures and student outcomes.

2.2.2. The mediating effects of students' learning processes

Studies have examined the association between teaching quality and student learning processes by focusing on selected dimensions. For example, some studies within the TBD framework investigated the relationships between the three basic dimensions of teaching quality and aspects of learning processes, such as *academic emotions* based on the control-value theory of achievement emotions (CVT; see Lazarides & Buchholz, 2019; Pekrun, 2006), or *situational interest* based on interest theory (see Dorfner et al., 2018; Hidi & Renninger, 2006). Most direct associations between teaching quality and the selected learning processes were as expected, but some unexpected results were also found (e.g., Dorfner et al., 2018; Lazarides & Buchholz, 2019). Dorfner et al. (2018) found that a supportive climate and cognitive activation predicted students' situational interest at the classroom level, but classroom management did not. Lazarides and Buchholz (2019) longitudinally investigated the relationship between the three basic dimensions of teaching quality and students' achievement

emotions. The authors found that at the classroom level, cognitive activation and student support were positively related to enjoyment, cognitive activation and classroom management were negatively related to boredom, and student support was negatively related to anxiety. However, the associations are mixed and remain unclear. This demonstrates the need for further investigation of the associations between teaching quality and learning processes.

Within the TBD model, the mediating factors between the three basic dimensions of teaching quality, and student motivation and achievement have been described based on SDT (e.g., Deci & Ryan, 2000) and constructivism (e.g., De Corte, 2004). For example, need satisfaction is assumed to mediate the relationship between student support and student motivation. However, student support can also be related to depth of processing and time-on-task when considering other theoretical perspectives. Therefore, in addition to the originally hypothesized relationships within the TBD model, a more integrative and comprehensive approach to explore the associations between these constructs is needed. Additional theoretical perspectives can help better explain the associations between the variables within the TBD model. Moreover, the entire TBD model was only investigated empirically in one study by Helm (2016). The author used the subdimensions of teaching quality and mediators to conduct a series of multilevel analyses. The results showed that, depending on the dimensions, the mediating role of each aspect of the learning processes differed. These puzzling findings underscore the importance of conducting more studies on the mediation assumptions of the TBD model. These are important gaps, considering that the TBD framework is a well-established and influential framework in the field of teaching quality.

Similarly, within the prominent motivation theory, AGT, the links between *classroom goal structures* and student-selected learning processes has been investigated in different contexts (e.g., Murayama & Elliot, 2009; Urdan, 2004). Other than academic achievement outcomes or school performance, studies in various contexts have found some associations

between *classroom goal structures* and certain aspects of learning processes such as students' emotions (e.g., Baudoin & Galand, 2017), motivation (e.g., Won et al., 2020), learning strategies, and achievement goals (e.g., Michou et al., 2013).

Yet, a clearer understanding of the underlying mechanisms between classroom goal structures and student outcomes is lacking. Within the works using AGT, the underlying mediating processes between classroom goal structures and students' outcomes were assumed to be *achievement goals* (see Section 2.1.2). Empirical works have found supporting evidence for this mediating role for student outcomes such as learning strategies, intrinsic motivation, self-concept, and school adjustment (e.g., Michou et al., 2013; Murayama & Elliot, 2009; Shim et al., 2013). However, other possibly important learning processes, such as *basic psychological needs* within SDT, have been neglected. This is important to consider as according to the SDT (Ryan & Deci, 2017) and SSMMD (Skinner et al., 2009), the three basic psychological needs are important psychological mechanisms that mediate between environmental factors, such as teaching behaviors, and student outcomes. Furthermore, it is unclear whether basic psychological needs mediate the relation between classroom goal structures and student outcomes, such as flow, vitality, and educational satisfaction, which are important indicators of well-being and optimal experiences (e.g., Csikszentmihalyi, 2014; Diener, 1984; Nix et al., 1999).

Moreover, the most of studies mentioned within the AGT have been conducted with middle or secondary school students. However, associations between classroom goal structures and students' achievement goals could be more evident in secondary schools than in primary school settings (Bardach et al., 2020a). Developmental factors, such as grade level, play a role in the association between mastery goal structures and student outcomes (Givens Rolland, 2012). Therefore, investigating these associations in particular age groups and settings is

important to distinguish developmental differences. Furthermore, empirical investigations of classroom goal structures and their indirect effects at the university level are scarce.

In addition to the two lines of empirical research focusing on the TBD and AGT frameworks, several reviews and meta-analyses have been conducted, revealing inconsistent findings regarding the effects of teaching quality on student outcomes (e.g., Kyriakides et al., 2013; Muijs et al., 2014; Praetorius et al., 2018; Roorda et al., 2011; Seidel & Shavelson, 2007; Wang et al., 2020). To interpret these inconsistent results, further research is necessary to better understand how the underlying mechanisms function as they can explain how teaching quality or its dimensions are related to student achievement, as the constructive notion is central to teaching and learning. Mediator variables, especially those related to student learning processes, should be considered when analyzing the link between teaching quality and student achievement. A clear understanding of the underlying mechanisms will further help in interpreting the inconsistent direct relationships.

To understand the mediating mechanisms, a few reviews have synthesized studies investigating the mediating effects of student engagement between specific dimensions of teaching quality and achievement (e.g., Roorda et al., 2017; Tao et al., 2022). A meta-analysis conducted by Roorda et al. (2017) showed that student engagement partially mediated the link between teacher-student relationship and student achievement. Another meta-analysis by Tao et al. (2022) found that student engagement and its components (i.e., cognitive, emotional, and behavioral) partially mediated the link between teacher support and student achievement. Thus, other mediating mechanisms may play a role in these relationships. Moreover, a more holistic consideration of the mediating role of various learning processes in the relationship between teaching quality and student achievement is needed. As few reviews exist on this topic, this issue constitutes an important research gap, considering the broad acceptance of the constructivist notion in the field (e.g., Klieme et al., 2009; Praetorius et al., 2018).

To fill the aforementioned gaps, this dissertation aims to examine (1) the mediating effects of students' learning processes on the association between teaching quality and student outcomes by focusing on their specific dimensions with the help of two empirical studies, and (2) through the systematic review, which aspects of teaching quality, learning processes, and achievement have been tested in empirical studies, and summarize their results.

3. Aims and overviews of the three contributions

This dissertation asks the following question: "*To what extend students' learning processes mediate the associations between teaching quality and student outcomes?"*. First, it investigates teaching quality in two empirical studies by considering two specific frameworks that describe the aspects of teaching quality: TBD and AGT. The first contribution of this dissertation is based on the AGT and SDT. It focuses on two specific dimensions of teaching quality by focusing on classroom goal structures (mastery and performance goal structures), a specific type of learning process (need satisfaction), and three learning-related outcomes (flow, vitality, and educational satisfaction). The second contribution is based on the TBD model. It focuses on the three basic dimensions of teaching quality (student support, cognitive activation, and classroom management), three specific types of learning processes (need satisfaction, depth of processing, and time-on-task), and two student outcomes (interest and achievement). Two specific research questions are derived for these two contributions:

1. Does need satisfaction (a specific dimension of learning processes) mediate the association between perceived classroom goal structures (specific dimensions of teaching quality) and students' flow, vitality, and educational satisfaction (specific outcomes)?
2. Do depth of processing, time-on-task, and need satisfaction (specific dimensions of learning processes) mediate the relationship between the three basic dimensions of teaching quality (specific dimensions of teaching quality), and student achievement and interest (specific outcomes)?

These research questions are addressed by focusing on the specific dimensions of teaching quality, learning processes, and outcomes. Publication 1 used a sample of university students in Turkey and their specific courses, while Publication 2 used a sample of secondary

school students in Germany and a specific subject, which was mathematics. These two publications empirically contribute to this thesis (Alp et al., 2018; Alp Christ, Capon-Sieber et al., in revision). The answers to these research questions have important implications for research and classroom practices. Understanding which learning processes are important mediating mechanisms in the relationship between certain teaching quality dimensions and student outcomes can help researchers to further investigate these mediating mechanisms with experiments and interventions in the future. Further, it can help teachers to support these learning processes by applying certain teaching behaviors in the classroom.

Second, a systematic review was conducted to better understand the empirical studies that investigated students' learning processes as the mediators between teaching quality and student achievement. Considering many theories and frameworks in the field, this systematic review takes an exploratory approach and views these constructs in general. Thus, the findings of the first and second contributions can be better interpreted with the help of a broad overview. The three aims of this systematic review are as follows. First, it aims to identify and categorize the types of learning processes that have been assessed as mediators between teaching quality and student achievement. Second, it aims to explore and compare the operationalization of learning processes in the reviewed studies. Third, it aims to give an overview of the results of the corresponding quantitative studies. Such a broad review can help researchers to identify important gaps and future directions for research and practice in the field of teaching quality. Accordingly, the following research questions are derived for this systematic review:

1. How was teaching quality conceptualized and operationalized in the reviewed studies?
2. What types of learning processes were assessed as mediators? How were they conceptualized and operationalized?
3. What were the results of empirical studies?

In summary, this dissertation first uses individual empirical studies to explore the mediating role of selected learning processes based on specific theoretical approaches (Publications 1 and 2). These two empirical contributions integrate different theoretical strands. Whereas the first contribution is based on AGT and SDT, the second is based on the TBD model and integrates several theoretical approaches, such as the control-value theory of achievement emotions (CVT; Pekrun, 2006) and expectancy-value theory (EVT; Wigfield & Eccles, 1992). Finally, the dissertation explores the conceptualizations and operationalizations of the constructs by systematically reviewing empirical studies (Publication 3). The three contributions are represented in Figure 2.

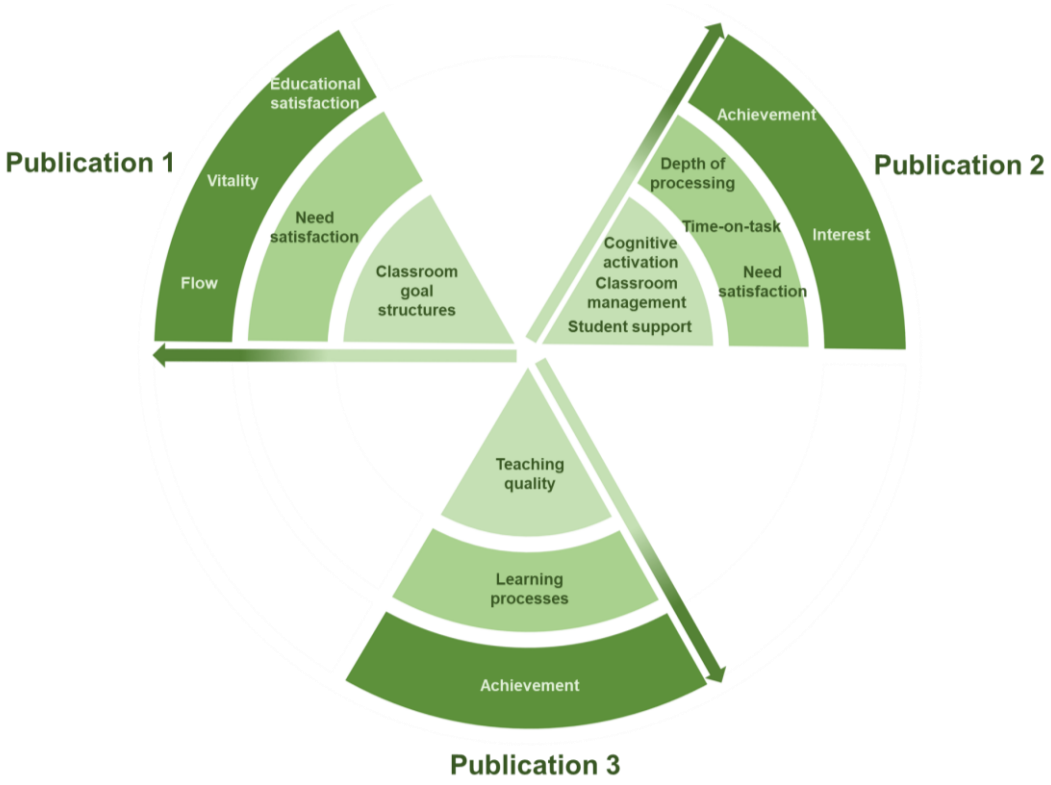

Figure 2. The structure of the three publications comprising this dissertation

4. Short summary of the three studies

This section summarizes the three contributions of this dissertation. A declaration of the author's own contribution to the three studies is provided in the Appendix.

4.1. Publication 1: Need satisfaction as a mediator between classroom goal structures and students' optimal educational experience

This article was published in:
Alp, A., Michou, A., Çorlu, M.S., & Baray, G. (2018). Need satisfaction as a mediator between classroom goal structures and students' optimal educational experience. *Learning and Individual Differences, 65,* 80-89. https://doi.org/10.1016/j.lindif.2018.05.012

Publication 1 investigates the indirect effects of classroom goal structures on students' optimal educational functioning through their need satisfaction. It focuses on specific dimensions of teaching quality, including classroom goal structures (mastery and performance goal structures), a specific dimension of learning processes (need satisfaction), and specific student outcomes (flow, vitality, and educational satisfaction). Studies have typically focused on the relationships between classroom goal structures and students' achievement goals using the AGT (e.g., Bardach et al., 2020a; Givens Rolland, 2012), as well as the relations between teachers' need support and need satisfaction using SDT (e.g., Vasconcellos et al., 2020). However, the interplay between the AGT (classroom goal structure) and SDT perspectives (need satisfaction) with respect to student outcomes has been neglected. Further, studies have mostly focused on the sports context (e.g., Quested & Duda, 2009). To understand achievement goals and goal structures within the context of a broader system, connecting these two theories is crucial for future educational psychology literature (see Urdan & Kaplan, 2020). Consequently, this work investigates the mediating effect of need satisfaction between classroom goal structures and student outcomes to address the mediating assumption using an integrative approach. Accordingly, the following hypotheses are proposed:

Hypothesis 1: Mastery goal structures are positively related and performance goal structures are negatively related to students' need satisfaction.

Hypothesis 2: Mastery goal structures attenuate any negative relationship between performance goal structures and need satisfaction, and vice versa.

Hypothesis 3: Mastery goal structures are positively associated with educational satisfaction or state flow and vitality through need satisfaction, whereas performance goal structures are negatively related to educational satisfaction, vitality, and state flow through need satisfaction.

The hypothesized relationships were investigated using a correlational design and a sample of Turkish undergraduate students in two studies. In Study 1, variables were assessed by focusing on students' undergraduate studies in general. The participants were 171 university students (60% female; M_{age} = 19.79, SD = 1.68). In Study 2, the variables were assessed by focusing on students' particular courses. After excluding 22 participants, the final sample consisted of 255 students (45% female, M_{age} = 19.75, SD = 1.67). All data analyses consisted of path analyses using manifest variables and bootstrap analyses to investigate the mediating effects. All main analyses were conducted using the R programming software (package lavaan).

The results of Study 1 (Figure 3) showed that need satisfaction was positively linked with mastery goal structures, but negatively linked with performance goal structures. Moreover, a positive association was found between need satisfaction, and the interaction of mastery and performance goal structures. Need satisfaction mediated the relationships of both mastery and performance goal structures with students' flow and educational satisfaction. The results of Study 2 (Figure 4) revealed that mastery goal structures were positively related to student need satisfaction, and positively and directly related to student flow and vitality. Additionally, need

satisfaction mediated the association between mastery goal structures, and student flow and vitality. However, performance goal structures were not related to need satisfaction.

Together, the findings showed that when teachers provide goal-related messages in the classroom that focus on understanding and learning (mastery goal structures), students' basic psychological needs are more likely to be satisfied. However, when teachers give goal-related messages focusing on outperforming others and competition (performance goal structures), students' basic psychological needs are less likely to be satisfied or that their psychological need satisfaction is not associated with those messages. Moreover, when students' basic psychological needs are satisfied, they are more likely to be in the state of flow, satisfied in their educational life, and be vital and energetic in their studies. These findings are in line with SDT, which assumes the importance of satisfying students' basic psychological needs for their positive and optimal educational outcomes (Deci & Ryan, 2000).

Thus, teachers' goal-related messages in the classroom seem to be important determinants of students' basic psychological needs. Furthermore, need satisfaction is one of the mediators that can link student educational outcomes with teachers' goal-related messages that focus on learning and understanding; moreover, these messages can also be directly and positively associated with those outcomes. This finding indicates that other underlying mechanisms or learning processes may explain these relationships. Rather than comparing students according to their grades or competition between them, emphasizing the importance of understanding in the classroom seems to be connected to students' need satisfaction. The type of goal-related messages teachers give in the classroom can make a difference to students' need satisfaction, which in turn affects their optimal educational experiences.

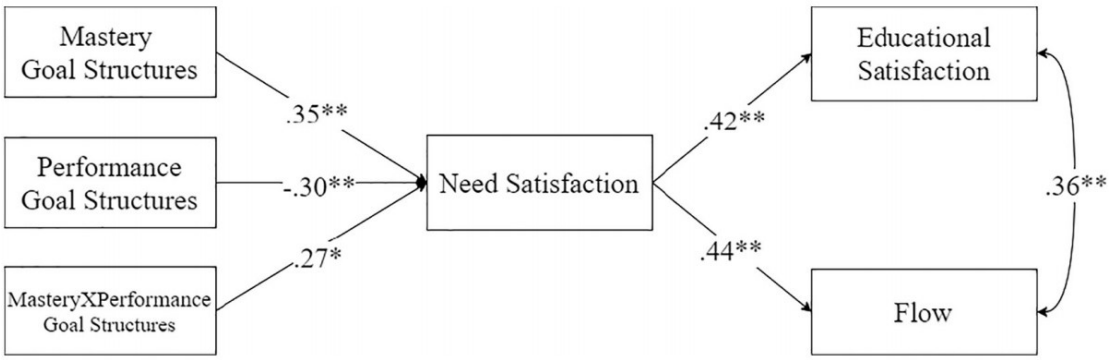

Figure 3. Indirect effects of classroom goal structures on educational satisfaction and state flow through need satisfaction (Alp et al., 2018, p. 84)

Note. *$p < 0.05$. **$p < 0.01$. The explained variance for need satisfaction is $R^2 = 0.15$, for educational satisfaction is $R^2 = 0.20$, and for flow is $R^2 = 0.24$.

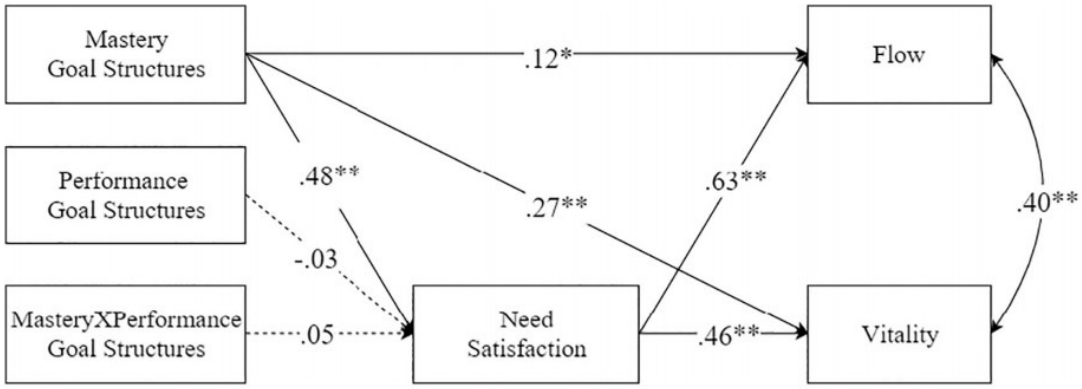

Figure 4. Indirect effects of classroom goal structures on state flow and vitality through need satisfaction (Alp et al., 2018, p. 86).

Note. *$p < 0.05$. **$p < 0.01$. The explained variance for need satisfaction is $R^2 = 0.19$, for flow is $R^2 = 0.47$, and for vitality is $R^2 = 0.39$.

4.2. Publication 2: Revisiting the Three Basic Dimensions model: A critical empirical investigation of the indirect effects of student-perceived teaching quality on student outcomes

This manuscript is accepted with minor revision:
Alp Christ, A.*, Capon-Sieber, V.*, Köhler, C., Klieme, E., & Praetorius, A. K. (in revision). Revisiting the Three Basic Dimensions model: A critical empirical investigation of the indirect effects of student-perceived teaching quality on student outcomes. *Frontline Learning Research.*
* The first two authors equally contributed to the conceptualization, writing, and revision of the manuscript.

The second contribution of this dissertation focuses on one of the most prominent models in German-speaking countries: the TBD (Klieme et al., 2001; 2009). Based on the opportunity-use model, the TBD model provides important assumptions about how students' learning processes mediate the associations between the three basic dimensions of teaching quality and student outcomes. However, these assumptions have not yet been empirically investigated (except Helm, 2016) and are currently based on a limited number of theories (e.g., SDT; Deci & Ryan, 2000). Therefore, in addition to the originally hypothesized paths, other possible paths may not have been noticed. Consequently, this work considered additional theoretical perspectives, such as the EVT (Wigfield & Eccles, 1992) and CVT (Pekrun, 2006), to extend the assumptions of the TBD model. By considering all possible paths, this contribution aimed to empirically investigate the indirect effects of students' perceived teaching quality (classroom management, cognitive activation, and student support) on their achievement and interest through students' learning processes (time-on-task, depth of processing, and need satisfaction).

Data were gathered from the TALIS Video Study conducted in Germany (OECD, 2020). After excluding vocational schools from the data, the final sample consisted of 958 secondary school students from 30 schools and 41 classrooms (M_{age} = 14.82, SD = 0.62; 50.5% female;

5.3% did not report their gender). In the study, the constructs assessed in the pre-test (T1) were operationalized in mathematics, whereas they were operationalized more specifically in quadratic equations in the post-test (T2). To test the assumptions, student-rated variables from T1 and T2 were used, and both correlational and longitudinal designs were applied. Several multilevel path models were used to test the direct effects of the three basic dimensions of teaching quality on student achievement and interest as well as their indirect effects through students' depth of processing, time-on-task, and need satisfaction by using bootstrap analyses. All analyses were conducted using R programming software with the lavaan package.

The multilevel analysis results with a correlational design indicated that in the direct effect models, at the student level, the three basic dimensions of teaching quality were positively associated with student interest. However, only student support was positively associated with student achievement. At the classroom level, classroom management and student support were positively associated with student interest, whereas classroom management was positively associated with achievement. Additionally, the correlational mediation models revealed that the three basic dimensions were positively associated with the mediators at both student and classroom levels. Furthermore, at both levels, positive associations were found between the mediators and outcomes, except for the association between time-on-task and achievement.

The results of the multilevel longitudinal path analysis revealed that in the three direct effect models, the three basic dimensions of teaching quality were not directly associated with mathematics achievement and interest at either the student or classroom levels. In the mediation models, some positive associations were found between the dimensions of teaching quality and student learning processes. Mediating effects were also observed at the student level. In line with the assumptions of the TBD model, depth of processing mediated the link between

cognitive activation and achievement. According to the newly introduced theoretical assumptions, time-on-task mediated the link between classroom management and interest, as well as between student support and interest; meanwhile, depth of processing mediated the link between student support and achievement. However, at the classroom level, none of these mediation assumptions were supported. In all models, between the two time points, a high stability of interest and achievement was observed at both levels. Our results highlight that some of the current assumptions of the TBD model and newly considered mediating assumptions are supported.

When discussing the findings of the second contribution, three crucial issues emerged: the sequence of the relationships, correlational versus longitudinal evidence, and the level of analyses.

First, the sequence of relationships should be reconsidered in future studies because of the complexity of the relationships. For example, classroom management was not positively or directly related to depth of processing. One reason could be that classroom management can be viewed as a prerequisite for other teaching quality dimensions such as cognitive activation (e.g., Charalambous & Praetorius, 2020). Students' different types of learning processes may be related to each other, and that the relationships are dynamic and reciprocal.

Second, most assumptions of the TBD model were supported with the correlational design, whereas only a few were supported with the longitudinal design. This finding emphasizes the need to replicate the results in different settings. Although correlational designs are commonly used because of their practicality and help establish the relationships between variables, more rigorous methods, such as longitudinal designs, are needed to reveal the directionality of the effects by controlling the variables at previous time points. Future experiments and interventions are needed to establish causality.

Third, at the classroom level, no mediating assumption was supported. One reason could be that each student is likely to perceive the same classroom activities or same teaching approach differently, and probably receives different treatment from the teacher because each student has different backgrounds, such as personalities, general beliefs, ability levels, and family characteristics; this is in line with the opportunity-use model (Helmke, 2012; Seidel, 2014). Furthermore, assessing teaching quality at both levels and not overlooking student-level effects is important. Operationalizations of teaching quality at the classroom level can include differentiation and adaptivity to consider the individual and unique interactions with students (Vieluf & Klieme, 2023).

In conclusion, the TBD model certainly benefits from expanding the hypothesis about mediators by considering cognitive and motivational theories in the field. Notably, the associations between the constructs are less specific than assumed by the TBD model. The results indicate that the conceptualizations and sequence of relationships should be reconsidered, and the operationalizations of the constructs should be revised to make them suitable for each level of analysis.

4.3. Publication 3: Learning processes, and their mediating role between teaching quality and student achievement: A systematic review

This article was published in:

Alp Christ, A., Capon-Sieber, V., Grob, U., & Praetorius, A. K. (2022). Learning processes and their mediating role between teaching quality and student achievement: A systematic review. *Studies in Educational Evaluation, 75,* 101209.
https://doi.org/10.1016/j.stueduc.2022.101209

The reviews and meta-analyses focused on the direct effects of teaching quality on student achievement and motivational outcomes (e.g., Praetorius et al., 2018; Wang et al., 2020). However, a comprehensive overview of empirical studies investigating the mediating role of students' learning processes in the relationship between teaching quality and student achievement was lacking. The third contribution is a systematic review that first explores the conceptualizations, operationalizations, and measurements of the assessed constructs, and then summarizes the results of the studies that empirically investigated these indirect effects. The results of the empirical studies were presented using categorizations based on two theoretical models: a comprehensive theoretical model of teaching quality, the MAIN-TEACH model, built by Charalambous and Praetorius (2020), and a motivational framework for learning processes, the SSMMD, built by Skinner et al. (2008).

The review aimed to be transparent and replicable by following stepwise procedures and providing supplementary materials. It involved searching for relevant studies in databases, such as Web of Science and Scopus. The selected studies were published in peer-reviewed journals in English or German, and conducted in general classroom settings from kindergarten to the undergraduate level. Studies were selected if they mentioned the effectiveness or quality of teaching, and implied a mediation analysis in their title, abstract, or keywords. Following this, full-text screening and quality assessment were carried out, and information was extracted from the studies, including citation details, research aims/questions, setting, country, sample size,

subject, study design, data analysis, study results, and conceptualizations and operationalizations of the constructs.

In this review, teaching quality was categorized according to the MAIN-TEACH model (Charalambous & Praetorius, 2020), whereas learning processes were categorized according to the SSMMD (Skinner et al., 2009). The findings revealed diverse conceptualizations and operationalizations of the constructs. Additionally, the mediating roles of *self* and *action* were mixed. The reviewed studies provided some insights about both theoretical and methodological issues.

One crucial finding was that the studies conceptualized, operationalized, and measured teaching quality in various ways. For example, teaching quality was conceptualized broadly in eight studies, whereas the other eight studies used a more specific conceptualization by choosing only one dimension of teaching quality, such as *warmth* in the teacher-student relationship. Teaching quality, which was assessed holistically by considering different dimensions of the MAIN-TEACH model, was labelled as *combined teaching quality.* To measure teaching quality, the reviewed studies used student, observer, and teacher ratings, as well as a combination of teacher and student ratings.

In the review, *self* was investigated in 10 studies, and *action* was investigated in 11 studies. Motivation- and engagement-related learning processes were mostly assessed as mediators in these categories. In some cases, studies conceptualized learning processes broadly and focused on one narrower dimension. To measure learning processes, the constructs were measured using student, observer, teacher, and a combination of teacher and observer ratings.

The review revealed the mixed mediating effects of *self* and *action*. Different aspects of *self* (such as goals and beliefs) mediated the relationships in 11 of the 30 paths. *Self* had mixed mediating effects in *combined teaching quality* and *socio-emotional support* categories.

Further, it was found to be a mediator in the *formative assessment* category. However, it was not found to be a mediator in two categories: *selecting and addressing content and subject specific methods* and *classroom and time management*. *Action* also had mixed mediating effects in 13 of the 23 paths. In particular, in the *socio-emotional support category*, *action* mediated the relationships in half of the cases, whereas in *combined teaching quality category*, *action* mostly mediated the relationships (7 out of 11 paths). Specifically, when the reviewed studies operationalized teaching quality as a whole, which included many different dimensions, it was mostly positively associated with the holistic view of learning processes (i.e., engagement).

During the review, several challenges were encountered and are discussed with possible solutions. First, to provide a broad overview of the area, studies which focused on the effectiveness and quality of teaching were searched for and reviewed. However, some studies may have been missed because they might not have labelled specific dimensions as teaching quality. Moreover, after categorizing the constructs according to the MAIN-TEACH model and SSMMD, very few studies were included in each category. Some studies could not be categorized according to the models because they fit into multiple combinations of categories (e.g., combined teaching quality). Second, the reviewed studies were based on various theoretical approaches, leading to high heterogeneity. The definitions and conceptualizations of teaching quality and learning processes substantially varied. One solution to this can be to focus on a narrower perspective and then reviewing specific dimensions of the constructs. Third, the studies used observer, student, and teacher ratings, as well as a combination of these ratings to assess teaching quality and learning processes. Moreover, some studies investigated specific dimensions of the constructs, whereas others investigated the constructs more holistically. Measurement and operationalization decisions could depend on theoretical reasonings. Still, future works should consider incorporating more transparent reasoning. Moreover, a holistic assessment of teaching quality and its specific dimensions should be

conducted. Fourth, although teaching quality and learning processes are distinct, some studies had overlaps between these constructs. For example, the teacher-student relationship in the socio-emotional support category can be viewed as both teaching quality and students' learning processes because both students and teachers contribute to the relationship. This may have influenced the mediating effects. Fifth, the reviewed studies' methodologies were not comparable (i.e., manifest versus latent variables, full and partial mediation approaches, and level of analyses). Further discussion is required to explain why certain methodological approaches are more suitable for mediation analysis. A comparative analysis of these different approaches may be helpful in demonstrating the impacts and advantages of certain methodologies.

