

The Behavior of Student Hand-raising as an Observable
Indicator of Student Engagement:
Exploring the Role of Hand-raising in Classroom Learning and
Its Relation to Student Motivation

Ricardo Böheim

Vollständiger Abdruck der von der Fakultät TUM School of Education der Technischen
Universität München zur Erlangung des akademischen Grades eines

Doktors der Philosophie (Dr. phil.)

genehmigten Dissertation.

Vorsitzende: Prof. Dr. Claudia Nerdel

Prüferinnen der Dissertation:

1. Prof. Dr. Christina Seidel
2. Prof. Dr. Mareike Kunter,
Goethe-Universität Frankfurt
3. Prof. Dr. Doris Lewalter

Die Dissertation wurde am 17.09.2020 bei der Technischen Universität München eingereicht
und durch die Fakultät TUM School of Education am 16.11.2020 angenommen.

Acknowledgements

As with everything I have accomplished in my life, this dissertation would not have been possible without the support and encouragement of many people.

First and foremost, I want to thank my advisor Prof. Dr. Tina Seidel for her continuous support throughout this exciting and challenging time. It has been an honor to learn and benefit from her notable research experience. Her enthusiasm for research and her genuine interest in the progress of my dissertation was motivating and inspiring. I appreciate her constructive feedback and well-considered comments that helped me during research and writing of this dissertation. Besides my advisor, I would like to thank my mentor Dr. Maximilian Knogler, who invested a considerable amount of time and effort to support my dissertation. I am very grateful for the many constructive discussions and his insightful critical feedback that helped me widen the perspective on my research. Further, I would like to express my sincere gratitude to Prof. Dr. Tim Urdan for the fruitful cooperation during my research visit at the Santa Clara University. I would like to thank Prof. Urdan for sharing his knowledge and experience with me, and for making my research visit such an enjoyable time.

My sincere thanks also go to Prof. Dr. Mareike Kunter and Prof. Dr. Doris Lewalter, who kindly agreed to join the examination committee, and to Prof. Dr. Claudia Nerdel for chairing it.

I gratefully acknowledge the German Research Foundation as the funding source for the two projects that supplied the empirical foundation for the investigations of the present dissertation (Grant No. SE1397/7-1 and Grant No. SE1397/5-3). A very special thank you goes out to the participating students and teachers in these projects. Moreover, I thank the projects' research teams, including their student assistants, for their engagement in data collection and video coding.

I would like to thank the whole team working at the Friedl Schöller Endowed Chair for Educational Psychology at the Technical University of Munich, who have been there for me during these last few years and offered their advice whenever I needed their support or companionship.

Finally, I would like to thank my family