The mixed findings revealed in this review cannot be explained solely by one factor, but by the interplay of different factors, such as conceptualizations, measurement, and operationalizations of the constructs. The high heterogeneity poses challenges in building quantitative syntheses and meaningful conclusions. Future reviews could synthesize a less heterogeneous group of studies using certain theoretical approaches.

5. Discussion

This dissertation aimed to investigate the mediating role of students' learning processes in the relationship between teaching quality and student outcomes. Two contributions empirically investigated the indirect effects, whereas one contribution systematically reviewed the empirical studies on this topic. For each contribution, the mediating assumptions were partially supported; however, there were cases where the mediating assumptions were not supported. Thus, this dissertation reveals the perplexing results of the mediating effects. The following sections discuss the most important findings from the three contributions. Based on these findings, the discussion consists of heterogeneity in conceptualizations of the constructs (Section 5.1) and influencing factors such as methodological, individual, and contextual aspects (Section 5.2). Following these issues, this dissertation moves the field forward by discussing its implications for research and practice (Section 5.3). Finally, the limitations are presented (Section 5.4) and conclusions are derived accordingly (Section 5.5).

5.1 Heterogeneity in the conceptualizations of the constructs

Given the different theoretical backgrounds in this dissertation, acknowledging the heterogeneity in the conceptualizations of the constructs is important. Discussing this aspect will help us understand the mixed results revealed in the three contributions.

This dissertation considered several theoretical approaches (e.g., the AGT, TBD, and MAIN-TEACH model) while investigating the indirect associations between the constructs. This dissertation included publications which integrated different theoretical strands. Within the first contribution, two studies were conducted based on the AGT and SDT. It highlights that the integration of these theories can enrich the description of the classroom environment, which is important to students' educational outcomes. This is important to consider because research has emphasized the urgent need to integrate motivational theories (Elliot & Sommet,

2023; Liu et al., 2016; Vu et al., 2022). In the second publication, the hypothesized relationships in the TBD model were critically discussed and enriched by prominent theories on motivation, cognition, and effort (e.g., EVT and CVT). In the third publication, a systematic review was conducted to better understand the indirect associations between teaching quality and student achievement by considering student learning processes as mediators. *Teaching quality* and *learning processes* were categorized according to the MAIN-TEACH model and SSMMD, respectively, to unveil these broad phenomena. The reviewed studies were also based on different theoretical backgrounds, which is one of the reasons for the heterogeneity in the conceptualizations and operationalizations of the assessed variables. Thus, this dissertation highlights the importance of integrating theories and need such attempts in the future.

The two publications investigated the relationships empirically, and attempted to integrate and connect the theoretical approaches (Publications 1 and 2). Although the assumed relationships have been investigated in individual empirical studies, an overview of the studies that investigated the mediation assumption is lacking. Therefore, we conducted a systematic review to fill this research gap (Publication 3). The systematic review revealed that the reviewed studies were based on various theoretical backgrounds (e.g., SDT, AGT, or CLASS) and the challenges of comparing the results were discussed (Publication 3). Considering the three publications, focusing on only single theoretical approaches to unveil complex phenomena, such as teaching quality and learning processes, seems practical within each theoretical approach. However, such complex constructs and their relationships cannot be defined or conceptualized using a single theory. Combining and comparing theories seems necessary for understanding the nature of the constructs, and improving both research within each theoretical approach and connecting the theories (Bikner-Ahsbahs & Prediger, 2010). Further, this dissertation shows the need to connect *teaching quality* and *motivation research* theoretically and empirically.

Due to the different theoretical backgrounds the studies based on, the assessed constructs were conceptualized by considering their single and specific dimensions (Publications 1 and 2), and as broad and multifaceted constructs that consist of different dimensions (Publication 3). The first contribution described *classroom goal structures* as a dimension of teaching quality. They were investigated in the models by focusing on two subdimensions: *mastery* and *performance goal structures*. The results revealed that the association between mastery goal structures and need satisfaction was positive. However, the association between performance goal structures and need satisfaction was found to be negative in one model, but no association was found in the other model. Mastery and performance goal structures had different associations with need satisfaction, and their mediating effects differed. The second contribution focused on *cognitive activation*, *classroom management,* and *student support* within the TBD model (Publication 2). The results showed that these three factors had different associations with each specific dimension of the learning processes. For example, in longitudinal mediation models, at the student level, classroom management was not associated with the depth of processing. The reason for these results from two contributions is that a specific dimension of teaching quality could be related to its counterpart, for which a strong effect might be hypothesized. Perhaps classroom management is a more reliable predictor for certain learning processes, such as time-on-task, because of its high relevance. Meanwhile, it could be seen as a necessary condition for depth of processing, but not an adequate dimension to affect it. Similarly, the performance goal structure can be more relevant for students' competence need satisfaction or performance goals (Bardach et al., 2020a). Thus, when considering the dimensions and sub-dimensions of teaching quality, their relationship to each aspect of learning processes and, ultimately, the indirect associations, might be different.

Interestingly, the systematic review revealed that when specific dimensions are assessed together holistically (i.e., *combined teaching quality*), they are more likely to be related to

learning processes consisting of several aspects (e.g., engagement). That is, single dimensions of teaching quality may not be adequate to be related to, or predict learning processes or achievements by themselves; a combination of dimensions may be necessary. This is supported by the fact that the bivariate effects found between *combined teaching quality* and students' learning processes (i.e., *self* and *action*) were mostly positive. Additionally, the dimensions that were combined differed across the studies; interestingly, *socio-emotional support* was referenced in most combinations. However, in the *socio-emotional support* category, the results of the unique bivariate and indirect effects were mixed. A possible reason for the more consistent effects in the *combined teaching quality* category compared to the effects for the separate *socio-emotional support* category could be that *socio-emotional support* is important for students' learning processes; however, it may not be adequate in and of itself to affect students' specific learning processes and achievement. It can either indirectly facilitate student learning through more direct learning of process-focused dimensions of teaching quality (Charalambous & Praetorius, 2020), or the teaching quality dimensions are effective when they are applied simultaneously. For example, when students face a problem and do not know how to solve it, only one aspect, such as *socio-emotional support* (e.g., being close and respectful), is important for supporting students trying to solve the problem; however, by itself, it does not solve the problem. Students need specific helpful feedback on content, which is core to the *formative assessment* dimension of the MAIN-TEACH model. Since only a post hoc analysis of the patterns across the reviewed studies was conducted, it is not certain whether *combined teaching quality* is effective because it includes *socio-emotional support*; arguing for causality is not possible. Future research should compare the effect of *socio-emotional support* with the effect of its combinations with other dimensions. This idea can be similarly tested with other specific dimensions of teaching quality.

There is further evidence that single teaching-quality dimensions may not be sufficient to affect learning processes or achievement. Although the systematic review (Publication 3) revealed that both *self* and *action* categories of learning processes have mixed mediating effects, *combined teaching quality* has the greatest indirect effect on student achievement through *action*. This implies that when teaching quality is measured using more than one dimension, aspects of student *action* (e.g., engagement, which is a multidimensional concept itself) usually act as mediators of achievement. These results are also in line with an SDT-based perspective which proposes that the global aspects of need supportive teaching explain student engagement better than the unique, additive, or synergistic effects of autonomy, competence, or relatedness support (Olivier et al., 2021). Similarly, within the AGT perspective, Linnenbrink (2005) found that the combination of mastery and performance goal structures had the most beneficial pattern for students' help seeking and achievement rather than the single dimensions. Future research should test whether this applies to other theoretical approaches.

Overall, this dissertation provides some hints about the heterogeneity in the conceptualization of constructs derived from different theoretical backgrounds. Instead of single dimensions, assessing teaching quality holistically might be more important for students' multidimensional learning processes, such as engagement. Future studies should compare the predictive validity of combining the teaching quality dimensions versus assessing them separately. If empirical studies focus on a holistic approach to teaching quality, investigating the effects of a holistic approach to learning processes (e.g., engagement) may be more appropriate. A similar view can be applied to the specific dimensions of these constructs. Future mixed-method studies, including interviews with students, can help in understanding whether teaching quality as a broad concept matters for students' learning processes and outcomes more than only a specific dimension of teaching quality.

5.2. Influencing factors: Methodological, individual, and contextual issues

This dissertation pursued a comprehensive approach to teaching quality, learning processes, and student outcomes, and their indirect associations. Under this approach, factors influencing the findings should be emphasized. These factors include *methodological* (e.g., study design and statistical modelling), *individual* (e.g., a particular group of students or students with certain characteristics), and *contextual aspects* (e.g., specific cultures, countries, or settings).

One reason for the inconsistent mediating effects within this dissertation could be *methodological aspects* such as the design of the studies, and different approaches to mediation analyses and the level of analysis. The two empirical contributions of this dissertation follow either a cross-sectional or longitudinal design. For example, in Publication 2, mediating effects were mostly found with a correlational design, whereas fewer mediating effects were found with a longitudinal design. Additionally, statistical modelling approaches differ; full- and partial-mediation approaches may have played a role in the findings of each contribution. For example, in Publication 1, the full mediation approach (Study 1) was used in one model, while the partial mediation approach (Study 2) was used in another model. Thus, the interpretations of the findings of these two models differ. Additionally, the level of analysis (multi- or single-level models) within the studies could have affected the results. The hypothesized relationships were assessed at the student, classroom, and school levels. In Publication 2, in the multilevel models, the student- and classroom-level results differed. These differences show that whether a study pursues a correlational or longitudinal design, uses different approaches to mediation, and has different level of analyses can produce mixed results. Although this situation warrants further studies that use similar mediation approaches and designs, the data or sample size in each study may not always allow for such homogeneity. This was also the case in this dissertation. For example, multilevel analyses could not be conducted in the first contribution

or in some empirical studies in the systematic review because of their small sample sizes. Thus, the results of the studies should be interpreted considering the unique approaches and limitations of each study.

Second, when considered within the context of certain groups of students, the mediating effects could differ. This is particularly evident in the results of the systematic review (Publication 3). For instance, in a study conducted in the U.S. with primary school students, Dotterer and Lowe (2011) found that mediating effects differed in significance depending on a student's level of previous achievement. This indicates that certain aspects of learning processes may be mediators for some groups of students, but not for others. This could be because teaching quality might not be universal, but should be adapted to the specific needs of each student (Vieluf & Klieme, 2023). Furthermore, in the systematic review, specific learning processes, such as metacognition, were not positively related to achievement in two studies conducted with primary school students. This could be because the studies concerned certain age groups that may have been unsuitable (see the reviews by Dent & Koenka, 2016; Ohtani & Hisasaka, 2018). Therefore, future studies should explicitly consider students' characteristics and the remarkable differences between students, such as person-centered methods.

Finally, contextual aspects may have affected the results. Referring to the opportunity-use model (Helmke, 2012; Seidel, 2014), this dissertation focuses only on three key broad constructs and the mediation chain: *teaching quality, learning processes,* and *outcomes*. However, the opportunity-use model also includes other aspects, such as socioeconomic background, school systems, culture, students' personalities or other traits, and prerequisites for their learning processes, such as prior knowledge (Atlay, 2019; Bell & Gitomer, 2023; Herbert et al., 2022; Seidel, 2014). Recent research argues that because of all these influencing factors for the interactive nature of students and teachers, it is challenging to conceptualize the

variables in quantitative research assuming linear relationships between them (Fauth et al., 2020; Vieluf & Klieme, 2023).

5.3. Implications for research and practice

The mixed findings of this dissertation can be explained in several ways. Furthermore, the field of teaching quality currently has inconsistent operationalizations, conceptualizations, and non-generalizable quantitative findings. Moreover, teaching quality has no universal definition, and the relationship between teaching and learning is interactive (Vieluf & Klieme, 2023). Considering these complexities and heterogeneities, and the factors influencing teaching and learning, this work has important implications for future research and practice.

Some implications can be derived for quantitative research and practice. Considering the discussions in the previous sections, the field requires more meta-analyses and reviews focusing on the mediation assumption of learning processes in specific settings, samples, contexts, age groups, and subjects by focusing on specific dimensions of the constructs (e.g., Roorda et al., 2017). To conduct these syntheses with less heterogeneity, more replication studies focusing on the same or similar operationalizations and conceptualizations of the assessed constructs within each theoretical approach in different settings, contexts, countries, subjects, or with different methods are needed. As “Much of the knowledge inherited from the past is the product of solving yesterday’s problems, which is of limited value in tackling the problems of today” (Bourner & Brook, 2019, p. 186), this can be achieved more efficiently by, for example, short reports (or brief reports) which mainly focus on methods for mediation analysis and results (for answering the same research questions and theoretical backgrounds of the previous studies). This can help gain more cumulative knowledge to inform future research and practice. Short quantitative reports on mediation can be especially effective when problems in teaching and learning occur in specific schools or classrooms, and practical and local

solutions to the current problems of improving certain outcomes through learning processes are urgently required.

To further improve current educational practices (see Krammer, 2023), investigations on the mediating role of learning processes could focus on local or regional, context-specific, and even school- or classroom-specific research by considering all possible relevant influencing factors for a specific sample (Bell & Gitomer, 2023). This could be achieved, for example, by *systems thinking*, which considers all relevant and connected parts of an overall system, rather than isolating them into individual sections (Flood, 2010). One way to pursue this approach is to conduct *action research*. This method helps in understanding and solving problems locally in social systems such as schools, classrooms, and learning situations (Bourner & Brook, 2019; Johnson, 2019). Owing to its dynamic nature, action research can help to better understand the complex, dynamic, and interactive effects between teaching quality, learning processes, and outcomes in specific educational settings and contexts. For example, in a certain classroom, at the beginning of the semester, various dimensions of teaching quality as well as students' various learning processes from different theoretical approaches can be identified through questionnaires, interviews, or observations. When specific dimensions of learning processes, such as *depth of processing*, *need satisfaction*, *or engagement*, are identified for students, ways of improving these aspects (such as providing specific goal-related messages or asking critical questions) can be explored, discussed, reflected, and worked on in depth with the students during the semester. A more holistic perspective for understanding the mediating role of learning processes can be taken to focus on improving student-specific outcomes such as achievement, motivation, and well-being at the end of the semester. Thus, a specific plan of action for understanding and improving mediating processes can be more efficiently developed and applied in classrooms.

A further implication of local and context-specific research can be for teacher education and continuing education. As a first step, future teacher education programs can train pre-service teachers on how to conduct *action research* in their future classrooms in cooperation with educational researchers at the institutes. More systematic collaboration between teachers at schools and researchers at educational institutions can be particularly beneficial. For example, continuing education programs can help in-service teachers address problems related to their teaching to improve the quality of their teaching and to foster students' effective learning processes in their classrooms, and find possible solutions by discussing those cases with the help of relevant prominent theoretical approaches in teaching and learning. This holistic approach has both practical and theoretical advantages. While teaching can become more effective for students' learning processes and outcomes, researchers can use the output of action research to develop theories on teaching and learning in these specific settings or contexts.

5.4. Limitations

The findings of this dissertation should be interpreted in the context of the limitations mentioned below; future research directions for research are suggested.

First, although this dissertation provides some evidence of how the assessed constructs are related, the studies were based on a limited number of relevant theories, frameworks, or models. Investigating all possible dimensions of the constructs within the relevant theoretical approaches was not possible and was not within the scope of this dissertation. For example, within the SDT, need supportive teaching behaviors are seen as important dimensions of teaching quality (e.g., Klieme et al., 2009; León et al., 2017). However, the systematic review did not particularly investigate all relevant studies conducted specifically within SDT. The syntheses of works within each theoretical approach should be conducted in the future. For example, systematic reviews on the mediating effects of basic psychological needs between

need supportive behaviors and student outcomes (e.g., student motivation and achievement) might be fruitful within the SDT in specific settings (see for example, Vasconcellos et al., 2020). After the empirical evidence in specific contexts within each theory was synthesized with reviews and meta-analyses, future overviews of the synthesis can aim to compare results from different theoretical approaches (Pollock et al., 2022).

Second, although this dissertation investigates various learning processes as mediators, it is evident that each aspect of learning processes may be related to another. Additionally, some student outcomes can be seen as learning processes, or vice versa. For example, students' flow experience (Publication 1) and individual interests (Publication 2) were assessed as outcomes. However, flow experience and interest can also be conceptualized as student learning processes, especially considering that interest develops over time and is an important predictor of learning (Hidi & Renninger, 2006). This issue is also evident when examining the relationships between the mediators. Publication 2 argued that the depth of processing, time-on-task, and need satisfaction can affect each other. For instance, high attention can lead students to think critically about their tasks. Several studies have investigated the relationship between different aspects of learning processes, such as basic psychological needs, achievement goals motivation, and other student outcomes in certain contexts, such as online teaching and physical education (e.g., Capon-Sieber et al., 2022; Jang et al., 2012; Karlen et al., 2019; Leo et al., 2022; Mouratidis et al., 2013). This dissertation revealed that the associations between learning processes and outcomes, as well as between different types of learning processes are dynamic and reciprocal. Future studies should investigate these relationships by assessing these constructs both holistically and separately in a single study.

Third, in the two empirical contributions of this dissertation, the constructs were measured using student perceptions, except for student achievement in Publication 2. A systematic review also revealed that most studies have used student ratings to assess these

constructs. Student ratings are valid, practical, and commonly used in the field (e.g., Fredricks, 2022; Lüdtke et al., 2009; Pekrun, 2020). Student ratings of teaching quality are better predictors of students' learning than ratings by teachers or observers (e.g., Kunter & Baumert, 2006). However, one challenge is that students may lack pedagogical insight into teaching; therefore, they may not observe teaching objectively (Fauth et al., 2020). Future studies can consider using students as "observers" in their classrooms. Training students to become observers of teaching quality can help them gain pedagogical insights into teaching and observe teaching more objectively. A more practical approach to assess teaching quality can be when training is conducted in higher education, especially in institutes of education where students are taught about teaching and learning. Similarly, students' self-reports are necessary to assess their learning; however, considering limitations such as social desirability, students might tend to over- or underestimate reality based on their perceptions of learning (Pekrun, 2020). Furthermore, in all contributions, common method bias may have occurred, especially when assessing constructs from the same perspective (Podsakoff et al., 2012). Future studies should compare the effects of multiple rater perspectives in separate and simple models.

Fourth, one limitation was the subject-specific or general assessment of the constructs. In Study 1 of the first contribution, need satisfaction was assessed generally. To address this methodological limitation, it was assessed considering its subject-specific aspects in Study 2. In the second contribution, students' perceptions pertained to mathematics in general, but the outcomes were specific to quadratic equations. Some reviewed studies (Zee & de Bree, 2017; Hughes et al., 2008) also revealed different mediating effects in different subjects. Thus, the results of these contributions cannot be generalized to all subjects, specific content, or topics.

Fifth, various contexts and settings were considered in this dissertation (see Section 5.2). The participants in the first two contributions were university students in Turkey (Publication 1), and secondary school students in Germany (Publication 2). Moreover, the systematic review

showed that the reviewed studies were conducted mostly in the U.S. and various European countries, and focused mostly on kindergarten and primary school students (Publication 3). The findings of these empirical studies may not be generalizable to any group of students with certain characteristics, age groups, countries, cultures, or settings, considering that teaching quality and learning processes could depend on these aspects (Bell & Gitomer, 2023; Herbert et al., 2022; Urdan & Kaplan, 2020).

Finally, this dissertation did not consider the causal effects of teaching quality. The use of different methodological approaches to investigate the assumed relationships might have affected the results. To establish causal relationships, future studies should investigate these issues through experiments and interventions. Subsequently, additional experiments and interventions can be synthesized.

5.5. Conclusion

This dissertation aimed to investigate the extent to which students' learning processes mediate the association between teaching quality and student outcomes. The three contributions of this dissertation partially support this mediation assumption. This work advances our knowledge in understanding the mediating role of students' learning processes and by revealing that confirming the general mediation assumption is not an easy task. To understand the underlying mechanisms between teaching quality and student outcomes, comparing and connecting different theoretical approaches and empirical studies may be needed (Bikner-Ahsbahs & Prediger, 2010; Praetorius & Charalambous, 2023; Urdan & Kaplan, 2020). In addition, the synthesis of quantitative studies in different contexts and settings, and action research can provide more definite and precise policy and practical implications. To achieve the purpose of education, students' learning processes that lead to the desired student outcomes can be better explored in each context by experimenting with certain high-quality teaching behaviors in the classroom, for example, with the help of action research.

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Appendices

Declaration of Authorship

I hereby declare that I am the sole author of this doctoral thesis and that I have not used any sources other than those listed in the bibliography and identified as references.

The three peer-reviewed articles of this dissertation were written in cooperation with other researchers: Prof. Dr. Anna-Katharina Praetorius, Dr. Vanda Capon-Sieber, Dr. Urs Grob, Dr. Carmen Köhler, Prof. Dr. Eckhard Klieme, Dr. Aikaterini Michou, Dr. M. Sencer Çorlu, and Dr. Gamze Baray.

I further declare that I have not submitted this thesis at any other institution in order to obtain a degree.

Zürich, 1 February 2024 Ayşenur Alp Christ

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Need satisfaction as a mediator between classroom goal structures and students' optimal educational experience

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ABSTRACT

Goal-related messages in a classroom are associated with students' experiences and functioning in learning. However, little is known about need satisfaction as a mediator that translates the classroom messages into students' optimal educational experience. In the present studies, we investigated in a sample of 171 (in Study 1) and 255 (in Study 2) Turkish undergraduate students (60% females; M_{age} = 19.79, SD = 1.68 and 45% females, M_{age} = 19.75, SD = 1.67 respectively), the relation of classroom goal structures to students' educational satisfaction (or vitality) and state flow through their experience of need satisfaction considering it as the psychological mediator. Path analysis with bootstrap showed that mastery goal structures (i.e., classroom environment focuses on learning and self-improvement) were positively related to need satisfaction while performance goal structures (i.e., classroom environment focuses on normative success) were either negatively related (Study 1) or unrelated (Study 2) to need satisfaction. Path analysis with bootstrap also showed that mastery goal structures were related to vitality, educational satisfaction and flow in class-related tasks through need satisfaction. Understanding need satisfaction as a mediator of classroom goal structures and optimal educational experience help teachers to reconsider their goal-related messages in the classroom.

1. Introduction

The motivational environment that teachers create in the classroom is related to students' psychological experience and functioning in educational settings. Studies conducted in the framework of Achievement Goal Theory (AGT; Elliot & Dweck, 2005) have shown that when students perceive that their teachers are focusing on learning and orienting them towards self-improvement (i.e., mastery goal structures; MGSs) compared to competition and normative success (i.e., performance goal structures; PGSs), they report adaptive patterns of behavior, affect and cognition (Kaplan & Midgley, 1999; Meece, Anderman, & Anderman, 2006; Skaalvik & Skaalvik, 2013). However, little is known about the need-related psychological experience that translates the learning-oriented classroom messages into adaptive patterns of behavior, affect, and cognition.

Up to now, mostly, competence-based motivation (such as students' achievement goals or self-efficacy) has been considered as a mediator between classroom goal structures and educational outcomes (Fast et al., 2010; Michou, Mouratidis, Lens, & Vansteenkiste, 2013; Shim, Cho, & Wang, 2013). In the present study, we assumed that students' adaptive functioning in MGSs are also related to students' satisfaction of their psychological needs as they have been defined by Self-Determination Theory (SDT; Deci & Ryan, 2000). On the one hand, MGSs respect students' own pace in developing their competence and empowers learning instead of competition (Meece, 1991; Patrick & Ryan, 2005). Consequently, it can help students to satisfy their own needs, such as being agents of their own actions (satisfaction of need for autonomy), feeling competent in classroom activities (satisfaction of need for competence) and relating their actions to those of others (satisfaction of need for relatedness). On the other hand, when students perceive their teachers focusing on performance and normative success (i.e., PGSs), they report less adaptive patterns of behavior, affect and cognition (Kaplan & Midgley, 1999; Meece et al., 2006; Skaalvik & Skaalvik, 2013). Probably, this is because students feel forced to follow and overcome others' pace in learning (frustration of need for autonomy), prove their ability (frustration of need for competence) and be opponents to their classmates (frustration of need for relatedness).

In an experimental laboratory study, Standage, Duda, and Pensgaard (2005) found that a mastery oriented environment during a co-ordination dance task was positively related to participants' need

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satisfaction and subjective well-being, while a performance oriented environment was negatively related to need satisfaction and well-being. However, this relation has not been investigated in educational settings. Moreover, even though there is evidence for an interaction of MGSs and PGSs in the prediction of educational outcomes (see Skaalvik & Federici, 2016), it has not been investigated whether perceived MGSs are positively related to need satisfaction independently of perceived PGSs or whether the two types of classroom goal structures interact in the prediction of need satisfaction. As MGSs conceptually seem compatible with need satisfaction, when such structures are perceived high by students in a classroom, they may attenuate the negative relationship of perceived performance goal structures to need satisfaction. If so, the interaction between MGSs and PGSs may also have an indirect effect on students' functioning and educational experience.

The first aim of the present study is to examine if students' need satisfaction is one of the mediators that translates the perceived classroom goal-related messages to educational experiences and therefore, whether the need satisfaction mediates the relation between students' perceived classroom goal structures and their educational satisfaction, vitality and state flow as indicators of their optimal educational experience. The second aim of the present study is to investigate to what extent the two types of the classroom goal-related messages, mastery and performance, are independently related to need satisfaction, and whether or not high perception of one type moderates the relation of the other type to need satisfaction. We believe that understanding need satisfaction as the mediator of classroom goal-related messages and optimal educational experiences help to reconsider the value of MGSs or PGSs.

1.1. Classroom goal structures

Classroom goal structures can be defined as teachers' goal-related messages that are communicated to students during classroom activities (Ames, 1992; Murayama & Elliot, 2009; Urdan, 2004a). For example, if a teacher emphasizes the demonstration of high competence proved by distinguished achievement, students tend to perceive that they should study to outperform others. Alternatively, if a teacher stresses understanding, learning, and self-improvement, students perceive that they need to study in order to learn and develop their competence in the given field. These two different examples correspond to PGSs and MGSs, respectively. MGSs indicate that the classroom environment is oriented towards understanding and learning, while PGSs mean that the classroom climate is oriented towards a normative success (Anderman & Midgley, 1997; Covington, 2000; Midgley et al., 1998; Murayama & Elliot, 2009; Nicholls, 1984).

Previous research showed that MGSs have adaptive while PGSs have maladaptive outcomes. Specifically, MGSs are positively associated with intrinsic motivation and academic self-concept (Murayama & Elliot, 2009), self-efficacy (Roeser, Midgley, & Urdan, 1996), use of effective learning strategies such as self-regulated learning (Wolters, 2004), deep level learning strategies (Michou et al., 2013; Miki & Yamauchi, 2005) and the experience of flow (Harwood, Keegan, Smith, & Raine, 2015). PGSs, on the other hand, are negatively related to intrinsic motivation (Meece et al., 2006), positively associated with surface level learning (Miki & Yamauchi, 2005), and self-handicapping strategies (Urdan & Midgley, 2001) or unrelated to learning strategies and achievement (Matos, Lens, Vansteenkiste, & Mouratidis, 2017). Few studies have also investigated the effects of multiple goal structures (i.e., focus on both MGSs and PGSs) on optimal educational experience. For instance, Linnenbrink (2005) found in an experimental study that the multiple goal structures condition has a positive and a significant effect on help seeking and achievement in elementary school students. Peng, Cherng, and Chen (2013), however, found that the multiple goal structures condition did not differ from the MGSs condition regarding their positive effects on creativity. Peng et al.'s (2013) finding indicates that the MGSs are enough to enhance high school students' creativity.

Since MGSs and PGSs predict different optimal educational experiences, they might also create different psychological experiences that mediate the relationship between students' perception about classroom goal structures and educational outcomes. The mediated psychological experiences can include, among others, the degree of students' psychological need satisfaction as it has been described by SDT (Deci & Ryan, 2000). By considering need satisfaction as the psychological experience that link classroom goals structures to outcomes, we deemed important to investigate also whether the need satisfaction is higher when multiple goal structures are perceived in a classroom compared to when one type of goal structures is perceived high and the other low.

1.2. Need satisfaction

According to SDT, there are three basic psychological needs: the need for autonomy, the need for competence, and the need for relatedness (Ryan & Deci, 2000). The need for autonomy refers to a sense of volition and agency. The need for competence corresponds to a sense of effectiveness, while the need for relatedness refers to a sense of belongingness and connectedness to others. When these needs are satisfied, personal growth and optimal functioning are achieved, whereas when the basic psychological needs are unmet, people experience ill-being (Ryan & Deci, 2000).

Research has shown that need satisfaction in educational settings enhances intrinsic motivation in the classroom (Niemiec & Ryan, 2009) and predicts students' general subjective well-being (Sheldon & Elliot, 1999), positive affect, school satisfaction (Tian, Chen, & Huebner, 2014), academic satisfaction and personal well-being (Mavor, Platow, & Bizumic, 2017, p.187), and school engagement (Skinner, Furrer, Marchand, & Kindermann, 2008). Similarly, in other settings, need satisfaction is related to flow experience (Schüler & Brandstätter, 2013; Schüler, Brandstätter, & Sheldon, 2013) and well-being (Gagne, Ryan, & Bergman, 2003; Reinboth & Duda, 2006) in sport, identity exploration during identity formation (Madjar & Cohen-Malayev, 2013), and pro-environmental behavior (Pelletier, 2002).

Previous research, thus, suggest that, optimal functioning and subjective-well-being are strongly associated with need satisfaction. Moreover, previous research that aimed to unveil the environmental conditions that facilitate individuals' need satisfaction have showed that when teachers are need-supportive, (e.g., give choices to and share the decision-making process with students) instead of being controlling (e.g., force students to act in particular ways), students report higher levels of need satisfaction (Niemiec & Ryan, 2009; Reeve, 2009). More specifically, research findings have indicated a mediating role of need satisfaction between need-supportive environment and positive outcomes. For example, it has been shown that need satisfaction mediates the relationship between perceptions of coach autonomy support and well-being (Adie, Duda, & Ntoumanis, 2012), secondary school students' perceived autonomy support and autonomous motivation (Haerens, Aelterman, Vansteenkiste, Soenens, & Van Petegem, 2015), and adolescents' perceived structure (i.e. perception of clear expectations and scaffolding provided by the teacher) and learning strategies and affect (Mouratidis, Vansteenkiste, Michou, & Lens, 2013; Reeve, 2006).

Thus, a considerable amount of research suggests that need satisfaction can be considered as a necessary psychological experience which mediates the relationship between need-supportive environment and individuals' well-being. The question is, therefore, to what extent need satisfaction can be also considered a necessary mediator between classroom goal structures and students' optimal educational experiences. Research in the sport context, for instance, has shown that perceived mastery climate was positively related to hip-hop dancers' need satisfaction (Quested & Duda, 2009). This is because mastery-focused climate fosters feelings of belongingness, feelings of efficacy (Harwood et al., 2015) and feelings of agency (Standage, Duda, & Ntoumanis, 2003). However, performance-focused climate seems either to be

negatively related to the fulfillment of need for relatedness (Harwood et al., 2015; Quested & Duda, 2009) and autonomy (Harwood et al., 2015) or to not be related to need satisfaction (Quested & Duda, 2009; Standage et al., 2003). Reinboth and Duda (2006) found also task involving coaching climate (a type of MGSs where emphasis is given on self-improvement, effort and shared contribution to the team's progress) to predict positively need satisfaction at the end of the training period, while ego involving coaching climate (a type of PGSs environment) did not predict negatively competence and autonomy satisfaction.

Research in sport settings provides evidence for the positive relation between MGSs and need satisfaction. Moreover, research in both sport and educational settings provides evidence for the positive relation between need satisfaction and desired optimal educational experiences. However, it remains unexplored to what extent MGSs or PGSs are related to need satisfaction, and through it to students' state flow and educational satisfaction or vitality, which are some of the indicators of optimal educational experience. We deem educational satisfaction, vitality and state flow as aspects of optimal educational experience because they have all been considered as indicators of subjective well-being (Demirbatir, 2015; Diener, 1984; Haq & Zia, 2013; Michalos, 2012; Ryan & Deci, 2001) and optimal educational experience (Csikszentmihalyi, 1990, 1997; Jackson & Marsh, 1996).

1.3. Present research

In the present research, we examined, in two studies, the relationship between students' perceived classroom goal structures, namely mastery and performance, need satisfaction, and optimal educational experience as it is expressed by state flow and educational satisfaction or vitality. We deemed important to investigate this relationship in two similar studies so as to address in Study 2 methodological weaknesses of Study 1 explained below.

The current studies extend previous research in some important ways. First, these studies investigated the relation of perceived achievement goal structures to need satisfaction in educational settings instead of sports context. Based on previous research in sport settings and taking into consideration that normative success is a less inherent characteristic of learning and education as it is of sports, we anticipated that perceived MGSs would be positively and perceived PGSs would be negatively related to students' need satisfaction (Hypothesis 1).

Second, the present studies investigated to what extent one type of classroom goal structure moderates the relationship between another type of classroom goal structures and need satisfaction. Linnenbrink (2005) found that the multiple goal structures have positive effects only on two out of nine educational outcomes. Similarly, Peng et al. (2013) found that the multiple goal structures do not differ from the MGSs regarding their positive effects on creativity, whereas Skaalvik and Federici (2016) found that performance goal structures moderate significantly the relationship between a MGSs and students' personal goal orientations. Based on these findings, we hypothesized that MGSs will attenuate any negative relationship between performance goals structures and need satisfaction and vice versa (Hypothesis 2).

Finally, the study examined the explanatory role of need satisfaction as a mediator between classroom goal structures and optimal educational experience. In doing so, we chose state flow and educational satisfaction or vitality as indicators of students' optimal educational experience because they have been considered as aspects of students' subjective well-being (Csikszentmihalyi, 1990, 1997; Diener, 1984; Jackson & Marsh, 1996; Ryan & Deci, 2001). Relying on the findings about the mediating role of need satisfaction between need-supportive environment and educational outcomes, we assumed that MGSs, a classroom environment compatible to psychological needs, would positively predict educational satisfaction or vitality and state flow through need satisfaction, whereas PGSs, a classroom environment that emphasizes competition, would negatively predict educational satisfaction or vitality and state flow through need satisfaction as a psychological mediator (Hypothesis 3).

2. Study 1

In Study 1, it was investigated the relationship of perceived MGSs and PGSs at a specific university course with students' need satisfaction and need frustration in their university studies in general as well as with students' educational satisfaction and flow experience during in-class activities or homework.

2.1. Method

2.1.1. Participants and procedure

Participants were 171 (60% females, 18 students did not report their gender; $M_{age} = 19.79$, $SD = 1.68$, 14 students did not report their age) Turkish university students from a private non-profit university in an urban area of Turkey. Eighty-six students came from social sciences and 82 students came from engineering and sciences (3 students did not report their department).

After getting ethical approval from the university's Ethical Committee, a research assistant administered a survey according to human subjects' principles. The survey lasted about 20 min. Before students completed the survey, they were informed about the purpose of the study and they were ensured that their participation was anonymous and voluntary. Participants were also informed that they could withdraw from the study at any time. Upon signing the consent form, participants reported their need satisfaction and need frustration in their university studies in general, the classroom goal structures of the specific course during which the data were collected (i.e., Algorithms and Programming I, Introduction to Psychology and Social and Political Philosophy I), their educational satisfaction with their university studies, and the flow experience during in-class activities or homework. The courses for which the students reported the classroom goal structures were obligatory for some of the students but elective for some others. All the instruments were translated to Turkish and they were adjusted according to the procedures proposed by Hambleton (1994). Each item in the questionnaires was assessed in a five-point, Likert-type scale ranging from 1 to 5, where 1 represented strong disagreement, and 5 represented strong agreement with the given statement.

2.1.2. Measures

2.1.2.1. Background variables. Students were asked to indicate their gender, age and department. The departments were categorized according to the classification used in Turkish high schools and university exams into *social sciences* and *engineering and sciences* departments. Therefore, psychology, political science, management, law, international relations, and economics departments were classified as *social science* departments; industrial engineering, electrical electronics engineering, computer engineering, physics and molecular biology departments were classified as *engineering and science* departments.

2.1.2.2. Classroom goal structures. Students' perception about classroom goal structures in a specific university class was assessed with 10 items from the Patterns of Adaptive Learning Scale (PALS; Midgley et al., 2000) and Urdan's (2004b) scale. Four items assessed performance-approach goal structures (e.g. in our class, getting good grades is the main goal) while six items assessed MGSs (e.g., in our class, it's important to understand the work, not just memorize it). A Confirmatory Factor Analysis (CFA) with two latent factors (one for PGSs and one for MGSs) yielded an adequate fit (see Table 3).

2.1.2.3. Need satisfaction. Students' need satisfaction and frustration were assessed by the Balanced Measure of Psychological Needs (BMPN; Sheldon & Hilpert, 2012). Nine items assessed *need satisfaction* (3 items for need for autonomy; e.g., I was free to do things my own way,

$\alpha = 0.57$; 3 items for need for competency; e.g., I was successfully completing difficult tasks, $\alpha = 0.82$; and 3 items for need for relatedness; e.g., I felt close and connected with other people, $\alpha = 0.70$). Accordingly, nine statements measured *need frustration* (3 items for need for autonomy; e.g., There were people telling me what I had to do, $\alpha = 0.36$; 3 items for need for competence; e.g., I did something that made me feel incompetent, $\alpha = 0.47$; and 3 items for need for relatedness; e.g., I had disagreements or conflicts with people, $\alpha = 0.47$). A CFA for a model where each set of the three items loaded on the respective latent factor, loaded on two higher-order latent factors, termed need satisfaction and need frustration did not yield an acceptable fit: *S-B*$\chi^2(131, N = 154) = 188.67$, $p < .01$, CFI = 0.876, SRMR = 0.09, RMSEA = 0.054 (90%-*CI*: 0.035–0.070). Given the low internal consistency of the need frustration subscales, we tested a CFA model in which the three sets of items of the need satisfaction subscales loaded on the respective latent factor loaded on a higher-order latent factor, termed need satisfaction. The fit of the model was good (see Table 3) and therefore a composite score of need satisfaction for each student was created by aggregating the nine items. The nine items of the need frustration subscales where excluded from the analysis.

2.1.2.4. Educational satisfaction. Five items from the Satisfaction with Life Scale (Diener, Emmons, Larsen, & Griffin, 1985) were adapted to educational life and assessed students' educational satisfaction (e.g., In most ways my educational life is close to my ideal). A CFA with the five items loading on a latent factor yielded a good fit (see Table 3).

2.1.2.5. State flow experience. Nine items from the Flow State Scale-2 (Jackson & Eklund, 2002) were used to assess students' flow experience during in-class activities or homework. Each of the nine items corresponded to one of the nine dimensions of flow (i.e., challenge-skill balance, action-awareness merging, clear goals, unambiguous feedback, concentration on task, time transformation and autotelic experience; e.g., Time flows while working on the task). A CFA with the nine items loading on a latent factor yielded an adequate fit (see Table 3).

2.1.3. Plan of analysis

We performed a CFA to verify the factor structure of all scales (see Measures section and Table 3). For preliminary analyses, we examined the descriptive statistics of the measured variables and the bivariate correlations among them by using SPSS 18. We also examined differences between disciplines and genders through MANOVA (see Table 1).

The main analyses involved path analysis with bootstrap using R programming software (package Lavaan) to investigate the mediating role of need satisfaction in the relationship of perceived classroom goal structures to educational satisfaction and state flow. As moderating effects of classroom goal structures on need satisfaction were hypothesized, the interaction term of MGSs by PGSs as well as MGSs and PGSs were included in the exogenous variables of the model. Perceived MGSs and PGSs, educational satisfaction and state flow were represented by the mean score of the measured variable and then centered around the mean. The interaction term of MGSs by PGSs was produced by multiplying the centered MGSs by the centered PGSs. Need satisfaction was defined by the mean of autonomy, competence and relatedness satisfaction and then centered around the mean.

The chi-square (*S-B*χ^2), the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR) and the comparative fit index (CFI) were used as indicators of model fit. A non-significant chi-square reflects a good model fit. SRMR at or < 0.05 reflects good fit (Hu & Bentler, 1995) while, $0.05 <$ SRMR < 0.08 reflects adequate fit. RMSEA at or < 0.05 and $0.05 <$ RMSEA < 0.08 represents a good and adequate fit respectively. Finally, $0.90 <$ CFI < 0.95 and CFI > 0.95 reflects adequate and good model fit respectively (Hu & Bentler, 1999; Kline, 2011). The tested model was estimated by both Maximum Likelihood with robust standard errors and scaled chi-square (MLM) and Bootstrap with 10,000 replications and 95% confidence interval (*CI*). Confidence intervals which do not include zero (0.00) indicate that the tested relationship is 95% reliable. In the results, we first report the beta coefficients of MLM and then confidence intervals of Bootstrap.

2.2. Results

2.2.1. Preliminary analysis

Descriptive statistics and bivariate correlations among the measured and background variables are presented in Table 2.

MANOVA did not yield significant gender differences but it showed significant differences between social sciences and engineering - sciences (Wilk's $\Lambda = 0.861$, F [5, 139] = 4.49, $p < .01$, multivariate $\eta^2 = 0.14$). Taking into consideration this difference as well as that age was significantly correlated with perceived MGSs and state flow, discipline and age were included as covariates in the subsequent analyses.

2.2.2. Main analysis

A path analysis was conducted to test our hypotheses. Inspection of Fig. 1 shows that all the hypothesized paths were significant and fit indices were good: S-Bχ^2 (6, $N = 133$) = 2.45, $p <$ .01. CFI = 1.000, SRMR = 0.016, RMSEA = 0.000 (90%-*CI*: 0.000–0.057)[1]. However, reports of only 133 (out of 171) students were included in the analysis due to missing values. As Fig. 1 shows, perceived MGSs were positively related to need satisfaction (MLM: $\beta = 0.35$, $p < .01$; Bootstrap: 95%-*CI*: 0.10–0.38) and perceived PGSs were negatively related to need satisfaction (MLM: $\beta = -0.30$, $p < .01$; Bootstrap: 95%-*CI*: −0.27–−0.07), confirming our Hypothesis 1.

It is worthy to note that perceived MGSs and need satisfaction were presented uncorrelated in the zero-order correlations while in the path model, when controlling for perceived PGSs, their relation appeared positive and significant. This result further supports an interaction between perceived MGSs and PGSs in the prediction of need satisfaction. Indeed, the interaction between MGSs and PGSs was also positively related to need satisfaction (MLM: $\beta = 0.27$, $p < .05$; Bootstrap: 95%-*CI*: 0.04–0.25). Inspection of Fig. 2 shows that students' need satisfaction was lower when PGSs were high and MGSs low compared to when both PGSs and MGSs were high.

Both educational satisfaction and state flow were positively related to need satisfaction (MLM: $\beta = 0.42$, $p < .01$; Bootstrap: 95%-*CI*: 0.43–0.93 and MLM: $\beta = 0.44$, $p < .01$; Bootstrap: 95%-*CI*: 0.30–0.62 respectively). A test of indirect effects showed that need satisfaction was mediated the relationship between perceived classroom goal structures and educational satisfaction and state flow confirming Hypothesis 3. More specifically, need satisfaction mediated the relationship between MGSs and educational satisfaction (MLM: $B = 0.16$, $SE = 0.06$, $z = 2.63$, $\beta = 0.15$, $p < .01$; Bootstrap: 95%-*CI*: 0.05–0.27), MGSs and state flow (MLM: $B = 0.11$, $SE = 0.04$, $z = 2.62$, $\beta = 0.15$, $p < .01$; Bootstrap: 95%-*CI*: 0.04–0.19), PGSs and educational satisfaction (MLM: $B = -0.11$, $SE = 0.05$, $z = -2.34$, $\beta = -0.12$, $p < .05$; Bootstrap: 95%-*CI*: −0.19–−0.03), as well as PGSs and state flow (MLM: $B = -0.08$, $SE = 0.03$, $z = -2.56$, $\beta = -0.13$, $p < .01$; Bootstrap: 95%-*CI*: −0.13–−0.02)[1]. We also checked the mediation of a moderator effect (Fairchild & MacKinnon, 2009; Frazier, Tix, & Barron, 2004) by examining the indirect effect of the interaction term to educational satisfaction and state flow through need satisfaction. Need satisfaction mediated the relationship between the interaction of MGSs and PGSs and educational satisfaction (MLM: $B = 0.10$, $SE = 0.05$, $z = 2.13$, $\beta = 0.11$, $p < .05$; Bootstrap: 95%-*CI*: 0.02–0.18) as well as the relationship between the interaction of MGSs and PGSs

[1] We also run a model with direct paths from classroom goal structures to educational satisfaction and flow but none of the direct paths for this partial mediation model were significant.

Table 1
CFA results and Cronbach alphas of the measured variables in Study 1.

Variables	α	χ^2	*N*	*df*	CFI	RMSEA	SRMR	90%-*CI*
Classroom goal structures	$\alpha_M = 0.87$ $\alpha_P = 0.84$	66.34	146	34	0.926	0.079	0.017	0.049–0.107
Need satisfaction	$\alpha = 0.71$	31.73	165	25	0.975	0.041	0.060	0.000–0.078
Educational satisfaction	$\alpha = 0.86$	2.99	163	5	1.000	0.000	0.017	0.000–0.082
State flow	$\alpha = 0.72$	41.34	168	27	0.935	0.071	0.063	0.039–0.101

Note. α_M = Cronbach alpha for MGSs, α_P = Cronbach alpha for PGSs.

Table 2
Means, standard deviations and bivariate correlations of the measured variables in Study 1.

Variables	1	2	3	4	5	6	7	8
Background variables								
1. Age	1							
2. Gender	0.01	1						
3. Discipline	−0.27**	0.10	1					
Independent variables								
4. MGSs	−0.24**	0.05	0.08	1				
5. PGSs	−0.11	0.06	0.34**	0.36**	1			
Dependent variables								
6. Need satisfaction	−0.13	0.18*	−0.04	0.10	−0.21**	1		
7. Educational satisfaction	−0.15	−0.07	−0.04	0.07	−0.10	0.42**	1	
8. Flow	−0.17*	−0.03	0.05	−0.01	−0.08	0.45**	0.49**	1
M	19.97	0.40	0.49	3.95	3.09	3.59	3.15	3.29
SD	1.66	0.49	0.50	0.81	0.99	0.56	0.89	0.59

Note. *$p < .05$. **$p < .01$. MGSs = mastery classroom goal structures; PGSs = performance classroom goal structures. Gender coded 0 = female, 1 = male; Discipline coded 0 = social sciences, 1 = engineering and sciences.

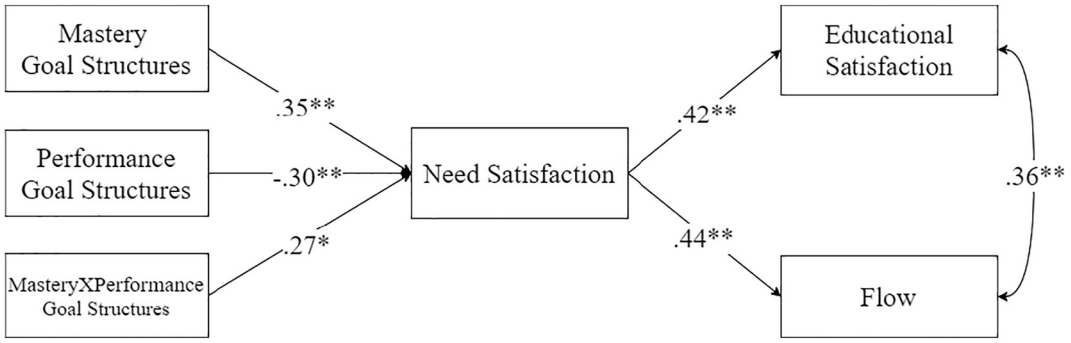

Fig. 1. The mediating role of need satisfaction between perceived classroom goal structures and educational satisfaction and state flow controlling for discipline differences and age (not shown for sake of clarity).
Note. *$p < .05$. **$p < .01$. Explained variance for need satisfaction is $R^2 = 0.15$, for educational satisfaction is $R^2 = 0.20$ and for flow is $R^2 = 0.24$.

and state flow (MLM: $B = 0.07$, $SE = 0.03$, $z = 2.03$, $\beta = 0.12$, $p < .05$; Bootstrap: 95%-*CI*: 0.01–0.12). This means that high MGSs attenuated the negative relationship between PGSs and educational satisfaction as well as state flow through need satisfaction.

2.3. Brief discussion

The purpose of this study was to investigate, whether students' need satisfaction serves as a mediator between perceived classroom goal structures and educational satisfaction and flow.

In line with the predictions, we found that perceived MGSs were positively related to students' need satisfaction, while PGSs were negatively related to students' need satisfaction (Hypothesis 1). We also found a positive relation between need satisfaction and the interaction of MGSs and PGSs suggesting that, when perceived MGSs were high as compared to when MGSs were low, the negative relation between PGSs and need satisfaction was attenuated. This finding supports Hypothesis 2. Finally, aligned with Hypothesis 3, we found that MGSs positively predicted educational satisfaction and state flow through need satisfaction, while PGSs negatively predicted educational satisfaction and state flow through need satisfaction.

While our predictions have been confirmed, it is worthy to note that, in the correlation table, classroom goals structures were appeared to be unrelated to educational satisfaction and flow despite findings of other studies that show a positive relation between them (e.g., Harwood et al., 2015). Our assumption is that this result is due to the different level to which students referred when they reported classroom goal structures, need satisfaction and optimal educational experiences. Classroom goal structures were assessed with reference to a specific course, while need satisfaction, flow and educational satisfaction were assessed with reference to their university education in general. Therefore, the full mediation of need satisfaction between classroom goal structures and optimal educational experience could occur due to a general level of assessment of the outcomes. To test this possibility and to address the issue of a large number of missing values in our dataset, we set up Study 2.

3. Study 2

Study 2 was almost identical to Study 1 with two exceptions: (a)

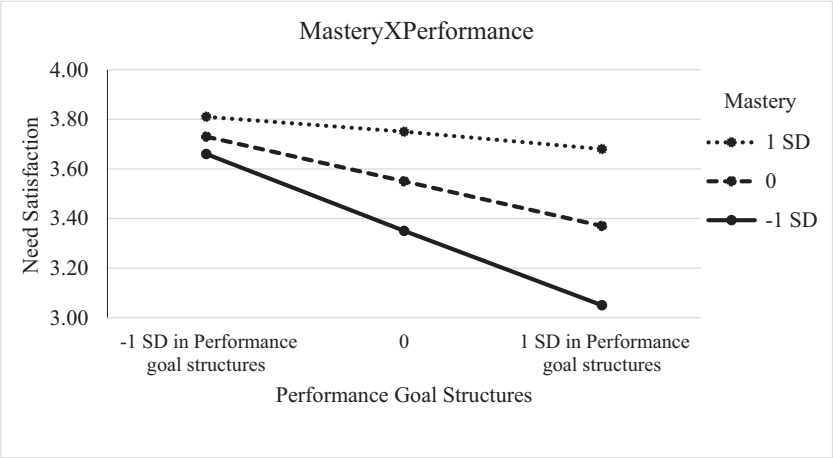

Fig. 2. Moderated effects of MGSs on the relationship between PGSs and need satisfaction.
Note. Y-axis represents the mean of need satisfaction. Need satisfaction has the lowest value, when MGSs are one standard deviation below zero and performance goal structures are high.

Table 3
CFA results and Cronbach alphas of the measured variables in Study 2.

Variables	α	χ^2	*df*	CFI	RMSEA	SRMR	%90-*CI*
Classroom goal structures	$\alpha_M = 0.87$ $\alpha_P = 0.69$	84.291	34	0.929	0.076	0.072	0.063–0.109
Need satisfaction	$\alpha = 0.84$	60.834	24	0.961	0.078	0.056	0.057–0.108
State flow	$\alpha = 0.83$	66.341	26	0.939	0.078	0.046	0.060–0.110
Vitality	$\alpha = 0.91$	0.192	2	1.000	0.000	0.003	0.000–0.056

Note. α_M = Cronbach alpha for MGSs, α_P = Cronbach alpha for PGSs. The presented CFA results for state flow were obtained after permitting two items to covary.

Need satisfaction and optimal educational experience were assessed with reference to the specific course for which the classroom goal structures were also assessed. (b) In order to specify optimal educational experience to a course level, we replaced educational satisfaction to vitality which is also considered as an indicator of optimal experience (Ryan & Deci, 2001). This is because educational satisfaction by nature refers to educational life in general while vitality can refer to a specific course. We believe that an assessment of the need satisfaction and optimal experience at the specific course level depict more reliably the mediating role of need satisfaction between classroom goal structures and educational experience.

In Study 2, in order to address the issue of a large number of missing values of Study 1, we administrated the survey online and submission would not be possible if all the questions were not answered. To avoid, however, random answers, in the online battery of the questionnaires, we included an item asking from the participants to give a specific answer. Students who did not give this answer were excluded from the analysis.

3.1. Method

3.1.1. Participants and procedure

Participants were initially 277 Turkish university students from a private non-profit university in an urban area of Turkey. However, 22 of them were excluded due to their wrong answer to the checking item. The final sample consisted of 255 (45% females, $M_{age} = 19.75$, $SD = 1.67$) students. Sixty-one students came from social science while 193 students came from engineering and sciences (1 student omitted to reply). As in Study 1, all the ethical procedures according to human subjects' principles were applied in Study 2. A research assistant administered in class-sessions an online survey for about 10 min. Participants reported their need satisfaction, flow, vitality and the classroom goal structures of the specific course during which the data were collected (i.e., Algorithms and Programming I, Introduction to Psychology, Introduction to Programming, Introduction to World Politics and Calculus I). The courses to which the students referred were either obligatory or elective.

3.1.2. Measures

The same instruments of Study 1 were used to measure classroom goal structures, need satisfaction and state flow. Additionally, four items from the Subjective Vitality Scale (Ryan & Frederick, 1997) were used to assess students' subjective vitality (e.g. “I feel alive and vital”). CFA results and Cronbach alphas of the measured variables are presented in Table 3.

3.1.3. Plan of analysis

The same plan of analysis as in Study 1 was followed.

3.2. Results

3.2.1. Preliminary analysis

Descriptive statistics and bivariate correlations among the measured and background variables are presented in Table 4. As it is indicated in Table 4, MGSs were positively related (and PGSs unrelated) to need satisfaction, state flow and vitality.

MANOVA did not yield any gender differences but it showed a significant difference between social sciences and engineering - sciences (Wilk's $\Lambda = 0.920$, $F\,[5, 248] = 4.33$, $p < .01$, multivariate $\eta^2 = 0.08$). Taking into consideration this difference, as well as that age was significantly correlated with perceived MGSs, discipline and age were included as a covariate in the subsequent analyses.

3.2.2. Main analysis

A path analysis to test our hypotheses yielded the following fit indices S-Bχ^2 (6, $N = 254$) = 30.45, $p < .01$. CFI = 0.935, SRMR = 0.044, RMSEA = 0.127 (90%-*CI*: 0.084–0.173). However, inspection of modification indices suggested direct paths from perceived MGSs to vitality and state flow to further improve the model's fit. By adding these paths, we obtained the following fit indices: S-Bχ^2 (4, $N = 254$) = 9.36, $p < .01$. CFI = 0.986, SRMR = 0.025, RMSEA = 0.073 (90%-*CI*: 0.0.000–0.134). As Fig. 3 shows perceived MGSs were positively related

Table 4
Means, standard deviations and bivariate correlations of the measured variables in Study 2.

Variables	1	2	3	4	5	6	7	8
Background variables								
1. Age	1							
2. Gender	−0.19**	1						
3. Discipline	−0.51**	0.28**	1					
Independent variables								
4. MGSs	−0.35**	0.04	0.18**	1				
5. PGSs	−0.07	−0.04	0.09	0.20**	1			
Dependent variables								
6. Need satisfaction	−0.02	0.09	−0.05	0.41**	0.05	1		
7. Flow	0.07	0.14*	−0.11	0.34**	−0.05	0.68**	1	
8. Vitality	0.02	0.10	−0.12	0.42**	−0.03	0.58**	0.65**	1
M	19.75	0.55	0.76	3.95	2.86	3.53	3.53	2.97
SD	1.67	0.50	0.43	0.87	0.85	0.77	0.72	1.12

Note. *$p < .05$. **$p < .01$. MGSs = mastery classroom goal structures; PGSs = performance classroom goal structures. Gender coded 0 = female, 1 = male; Discipline coded 0 = social sciences, 1 = engineering and sciences.

to need satisfaction (MLM: $\beta = 0.48$, $p < .01$; Bootstrap: 95%-*CI*: 0.32–0.53). However, perceived PGSs and the interaction between perceived MGSs and PGSs were not significantly related to need satisfaction. Partially supporting our Hypothesis 1, it seems that when university students perceive a learning orientation in classroom goal structures, they also report high level of need satisfaction.

Both state flow and vitality were positively related to need satisfaction (MLM: $\beta = 0.63$, $p < .01$; Bootstrap: 95%-*CI*: 0.49–0.68 and MLM: $\beta = 0.46$, $p < .01$; Bootstrap: 95%-*CI*: 0.52–0.82 respectively). A test of indirect effects showed that need satisfaction was mediated the relationship between perceived MGSs and flow (MLM: $B = 0.25$, $SE = 0.38$, $z = 6.48$, $\beta = 0.30$, $p < .01$; Bootstrap: 95%-*CI*: 0.17–0.32) and between MGSs and vitality (MLM: $B = 0.28$, $SE = 0.05$, $z = 5.67$, $\beta = 0.22$, $p < .01$; Bootstrap: 95%-*CI*: 0.19–0.38). In addition, MGSs were directly related to flow (MLM: $\beta = 0.12$, $p < .05$; Bootstrap: 95%-*CI*: 0.02–0.19) and vitality (MLM: $\beta = 0.27$, $p < .01$; Bootstrap: 95%-*CI*: 0.20–0.48).

3.3. Brief discussion

The purpose of this study was to investigate the mediating role of need satisfaction between perceived classroom goal structures and optimal educational experience after addressing methodological weaknesses of Study 1. Specifically, in this study, we asked students to report their perceived classroom goal structures, need satisfaction and vitality and state flow in the framework of a specific course than in their education in general.

We found that perceived MGSs were positively related to students' need satisfaction. This finding partially supported Hypothesis 1 as PGSs were not related to need satisfaction. When students reported their need satisfaction at the specific level at which the goal structures had been also reported, PGSs were not a significant negative predictor of need satisfaction as it was the case in Study 1. Research in sport context has shown that performance-focused climate is either negatively related to the fulfillment of need for relatedness and autonomy (Harwood et al., 2015; Quested & Duda, 2009) or, similar to the results of Study 2, unrelated to the fulfillment of need for autonomy and competence (Quested & Duda, 2009). Reinboth and Duda (2006) also showed that ego involving coaching climate failed to negatively predict changes in competence, autonomy and coach-related relatedness satisfaction. It seems, therefore, that the research findings, neither in sport nor in educational context are consistent about a negative relation of PGSs and need satisfaction although they clearly show that PGSs do not satisfy people's psychological needs. Since in our study we investigated the need satisfaction as a composite variable, future research is necessary to examine the relationship between classroom goal structures and the three separate psychological needs in educational settings.

The results of Study 2 did not also support our assumption that MGSs will attenuate the negative relationship between PGSs and need satisfaction (Hypothesis 2) as it is shown by the non-significant relation between the interaction of MGSs and PGSs and need satisfaction. This result seems logical as PGSs was not also related to need satisfaction in this study.

Finally, in partial support of Hypothesis 3, we found that need satisfaction partially mediated the relationship between MGSs and state flow and vitality. MGSs were also directly related to the indicators of optimal educational experience. When the climate of a specific course focuses on learning and self-improvement, students' psychological

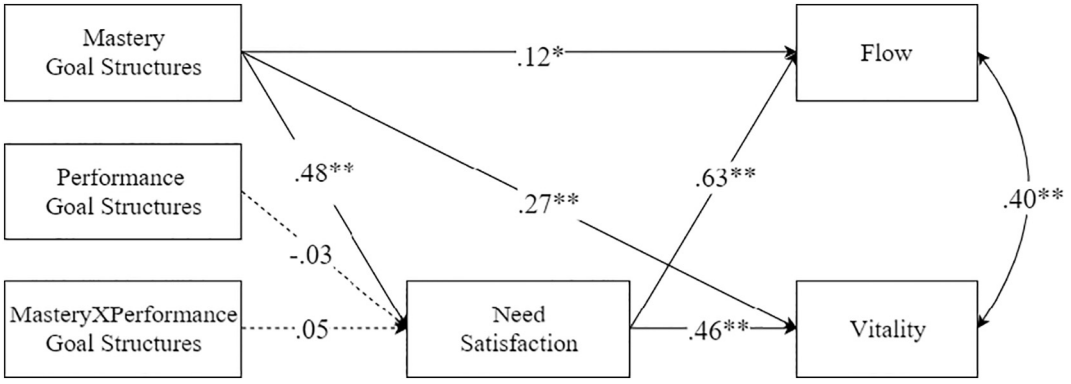

Fig. 3. The mediating role of need satisfaction between perceived classroom goal structures, state flow and vitality controlling for discipline differences and age (not shown for sake of clarity).
Note. *$p < .05$. **$p < .01$. Explained variance for need satisfaction is $R^2 = 0.19$, for flow is $R^2 = 0.47$ and for vitality is $R^2 = 0.39$.

needs at this course are satisfied, while the learning-focused climate promote also students' vitality and experience of flow at this course. The findings of Study 2 showed that perceived MGSs are important for satisfying students' psychological needs and promoting their optimal educational experience.

4. Discussion

The purpose of these studies was to investigate, whether students' need satisfaction serves as a mediator between perceived classroom goal structures and educational satisfaction or vitality and flow. Thus, we, first, examined whether perceived MGSs and PGSs are positively and negatively respectively related to students' need satisfaction. We, then, examined, whether high perceived MGSs attenuate the negative relationship between PGSs and need satisfaction. Finally, we examined the extent to which classroom goal structures have indirect effects on educational satisfaction or vitality and state flow through need satisfaction.

In line with the predictions, in Study 1, we found that perceived MGSs and PGSs were positively and negatively related to students' need satisfaction, respectively (Hypothesis 1). However, in partially support of Hypothesis 1, in Study 2, we found only perceived MGSs to be positively related to students' need satisfaction. The main message from both studies is that, when students perceive that they can organize their learning according to their own abilities and preferences and this self-referenced improvement is respected by their educational environment (i.e. perceived MGSs), their psychological needs are more likely to be satisfied. This result supports previous findings in laboratory studies or sport settings. For instance, Standage et al. (2005) found that a mastery-oriented environment during a laboratory co-ordination task was positively related to participants' need satisfaction and subjective well-being. Similarly, Reinboth and Duda (2006) found that task involving coaching climate (i.e., a climate focused on the task at hand and self-improvement) positively predicts need satisfaction at the end of the training period.

In contrast, when the classroom focuses on grades and outperforming others, students feel as opponents of their peers and in a situation to protect and prove their competence. In such an environment, there is not enough space for sharing with others, self-initiation in learning and feelings of effectiveness unrelated to others performance. Our findings suggest that, when students perceive high PGSs, students' psychological needs are less likely to be satisfied. Previous research in sport context also showed either a negative relation between ego-involving interpersonal context and participants' need satisfaction (Harwood et al., 2015; Standage et al., 2005) or no relation between them (Quested & Duda, 2009; Reinboth & Duda, 2006).

Regarding our assumption that perceived MGSs will attenuate any negative relationship between perceived PGSs and need satisfaction; this was true in Study 1, where the negative relation did exist. However, it was not true in Study 2, where these two variables were unrelated. These findings partially support our Hypotheses 2 and show that MGSs are sufficient for students' need satisfaction as Peng et al.'s (2013) had also shown. This is because the positive interaction between MGSs and PGSs in Study 1, shows that, when students perceived high both types of classroom goal structures, they reported either approximately the same amount of need satisfaction compared to when they perceived only high MGSs or higher need satisfaction compared to when they perceived only high PGSs. The results of both Study 1 and 2 do not support the superiority of multiple goals structures for students need satisfaction. The message, therefore, for educators and policy makers is that the MGSs make the difference in the satisfaction of students' psychological needs.

Aligned with Hypothesis 3, we found that MGSs positively predicted educational satisfaction and state flow as well as vitality through need satisfaction. On the other hand, PGSs either negatively predicted educational satisfaction and state flow through need satisfaction (Study 1) or were unrelated to optimal educational experience (Study 2). It is important to note also that MGSs were directly related to both state flow and vitality. These findings suggest that, if classrooms focus on learning and understanding, students' psychological needs are satisfied and they experience high educational satisfaction, state flow and vitality. In contrast, if classrooms focus on students' performance and competition only, students' psychological needs are not satisfied and their optimal educational experience is either low or totally unrelated to the competition classroom goal messages. It seems that need satisfaction is one of the mediators that links MGSs with students' educational outcomes, while, at the same time, MGSs can be also positively and directly related to educational experience. As for the PGSs, they do not appear to be steadily related to optimal educational experience through need satisfaction. This finding suggests that PGSs might be steadier predictors for other educational outcomes than vitality and state flow and might follow a different pathway to these educational outcomes compared to MGSs. Recently, Mouratidis, Michou, Dermiciouglu, and Sayil (2018) found that while MGSs predict math grades through personal mastery goals and challenge-seeking, PGSs predict math grades only through personal performance-approach goals. Challenge-seeking is an optimal educational experience with which PGSs are not related to predict through them students' performance. Further research, therefore, is needed to clarify to what extent mediators between PGSs and educational outcomes as well as their direct relations are different from the mediators between MGSs and educational outcomes as well as their direct relations.

The findings of the present study as a whole support Urdan's (2010) suggestion that research outside of the Achievement Goal Theory framework, could enrich the description of the classroom environment that is adaptive for student development. The findings of our study also show that some constructs of the Achievement Goal Theory can be complemented by constructs of the Self Determination Theory in explaining learning and development and, as several other recent studies have indicated (e.g., Benita, Roth, & Deci, 2014; Ciani, Sheldon, Hilpert, & Easter, 2011; Madjar, Nave, & Hen, 2013; Michou, Vansteenkiste, Mouratidis, & Lens, 2014; Vansteenkiste, Lens, Elliot, Soenens, & Mouratidis, 2014), research on the intersection of the two theories could be promising for a better understanding of achievement striving.

Our findings also extend previous research that has shown a need-supportive university classroom environment to be linked to positive educational outcomes through need satisfaction (e.g., Tze, Klassen, & Daniels, 2014). They suggest that additional to need-supportive environment MGSs (emphasis on learning, understanding and self-improvement) are also important for students' subjective-well-being and optimal educational experience. Moreover, our findings suggest that PGSs are either negatively related or unrelated to students' psychological needs and either negatively related or unrelated to optimal educational experience. This is an important element to be taken into consideration by teachers, who sometimes promote competition and normative success in the classroom as a means to foster students' performance. Research provides evidence that, indeed, when students endorse performance goals promoted by the environment, they may get high grades at school (Hulleman, Schrager, Bodmann, & Harackiewicz, 2010). However, as our findings showed, a performance-oriented environment is not beneficial for students' psychological needs, students' satisfaction at school, flow during homework and vitality. Teachers should not ignore the cost of their focus on normative success and high grades for students' subjective well-being and optimal educational experience. Future research could investigate how teachers' approaches for students' autonomy support described by the SDT perspective (see Reeve, 2006) can be combined with non-normative evaluation and learning-focused messages described by the AGT framework (Meece et al., 2006) in order to satisfy students psychological needs.

Our study, however, has some limitations that should be taken into consideration when discussing the findings. Firstly, a cross-sectional

design was adopted and all measures in the study were self-reported. Therefore, this study did not investigate any causal relationship between the studied variables, and the information related to the classroom goal structures was not cross-checked by third part's assessments (e.g., teachers' or observers' perception about the classroom goal structures).

Second, the samples were recruited from one university in Turkey and therefore, it remains to be seen whether or not the results can be generalized for other cultures or age groups (e.g., high school or middle school students). Therefore, further research is necessary with bigger samples from different institutions and countries as well as longitudinal or experimental design to capture the causal relationship of the educational environment to students' outcomes through need satisfaction. It is true that we cannot exclude the case that students' need satisfaction or educational experience influences their perception of the classroom environment. Moreover, as Turner, Gray, Anderman, Dawson, and Anderman (2013) found that perceptions of classroom goal structures changes over time, longitudinal studies could also clarify to what extent the relationship between classroom goal structures and need satisfaction changes over time.

Fourth, since classroom goal structures are contextual constructs, class-level differences could occur. In this study, we did not consider to what extent classroom goal structures at the class level predict need satisfaction and educational outcomes. Regarding this issue, further research is needed with bigger samples nested in sufficient number of classrooms for multi-level analysis.

Fifth, in Study 1, neither the internal consistency nor the CFA for the need frustration subscales was acceptable so as to examine its mediating role between classroom goal structures and educational experience. In Study 2 also, we did not assess need frustration as we were interested in replicating the results of Study 1 while addressing methodological weaknesses. Future research could investigate whether PGSs are positively related to need frustration and to what extent this relationship can be attenuated by MGSs so as to clarify the role of a competitive climate on students' well-being. Future research could also investigate the relationship of the satisfaction or frustration of the three psychological needs separately to classroom goal structures and educational outcomes to depict a more refined picture. To this end, especially in studies with Turkish samples, the low internal consistency of autonomy satisfaction ($\alpha = 0.57$ Study 1; $\alpha = 0.58$ Study 2) in the present studies should be considered. Finally, previous research has shown that achievement goals are mediators between perceptions of classroom environment and educational outcomes (e.g., Church, Elliot, & Gable, 2001) as well as that motivation is a mediator between need satisfaction and outcomes (McDonough & Crocker, 2007; Mouratidis, Vansteenkiste, Lens, & Sideridis, 2008; Niemiec & Ryan, 2009). Therefore, future research should also include motivation in another mediating level between need satisfaction and educational outcomes.

In conclusion, this study highlighted need satisfaction as a psychological mediator that relates MGSs to learners' subjective-well-being and optimal educational experience. In doing so, this study also provides evidence to teachers about the benefits of MGSs for students need satisfaction, vitality, flow in subject-related tasks and educational satisfaction. Current findings suggest that future intervention programs which aim to increase students' optimal educational experience should focus, among other practices, on diminishing PGSs and enhancing the provision of mastery goals in the classroom environment.

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Publication 2:

Revisiting the Three Basic Dimensions model: A critical empirical investigation of the indirect effects of student-perceived teaching quality on student outcomes

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Revisiting the Three Basic Dimensions model: A critical empirical investigation of the indirect effects of student-perceived teaching quality on student outcomes

Abstract

The Three Basic Dimensions (TBD) model, the leading model of teaching quality in German-speaking countries, theorizes three mediation paths for the effect of teaching quality on student outcomes. However, the existence of these paths and their effects have largely not been empirically tested. This study investigated the mediating role of depth-of-processing, time-on-task, and need satisfaction between student-rated teaching quality and student mathematics achievement and interest, expanding the TBD model to include mediation paths suggested by theories of motivation, cognition, and effort. Data from the TALIS Video Study for Germany, comprising 958 secondary school students in 41 classrooms, were used to run multilevel longitudinal and correlational mediation analyses. The results only found mediation effects at the student level; there were no mediating effects at the classroom level. Not all of the hypothetical relationships thought to exist between the mediators and achievement and interest outcomes were confirmed. The conceptual sequence of the variables, the choice of correlational vs. longitudinal evidence, and the level of analysis were all shown to have an impact on the results. The study thus confirms some of the assumptions of the TBD model, identifies new paths between teaching quality and student outcomes, and provides suggestions for how to proceed with further investigation of a model which should be expanded and empirically tested.

Keywords: Teaching quality, learning processes, mediation, interest, achievement; three basic dimensions

= 10790 words

1. Introduction

The Three Basic Dimensions (TBD) model of teaching quality is influential and widely used by researchers in the field of teaching quality, particularly in German-speaking countries (Klieme et al., 2006, 2009; Kunter & Trautwein, 2013; Praetorius et al., 2018; Reusser et al., 2010). This model, developed by Klieme et al. (2001, 2009), offers a concise framework for understanding the aspects of teaching quality by categorizing them into three key dimensions: cognitive activation, classroom management, and student support. One of its principal advantages over the many other models and frameworks is that it explains student learning processes, focusing on the mediating role that they play between teaching quality and student outcomes. For example, it hypothesizes that depth of processing mediates between cognitive activation and student achievement, which suggests that cognitive activation only has a significant impact on learning outcomes when students engage in deep processing (Klieme et al., 2006, see Figure 1). However, researchers have rarely conducted a systematic examination of mediators (for an exception, see Helm, 2016). Although the role of mediators has been supported by results from studies focusing on specific paths in the model (for cognitive activation, e.g., Hiebert & Grouws, 2007; Stein & Lane, 1996; for classroom management, e.g., Hospel & Galand, 2016; Kunter, et al., 2007; and for student support, e.g., Kiemer et al., 2018; Mouratidis et al., 2013), overall, empirical research remains limited.

The incorporation of mediators between teaching quality and student outcomes in the TBD model was guided by selected theoretical considerations, primarily rooted in Self-Determination Theory (SDT, Ryan & Deci, 2000) and constructivism (De Corte, 2004; Diederich & Tenorth, 1997; Pauli & Reusser, 2006). Such a narrow focus may miss other valid theoretical perspectives that might explain the mediators and observed student outcomes. Moreover, the reasoning behind the choice of theory to explain mediation pathways in the TBD model is not well-articulated in the literature. The lack of clarity creates potential gaps in our understanding of the model and could lead to an incomplete representation of the role of mediators between teaching quality and student outcomes. It is therefore important to consider the possibility of additional theoretically likely relations between the variables in the model. For example, in the context of the original model, depth of processing is influenced by cognitive activation and classroom management. However, by incorporating theoretical insights from other theories, such as the elaboration likelihood model (ELM, Petty & Cacioppo, 1986), we propose that elements of student support, such as activities that accentuate the relevance of tasks, may also contribute to increased depth of processing.

This paper aims to address these gaps in the theoretical and empirical foundations of the TBD model. It seeks to comprehensively test the assumptions of the model, including additional possible mediation pathways, to provide a more robust understanding of the relationship between teaching quality and student outcomes.

1.1 The Three Basic Dimensions model of teaching quality

The TBD model (Figure 1) identifies cognitive activation, classroom management, and student support as the key aspects of teaching quality that affect student outcomes such as achievement and motivation. In particular, cognitive activation and classroom management are assumed to have an effect on student achievement and student support is linked to student motivation. The results of an empirical analysis conducted by Klieme et al. (2001) provide support for this idea. Emphasizing the role of student understanding, attentiveness, and motivation in the learning process (Diederich & Tenorth, 1997), the basic dimensions have been theoretically linked to students' *depth of processing, time-on-task,* and *need satisfaction* (i.e., student use of learning opportunities) (Klieme et al., 2006, 2009; Klieme & Rakoczy, 2008; see Figure 1). Specifically, it has been hypothesized that cognitive activation is linked to depth of processing, that student support has an effect on need satisfaction, and that classroom management is linked to depth of processing, time-on-task, and need satisfaction. For simplicity and parsimony, the original TBD model design had a focus on pathways that included mediators between teaching quality and student outcomes based on the specific theoretical considerations used to formulate the basic dimensions (Ryan & Deci, 2000; De Corte, 2004; Diederich & Tenorth, 1997; Pauli & Reusser, 2006). To better explain how these dimensions relate to the use of learning

opportunities by students, we first describe the basic dimensions in Section 1.1.2, then explain the mediators and outcomes in detail.

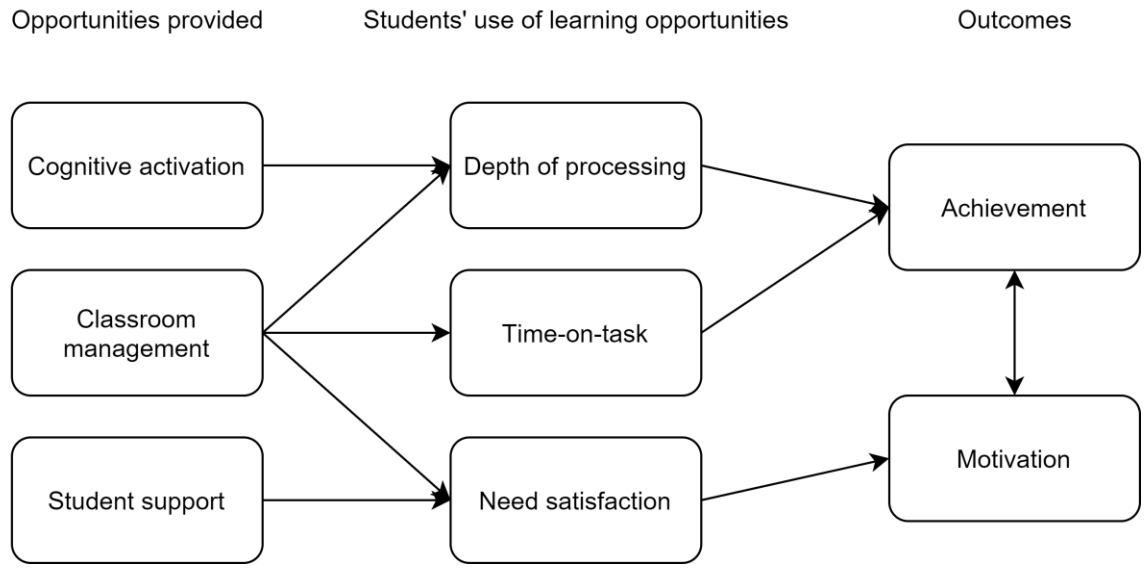

Figure 1. The relations between the three basic dimensions and student achievement and motivation according to the TBD model (adapted from Klieme et al., 2009).

1.1.2 The three basic dimensions of teaching quality

Cognitive activation. This dimension is based on socio-constructivist learning theories (Aebli, 2011; Piaget, 1992; Vygotsky, 1978), which emphasize the independent construction of knowledge and interaction with others within the zone of proximal development (ZPD, Vygotsky, 1978). The current understanding of cognitive activation encompasses multiple facets that aim to stimulate higher-order cognitive processes (Lipowsky & Hess, 2019; Ziegelbauer, 2009). This includes encouraging students to understand learning content by providing challenging tasks so that prior knowledge is activated, practicing content-related discourse, and fostering active participation in critical class discussions (Förtsch et al., 2018; Klieme et al., 2009; Lipowsky et al., 2009; Lotz, 2016; Praetorius et al., 2014, 2018; Rakoczy & Pauli, 2006). The teaching behaviors should show an understanding of how students think and support their cognitive independence (Lotz, 2016), self-regulation and metacognition (Praetorius et al., 2018; Rieser et al., 2016).

Classroom management. This dimension encapsulates the "effective strategies for organizing classrooms" proposed by several researchers (Doyle, 1986; Emmer & Stough, 2001; Evertson, 1989; Kounin, 1970a, 1970b; Kunter et al., 2007). The strategies result in increased learning time. This is largely the result of the "withitness" of a teacher, which means that a teacher is omnipresent during a lesson and informed about all that is happening in the classroom. With efficient time use, making effective transitions between topics and having clear rules and routines, a teacher can ensure the smooth running of the classroom. Successful classroom management also includes early, prompt, intervention to prevent disruptions and discipline problems (Kounin, 1970a; Kuger, 2016; Praetorius et al., 2018).

Student support. This dimension is based on SDT (Ryan & Deci, 2000, 2017) and comprises the support of student competence, autonomy, and relatedness (Klieme et al., 2009). Student support involves understanding student needs, helping them when needed, providing them with suitable options, and explaining the relevance of the tasks. It also includes giving constructive feedback, addressing student errors and misconceptions in a positive manner, and nurturing an atmosphere of mutual care and respect in the classroom (see Fauth et al., 2014, 2019; Lipowsky et al., 2009; Praetorius et al., 2018).

1.1.3 Mediators between teaching quality and student outcomes

Depth of processing. Based on cognitive constructivist learning theory (De Corte, 1995), depth of processing, or high-level thinking, is a student's reaction to cognitively activating teaching (Klieme & Rakoczy, 2008). The concept of depth of processing – the level at which a student processes what they are taught – encompasses skills such as critical thinking, reasoning, making sense, finding patterns, solving non-routine problems, as well as some aspects of self-regulation and metacognition (Baumert et al., 2010; Boston & Candela, 2018; Klieme et al., 2009; Lipowsky et al., 2009; Praetorius et al., 2018). Mathematics teaching, in particular, should incorporate challenging tasks that are neither too easy nor too hard so that students can develop an in-depth understanding of concepts, not just memorize facts (Hiebert & Grouws, 2007; Silver & Stein, 1996; Stein et al., 1996; Stein & Lane, 1996). Depth of processing has been empirically linked to student achievement (e.g., Chi & Wylie, 2014; Clifford, 1990; Lipowksy et al., 2009) and conceptual development (Stein et al., 1996; Stein & Lane, 1996). In the TBD model depth of processing mediates the relation between cognitive activation and student achievement, and classroom management is assumed to be directly related to depth of processing since a learning environment that helps students to pay attention is seen as an important prerequisite for in-depth engagement with a task (e.g., Lipowsky & Hess, 2019).

Time-on-task. Time-on-task is the class time during which students are actually engaged in activities leading to learning and performance (Brophy, 2006; Emmer & Stough, 2001; Finn & Zimmer, 2012; Fisher et al., 1981; Rakoczy, 2006; Wang et al., 1993). In the TBD model, time-on-task is a response to classroom management, which in turn is a strong predictor of student learning and achievement (Böheim et al., 2020; Brophy, 2000; Hattie, 2009; Klieme et al., 2009; Seidel & Shavelson, 2007).

Need satisfaction. Research based on SDT resulted in the addition of the satisfaction of the three basic needs for autonomy, competence, and relatedness as a mediator between student support and motivation (Klieme & Rakoczy, 2003). The need for autonomy is the need to experience personal freedom, volition, and choice (Vansteenkiste et al., 2010). The need for competence is the student's desire for mastery and effectiveness during tasks (Ryan & Deci, 2002). The need for relatedness refers to the desire for close and warm relationships (Baumeister & Leary, 1995; Deci & Ryan, 2002). According to SDT teaching behaviors can influence whether student needs are satisfied (Black & Deci, 2000). Within the TBD model classroom management is an important prerequisite for the satisfaction of students' basic needs because, for example, well-organized, undisturbed classrooms may mean students feel more effective when performing tasks (Kunter et al., 2007).

1.2 Revisiting the TBD model

The TBD model assumes that classroom management has an influence on all three mediators (depth of thinking, time-on-task, and need satisfaction), and cognitive activation and student support affect depth of processing and need satisfaction respectively (see Figure 1). There is strong empirical evidence for the role played by single mediators (e.g., Hiebert & Grouws, 2007; Stein & Lane, 1996 for cognitive activation; Hospel & Galand, 2016; Kunter, et al., 2007 for classroom management; and Kiemer et al., 2018; Mouratidis et al., 2013 for student support). However, the current TBD model proposes a complex web of influences and theoretical assumptions which have been added incrementally over time. It is therefore important to periodically review and possibly revise these assumptions and the mediation paths proposed by Klieme et al. (2006). The need for a review has been underscored by recent evidence that many of the assumptions are not empirically supported (Praetorius et al., 2018). Therefore, robust model and theory building warrants a thorough revisit and in-depth investigation of the entire TBD model (Praetorius et al., 2020a).

Section 1.2.1 is a discussion of the possible alternate paths derived from several established theories of motivation and cognition, such as expectancy-value theory, that were not explicitly considered in the formulation of the TBD model but have considerable overlap with its core assumptions (EVT; Wigfield & Eccles, 1992).

Relevant theories were systematically selected, by using the definitions of the dimensions and mediators within the TBD model and conducting a literature search for studies that assessed those constructs, including their subdimensions. Given that the TBD model has a structural component (quality dimensions) and a process component (effectiveness) with psychological mediators, we prioritized studies grounded in motivational and

cognitive psychological theories. The objective was to improve the theoretical basis of the TBD model and provide a more comprehensive understanding of the underlying processes that affect how teaching quality impacts student outcomes.

When the theoretical views and their empirical insights were incorporated into the TBD model, it became evident that additional mediation paths may exists. For example, several theories in the domain of achievement motivation, such as interest theory (IT; Hidi & Renninger, 2006) and the control-value theory of achievement emotions (CVT; Pekrun, 2006), suggest that an optimal challenge or even being engaged in a task may affect not only achievement, but also motivational and cognitive processes (see for example Vu et al., 2022; Wentzel & Miele, 2016).

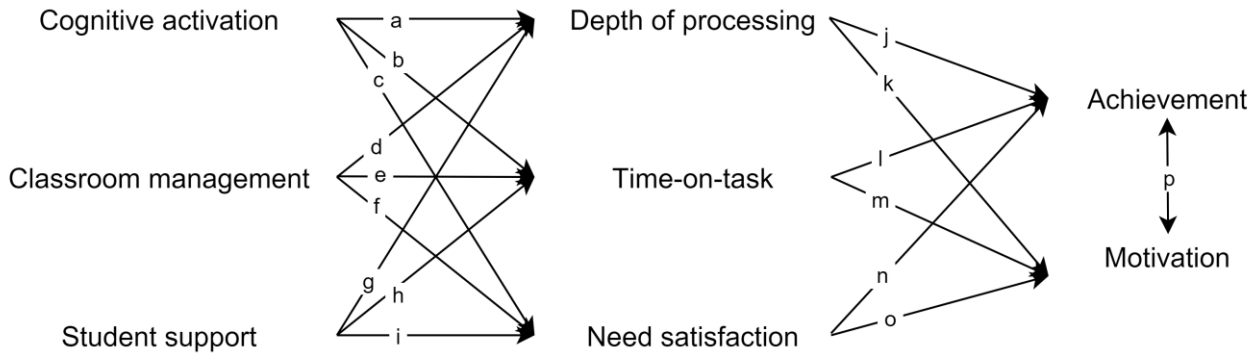

Figure 2. Possible relationships between the different parts of the TBD model.

1.2.1 Mediating paths for cognitive activation

The TBD model assumes a relation between cognitive activation and depth of processing (Figure 2, Path-a). However, theoretical and empirical evidence suggests that cognitive activation might also affect time-on-task (Figure 2, Path-b) and need satisfaction (Figure 2, Path-c). Cognitively challenging activities or tasks can direct student attention to particular aspects of content and specify methods by which information is processed and thus influence time-on-task (Doyle, 1983). This idea was also explored in the specific field of mathematics teaching by Stein et al. (1996). For example, when a teacher asks questions or presents problems without obvious solutions, students are more likely to pay close attention. These arguments are consistent with most authoritative views on achievement motivation. According to EVT student behavior can be seen as a product of the expectancy of success and value of reward (Atkinson, 1957; Heckhausen, 1991; Wigfield & Eccles, 1992).

The theory of motivational intensity (MIT) distinguishes between mere willingness to engage in a task and actual effort (Brehm & Self, 1989; Richter et al., 2016). According to this theory, conditions are identified which determine how much resource is allocated for engaging in a task. Moreover, a principle of resource conservation is proposed where it is assumed that even if the willingness to engage in a task is high, only as much effort as needed to succeed in a task will be allocated (Brehm & Self, 1989). If a task is very easy, effort will be low. When a task is too difficult or when the difficulty exceeds the value of a given reward, a student is likely to disengage from the task, resulting in diminished time-on-task. Given the fact that optimal task difficulty (Hiebert & Grouws, 2007), as well as adaptivity and individualization (Helm, 2016; Lotz, 2016; Rakoczy & Pauli, 2006) are important parts of cognitive activation, an effect on time-on-task is also highly probable.

Theoretical and empirical evidence also suggests that cognitive activation can be related to students' satisfaction of basic psychological needs (Figure 2, Path-c). According to EVT (Wigfield & Eccles, 1992) and SDT (Ryan & Deci, 2017), when teachers give optimally challenging tasks, students' expectancies for success can be fostered (EVT; Wigfield & Eccles, 2002) and in a similar vein their competence need can be satisfied (SDT; Reeve, 2006; 2016). Similarly, the basic need for autonomy can be satisfied when teachers present non-

routine problems, as it fosters students' critical thinking and encourages them to solve the tasks using their own methods, which is an important aspect of autonomy in the classroom (SDT; Reeve 2009; Reeve & Jang, 2006). If the students perceive the tasks as valuable and relevant, their basic psychological need for autonomy will be satisfied (SDT; Reeve & Jang, 2006). Empirical studies based on SDT support this link. For example, cognitive activation indirectly affected student interest and self-efficacy through autonomy and competence need satisfaction (Schukajlow et al., 2019; Schukajlow & Krug, 2014). Another study argued that a potential underlying mechanism between cognitive activation and student enjoyment in mathematics could be autonomy and competence need satisfaction (Lazarides & Buchholz, 2019). Moreover, cognitively activating behaviors such as aiming to foster cognitive independence, directly affect autonomy (Lotz, 2016). Since co-construction of knowledge is an important part of cognitive activation, the experience of relatedness could also be affected (see Ryan & Powelson, 1991; Sun & Chen, 2010 for the interplay and similarity of those constructs).

1.2.2 Mediating paths for classroom management

Within the TBD model *classroom management* is expected to affect all three mediators. Classroom management has been shown to affect time-on-task (Emmer & Stough, 2001; Finn & Zimmer, 2012; Fisher et al., 1981; Rakoczy, 2006; Wang et al., 1993) (Figure 2, Path-e), aspects of cognitive engagement (i.e., use of learning and self-regulation strategies) (Hospel & Galand, 2016) (Figure 2, Path-d), and students' need satisfaction (Kunter et al., 2007) (Figure 2, Path-f). Thus, classroom management should be relevant for all student learning processes (i.e., depth of processing, time-on-task, need satisfaction) in the classroom.

1.2.3 Mediating paths for student support

According to SDT, student support has a positive effect on the satisfaction of students' basic psychological needs (Ahn et al., 2021; Deci & Ryan, 2000; Jang et al., 2012; Kiemer et al., 2018; Mouratidis et al., 2013; Zhang et al., 2011) (Figure 2, Path-i). However, student support is also likely to be related to depth of processing (Figure 2, Path-g) and time-on-task (Figure 2, Path-h), which differs from what is postulated in the TBD model.

By engaging in supportive teaching behavior, characterized by mutual respect, teachers actively promote a positive learning environment. Students are not distracted by a negative teacher-student relationship that could elicit emotions that interfere with attention and self-regulation (Blair, 2002; Murray & Pianta, 2007). A good relationship between teachers and students also allows students to actively participate in their learning environment (Hughes et al., 2008; Pianta & Steinberg, 1992). Similarly, by giving constructive feedback, approaching student errors and misconceptions in a positive way, and monitoring student progress, teachers increase active learning time (Grabinger & Dunlap, 1995; Grabinger et al., 1997). Cognitive information processing theory (IPT; Atkinson & Shiffrin, 1968; Driscoll, 2005), states that students are attentive when they select and process information that is very important and meaningful for them. One key aspect of student support is making the information relevant and meaningful to the students (see also Ahmadi et al., 2022). For example, when teachers engage in autonomy supportive behaviors such as providing rationales for the content and personal relevance, then students are more likely to pay attention during the lesson because the information is useful, meaningful, and important to them (Lietaert et al., 2015).

A positive climate also allows students to try new and creative solutions without reservations (Chan & Yuen, 2014), an important aspect of depth of processing. This is because an encouraging, respectful, supportive, and positive learning environment that is open to creativity and improvement, encourages students to seek challenges (Turner & Meyer, 2004). In addition, according to the elaboration likelihood model (ELM, Petty & Cacioppo, 1986) when teachers highlight the relevance of the tasks to students, the students' personal involvement increases, which in turn fosters depth of processing (Illies & Reiter-Palmon, 2004; Petty et al., 1983; Mitchell, 1993).

Interest theory has been used to describe the relation between personal involvement, depth of processing, and time-on-task (Hidi & Renninger, 2006; Renninger & Hidi, 2002). When a student's attention is triggered by relevant tasks and personal involvement, they will also become interested in content. Several studies confirm the link between aspects of student support and aspects of depth of processing such as self-

regulation and deep learning strategies (Hospel & Galand, 2016; Rieser et al., 2016; Ruiz-Alfonso & León, 2019; Wang & Eccles, 2013), higher analytical problem-solving skills, and student challenge preferences (Boggiano et al., 1988; 1993; Guay et al., 2008). Positive relations have also been identified between student support and time-on-task (Chiu, 2004; Deci et al., 1994; Stallings, 1980). All these studies lend weight to the hypothesis that student support can predict depth of processing and time-on-task.

1.2.4 Student use of opportunities and student outcomes

Because the mediators are interrelated, the relationship between the depth of processing, time-on-task, and need satisfaction mediators and motivation and achievement outcomes might also be less discrete than how they are shown in the model (Figure 2, paths j, l, and o); the original model already indicated the relationship between motivational outcomes and achievement (Figure 2, Path-p). Other important theories, such as CVT (Pekrun, 2006), also suggest that depth of processing and time-on-task could be related to motivational outcomes (Figure 2, Paths k and m). For example, students who think critically and solve modelling problems by constructing multiple solutions have a greater interest in the subject (Schukajlow & Krug, 2014) and higher self-efficacy (Schukajlow et al., 2019). Interest and self-efficacy have been treated as motivational outcomes in TBD research (Figure 2, Path-k) (Dorfner et al., 2018; Fauth et al., 2014, 2019; Förtsch et al., 2017; Li et al., 2020).

Time-on-task not only promotes academic achievement (Evertson & Harris, 1992; Good & Brophy, 2003), but also appears to be relevant for fostering student motivation (Butler & Shibaz, 2008; Lazarides & Buchholz, 2019; Rakoczy, 2006) (Figure 2, Path-m). This relationship is also suggested by other motivation theories such as interest theory and CVT. In these instances, it is hypothesized that being on task or processing information at a deep level creates positive emotions for students (i.e., activity emotions), which in turn fosters their interest and motivation.

Finally, as proposed in the TBD model it is hypothesized that need satisfaction affects motivational outcomes which in turn affect achievement (Figure 2, Path-o-p). Studies have shown a link between the satisfaction of a student's needs and their autonomous motivation (e.g., Mouratidis et al., 2015; Ryan & Deci, 2009), interest (e.g., Kunter et al., 2007), and self-efficacy (e.g., Sun et al., 2020; Zhen et al., 2017) (Figure 2, Path-o). However, according to SDT, when students' basic psychological needs are satisfied, they display improved academic performance and achievement (Ryan & Deci, 2017). Theoretical considerations based on SDT, in combination with the studies which found positive relationships between need satisfaction and student achievement (Badri et al., 2014; Wang et al., 2019; Zhou et al., 2021), lead us to hypothesize that need satisfaction is positively related not only to motivational outcomes, but also to achievement. Depth of processing and time-on-task is likely to be linked to motivational outcomes and need satisfaction can be related to achievement.

1.3 Study

A review of theories in the field of cognitive and motivational psychology and relevant empirical evidence strongly suggests that there should be more mediation paths than those which have been discussed in the TBD literature to date. Our assumption will be tested by constructing models which consider the assumptions of the original TBD model and additional possible paths. Our concrete hypotheses are as follows:

H1: The three basic dimensions of teaching quality are all related to the development of student achievement and interest.

H2: Cognitive activation indirectly predicts the development of student achievement and interest through depth of processing, time-on-task, and need satisfaction.

H3: Classroom management indirectly predicts the development of student achievement and interest through depth of processing, time-on-task, and need satisfaction.

H4: Student support indirectly predicts the development of student achievement and interest through depth of processing, time-on-task, and need satisfaction.

2. Methods

This study investigates whether student perceptions of cognitive activation, classroom management, and student support indirectly affect student achievement and interest in mathematics through depth of processing, time-on-task, and need satisfaction. We analyzed data collected in Germany as a part of the Teaching and Learning International Survey (TALIS) Video Study conducted by the Organisation for Economic Co-operation and Development (OECD, 2020).

2.1 Participants and procedures

The study sample was selected from participants in the TALIS Video Study for Germany using convenience sampling. The initial sample consisted of 1143 students from 50 classrooms and 39 schools. There are big differences in learning goals, school curricula, and student achievement levels between schooling tracks in Germany (Hachfeld & Lazarides, 2020). Therefore, we removed participants in vocational schools from the data, leaving a final sample of 958 students who were attending the academic "Gymnasium" track. Students were from 41 classrooms and 30 schools (M_{age} = 14.82, *SD* = 0.62; 50.5 % females; 5.3% did not report their gender). The average number of students per classroom was 23.37 (*SD* = 4.73, min = 11 max = 31). Of 41 classrooms, the majority (35) were 9th grade level and six were 8th grade. Most of the students reported that they were born in Germany (*n* = 869), *n* = 36 students reported that they were born in other countries, and *n* = 53 did not report their country of birth.

The TALIS Video Study conformed to ethical standards (OECD, 2020). School principals, teachers, students, and their parents were informed about the purpose of the study. The participants were assured that their participation was anonymous and voluntary and that their information would be secure and confidential.

2.2 Instruments and measures

The student survey asked about family and peer circumstances and aspects of students' cognitive, motivational, and emotional learning. It also asked students for their perceptions of teaching quality in the mathematics lessons at the beginning of a specific teaching unit, *quadratic equations* (McCaffrey et al., 2020; Praetorius et al., 2020b). In the TALIS Video Study, the constructs measured in the pre-test (T1) are operationalized in terms of mathematics in general, whereas the constructs measured in the post-test (T2) are operationalized only in terms of quadratic equations. To test our hypotheses, variables from the first and second measurement points were used. The number of days between pre-test (T1) and post-test (T2) ranged from 22 to 130 (*M* = 58.83, *SD* = 26.01) (see Supplementary Material).

Teaching quality dimensions were measured using student rating, which is considered a valid, reliable, and efficient measure of teaching quality (van der Scheer et al., 2019). Depth of processing, time-on-task, need satisfaction, and interest were assessed using student self-reports. Self-reports are useful for assessing constructs that are not directly observable such as student use of learning opportunities (Appleton et al., 2006; Fredricks & McColskey, 2012).

Many items in the TALIS Video Study questionnaire were based on previous TALIS and Programme for International Student Assessment (PISA) studies (OECD, 2020; Praetorius et al., 2020b, pp. 4-7). The concrete item wordings of the assessed constructs are shown in Appendix A. Each item was assessed using a four-point Likert scale. Negative items in the questionnaire were reverse-coded. To account for level-specific reliability (Geldhof et al., 2014), we calculated McDonald's omega (ω; McDonald, 1999) for both the within and between levels; these are reported in Table 1. We also calculated the descriptive statistics for each item and each subscale (see Supplementary Material).

2.2.1 Independent variables: Three dimensions of teaching quality (TBD)

In the TALIS Video Study for Germany student perceived cognitive activation, classroom management, and student support were assessed using items similar items to those used in previous TALIS and PISA studies (OECD, 2020). Student self-reported cognitive activation was assessed with seven items designed to reveal their perceptions of whether teachers presented tasks and their solutions in a manner that

would promote conceptual understanding and content-based discourse (e.g., "Our mathematics teacher gives tasks that require us to think critically"). Student self-reported classroom management was initially assessed using 10 items related to disruptions, transitions, monitoring, and clarity of rules (e.g., "In the lesson, our teacher is clear to us why certain rules are important"). However, we excluded two items from the study because of negative correlations between them and other classroom management items, resulting in eight items for measuring classroom management (See Table 1). Student self-reported student support was assessed using 11 items including four covering teacher support, autonomy support, and competence support (e.g., "Our mathematics teacher makes me feel confident in my ability to learn the material").

2.2.2 Mediators: Student use of learning opportunities

Student use of learning opportunities was assessed using three scales (OECD, 2020; Vieluf et al., 2020). Student perceived depth of processing was assessed with three items (e.g., "I keep thinking about tasks until I really understand them"). Student perceived time-on-task was assessed using three items (e.g., "I pay attention in mathematics class"). Student perceived need satisfaction was assessed using three items (e.g., "I feel I can decide on things on my own").

2.2.3 Outcomes: Interest and Achievement

We chose student individual interest in mathematics, which was also used as an outcome in the report of TALIS Video Study and by other studies, as a motivational outcome (Herbert et al., 2022; Zhu & Kaiser, 2022). Student self-reported interest in mathematics was assessed at T1 using three items (e.g., "I am interested in mathematics"). Student self-reported interest in quadratic equations was assessed after the lesson, T2, using three items (e.g., "I was interested in the topic of quadratic equations").

The students' general knowledge of mathematics was assessed using 30 multiple-choice items. The pre-test focused on the key prerequisites for the conceptual understanding of quadratic equations. Several items in the pre-test (T1) also covered students' general knowledge of mathematics and precursors to understanding quadratic equations such as numbers, algebraic expressions, and algebraic equations. The post-test (T2) focused on students' knowledge of quadratic equations and its applications (McCaffrey et al., 2020).

2.3 Data analysis

We tested our hypothetical mediation paths with correlative (preliminary) and longitudinal (main) analyses run using the lavaan package (v0.6-8; Rosseel, 2012) in R programming software (R Development Core Team, 2020). The R code for all the analyses is included in the Supplementary Material.

To assess the reliability of the aggregated student variables, intraclass correlation coefficients (ICC1 and ICC2) were computed for all model variables (see Table 1). ICC1 ranged between 4% and 37%. This range shows the extent to which the individual ratings of the variables are attributable to classroom membership (LeBreton & Senter, 2008). ICC2 is the reliability of the class-average constructs and ranged between 45% and 93%. ICC2 values between 70% and 85% indicate acceptable levels of reliability (LeBreton & Senter, 2008; Lüdtke et al., 2009).

To account for the hierarchical structure of the data, the main analyses were multilevel longitudinal path analyses. Due to the complexity of the TBD model, in this study we investigated the mediating effects of three mediators for each dimension of teaching quality in three separate models. In keeping with the methodology employed in other empirical studies investigating mediation between teaching quality and student achievement (e.g., León et al., 2017; Ruiz Alfonso & León, 2017; Theis et al., 2020), we used 1-1-1 and 2-2-2 models so that between groups effects and within-group effects were separated (Preacher et al., 2011). Because the cluster size was too small to apply latent models and due to the complexity of the models, we averaged the items per scale and used the resulting mean scores as manifest variables in our path models. Moreover, due to the non-normality of the assessed variables (see Supplementary Material), we used the maximum likelihood with robust standard errors (MLR) estimator (Savalei & Rosseel, 2021).

Fifty-one students for whom all values were missing for all the assessed variables were removed from the analyses, leaving a total sample of $n = 907$. The percentage of missing values for the assessed scales for

the total sample ranged from 0.1% to 0.7%. We did not apply a special missing value treatment because of this low percentage (Kline, 2011, p.55).

We used the comparative fit index (CFI), the Tucker–Lewis index (TLI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) to evaluate model fit. Adequate fit is achieved when the CFI and TLI are between .90 and .95. RMSEA and SRMR show adequate fit when they are between .05 and .08 (Hu & Bentler, 1999). Because distributions of indirect effects could be non-normal, the bootstrapping method was used to calculate confidence intervals for the indirect effects (N = 1000 bootstrap samples; Preacher & Hayes, 2008). The indirect effects are considered statistically significant when the 95% confidence intervals do not include zero (Cheung & Lau, 2008; Mackinnon et al., 2004).

3. Results

3.1 Descriptive statistics and bivariate correlations

Descriptive statistics and bivariate Pearson's correlations for all observed variables at the classroom and student level are presented in Table 1. Positive correlations between the independent variables (the three basic dimensions of teaching quality) and all the mediators (depth of processing, time-on-task, and need satisfaction) were found at both classroom and student levels. However, not all the expected correlations between independent variables and outcomes (interest and achievement), as well as between the mediators and outcomes were found. For example, at the student level the three basic dimensions of teaching quality were not correlated with achievement at T1.

3.2 Preliminary analysis

3.2.1 Relationships between teaching quality, learning processes, and student outcomes

As a first step, we conducted multilevel path analyses using all the variables that had been assessed at the same point in time (i.e., T1). The results of the three separate direct effect models indicated that, at the student level, all the three basic dimensions of teaching quality were positively related to student interest and only student support was positively related to student achievement. At the classroom level, classroom management and student support were positively related to student interest, and classroom management was positively related to achievement.

In a second step, we tested the three mediation models. The correlational mediation analyses indicated that all the three basic dimensions were positively related to all the mediators at both student and classroom levels. Furthermore, the positive associations were found between all the mediators and outcomes at both levels, except for time-on-task and achievement (for details, see Supplementary Material).

3.3 Main analysis

3.3.1 Longitudinal relationships between teaching quality and student outcomes

We estimated three multilevel longitudinal path analyses. By conducting three separate direct effect models using longitudinal data, we tested the direct relationship between the three dimensions of teaching quality at T1 and student achievement and interest at T2 while controlling for student achievement and interest at T1. The model fit indices are sufficient except for TLI which has slightly less than acceptable fit values (see Table 2). The results of the three multilevel path models indicate that the three basic dimensions of teaching quality were not directly associated with mathematics achievement and interest at T2 either at the classroom level or the student level, controlling for student achievement and interest at T1 (see Figure 3). Strong positive relationships between T1 interest and T2 interest and between T1 achievement and T2 achievement were found at both the classroom and student levels. At the student level, the three dimensions of teaching quality at T1 were positively associated with student interest at T1, whereas at the classroom level, only student support at T1 was found to be positively related to student interest at T1.

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Table 1

Descriptives, ICCs, reliability estimates (ω), and within and between level intercorrelations between the measured variables

	1	2	3	4	5	6	7	8	9	10
1. Cognitive activation (T1)	1	.15***	.48***	.26***	.17***	.32***	.27***	-.02	.16***	-.01
2. Classroom management (T1)	.14***	1	.31***	.07	.18***	.22***	.16***	-.02	.12**	.00
3. Student support (T1)	.49***	.22***	1	.32***	.26***	.60***	.46***	.08	.28***	.10
4. Depth of processing (T1)	.24***	.09	.32***	1	.34***	.45***	.54***	.25***	.36***	.25***
5. Time-on-task (T1)	.14***	.21***	.21***	.34***	1	.26***	.33***	.07	.27***	.06
6. Need satisfaction (T1)	.33***	.20***	.62***	.47***	.26***	1	.52***	.25***	.28***	.21***
7. Interest (T1)	.24***	.18***	.48***	.54***	.35***	.54***	1	.22***	.56***	.25***
8. Achievement (T1)	-.03	.08	.03	.27***	.10*	.22***	.18***	1	.09	.58***
9. Interest (T2)	.15***	.12**	.30***	.38***	.28***	.30***	.58***	.06	1	.18***
10. Achievement (T2)	-.05	.10*	.08	.27***	.08	.20***	.24***	.61***	.21***	1
$Mean_{within}$	2.62	3.01	2.98	2.66	3.10	2.86	2.40	.73	2.17	.50
SD_{within}	.49	.47	.56	.63	.54	.64	.78	.15	.73	.19
ICC1	.10	.37	.26	.04	.04	.11	.13	.20	.12	.16
ICC2	.72	.93	.89	.50	.45	.73	.77	.85	.73	.80
ω_{within}	.65	.60	.86	.67	.73	.63	.85	-	.81	-
$\omega_{between}$	.74	.95	.98	1.00	.95	.90	.98	-	.99	-

Note. *$p < .05$, **$p < .01$, ***$p < .001$. Student-level correlations are displayed below the diagonal and classroom-level correlations are displayed above the diagonal.

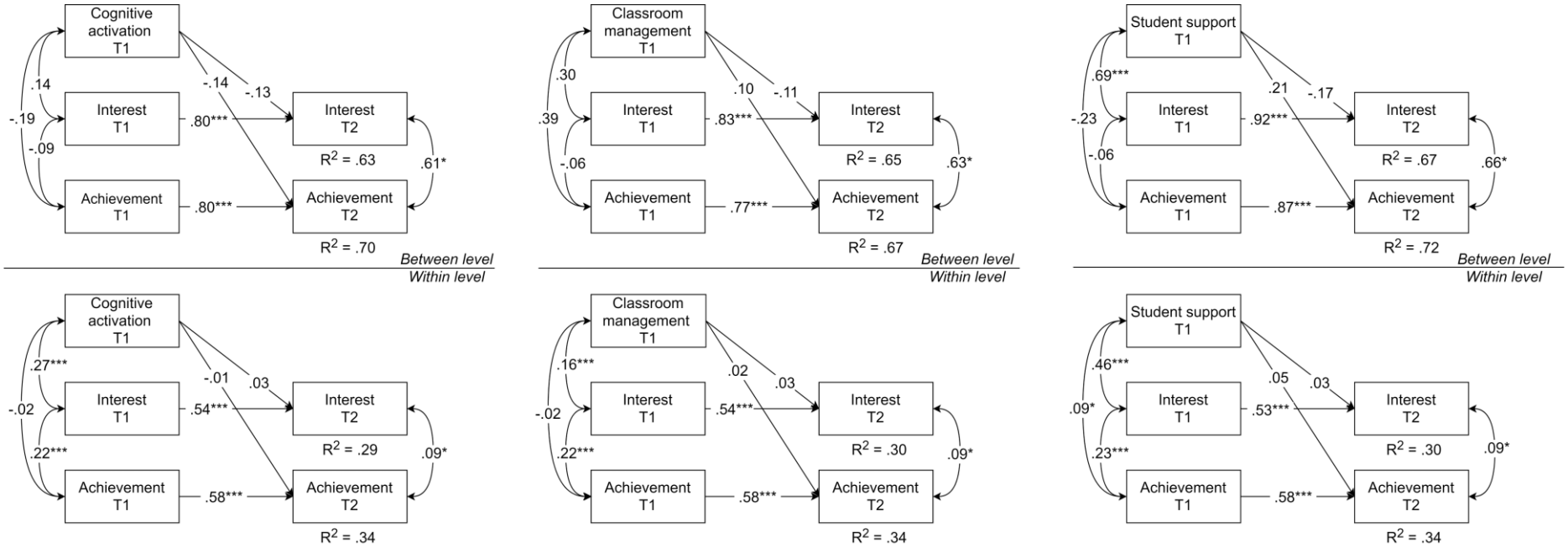

Figure 3. Models of the effects of three basic dimensions of teaching quality in T1 on student achievement and interest in T2 controlling for student achievement and interest at T1.

Note. *$p < .05$,**$p < .01$, ***$p < .001$.

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Table 2

Model fit indices

Model fit indices	$\chi 2$	*p*	CFI	TLI	RMSEA [90%-CI]	$SRMR_{within}$	$SRMR_{between}$
Direct effects models							
1. Cognitive activation	34.841	< .000	.958	.790	.098 [.067 - .132]	.037	.073
2. Classroom management	21.900	< .000	.977	.885	.075 [.047 - .106]	.036	.055
3. Student support	17.571	= .001	.985	.924	.065 [.037 - .096]	.030	.024
Mediation models							
4. Cognitive activation	9.294	= .054	.997	.952	.041 [.000 - .075]	.013	.026
5. Classroom management	7.624	= .106	.998	.967	.034 [.000 - .068]	.012	.022
6. Student support	8.557	= .073	.997	.964	.038 [.000 - .072]	.012	.015

3.3.2 The mediating role of student use of learning opportunities

After investigating the direct effect models, we constructed three separate multilevel longitudinal mediation models for each of the three dimensions of teaching quality: cognitive activation, classroom management, and student support. As with the direct effect models, strong positive relationships between interest at T1 and at T2 and between achievement at T1 and T2 achievement were found at both the classroom and student level.

All three mediators - depth of processing, time-on-task, and need satisfaction - were added to the direct effect models. The multilevel mediation models yielded satisfying fit indices (see Table 2). We also conducted bootstrap analyses to calculate the mediating effects of depth of processing, time-on-task, and need satisfaction because the distribution of the mediating effects can be non-normal (Preacher & Hayes, 2008). The results of the bootstrap analyses are shown in Table 3. The three multilevel mediation models generated the following results:

Cognitive activation: Cognitive activation at T1 was positively related to need satisfaction at T1 at both the student and classroom level, and depth of processing at T1 at the student level (see Figure 4). Mediation analyses revealed that depth of processing at T1 mediated the relation between T1 cognitive activation and T2 achievement (β = .02; *SE* = .00; 95%-CI: [.00, .01]) at the student level.

Classroom management: Classroom management at T1 was positively related to time-on-task at T1 at both the student and the classroom level, and need satisfaction at T1 at the student level (Figure 5). Mediation analyses also confirmed the mediating role of T1 time-on-task between T1 classroom management and T2 interest (β = .01; *SE* =.01; 95%-CI: [.00, .04]).

Student support: For student support, a positive relation between T1 student support and T1 need satisfaction was found both at the classroom level and at the student level (see Figure 6). Relations with T1 depth of processing and T1 time-on-task were also found at the student level. Mediation analyses showed that T1 depth of processing mediated the relation between T1 student support and T2 achievement (β = .01; *SE* =.00; 95%-CI: [.00, .01]), whereas T1 time-on-task mediated the relation between T1 student support and T2 interest (β = .01; *SE* =.01; 95%-CI: [.00, .03]) at the student level.

It is important to note that some of the standardized regression (beta) coefficients in the models are larger than 1.00. This is primarily due to the multicollinearity and low variance of the variables at the classroom level (i.e., ICC's of depth of processing and time-on-task were .04).

In summary, in our analyses, none of the mediation assumptions were supported at the classroom level, but some of them were supported at the student level.

Table 3

Results of bootstrap analyses

Mediation Models	Classroom level			Student level		
Model 4. Cognitive activation	*β*	*SE*	%95CIs	*β*	*SE*	%95CIs
Depth of processing → achievement	.00	.02	[-.03, .03]	.02	.00	[.00, .01]
Depth of processing → interest	.00	.01	[-.02, .02]	.01	.01	[-.00, .04]
Time-on-task → achievement	-.10	.06	[-.15, .07]	-.00	.00	[-.00, .00]
Time-on-task → interest	.02	.11	[-.19, .23]	.01	.01	[.00, .02]
Need satisfaction → achievement	-.02	.08	[-.17, .16]	.01	.00	[.00, .01]
Need satisfaction → interest	-.13	.33	[-.83, .45]	-.01	.01	[-.03, .01]
Model 5. Classroom management						
Depth of processing → achievement	-.01	.01	[-.02, .02]	.00	.00	[-.00, .00]
Depth of processing → interest	-.00	.02	[-.03, .03]	.00	.01	[-.01, .01]
Time-on-task → achievement	.30	.06	[-.04, .19]	-.00	.00	[-.01, .00]
Time-on-task → interest	.05	.18	[-.31, .39]	.01	.01	[.00, .04]
Need satisfaction → achievement	.00	.00	[-.01, .01]	.01	.00	[-.00, .01]
Need satisfaction → interest	.01	.04	[-.07, .09]	-.01	.01	[-.03, .01]
Model 6. Student support						
Depth of processing → achievement	-.00	.02	[-.04, .04]	.01	.00	[.00, .01]
Depth of processing → interest	.00	.01	[-.02, .02]	.01	.01	[-.00, .03]
Time-on-task → achievement	.01	.04	[-.08, .08]	-.01	.00	[-.01, .00]
Time-on-task → interest	.03	.10	[-.18, .23]	.01	.01	[.00, .03]
Need satisfaction → achievement	-1.17	.20	[-.67, .11]	.02	.01	[-.00, .02]
Need satisfaction → interest	-.29	.68	[-1.56, 1.10]	-.02	.02	[-.07, .02]

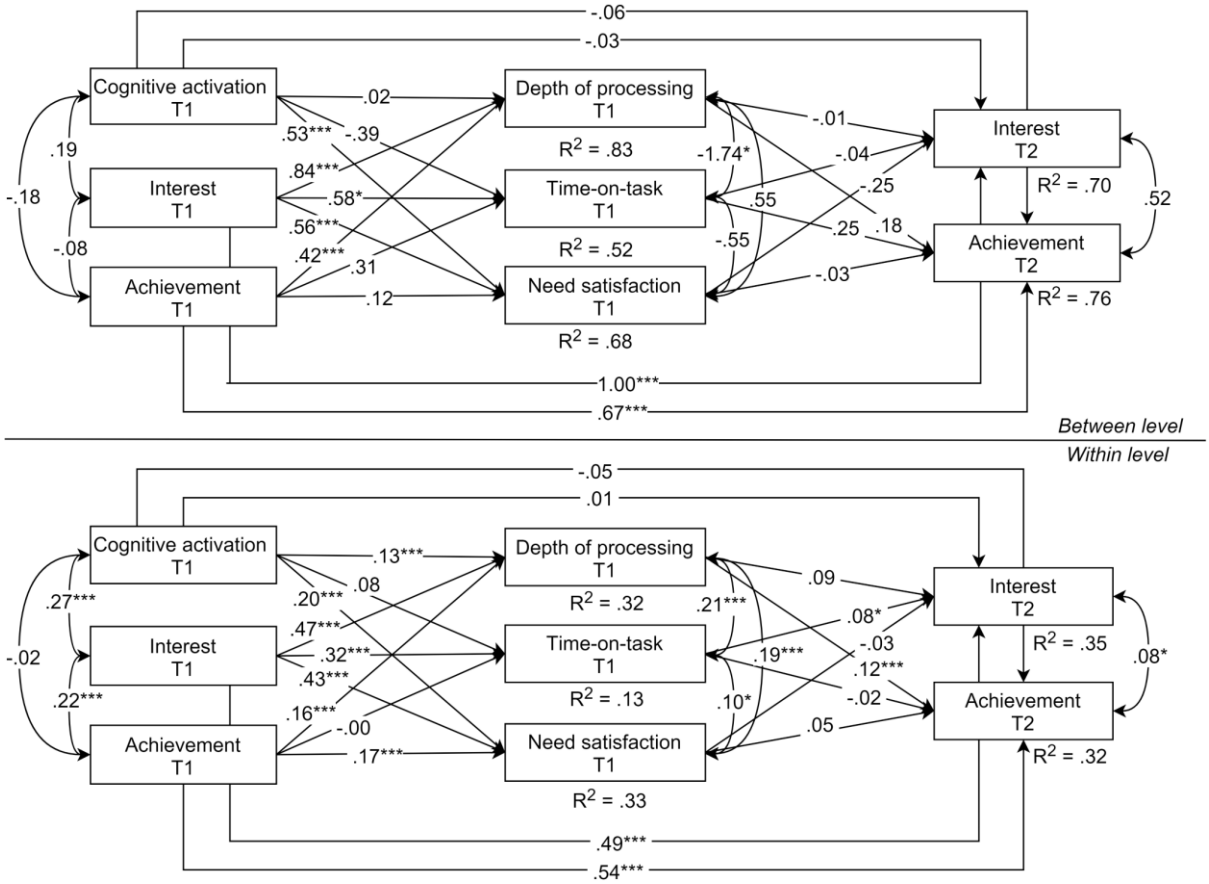

Figure 4. Mediation model for cognitive activation with standardized coefficients.

Note. (*$p < .05$, **$p < .01$, ***$p < .001$)

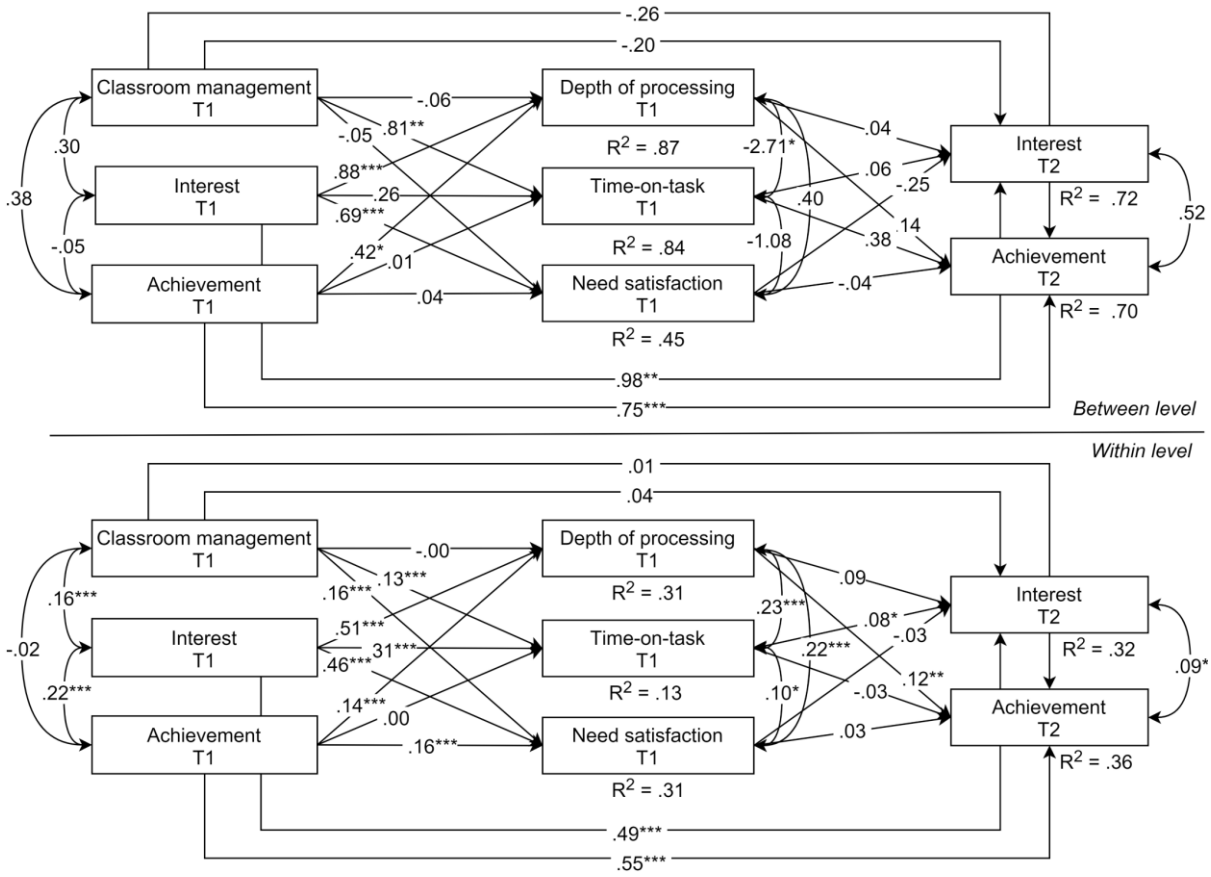

Figure 5. Mediation model for classroom management with standardized coefficients.

Note. (*$p < .05$,**$p < .01$, ***$p < .001$).

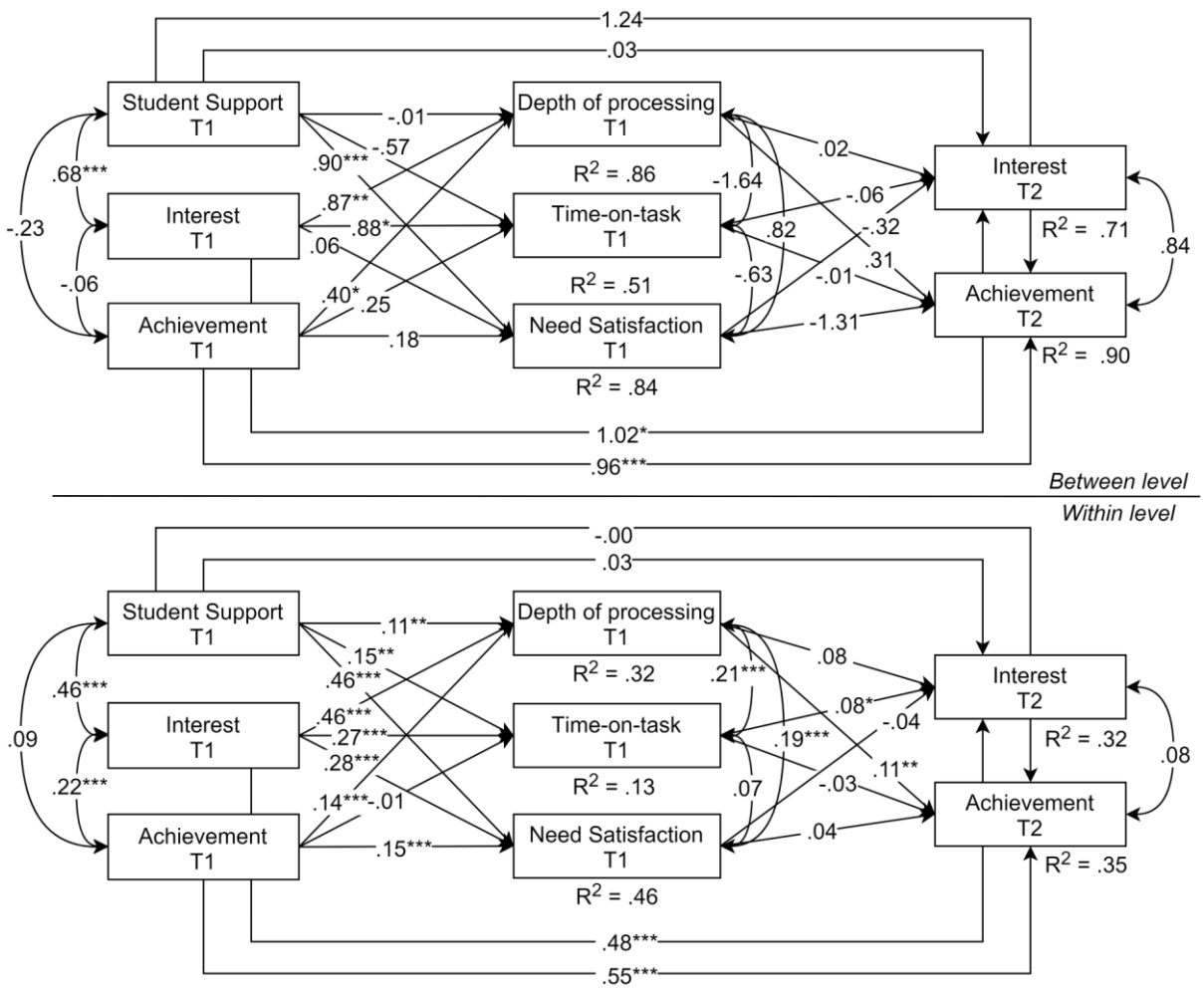

Figure 6. Mediation model for student support with standardized coefficients

Note. (*$p < .05$,**$p < .01$, ***$p < .001$).

4. Discussion

This study aimed to investigate the mediating role of student learning processes in the relationship between the three basic dimensions of teaching quality and student outcomes in mathematics by focusing on and extending on the hypotheses of the TBD model (Klieme et al., 2009). Contrary to the premise of the TBD model and our reasoning, the results of our study showed no statistically significant direct effects of the teaching quality dimensions on student outcomes at either the classroom or individual level. Positive associations were found between teaching quality dimensions and mediators, but the partial mediation models at the classroom level failed to confirm the mediation hypotheses. At the student level, consistent with the TBD model, depth of processing mediated the relationship between cognitive activation and achievement. However, contrary to the predictions of the TBD model and consistent with our new hypotheses, the following relationships were found at the student level: Time-on-task mediated the relationship between classroom management and interest, and between student support and interest. Depth of processing mediated the relationship between student support and achievement. These results suggest that the TBD model could benefit from an expansion of its hypotheses about mediators using relevant theoretical approaches such as EVT (Wigfield & Eccles, 1992) and ELM (Petty & Cacioppo, 1983).

4.1 Conceptual expansion of the TBD model

The varied results of this study suggest that the relationships between the variables are more complicated than we had initially predicted. In its current form the TBD model is based on the assumption that there is a clearly defined sequence of teaching quality dimensions and their associated mediators. The relatively simplified structure of the model was possibly deliberate, but it has resulted in a model that struggles to reflect the full complexity of teacher student interactions. It is therefore important that the model is expanded and refined. We believe that subsequent research needs to reassess four key assumptions of the current model: that relationships between teaching quality dimensions and their mediators are sequential; that the relationships between mediators are relatively simple; that there are more mediators than previously assumed; that there is the possibility that the relationships between the variables are bidirectional.

The conceptual sequence of the variables in the TBD model, particularly for dimensions of teaching quality, led to our hypothesis that classroom management would be positively related to depth of processing at both student and class level. However, our results did not support this. One explanation could be that classroom management indirectly influences depth of processing through cognitive activation (Charalambous & Praetorius, 2020; Klieme et al., 2001). It acts as a pre-condition for the other teaching quality dimensions. This idea is supported by empirical evidence that classroom management predicts cognitive activation at the classroom level (Dorfner et al., 2018). Classroom management alone may not be enough to promote depth of processing, but it may play an enabling role. Researchers should continue to explore the existence of potential mediators between classroom management and depth of processing.

The second fundamental assumption of the TBD is that the variables are related in a specific way. Our study found that not all the hypothesized relationships we thought might exist between the mediators (depth of processing, time-on-task, and need satisfaction) and achievement and interest outcomes were supported. Specifically, at the student level, we found that time-on-task predicted student interest and depth of processing predicted student achievement, but none of the other postulated relationships were observed. These findings could suggest that the interplay between the mediators is more complex than initially assumed and that the current three-factor structure might not be the best representation of the processes. For instance, SDT (Ryan & Deci, 2017) proposes that need satisfaction may be a pre-condition for time-on-task and depth of processing, Schlesinger and Jentsch (2016) argued that time-on-task might be necessary for deep processing to occur, and according to Brown and Ryan (2003), conscious attention might be needed to meet psychological needs. We recommended that future research considers the possibility that the constructs are sequential; one acts as a pre-condition for another.

The third assumption of the current TBD model that our findings cast doubt on is that only three aspects of learning processes mediate the relationship between the three basic dimensions of teaching quality

and student outcomes. Being based on the TBD, our paper focused on an analysis of these aspects. However, given the various theoretical approaches explored in this study, other aspects such as emotions related to achievement (CVT; Pekrun, 2006) and expectancies and values (EVT; Wigfield & Eccles, 1992) could also be included in the model. The inclusion of these mediators in particular could be productive since studies supporting the relationship between the three basic dimensions of teaching quality and these learning processes already exist (e.g. Burić & Kim, 2020; Lazarides & Buchholz, 2019).

The fourth assumption of the TBD model is that some variables are related to others in only one direction. We investigated the relationship between teaching quality at T1 and mediators at T1 and the relationship between mediators at T1 and achievement and interest at T2. We found depth of processing at T1 predicted student interest at T2. But this relationship might be bi-directional over the long term (Hidi & Renninger, 2006), i.e., when students are interested in mathematics, they tend to think more critically and try to solve more challenging problems. Likewise, our study showed that interest and achievement at T1 are related to mediators at T1 but the direction of the effects could not be ascertained because they were investigated at the same point in time. This is also true for the relations between teaching quality dimensions and mediators. Therefore, future studies should consider using more suitable designs such as cross lagged models and three measurement points to separately investigate the longitudinal mediating effects of each mediator.

The relationships may also be influenced by control variables and moderators, such as student personality traits, adding yet more complexity to any analysis. Study designs should test and expand theoretical assumptions, using robust experimental or intervention designs. It is also vital to acknowledge the complexity of an educational reality encompassing countless interactions between teachers and students, not unfairly described as a "hall of mirrors" (Berliner, 2002, Cronbach, 1975). It is essential to recognize that continued exclusive reliance on quantitative methods such as mediation analysis may not capture the full complexity of the system. Qualitative approaches and mixed method studies are needed to further develop the TBD model (Schlesinger et al., 2018).

4.2 Correlational vs. longitudinal evidence

Our study highlighted that choosing whether to use correlational or longitudinal analyses can have a significant impact on the results. The direct effect models using a correlational design resulted in mostly positive direct associations. Contrary to our hypothesis, direct effect models with a longitudinal design revealed that at both levels, cognitive activation, classroom management, and student support did not directly predict achievement or interest. In correlational mediation models all paths, with the exception of the relationship between time-on-task and achievement, showed positive associations at both levels. However, in longitudinal mediation models, some mediating effects were found only at the student level.

Correlational research design is frequently used to confirm theoretically predicted relationships between variables in educational research because it is a practical approach. Most of the relationships we found using a correlational design were positive but the same was not true when the data were analyzed longitudinally. This discrepancy is important and researchers should investigate differences between correlational and longitudinal data in other settings.

Correlational results do not, however, establish causality or the direction of effects. To avoid potential misconceptions, researchers should not rely only on correlational designs for research that may have practical implications for teachers. Also, the interpretation of correlational findings needs careful framing. For instance, correlational studies should avoid using directional language such as "affect" or "predict" to minimize potential misinterpretations. Although correlational studies can be a practical tool in the early stages of a new area of research, helping to identify any relationships, when the research field is saturated with the correlational studies, as it is in teaching quality research, we recommend the use of stronger methods such as longitudinal or experimental designs so that the directionality of effects can be established.

Although less used, longitudinal designs have the advantage of being able to reveal the direction of effects. They do, however, pose challenges. Firstly, using short time intervals between measurement points in longitudinal studies often results in a high stability of the variables over time (Begrich et al., 2023). This issue

was observed in the analysis of student achievement and interest in our study. The high stability of outcome variables implies that the remaining variables, such as the dimensions of teaching quality at T1 or mediators at T1, only explain a little of the variance (Adachi & Willoughby, 2015; Praetorius et al., 2018; Warner et al., 2017). In future, researchers could mitigate this effect by having longer intervals between measurement points. Extended intervals would also enable the monitoring of significant transitions, such as a change of teacher or shifts in classroom dynamics (Begrich et al., 2023). Another interesting avenue for future research would be to examine whether study outcomes are affected by time between measurements. In our study there was considerable variance in intervals, from 22 to 130 days. It would be interesting to analyze the differences between classes where the interval was larger and those where it was smaller by for example, dividing data at the median time interval, to determine the effect of time intervals on the stability of outcomes. However, due to the limitations imposed by the relatively small size of our study sample and the limited number of classrooms, it was not possible to run such a complex model (Hox & McNeish, 2020; Maas & Hox, 2005). Secondly, despite providing valuable insights, longitudinal studies only assess specific time points and do not denote any causal link between variables. Therefore, experiments or interventions are required to confirm the effects between the variables or determine the absence of effects in certain contexts and settings. For example, teaching quality could be manipulated by training a group of teachers to set optimally challenging tasks that cater to the level of each student. The results from this group could then be compared to a control group providing regular lessons using an experience sampling approach to investigate what effect the treatment had on their learning processes and outcomes (see Schukajlow et al., 2023; Talić et al., 2022).

While correlational studies give an initial indication of the relationships between variables, sometimes, these relationships are not confirmed by a longitudinal study, as is the case here. Longitudinal design in TBD research can be improved by having longer intervals between measurement points. However, more rigorous and holistic approaches are necessary in order to be able to show the effect of teaching quality on learning processes and then, in turn, on student outcomes.

4.3 Level of analyses

We ran the models at both the student and classroom levels and the results differed, depending on the level of analysis. In order to better understand how much individual student perceptions differed from the shared class perception, we separated within group and between group effects (Fauth et al., 2014; Marsh et al, 2012). This was also helpful for identifying the most suitable constructs for each level. For example, at the classroom level the low ICC1 of depth of processing and time-on-task showed that only 4% of the variance in those variables could be attributed to classroom membership. These two variables are also problematic when looking at low ICC2. Although considering between-level effects for variables with low ICC's is possible when intraclass correlations are nonzero and number of individuals per group is high (Julian, 2001; Lazarides & Buchholz, 2019), these effects must be interpreted with caution.

Given the low ICCs, especially for depth of processing and time-on-task, it appears that these constructs might be more idiosyncratic. While students in the same classroom are taught by a single teacher and may share some learning processes related to their common activities, such as solving specific mathematical problems (e.g., Hill & Rowe, 1996), each student-teacher interaction remains unique. This is because each student has different personality traits, beliefs, values, and a different ability level, prior knowledge, and family background (Helmke, 2012; Seidel, 2014), all of which will probably influence how they perceive any activity or teaching approach. This observation has important implications. Although researchers have been mostly treating teaching quality as a classroom level construct, it might be more important to consider teaching at both levels, paying attention to the individual level effects. Studies which mostly assessed teaching quality at classroom level could have missed the effect of individual variables.

Our results could have also been affected by the inadvertent inclusion of ambiguously worded items or subscales in our assessment tools (Mu et al., 2022). Researchers should consider refining operationalizations of teaching quality to include aspects such as differentiation and adaptivity (Vieluf & Klieme, 2023). This would allow teaching quality measures to encompass individual and unique interactions with students, thus enhancing their relevance at the classroom level.

A study can be interested in relations at the classroom level, the student level, or both (Senden et al., 2023; Stapleton et al., 2016). While the levels of analysis in a study depend on the data and research questions (Marsh et al., 2012), teaching and learning occur at both student and classroom levels and the effects at each level might be different. Although studies consider teaching quality most often at the classroom level, it is important that we do not ignore the effect of teaching quality at the individual level and reconsider the operationalizations of teaching quality with respect to differentiation and adaptivity. Future methodological studies could explore the role of teaching quality and learning processes, particularly by using qualitative interviews, to develop more effective measures.

4.4 Implications for teaching practice

The primary focus of our study was to improve the conceptual understanding of teaching and its effects on student outcomes for future research into teaching quality and the findings demonstrate that we are a long way from fully understanding the mediating mechanisms that underlie how teaching affects learning. While these factors make it more difficult to suggest implications for practice than, for example, for an intervention study, we do believe that the results are relevant to teaching practice in two ways.

First, that the study found no mediation effects at the classroom level, but several at the student level, suggests that teachers should shift their focus from the class to the student. This requires a more adaptive and individualized approach to teaching, one that is responsive to the evolving dynamics of the class and addresses not just the collective needs of the class but also the unique needs of each student (Vieluf & Klieme, 2023). While this is not an original recommendation – researchers have been discussing the idea, mostly at a theoretical level, for decades – our study provides supporting empirical evidence. Clearly, this is a challenging remit for teachers. Support could include developing formative tools to help teachers gather and interpret student perceptions of teaching and use of learning materials, and providing concrete guidance on how to incorporate this information into daily lesson plans (Decristan et al., 2015; Pinger et al., 2018).

Second, results suggest that the mechanisms through which teaching shapes learning are far more complex than researchers into teaching effectiveness had hitherto hypothesized. Not only has our study uncovered a more intricate array of mediation pathways within the original model than previously identified, but it also suggests that an expansion to encompass adjacent theoretical frameworks such as EVT (Wigfield & Eccles, 1992) may reveal yet more mediators. This complexity means that there can be no standard teaching "recipes" that work for all students (see Vieluf, 2022). Of course teachers, especially trainees, find recipes appealing but these results suggest that teaching is too complex and constrained by context for such prescriptions.

To conclude, our study highlights the importance of focusing on the individual student's use of learning opportunities, resonating with constructivist principles that emphasize the importance of the individual's construction of knowledge (Aebli, 2011; Piaget, 1992). This in turn underscores the value of an adaptive and flexible approach to teaching; one that is responsive to the evolving dynamics of the classroom (Vieluf & Klieme, 2023).

4.5 Limitations and Future Directions

First, contrary to our expectations, cognitive activation was not related to time-on-task at either the classroom or student level. Looking at the operationalization of the constructs in more detail, it becomes evident that our study operationalized cognitive activation specifically as teachers providing tasks that require critical thinking and presenting problems with no obvious solutions, whereas time-on-task was defined and operationalized as paying attention during the mathematics lesson, but not specifically when solving complex tasks or undertaking critical thinking. When comparing the operationalization of the constructs, it appears that time-on-task was more generally operationalized than cognitive activation. In a similar vein, the variables at T2 referred to a specific mathematic lesson on quadratic equations, whereas teaching quality and the mediators referred to mathematics in general. Those issues with operationalization could have resulted in greater variability in the way students interpret and respond to the items, which may not have been evident when analyzing the results. Some students might usually listen to instructions and pay attention during the lessons

but perhaps not be particularly attentive when solving complex problems or vice versa. Some students may also be more interested or more successful in some academic domains than in others (Jansen et al., 2019). As, this study operationalized the assessed variables in mathematics, quadratic equations in particular, future studies should investigate other topics in mathematics or other subjects. Considering all these issues, it would be fruitful to compare the effects by using different operationalizations of the constructs within one study.

Second, in the TALIS Video Study space restrictions in the questionnaire meant the item for assessing some variables did not permit a detailed investigation of the subdimensions. For example, need satisfaction was assessed by three items, one item for each need: autonomy, competence, and relatedness. Research in SDT has begun to focus on the negative impact of need frustration, not just the positive effect of need satisfaction. We suggest that future studies on the TBD model incorporate these theoretical developments by using more comprehensive and well-established questionnaires such as the Basic Psychological Needs Satisfaction Scales (BPNSS; Deci & Ryan, 2000; Gagné, 2003), the Balanced Measure of Psychological Needs (BPMN; Sheldon & Hilpert, 2012), and the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS; Chen et al., 2015, Van der Kaap-Deeder et al., 2020).

Third, the achievement test used in the TALIS Video Study focused on low-level cognitive demands such as memorization and procedures without connections (Stein & Lane, 1996), and did not adequately assess students' high-level thinking. This limitation was due in part to the difficulty of optimizing the achievement test for the diverse curricula in the countries participating in the TALIS Video Study (Herbert et al., 2022). It is also important to consider that the way the test was administered during the study differed from usual classroom procedures and this may have affected the performance of some students. For example, some students may have been less attentive or more anxious during the test, which could have influenced their performance. It is therefore important to carefully consider the selection and adaptation of measures to accurately capture the constructs of interest in research and to also consider the potential impact of situational factors on performance.

Fourth, the sample in our study was recruited from secondary schools in Germany. Therefore, the results cannot be generalized for other age groups (e.g., primary school or university) or other countries because teaching and its effects on student outcomes have been found to be affected by culture (e.g., Bellens et al., 2019). The results also differed when the effects of the three basic dimensions of teaching quality on student outcomes was analysed for the different countries which participated in the TALIS Video Study (Herbert et al., 2022). Therefore, cross-cultural studies should investigate mediating effects to strengthen the generalizability of our findings.

The fifth limitation relates to measurement perspective, which can have an impact on study results (e.g., Zee et al., 2013). This study used student ratings, which are considered valid and are commonly used in the field, to measure all of the variables except achievement (Appleton et al., 2008; De Jong & Westerhof, 2001; Fredricks, 2022; Lüdtke et al., 2009). Student ratings of teaching quality have been found to be a better predictor of student variables than teacher and observer ratings (e.g., Kunter & Baumert, 2006; Styck et al., 2020; Wagner et al., 2016). However, observer ratings are also an objective and reliable measure of teaching quality (Clausen, 2002) and it may be that only using student rating, except in the case of achievement, introduces a risk of common method bias, particularly in correlational analyses (Podsakoff et al., 2003; 2012). Although it is difficult to identify this bias, future studies might consider using a marker variable which is theoretically unrelated to the other variables of the study (Williams et al., 2010). Self-report surveys might also be affected by what is socially desirable, leading to over- or under-representation of the participant's actual behavior (Fredricks, 2022). We suggest future studies incorporate multiple perspectives to measure variables and, for simplicity, when comparing mediating effects according to rater perspectives, focus only on specific paths within the same study (Fauth et al., 2020).

To summarize, neither the direct nor the indirect effect models in our study provide clear answers about the hypothesized relationships. There could be multiple reasons for these findings. Our results reveal the critical importance of certain choices made while designing and analyzing a study. It seems that the conceptual sequence of the variables, the choice of correlational vs. longitudinal evidence, and the level of analysis all

have an impact on the results. Our finding is in line with recent reviews that have also revealed inconsistent results (see Alp Christ et al., 2022; Praetorius et al., 2018). Thus, one important take home message is that current quantitative results on the direct and indirect effects of teaching quality on student outcomes are not easy to interpret. Considering that teaching quality is understood as a co-construction between teachers and students (Fauth et al., 2020; Praetorius et al., 2018) and that teaching quality should affect students' learning processes first before student outcomes such as achievement, a clear focus on the interplay between teaching quality and student learning processes seems to be more essential and practical for further theoretical and empirical developments of the TBD model (see also Hiebert & Stigler, 2023).

5. Conclusions

This study is the first to investigate relationships within the entire TBD model using a longitudinal design. It does so by enriching the TBD model with well-established cognitive and motivational theories. The multilevel mediation analyses using both correlational and longitudinal designs revealed varied results which depended on study design and level of analysis and once again highlighted the complexity of the relationships between teaching quality, student learning processes, and student outcomes (see also Alp Christ et al., 2022). Our study contributes to the literature by supporting some of the assumptions of the TBD model and finding new paths between teaching quality and student outcomes. In line with recent appeals in the field (Praetorius & Charalambous, 2023; Vieluf & Klieme, 2023), our study advocates for augmenting the current model with supplementary theories pertaining to cognition, motivation, and effort, to advance the field.

Keypoints

- The assumptions of the TBD model are revisited and expanded using leading motivational and cognitive theories.
- First longitudinal investigation of the entire TBD model, integrating new possible mediating paths.
- Multilevel mediation analyses show diverse outcomes for direct and indirect effects, highlighting model intricacies.
- Conceptual and methodological choices can have a significant influence on the results.

Supplementary Material

Supplementary material for this article can be found online.

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Conflicts of interest

All authors declare no conflict of interest.

Author Contributions

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Appendix

Items assessed in the TALIS Video Study Student Questionnaire

Cognitive activation with discourse (T1) (1= never or almost never , 2 = occasionally, 3 = frequently, 4 = always)

Our mathematics teacher presents tasks for which there is no obvious solution.
Our mathematics teacher presents tasks that require us to apply what we have learned to new contexts.
Our mathematics teacher gives tasks that require us to think critically.
Our mathematics teacher asks us to decide on our own procedures for solving complex tasks.
Our mathematics teacher gives us opportunities to explain our ideas.
Our mathematics teacher encourages us to question and critique arguments made by other students.
Our mathematics teacher requires us to engage in discussions among ourselves.

Classroom management (T1) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

When the lesson begins, our mathematics teacher has to wait quite a long time for us to quieten down.
We lose quite a lot of time because of students interrupting the lesson.
There is much disruptive noise in this classroom.
In our teacher's class, we are aware of what is allowed and what is not allowed.
In our teacher's class, we know why certain rules are important.
Our teacher manages to stop disruptions quickly.
Our teacher reacts to disruptions in such a way that the students stop disturbing learning.
In our teacher's class, transitions from one phase of the lesson to the other (e.g., from <class> discussions to individual work) take a lot of time.

Student Support (T1) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

Our mathematics teacher gives extra help when we need it.
Our mathematics teacher continues teaching until we understand.
Our mathematics teacher helps us with our learning.
Our mathematics teacher makes me feel confident in my ability to do well in the <course>.
Our mathematics teacher listens to my view on how to do things.
I feel that our mathematics teacher understands me.
Our mathematics teacher makes me feel confident in my ability to learn the material.
Our mathematics teacher provides me with different alternatives (e.g. learning materials or tasks).
Our mathematics teacher encourages me to find the best way to proceed by myself.
Our mathematics teacher lets me work on my own.
Our mathematics teacher appreciates it when different solutions come up for discussion.

Depth of processing (T1) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

I keep thinking about tasks until I really understand them.
I think intensively about the mathematical content.
I develop my own ideas regarding the topic taught.

Need satisfaction (T1) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

I feel that I can decide on things on my own.
I feel understood by my mathematics teacher.
I feel confident in my ability to learn this material.

Time-on-task (T1) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)

I pay attention in mathematics class.
I listen to the instruction given in class.
I let my mind wander during the lessons.

Interest (T1) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)
I am interested in mathematics.
I often think that what we are talking about in my mathematics class is interesting.
After mathematics class I am often already curious about the next mathematics class.

Interest (T2) (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree)
I was interested in the topic of quadratic equations.
I often thought that what we were talking about in my mathematics class during the unit on quadratic equations was interesting.
After my mathematics class on the topic of quadratic equations I was often already curious about the next mathematics class.

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Publication 3:

Learning processes and their mediating role between teaching quality and student achievement: A systematic review

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Learning processes and their mediating role between teaching quality and student achievement: A systematic review☆

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ABSTRACT

This systematic literature review was conducted in order to further the understanding of how learning processes act as mediators between teaching quality and student achievement. Eighteen quantitative studies were included for analysis. In 24 of 53 mediation paths (45%) learning processes were identified and confirmed as mediators and in 29 mediation paths (55%) non-significant mediating effects were found. The complexity of the included studies' context, methodology, conceptualization, and operationalization posed challenges for a quantitative synthesis. The findings provide some initial ideas for how to better design future research into indirect effects of teaching quality.

Identifying the factors which affect educational outcomes enables the creation of optimal learning environments and improves student achievement (Hattie, 2009). There is general consensus that teaching quality is crucial for learning (see for example Fauth et al., 2019; Rimm-Kaufman & Hamre, 2010) so it is not surprising that many empirical studies demonstrate a positive relation between teaching quality and a key aspect of student learning, student achievement (for overviews see Muijs et al., 2014; Seidel & Shavelson, 2007). However, studies have also found non-significant direct effects between teaching quality and student achievement (for an overview see Praetorius et al., 2018). From a constructivist perspective, this inconsistency can be explained by looking at the mechanisms that operate between teaching and achievement, the learning processes undertaken by students in order to learn the content being taught (De Corte, 2004; see also the opportunity-use model, Helmke, 2012). This review aims to develop a better understanding of these mechanisms by categorizing how researchers have conceptualized, operationalized, and measured teaching quality and learning processes, and reporting how the studies show that learning processes mediate the relationship between teaching quality and student achievement.

1. Conceptualizing teaching quality and its link to achievement

Based on the educational effectiveness paradigm (see Fauth et al., 2019; Praetorius et al., 2017; Rimm-Kaufman & Hamre, 2010; Scheerens & Blömeke, 2016; Seidel & Shavelson, 2007), we define teaching quality as a social practice that is co-constructed by students and teachers around content, has been shown to have a positive impact on student learning, and accords with normative assumptions, values, and beliefs (see Berliner, 2005; Fenstermacher & Richardson, 2005; Praetorius et al., 2018). In order to empirically study such a complex construct, researchers have developed a number of frameworks and models that use sets of distinct dimensions to describe teaching quality.

One such model is the MAIN-TEACH (Charalambous & Praetorius, 2020). This model offers an integrative systematization of generic and subject-specific dimensions of teaching quality across many different subjects (see Praetorius et al., 2020; Praetorius & Gräsel, 2021), relates the dimensions to each other, and is based on a synthesis of 12 generic, content-specific and hybrid frameworks currently in use, such as the Classroom Assessment Scoring System (CLASS) and the Three Basic Dimensions (TBD). The model has seven dimensions: Selecting and addressing content- and subject-specific methods (e.g., choosing

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relevant and developmentally appropriate methods and content), supporting practice (e.g., selecting tasks for students to strengthen their procedural knowledge), cognitive activation (e.g., using questioning techniques to foster critical thinking), formative assessment (e.g., giving high-quality feedback for improvement), classroom and time management (e.g., maintaining rules and routines), socio-emotional support (e.g., creating a respectful and caring atmosphere), support for active engagement (e.g., requiring participation) and differentiation and adaptation (e.g., adaptation of tasks according to students' previous achievement levels).

Reviews have revealed that studies into how these dimensions of teaching quality affect student achievement often have inconsistent results. For example, a review of studies conducted within the TBD framework, which focuses on the dimensions of cognitive activation, classroom management, and student support, found the theoretically predicted relations between the dimensions and student outcomes in only about half of the studies (Praetorius et al., 2018). A meta-analysis found that the association between the quality of the teacher-student relationship and student achievement was positive in most studies and negative in others (Roorda et al., 2011). Studies have reported that teaching quality dimensions have statistically significant positive, statistically non-significant, or even statistically significant negative direct relations with student learning outcomes. It is important to identify the reason for these varied results and this requires an improved understanding of the theoretical underpinnings of the relationship between teaching quality and student achievement.

According to constructivist learning theory, teaching quality does not directly affect student achievement, but has an indirect effect when students use the learning opportunities provided by the teacher (see for example Fend, 1984; Helmke, 2003; Seidel, 2015). The relationship between teaching quality and student achievement is therefore a sequential one. Teaching quality has an influence on aspects of student learning processes, such as attention or motivation, which in turn affect achievement. When learning processes are linked to achievement they can serve as explanatory mechanisms, even when the direct relationship between teaching quality and student achievement is not statistically significant (see Rucker et al., 2011). Equally, when studies show a statistically non-significant direct effect of teaching quality on student achievement, it does not necessarily mean that teaching quality had no effect on achievement. It may be that mediating mechanisms through which teaching quality indirectly affects student achievement play a role (see Rucker et al., 2011; for studies in other fields with statistically non-significant direct effects but significant indirect effects see, for example, Golke et al., 2019; Han et al., 2016). Therefore, studying mediators between teaching quality and student achievement should help to explain the mixed direct effects found by studies.

1.1. Conceptualizing learning processes and their role as mediators

Learning processes are defined and operationalized in many ways by different disciplines in education and psychology, but theoretical frameworks also vary within disciplines (e.g., León et al., 2017; Reyes et al., 2012). For example, the opportunity-use model, an important theoretical approach in research on teaching quality, describes the mediation between teaching and learning (e.g., Cappella et al., 2016; Helmke, 2012; Klieme et al., 2009). Helmke (2012), in his version of the opportunity-use model, categorizes learning processes based on when they happen (time-on-task during instruction vs. learning processes outside of the classroom). Lipowsky (2006) emphasizes exercises, revision, and homework, while Seidel (2014) focuses on student variables related to motivation and emotion. The TBD model of teaching quality (Klieme et al., 2009; Praetorius et al., 2018), which is also based on the opportunity-use model, assumes that time-on-task, high-level thinking, and satisfaction of three psychological needs are the mediating factors between teaching quality (i.e., classroom management, cognitive activation, and student support) and student outcomes. In the conceptual model of teaching, self-regulation, school engagement, and motivation are mediating factors between teaching quality (i.e., classroom organization, emotional climate, and instructional method) and student outcomes (Cappella et al., 2016). The umbrella term *learning processes* covers a very diverse group of variables.

Any one variable may also be conceptualized in many different ways. For example, some models describe student engagement as a learning process (e.g., Vermunt & Verloop, 1999) but researchers make different assumptions about the exact nature of student engagement. While Reyes et al. (2012) define student engagement in terms of motivation and consider effort, interest, and enjoyment as indicators of motivated behavior, León et al. (2017) focus on the volitional and self-regulatory aspects of engagement. Motivation and volition are connected, but they are conceptually different (see Elbe & Sieber, 2020; Filsecker & Kerres, 2014). [5]

Although learning processes are heterogeneous (Vieluf, 2022), it is generally agreed that *learning processes* are those personal student processes that contribute to an individual's learning in the classroom. These processes include self-directed changes in cognitive structures, knowledge networks, and understanding of the world, as well as in motivation, emotions, attitudes, and beliefs (Seidel, 2014). Other processes which refer to metacognition or even external aspects observable by others, have also been defined as learning processes (Vieluf, 2022). Therefore, to correctly categorize the processes addressed in this systematic review, it is important to use a comprehensive framework. The self-system model of motivational development (SSMMD; Connell & Wellborn, 1991; Skinner et al., 2009) takes an integrative stance on the differences in the conceptualization and operationalization of learning processes by differentiating between *self* and *action* (see Dinçer et al., 2019). *Self* is the motivational system which includes beliefs, values, attitudes, and self-perceptions and refers to motivational aspects (e.g., basic psychological needs, self-efficacy, competence, intrinsic motivation). *Action* is directed by motivational processes and refers to engagement-related aspects (e.g., self-regulation, participation). Using the broad categories of *self* and *action* enables a categorization of the many learning processes so that those that can act as mediators between teaching quality dimensions and student achievement can be identified. Viewing the learning process in terms of *self* and *action* also allows for an assessment of whether the learning processes are more proximal or distal to the *self*. This distinction is helpful in light of possible issues with the operationalization, measurement, and mediating effects of those learning processes. While aspects in the *self* category are likely to be best assessed by students, aspects categorized as *action* may be more suitable for assessment by observers, parents, or teachers (Connell & Wellborn, 1991).

1.2. The review

This systematic literature review aims to identify and describe published studies that examine the mediating paths between teaching quality and student achievement. To categorize the different studies, we use two models, the MAIN-TEACH model and the SSMMD. The categorization of the studies or mediating paths contributes to our review in two ways. First, it enables the presentation of the expansive concepts of teaching quality and the learning processes in a compact and structured fashion. Second, using the MAIN-TEACH model and the SSMMD helps to identify the number of studies or paths in each category, allowing for more differentiated analyses for teaching quality dimensions and learning processes.

We address the following research questions:

[5] Motivation is about building intentions and is seen as the force behind goals, but volition is seen as the process which turns one's intention to action and is responsible for attaining goals (Schunk, 1996).

1. How is teaching quality conceptualized and operationalized in the reviewed studies?
2. What types of learning processes are assessed as mediators? How are they operationalized?
3. What do the findings of empirical studies tell us about how learning processes function as mediators between teaching quality and student achievement?

2. Method

This section presents the inclusion-exclusion criteria, literature search, selection process, quality assessment, and data extraction methods used. To ensure transparency and replicability, we explain the rationale for our decisions and refer readers to Supplemental Material II (see Tables S6-S11), which gives further, detailed, information on the methodology of our review. We also report on the challenges posed by the review process as a guide for future researchers (Alexander, 2020).

2.1. Inclusion-exclusion criteria

Teaching quality. We selected the aspects of conceptualizing and measuring teaching quality, learning processes, and student achievement that would qualify a study for inclusion or exclusion. First, we defined teaching quality as teaching characteristics involving teacher-student interactions in the classroom (Fauth et al., 2019; Rimm-Kaufman & Hamre, 2010). Aspects such as teacher planning, materials, or curriculum are important for preparing teaching and learning but are conceptually separate from the actual teaching and learning processes that happen in the classroom (Openshaw & Clarke, 1970), so we excluded studies focusing only on teacher preparation or homework quality. Teacher characteristics such as self-discipline and motivation were also excluded because these are teachers' personal traits rather than teaching behaviors (Rimm-Kaufman and Hamre, 2010). Studies which conceptualized the quality of the learning environment as a combination of teaching quality both in and out of the classroom, focusing on whole school, faculty, or university quality, were also excluded. Second, we did not set a criterion to exclude studies on the basis of assessment method (e.g., student, teacher, or observer ratings). We instead looked at how teaching quality was conceptualized and operationalized. Because teaching quality is highly teacher-specific (Wagner et al., 2013), we excluded studies that operationalized teaching quality only at the school level or by aggregating several teachers. Third, we focused on typical classroom teaching, face-to-face interactions between teachers and students. We excluded research into interactions in other settings such as distance education, online learning, flipped classrooms, and blended learning. Finally, we included studies where teaching quality was not only assessed as an independent variable. For example, in one study students' personality traits were predictors of student-teacher relationship quality, which in turn was the predictor of students' motivational beliefs and achievement.

Learning processes. For learning processes, we included state variables of students' behavioral, emotional, motivational, or cognitive learning experiences such as attention, engagement, motivation, and emotion (Schukajlow et al., 2017). We excluded studies that assessed student background variables such as ethnicity and socio-economic status (SES) as mediators or considered intelligence, personality traits, general beliefs, or values, because these are conceptually separate from learning processes (Helmke, 2012; Seidel, 2014; Vieluf et al., 2020).

Student achievement. Student achievement outcomes were measured by a test, specific task, course grade, or self-reported test results. Studies could include more than one predictor, mediator, or outcome. Standard, serial, and multiple mediation analyses were included. One important criterion for inclusion was that studies had to mention mediation, explicitly or implicitly, in their aims or research questions (see Supplemental material II for a more detailed explanation). One study excluded two hypothetical mediation paths in its mediation model because the classroom level correlation between two teaching quality dimensions and the learning process/achievement was non-significant before mediation was analyzed (Pakarinen et al., 2010). We could not investigate these paths in our review.

We included studies conducted in classroom settings in regular education from kindergarten to undergraduate university level. We excluded studies involving children below age four and graduate students. The review's goal was to summarize and compare studies from a general population so we excluded studies that focused on gifted students or students with special educational needs (SEN) or disabilities. However, we included studies that controlled for students with SEN in their models.

The review included English and German articles published in peer-reviewed journals. There was no pre-set boundary for publication year. Books, book chapters, conference proceedings, theses, and dissertations were excluded (for a similar procedure, see e.g., Heitink et al., 2016). During the title-abstract screening we also excluded articles for which there were no abstracts available on the databases. The review focuses on mediation analysis in quantitative empirical studies. Therefore, we excluded qualitative, mixed-method, and case studies, literature reviews, meta-analyses, methodological papers (e.g., the development of an instrument), and theoretical papers.

2.2. Literature search

We searched the literature in November and December 2019. We retrieved relevant studies in EBSCO (ERIC, PsycINFO, PsycARTICLES), Web of Science, Scopus, FIS Bildung, and Google Scholar. First, we scanned some well-known articles, book chapters, and theoretical papers to find the appropriate keywords and phrases for the search such as "process-mediation-product" (e.g., Brophy, 1986) and combined "quality of teaching", "mediation", "student", and "achievement" (PICOS, Participants, Interventions, Comparisons, Outcomes, Study Design; O'Connor et al., 2008). We included their synonyms, antonyms, and hyphenated versions for a more comprehensive search. We conducted broad searches to explore how teaching quality or teaching effectiveness are investigated. Specific dimensions were not searched for. We also translated keywords and phrases from German. The names of German models (i.e., Angebots-Nutzungs-Modell) were translated into English differently in different publications (e.g., opportunity-use model or offer-use model). So, we tailored our strategy to ensure consistency between databases (Kugley et al., 2016). For example, we used a Boolean operator "NEAR/2" for Web of Science and "W2" for Scopus. These operators helped to find keywords close to each other. For instance, "quality NEAR/2 teaching" targeted a wide range of combinations of phrases such as "quality of mathematics teaching" (see a sample search strategy in Table S6).

We needed to amend these search strategies for FIS Bildung and Google Scholar because of technical limitations such as a lack of operators, truncations, and space (Boeker et al., 2013). For FIS Bildung, we conducted separate searches by combining different keywords (for an example in FIS Bildung, see Okan et al., 2018). In Google Scholar, we selected only the most relevant group of keywords and searched for them separately. We screened the first 10 pages (i.e., 100 results, in total 400 results) because the number of irrelevant results increases in later pages (Bramer et al., 2017; Kulik & Fletcher, 2016). Finally, we used a backward and forward snowballing technique, checking reference lists and tracking citations, to enhance the literature search (Brunton et al., 2012).

2.3. Selection process

The selection procedure is presented in Fig. 1. A search of databases that support advanced systematic searches resulted in 995 references. FIS Bildung and Google Scholar yielded a further 48 and 400 references respectively. In total, 1443 results were identified. We exported the

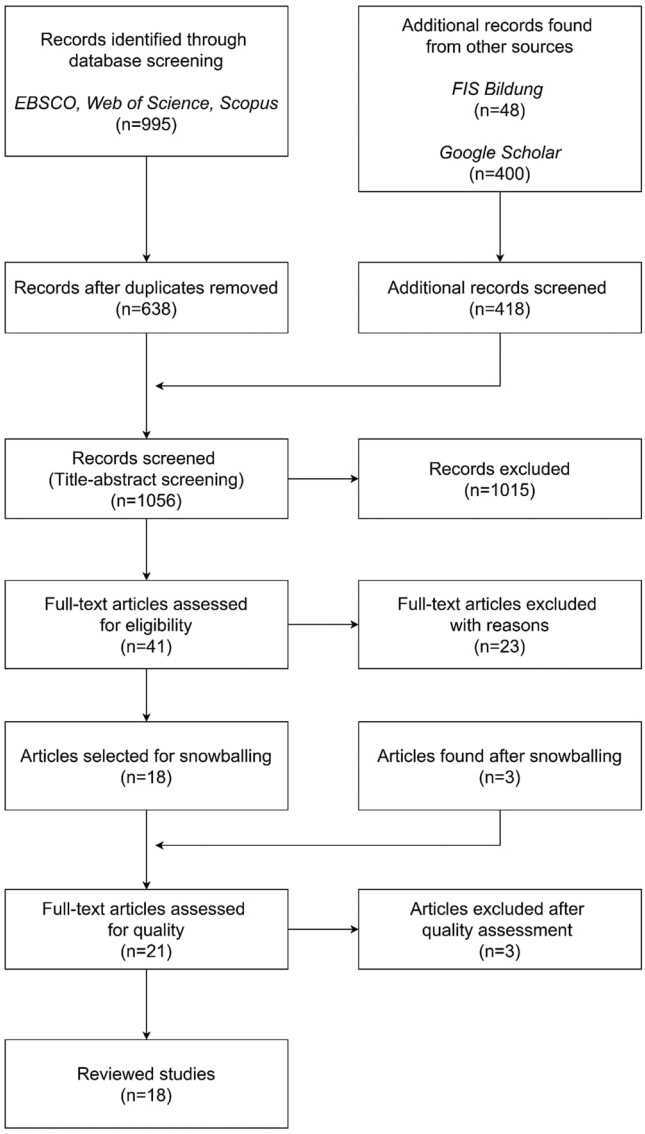

Fig. 1. Flow diagram of the systematic review.

search results to JabRef for title-abstract screening. First, duplicates were manually removed, then titles and abstracts were screened (Gough et al., 2012; Higgins & Green, 2011). The first phase of title-abstract screening was trivial exclusion. If abstracts mentioned that studies were not quantitative or published in a peer-reviewed journal, we excluded them without further investigation. In the second phase, we eliminated abstracts based on the other inclusion-exclusion criteria. Mentioning quality or effectiveness of teaching either in the title, abstract, or keywords, and implying mediation analysis between teaching quality, learning processes, and achievement were two important criteria for selecting abstracts (for the title-abstract screening form, see Table S7). After this procedure, the second author checked and confirmed that each selection was accurate and consistent. We did not compute the number of excluded studies per criterion because any study could have been excluded on the basis of more than one criterion (e.g., teaching quality, learning processes, achievement, and mediation).

For the full-text screening, the first author trained a second rater on the aims, inclusion-exclusion criteria, and the screening and coding procedure (Gough et al., 2012; Petticrew & Roberts, 2006). We used Mendeley Reference Management Software in this phase. The two raters coded one study together. The second rater then screened a random sample of 41 studies (24%) independently, using the guide and the full-text screening form (see Table S8). Inter-rater reliability, percentage agreement, was 70%, which is considered sufficient (see Jonsson & Svingby, 2007). We discussed debatable items and revised our inclusion-exclusion criteria until full agreement was reached. This procedure resulted in the inclusion of 18 of the 41 studies (see Table S9 for a detailed description of the reasons for exclusion). Checking the reference lists of the 18 studies forwards and backwards resulted in the inclusion of three more studies (see Table S10).

2.4. Quality assessment

We used the *Methodological Quality Questionnaire* to critically appraise the studies (MQQ, Acosta, Garza, Hsu, Goodson, 2020; Acosta, Hsu, Goodson, Padrón et al., 2020). We used only the first seven of the nine questions in the questionnaire because the last two covered implications and practices that were outside the scope of our review (see Supplemental II for the details). The first author and a second rater assessed the quality of each study, checking if they satisfied the seven criteria and marking "yes" or "no" answers (e.g., "Was the research design described?"). The first author trained the second rater. The raters worked together to code a study. Then they each independently coded another randomly selected study. The inter-rater coding agreed 100%, but the raters discussed their rationales for their judgements to ensure that agreement was not the product of chance. Then, the second rater assessed the quality of a random subsample of the selected articles in English (7 of the 21 studies) and one in German. Inter-rater reliability was 96.9%, which is considered a good level of consistency (Jonsson & Svingby, 2007). Raters resolved all disagreements by discussing their justifications for excluding a study (Higgins & Green, 2011). The first author then assessed the quality of the remaining studies. One study was excluded because of missing data analysis information. Another study was excluded because the indirect effect had not been reported and could not be derived from the published results. After the quality assessment, the authors discussed any remaining issues and excluded another study because of a lack of clarity in the data analysis and incomplete reporting of results.

2.5. Data extraction

We extracted data and recorded the following information for each of the 18 selected studies: Citation, aims and/or research questions, country, setting, participants, sample size, course subject, research design, data analysis, model variables, predictors, mediators, outcomes, conceptualization and operationalization of teaching quality and learning processes, and results.

2.6. Methodology for interpreting study results

The review aims to describe the studies in this field and categorize teaching quality and learning processes using established models. Although it is not a meta-analysis, the results of the studies are reported by relying on the most recent developments in synthesizing mediation effects using the beta coefficients of the bivariate effects (Cheung, 2020). In the result tables we report both the statistical significance of indirect effects and the effect size of a given effect (Preacher & Kelley, 2011). The standardized beta coefficients (β) of the directed bivariate paths and the mediation effects were recorded (Table S5). When they were unreported, the mediation effect was calculated by multiplying two reported beta coefficients. The standardized beta coefficients for two studies were also calculated from reported unstandardized coefficients (B) and standard deviations (SD). We treated effects where $p < .05$ as statistically significant.

The studies assessed mediation in different ways. Most of the studies in the review include complex models with more than one predictor or mediator where the effect of a specific variable and the mediation effect of interest could have been affected by shared variance with other

variables in the model. For some studies, the table only shows parts of the model. Some variables were outside the scope of the review and others were assessed as variables at different points in time. Therefore, we highlighted the variables of interest for our review and reported other variables separately in Tables S2 and S5. The tables show the diversity and complexity of the results of mediation models that include multiple predictors, mediators, or outcomes and have a variety of approaches to mediation.

3. Results

This section reports the descriptors, design and data analysis methods, conceptualizations and operationalizations of teaching quality and learning processes, and results of the selected studies. When summarizing and describing the results of the selected studies, learning processes were first categorized as *self* or *action*. Under the *self* and *action* headings the results were categorized according to the MAIN-TEACH model of teaching quality. The detailed tables are available as supplemental material (see Tables S1-S5).

3.1. Study descriptors

The aims and research questions of the selected studies are presented in Table S1 and the basic characteristics (e.g., settings and country) can be found in Table S2 and Fig. 2. Although the search was open-ended in terms of date, the included articles were all published after 2007, highlighting the increased interest in examining the mediating role of learning processes between teaching quality and student achievement over the past 15 years. The majority of study participants were primary/elementary and secondary/high school students. Most of the studies were conducted in European countries or the U.S.A. and focused on mathematics and reading. The studies measured achievement using tests, course grades, a combination of tests and tasks, and self-reports of a test.

3.2. Study design and data analysis

We used authors' classifications to categorize studies as either longitudinal or cross-sectional. Two studies that used only covariates from a previous time point and investigated the mediating effects within one-time point were also categorized as longitudinal (Guo et al., 2011; Ponitz et al., 2009).

The studies analyzed the data using regression analysis, SEM, path analysis, a cluster-robust standard errors approach, or multilevel analysis (i.e., manifest or latent modeling). Nearly half of the studies ignored the nested structure of the data; the others considered students to be nested within classrooms or schools (see Table S2). We included all of the studies in our analyses, regardless of whether they considered nesting, but also checked to see if the results varied when only studies that addressed nesting were analyzed (see Section 3.5).

3.3. Conceptualization and operationalization of teaching quality

To categorize teaching quality according to the MAIN-TEACH model, sample items provided in the papers and/or the authors' descriptions were used (see Table S3). Four of the eight dimensions in this model were identified in the reviewed studies: *Classroom and time management, socio-emotional support, selecting and addressing content and subject-specific methods*, and *formative assessment*. The other four dimensions – *differentiation and adaptation, support for active engagement, supporting practice*, and *cognitive activation* – were not found in the studies. However, nine studies assessed a combination of at least two dimensions of the MAIN-TEACH model. For example, instructional support covers more than one of the MAIN-TEACH dimensions. We labelled this multi-dimension category *combined teaching quality*. The studies and dimensions included in *combined teaching quality* are reported in Appendix A.

As expected, the studies in this review conceptualized, operationalized, and measured teaching quality in many different ways (see Praetorius & Charalambous, 2018). Eight studies conceptualized teaching quality using theoretical frameworks such as Self-Determination Theory (SDT) or CLASS, which categorize aspects of teaching in ways that differ from the categorization chosen for this review. For example, instructional support in CLASS had to be put in the *combined teaching quality* category in our systematic review because it includes two MAIN-TEACH dimensions, cognitive activation and formative assessment. Eight studies used broader terms to conceptualize and operationalize teaching quality as, for example, classroom quality (e.g., Ponitz et al., 2009), while eight others used a narrower conceptualization, selecting one specific aspect from a dimension of teaching quality, such as warmth in the teacher-student relationship, as an indicator for the broader dimension (e.g., Hughes et al., 2012). Two studies conceptualized teaching quality using the entire CLASS framework and assessed each of its dimensions (i.e., emotional support, classroom organization, instructional support) separately (Hu et al., 2018; Pakarinen et al., 2010).

The studies used student ratings ($n = 9$), observer ratings ($n = 6$), teacher ratings ($n = 1$), or a combination of student and teacher ratings ($n = 2$) to measure teaching quality (see Fig. 2, Table 1, and Supplementary Excel file).

3.4. Conceptualization and operationalization of learning processes

We retrieved the conceptualization and operationalization of learning processes from the original publications and categorized them according to the sample items used to assess the constructs (see Table S4). If no sample item was provided, we chose one item at random from the scales. If the scales were not available, we noted that no sample item could be provided. If items were highly heterogeneous, we categorized these constructs according to the predominant focus of the items that were consistent (e.g., task orientation, Zee & de Bree, 2017). A few studies included descriptions instead of sample items (e.g., total amount of time, McLean et al., 2016). The items for assessing learning processes varied by subject or even topic specificity within a study. For example, Burns et al. (2019a) measured students' intrinsic value of science by combining enjoyment of science in general with interest in a specific science topic. In most cases it was possible to categorize learning processes as either *self* or *action*. However, some studies considered both *self* and *action* when assessing learning processes (e.g., psychological engagement, Dotterer & Lowe, 2011). We chose to categorize those cases as *action* because *action* is directed by *self* and therefore covers *self*, but *self* does not cover *action* (see Skinner et al., 2009).

When the learning processes were categorized as either *self* or *action* (Skinner et al., 2009), it emerged that 10 studies had investigated *self* and 11 studies had investigated *action* as mediators. Within those categories, motivation-related learning processes (e.g., goals, values, beliefs) in *self* and engagement-related (e.g., behavioral engagement) learning processes in *action,* were assessed most often. The conceptualization and the operationalization of learning processes were generally consistent with each other. However, some studies began by considering broad concepts (e.g., behavioral engagement) only to then focus on one specific factor (e.g., paying attention; Dotterer & Lowe, 2011). It is notable that in some instances, learning processes were operationalized in different ways by studies using the same theoretical framework (e.g., behavioral engagement in the CLASS framework; Dotterer & Lowe, 2011; Ponitz et al., 2009), and sometimes even within a single study (e.g., Zee & de Bree, 2017).

Most of the studies ($n = 12$) only used student self-reporting to measure learning processes. Some only used observations ($n = 3$), others only teacher ratings ($n = 2$), and one used a combination of observer and teacher ratings ($n = 1$) to measure learning processes (see Fig. 2, Table 1, and supplementary Excel file). When the variables were categorized, it emerged that *self* was only captured using student ratings.

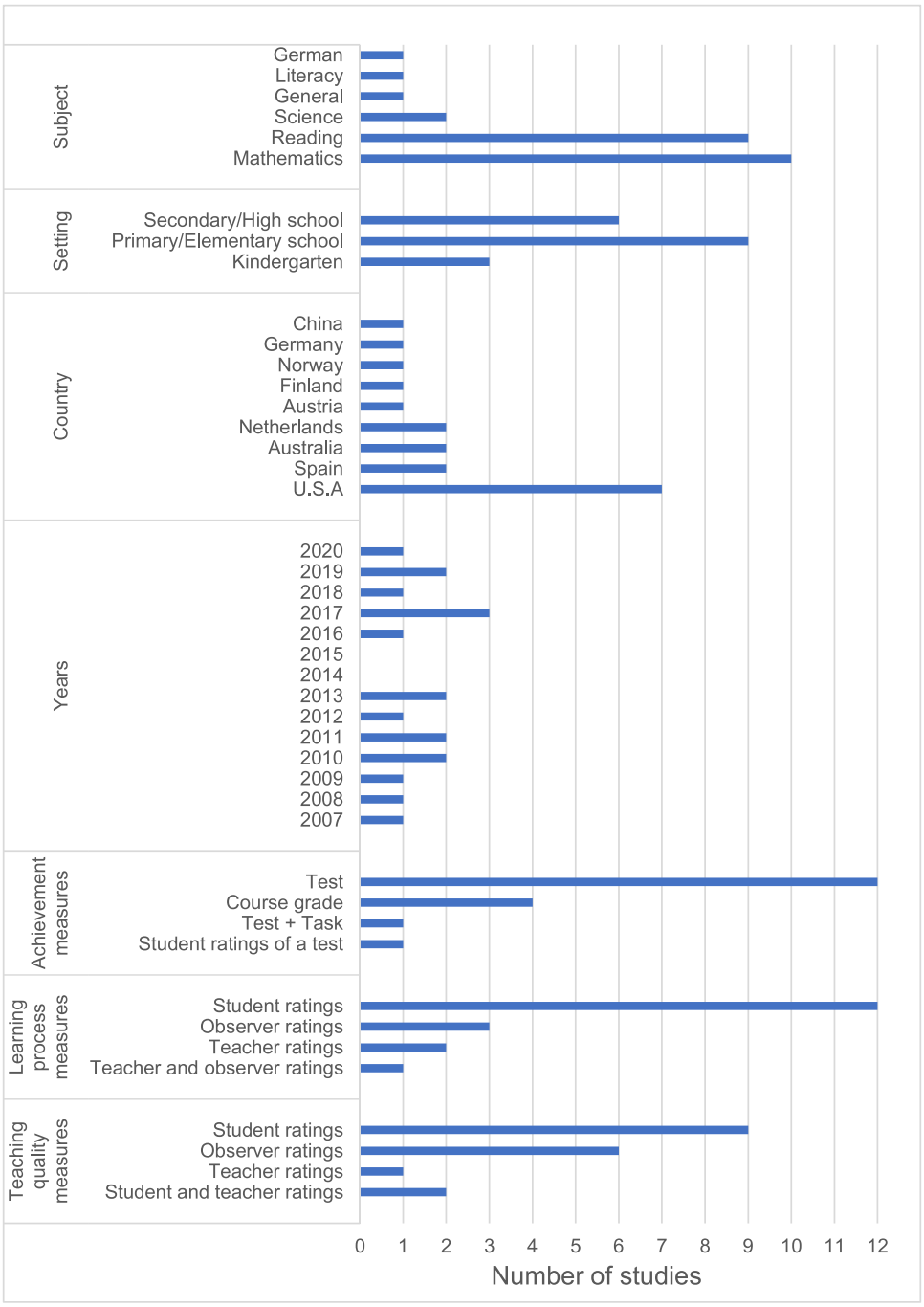

Fig. 2. Number of studies per year, country, setting, subject, and measurements.

However, student, teacher, observer, or teacher and observer ratings were all used to capture *action*.

3.5. *Mediating effects in the reviewed studies*

The results revealed that the mediating effects of learning processes were mixed. In 24 of 53 mediation paths (45%) learning processes were confirmed as mediators and in 29 of 53 mediation paths (55%) non-significant mediating effects were found. To examine the results in detail, in Sections 3.5.1 and 3.5.2 the mediating paths are described using the MAIN-TEACH model for teaching quality and the SSMMD model for learning processes (Skinner et al., 2009). When just the studies that considered the nested structure of the data were analyzed, the

Table 1
The mediators investigated in the reviewed studies under the teaching quality and learning processes categories, and their mediating effects.

Teaching quality		Mediator: Self	Achievement	Mediation effect			Citation
				Level	Yes	No	
Classroom and time management	Classroom organization (OR)	Reading attitude (SR-I)	Test, Task	L1		x, x	Hu et al. (2018)
	Classroom organization (OR)	Learning motivation (SR-I)	Test	L2		x	Pakarinen et al. (2010)
Socio-emotional support	Emotional support (OR)	Reading attitude (SR-I)	Test, Task	L1	x, x		Hu et al. (2018)
	Closeness (SR) and conflict (SR)	Task orientation (SR)	Test	L1		x, x, x, x	Zee and de Bree (2017)
	Warmth (SR-I) and conflict (SR-I)	Competence belief (SR)	Test	L1	x	x, x, x	Hughes et al. (2012)
	Closeness (SR) Closeness (TR), Conflict (TR), Dependency (TR)	Motivational beliefs (SR)	Test	L1	x, x, x, x	x, x, x, x	Zee et al. (2013)
Selecting and addressing content- and subject-specific methods	Teacher's emphasis on the usefulness of class content (SR)	Harmonious passion (SR) and learning motivation (SR)	Course grade	L2		x	Ruiz-Alfonso and León (2017)
Formative assessment	Growth feedback (SR)	Intrinsic value (SR)	Test	L3, L1	x, x		Burns et al. (2019a)
	Teacher feedback and feedforward (SR)	Best goal setting (SR)	Test	L1	x		Burns et al. (2019b)
Combined teaching quality	Instructional support (OR)	Reading attitude (SR-I)	Test, Task	L1		x, x	Hu et al. (2018)
	Classroom structure (SR)	Mastery goal (SR)	SR of a test	L1	x		Bergsmann et al. (2013)
	Perceived fulfillment of needs (SR)	Mastery goal (SR)	Course grade	L2, L1		x, x	Theis et al. (2020)

Teaching quality		Mediator: Action	Achievement	Mediation effect			Citation
				Level	Yes	No	
Socio-emotional support	Support (SR + TR)	Engagement (TR)	Test	L1	x, x		Hughes and Kwok (2007)
	Support and Conflict (TR)	Effortful engagement (TR)	Test	L1	x, x		Hughes et al. (2008)
	Warmth (SR-I) and conflict (SR-I)	Behavioral engagement (TR)	Test	L1	x, x	x, x	Hughes et al. (2012)
	Closeness (SR) and conflict (SR)	Metacognition (SR)	Test	L1		x, x, x, x	Zee and de Bree (2017)
Combined teaching quality	Classroom quality (OR)	Behavioral engagement (OR+OR+TR)	Test	L1	x		Ponitz et al. (2009)
	Classroom quality (OR)	Engagement (OR)	Test	L1	x		Guo et al. (2011)
	Teaching quality (SR)	Effortful engagement (SR)	Course grade	L2	x		León et al. (2017)
	Classroom quality (OR)	Amount of time spent off-task (OR) and in transition (OR)	Test	L2	x x		McLean et al. (2016)
	Classroom context (OR)	Behavioral engagement (OR)	Test	L1	x	x	Dotterer and Lowe (2011)
		Psychological engagement (OR)	Test	L1	x	x	
	Classroom structure (SR)	Metacognition (SR)	SR of a test	L1		x	Bergsmann et al. (2013)
	Teaching quality (SR)	Strategies, motivation discipline (SR)	Course grade	L1		x	Christophersen et al. (2010)

Note. When there is more than one mediating effect, different subdimensions of teaching quality dimensions (Hughes et al., 2012; Zee & de Bree, 2017; Zee et al., 2013), measurements of the same subdimension (Zee et al., 2013), student groups (Dotterer & Lowe, 2011), levels of analysis (Burns et al. 2019a; Theis et al., 2020) or achievement in different subjects (Hu et al., 2018; Hughes & Kwok, 2007; Hughes et al., 2008; Hughes et al., 2012; Zee & de Bree, 2017; Zee et al., 2013) were investigated. SR = Student rating, SR(I) = Interview with students, TR = Teacher rating, OR = Observer rating, OR(V) = Video analysis. L1 = Student level mediation, L2 = Classroom level mediation, L3 = School level mediation.

findings were still mixed.[6]

3.5.1. *Self as a mediator*

Our review found that the following mediators were investigated in the category of *self*: Reading attitude, learning motivation, task orientation, competence belief, motivational beliefs, harmonious passion, intrinsic value, best goal setting, and mastery goals (see Supplemental Material, Table S1). *Self* was investigated as a mediator in five categories of teaching quality: *Classroom and time management, socio-emotional support, selecting and addressing content and subject-specific methods, formative assessment,* and *combined teaching quality*.

Two studies investigated *self* in the *classroom and time management* category. Hu et al. (2018) conducted analyses at the student level (without considering the nested structure of the data) and found that reading attitude mediated neither the relation between classroom organization and receptive vocabulary, nor between classroom organization and Chinese reading. Pakarinen et al. (2010) conducted multilevel analysis and found that in the *self* category learning motivation also did not mediate the relation between classroom organization and phonological awareness at classroom level (Pakarinen et al., 2010). *Self* was not found to be a mediator in either of these studies.

Four studies investigated *self* at student level in the *socio-emotional support* category. Two of these studies did not consider the nested

[6] The results showed that *self* was found to be a mediator at school level in one study (Burns et al., 2019), but at classroom level it was not a mediator in three studies (Pakarinen et al., 2010; Ruiz-Alfonso & León, 2017; Theis et al., 2020). *Action* was a mediator at classroom level in two studies (León et al., 2017; McLean et al., 2016). Four studies considered the nested structure of the data by using the cluster robust standard errors approach: Hughes & Kwok (2007), Hughes et al. (2008), Hughes et al., (2012) and Zee et al. (2013). All of these were conducted in the socio-emotional category and their mediating effect findings were also mixed.

structure of the data. Hu et al. (2018) found that reading attitude mediated the relation between emotional support and both receptive vocabulary and Chinese reading at student level. However, Zee and de Bree (2017) found that task orientation was neither a mediator between closeness and students' reading and mathematics achievement, nor between conflict and their reading and mathematics achievement at student level. The other two studies did not conduct multilevel analysis but addressed the nested structure of the data by employing a cluster-robust standard errors approach. Hughes et al. (2012) found that students' mathematics competence beliefs did not mediate the relation between warmth and mathematics achievement. Students' reading competence beliefs also did not mediate the relation between warmth and reading achievement. The same study also investigated perceived conflict with teachers. Students' mathematics competence beliefs mediated the relation between conflict and mathematics achievement. However, reading competence beliefs did not mediate the relation between conflict with teachers and reading achievement (Hughes et al., 2012). Zee et al. (2013) found that motivational beliefs mediated neither the relation between conflict and student achievement nor between teacher-rated closeness and student achievement in reading and mathematics. However, in the same model motivational beliefs mediated the relation between student-rated closeness and reading and mathematics achievement as well as the relation between dependency and achievement in reading and mathematics. These findings reveal that the mediating effects of *self* in this category are mixed at student level.

One study investigated *self* in the *selecting and addressing content and subject-specific methods* category. In a multilevel serial mediation analysis, harmonious passion mediated the relation between teachers emphasizing the usefulness of class content and students' learning motivation at classroom level but harmonious passion and learning motivation did not mediate for students' mathematics achievement at classroom level (Ruiz-Alfonso & León, 2017). *Self* did not act as a mediator for achievement in this category.

Two studies investigated *self* in the *formative assessment* category. Burns et al. (2019a) conducted multilevel analyses and found that intrinsic value was a mediator between growth feedback and students' science achievement at both the student and school levels. Burns et al. (2019b) also found that personal-best goal setting mediated the relationship between teacher feedback and feedforward and students' mathematics achievement at student level, but they did not consider the nested structure of the data in their study. In both studies *self* was a mediator in this category.

Three studies investigated *self* in the *combined teaching quality* category (see Table S2 for conceptualizations of teaching quality). Reading attitude did not mediate the relation between instructional support (i.e., concept development, quality of feedback, and language modeling) and students' receptive vocabulary and Chinese reading at student level (Hu et al., 2018). One study conducted multilevel analyses and investigated mediation only at the student level. Mastery goals was a mediator between classroom structure (i.e., task, authority, and evaluation and recognition) and student achievement at student level (Bergsmann et al., 2013). However, another study found it was not a mediator between a need-supportive climate (i.e., autonomy, competence, and relatedness support) and student achievement at both student and classroom levels (Theis et al., 2020). Three studies revealed that *self* has mixed mediating effects in this category.

In sum, different aspects of *self* mediated relations in 11 of the 30 paths in five categories of teaching quality. Aspects of the *self* were found to act as mediators in the *formative assessment* category but did not mediate for achievement in *classroom and time management* and *selecting and addressing content and subject-specific methods*. Moreover, *self* had mixed mediating effects in the *socio-emotional support* and *combined teaching quality* categories. Studies which considered the nested structure of the data investigated *self* in eight of the 30 paths. In three of eight paths *self* was investigated at classroom level and was found not to mediate in any of them. In one path it was investigated at school level and acted as a mediator. In the remaining four paths *self* was investigated by studies using a cluster-robust standard errors approach and it was found to act as a mediator in one of them. Studies that did not consider the nested structure of the data investigated *self* in 22 paths and found that it mediated relations in nine of them.

3.5.2. Action as a mediator

According to the SSMMD, *action* is directed by human motivation and represents engagement-related activities such as participation, cognition, and self-regulation. The following mediators were investigated in the *action* category: Engagement, behavioral engagement, psychological engagement, effortful engagement, time spent off-task and in transition, metacognition, and a combination of strategies used, motivation, and discipline. *Action* was investigated as a mediator between two teaching quality categories, *socio-emotional support* and *combined teaching quality,* and achievement (see Supplemental Material, Table S1).

Four studies investigated *action* at student level in the *socio-emotional support category*. A study by Zee and de Bree (2017) did not consider the nested structure of the data and found that metacognition mediated neither the relation between closeness and achievement nor that between conflict and achievement. The following three studies considered the nested structure of the data by using a cluster-robust standard errors approach. In one study engagement mediated the relationship between support and achievement in mathematics and reading (Hughes & Kwok, 2007). In another study, support and conflict were assessed jointly in the models. Effortful engagement was a mediator between either support or conflict and reading achievement in one model and in another it mediated the relations between support or conflict and mathematics achievement (Hughes et al., 2008). Another study looking at behavioral engagement tested two models to investigate the indirect effects of warmth on students' reading and mathematics achievement while two other models tested the indirect effects of conflict on students' reading and mathematics achievement. When the indirect effects between conflict and achievement were investigated, behavioral engagement was found to be a mediator between conflict and both mathematics and reading achievement in two models (Hughes et al., 2012). However, in the other two models behavioral engagement did not mediate the relation between warmth and reading and mathematics achievement (Hughes et al., 2012). *Action* thus seems to have mixed effects in the *socio-emotional support* category.

Seven studies investigated *action* as a mediator in the *combined teaching quality* category (see Table S2 for conceptualizations of the combined teaching quality category). In most cases it was shown to be a significant mediator between teaching quality and achievement.

Five of the studies investigated mediation at the student level. Metacognition did not mediate the relation between classroom context (i.e., task, authority, and evaluation/recognition) and student achievement at student level (Bergsmann et al., 2013). Teaching quality (i.e., teacher eliciting interest, teacher building relationships, and teacher pressure) did not have an indirect effect on achievement affecting student motivation, discipline, and strategy use at student level (Christophersen et al., 2010). Classroom quality (i.e., emotional, organizational, and instructional support), however, did affect achievement through behavioral engagement at student level (Ponitz et al., 2009). Similarly, classroom quality (i.e., emotional support and instructional support) indirectly affected students' achievement at student level through engagement, which was operationalized as attention and self-reliance (Guo et al., 2011). Dotterer and Lowe (2011) investigated the indirect effects of classroom context (i.e., conflict with teacher, classroom social/emotional climate, and instructional quality) on student achievement at student level. They looked at mediating effects in students who struggled in class and those who did not and found that behavioral engagement and psychological engagement only mediated relations in students who were not struggling.

Two studies investigated mediation at classroom level. Effortful

engagement was a mediator between teaching quality (i.e., autonomy, competence, relatedness support) and student achievement at classroom level (León et al., 2017). Classroom quality (i.e., instruction, management, and organizational systems) indirectly affected students' picture vocabulary at classroom level through amount of time spent off-task and in transition in the classroom (McLean et al., 2016). Thus, *action* mediated most of the relations in this category.

Various aspects of *action* mediated the relations in 13 of 23 paths in two categories of teaching quality: *Socio-emotional support* and *combined teaching quality*. When we look at the *socio-emotional support category, action* mediated the relations in half (six of 12) of the paths, and it mediated relations in seven of 11 paths in the *combined teaching quality* category. When we look at the level at which data were measured, studies which considered the nested structure of the data investigated *action* in 11 of 23 paths. Of these 11 paths, *action* was investigated at classroom level in three mediation paths and it mediated the relations in all three of them. *Action* was also investigated in studies with a cluster-robust standard errors approach and it mediated in six of eight paths. *Action* was investigated in 12 paths in studies which did not consider the nested structure of the data and it mediated the relations in four of them.

4. Discussion

This systematic review aimed to answer the following research questions: 1. How is teaching quality conceptualized and operationalized in the selected studies? 2. What types of learning processes are assessed as mediators? How are they operationalized? 3. What do the findings of empirical studies tell us about how learning processes function as mediators between teaching quality and student achievement? When answering the first and the second research questions, the complexity and diversity of the conceptualization, operationalization, and measurement of the constructs, as well as the studies' limited comparability became apparent. To answer the third research question, the review categorized learning processes as *self* or *action* and investigated their role as mediators. Because of the complex nature of the findings, our discussion focuses on the five main challenges of our systematic review, its limitations and possible solutions.

4.1. Challenge 1: Data basis of the review

Teaching quality is a complex phenomenon with many dimensions so we searched for and reviewed publications that mentioned effectiveness or quality of teaching in either their title, abstract, or keywords in order to get as full a picture as possible of the papers in this area. However, some studies that looked at certain aspects of teaching quality may have been missed because the selection criteria referred to concepts that studies may have labelled as classroom management rather than teaching quality. Also, many aspects of teaching quality in the studies could not be assigned to just one category but rather fit into multiple combinations of categories. Moreover, half of the categories in the MAIN-TEACH model did not explicitly appear in our review. This could indicate that the mediating role of learning processes between those dimensions of teaching quality and student achievement have not yet been examined in terms of teaching quality and effectiveness, relevant studies which investigated those four dimensions were not picked up by our search technique, or some studies in the *combined teaching quality* category include those missing dimensions within their holistic assessments (see Appendix A). Instructional support, for example, includes more than one dimension in the MAIN-TEACH model (e.g., *cognitive activation*, *formative assessment,* and *selecting and addressing the content and subject-specific methods*). Some of the challenges described are also true for the SSMMD.

Using the MAIN-TEACH model and the SSMMD for categorization resulted in too few studies falling into each of the categories for us to be able to draw a firm conclusion that *self* or *action* mediate in some teaching quality categories but not in others. The variety of operationalizations employed in the studies and the small number of studies that fell into each teaching quality category meant that, although we were able to classify the results into our mediator categories, we were unable to analyze all possible combinations of teaching quality dimensions and the learning process variables. For example, we could not analyze how *self* mediated the relation between quality of feedback and achievement because there were only two relevant studies in our review. This suggests that it might be more productive to focus future reviews on studies with similar conceptualizations and operationalizations. It would also be interesting to investigate whether changing the search strategy to include keywords that focus on certain dimensions of teaching quality or a particular theoretical approach would result in a more synthesizable selection of studies.

4.2. Challenge 2: Heterogeneity of studies

This review showed that what researchers mean when they refer to teaching quality, learning processes, and achievement varies a great deal from study to study. Studies were based on a variety of theoretical frameworks or theories (e.g., CLASS, Self-Determination Theory, Achievement Goal Theory) each of which conceptualizes teaching quality and learning processes in its own way. For example, one study conducted within SDT, conceptualized teaching quality as autonomy, competence, and relatedness support, whereas other studies conducted within the CLASS conceptualized it as classroom organization, emotional support, and instructional support. While some aspects of these theoretical approaches overlap, there are also fundamental differences between them in how they conceptualize and operationalize constructs. This made summarizing the review results problematic.

Even when publications were based on the same theoretical framework, they differed in how they divided or combined dimensions of teaching quality and learning processes. Synthesizing the results using the MAIN-TEACH model was therefore challenging. One reason for this situation is that many of the studies had created holistic measures of teaching quality encompassing multiple aspects of teaching. This could only be resolved by using a 'rest of' category (*combined teaching quality*). Because so many of the studies fell into the *combined teaching quality* category, the number assigned to the MAIN-TEACH categories was low.

Reflecting on why such heterogeneity exists and whether there is anything we can do about it, one needs to start by acknowledging that complex areas such as teaching and teaching quality cannot be explained using a single theoretical approach (Bikner-Ahsbahs & Prediger, 2010). Researchers using the same theoretical approach can understand each other because they use similar terms, definitions, and structures, but understanding those who use different approaches is harder. One solution could be to constrain future reviews to one theoretical framework. However, this can limit the cumulative knowledge generated in the field. Another solution could be to use networking strategies that emphasize interaction and collaboration between research groups with different theoretical approaches so that the results are more cumulative (Bikner-Ahsbahs & Prediger, 2010; Charalambous et al., 2021). Applied to the mediation effects focus of this review, future studies could be improved by researchers using at least two theoretical approaches in each empirical study so that a clearer picture of the similarities and differences between theoretical frameworks could emerge and future reviews could be facilitated.

4.3. Challenge 3: Operationalization and measurement of constructs

Our systematic review encountered some major problems deriving from the varied ways the studies had operationalized and measured constructs.

Selecting who rates teaching quality and learning processes and how achievement is operationalized in a study is a critical decision for any research into the relationship between teaching quality, learning processes, and achievement because the measurement perspective

influences the results (e.g., Styck et al., 2020; Virtanen et al., 2015). The studies in our review used student, teacher, and observer ratings, and a combination of student and teacher ratings to measure teaching quality. To measure learning processes, they used student, teacher, and observer ratings, and a combination of observer and teacher ratings. *Self* was only operationalized by student ratings, whereas *action* was measured by student, teacher, and observer ratings. Achievement was measured using course grades, specific standardized tests, or tasks, resulting in a heterogeneous data set.

Some studies in this review investigated specific dimensions of teaching quality, learning processes, and achievement (e.g., emotional support, behavioral engagement, numeracy), while others assessed them more holistically (e.g., classroom quality, student engagement, course grade in mathematics) (see also Section 4.2). Holistic scores were frequently used to represent aspects of teaching quality and learning processes, which meant individual aspects could not be compared, even when the studies had used the same theoretical framework. For example, using the CLASS framework, Ponitz et al. (2009), assessed teaching quality holistically by grouping classroom organization, emotional support, and instructional support and Hu et al. (2018) assessed teaching quality by separately assessing classroom organization, emotional support, and instructional support. As a result of these variations, it was not possible to make a useful comparison between the two studies.

When teaching quality is assessed in a model that combines a number of different dimensions, it is difficult to unpack which specific dimension has an effect and how great that effect might be. This is an issue because it hinders ongoing attempts to describe teaching quality by separating the different dimensions in order to get a clearer understanding of the complex nature of teaching (Praetorius & Charalambous, 2018). Even though the use of holistic scores means that the conclusions are less specific, our review showed that researchers often use them. There are a number of possible explanations for this. Combining scores might increase the probability of finding significant effects and the holistic assessment of constructs generally results in simpler, more workable, statistical models. One could also argue that it is unlikely that single dimensions have significant effects and that it is only worthwhile investigating combinations of dimensions. Future studies which compare holistic assessment and the specific assessment of the constructs in separate models would enable an evaluation of the relative validity of these approaches.

Choosing how any dimension is operationalized and measured is of great importance when designing a study. The choice of measurement perspective is dependent on theoretical reasoning (see e.g., Fauth et al., 2020) that suggests which perspective is best for studying which type of mediation effect. Similarly, the choice of whether to use a broad or narrow operationalization is dependent on the study's theoretical basis and research questions. We suggest that there should be increased transparency about how such research decisions have been made. Including supplementary files that explain the reasons for choosing a particular measurement perspective or dimension and any results for individual dimensions in future studies would help other reviews and meta-analyses contribute to our cumulative knowledge. Research groups who work on similar topics within the same theoretical framework could also communicate the decisions they have made about the conceptualization, operationalization, and measurement of constructs before they begin a project so that they could get feedback from other research groups within their field. This transparency could be achieved, for example, by pre-registration of studies and other open-science practices (Charalambous et al., 2021).

4.4. Challenge 4: The conceptual overlaps between teaching quality and learning processes

Although learning processes and teaching quality appear to be distinct constructs, their operationalizations can overlap and the overlap could influence how mediating effects are identified. When teaching is considered co-constructive (see Praetorius et al., 2018; Thommen et al., 2021; Vieluf, 2022), it is particularly difficult to clearly separate teaching quality from learning processes. This also applies to the MAIN-TEACH model and the studies in our review. For example, both teachers and students contribute to the quality of the teacher-student relationship (Cappella et al., 2016). The reviewed studies in the *socio--emotional support* category usually measured this dimension by focusing on the relationship between the teacher and individual students (e.g., "I have a good relationship with my teacher"), but this measure also includes information students have about *self*.

As we are far from having a full understanding of the relations between teaching quality and learning processes, it might be fruitful for researchers to initially concentrate exclusively on the relation between these two constructs instead of attempting to understand the entire process that connects teaching quality via learning processes to learning outcomes (for similar arguments in favor of simplifying the chain, see (Hiebert & Stigler, 2022).

4.5. Challenge 5: Studies using diverse methodologies to investigate mediation

The different methodological approaches used for conducting mediation analysis by the studies in the review could also have contributed to the heterogeneity of the results. Not only were the statistical models not easily comparable (i.e., latent factors vs. manifest variables), but the models also did not always include direct paths from teaching quality to achievement (i.e., full- and partial-mediation approaches). Most importantly, the mediation analyses were conducted at different levels; studies analyzed mediation at school, classroom, or student level. These differences could have significantly influenced the results. Teaching occurs in classroom settings which are nested in nature. However, many of the studies in our review ignored the nested structure of the data. Although the findings of our review are not conclusive, and they remain so even when we only look at those studies that take the nested structure into account, we suggest future studies do not ignore the nested structure of the data. Ignoring it may threaten the validity of results (Lüdtke et al., 2009). Finally, differing levels of statistical power, resulting from varying sample sizes, most likely affected the significance of the results. Overall, the varied approaches used for conducting mediation analysis made it difficult to compare mediating effects.

We need further discussion about why certain methods are more or less suited for analyzing mediation. Comparing different methods in empirical studies could help to show the impact of using a specific methodology on the results, allowing for the advantages and disadvantages of methods to be identified. If researchers could agree on some methodological issues, at least, then homogeneity between studies would be improved.

5. Conclusion

This review highlighted the relations between teaching quality and learning processes and how these in their turn are related to student achievement. It found significant and non-significant mediating effects for both the *self* and *action* categories of the MAIN-TEACH model. Our analyses provide some clues as to why the mediating effects of learning processes identified by researchers were so variable. The inconsistent mediating effects could not be explained by any one factor. Instead, they are likely to be caused by the interplay of multiple relevant factors (e.g., conceptualizations and operationalizations of the constructs). The complexity and heterogeneity of the reviewed studies make it difficult to compare empirical evidence, identify any clear patterns, or draw any firm conclusions.

We began this exercise by attempting to synthesize how teaching quality and learning processes were defined by the wide range of

theoretical frameworks and models in this field. We then provided an overview of the studies conducted, identified the challenges of the exercise, and provided some initial ideas about the factors that should be considered in future studies of mediation processes. The complexity in the field of teaching quality research revealed by this systematic review indicates that it is, as yet, too early to come to any firm conclusions about the mediation chain that could inform teaching practice. The next steps for building meaningful syntheses of empirical research could include an increase in studies operationalizing and assessing constructs using comparable methods. This could be achieved by increasing research transparency (e.g., publishing detailed justifications for choices made when designing studies) and fostering networking between researchers and would result in a more coherent and cumulative body of research (see Charalambous & Praetorius, 2020; Charalambous et al., 2021).

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Declaration of interest

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Appendix A. List of teaching quality variables that fell into the combined teaching quality category and the corresponding MAIN-TEACH dimensions

Study	Term	Dimensions as named in the study	Dimensions according to the MAIN-TEACH model
Dotterer and Lowe (2011)	Classroom context	Instructional quality	*Formative assessment*
		Socio-emotional climate	*Classroom and time management*
		Teacher-student conflict	*Selecting and addressing the content and subject-specific methods*
			Socio-emotional support
Theis et al. (2020)	Perceived need support	Autonomy support	*Support for active engagement*
		Competence support	*Formative assessment*
		Relatedness support	*Cognitive activation*
			Socio-emotional support
McLean et al. (2016)	Classroom quality	Individualized instruction	*Differentiation and adaptation*
		Orientation/organization	*Classroom and time management*
		Warmth and responsiveness	*Socio-emotional support*
		Control, Discipline	
León et al. (2017)	Teaching quality	Autonomy support	*Support for active engagement*
		Competence support	*Cognitive activation*
		Relatedness support	*Formative assessment*
			Socio-emotional support
			Selecting and addressing the content and subject-specific methods
Bergsmann et al. (2013)	Classroom structure	Task	*Cognitive activation*
		Authority	*Support for active engagement*
		Evaluation/recognition	*Formative assessment*
Hu et al. (2018)	Instructional support	Promote children's higher-order thinking skills	*Cognitive activation*
		Provide specific feedback in the learning process	*Formative assessment*
		How teachers model and encourage language use	*Selecting and addressing the content and subject-specific methods*
Ponitz et al. (2009)	Classroom quality	Instructional support	*Cognitive activation*
		Emotional support	*Formative assessment*
		Classroom management	*Selecting and addressing the content and subject-specific methods*
			Socio-emotional support
			Classroom and time management
Guo et al. (2011)	Classroom quality	Emotional support	*Socio-emotional support*
		Instructional support	*Classroom and time management*
			Selecting and addressing the content and subject-specific methods
Christophersen et al. (2010)	External variable	Interest	*Selecting and addressing the content and subject-specific methods*
		Relation	*Socio-emotional support*
		Pressure	

Appendix B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.stueduc.2022.101209.

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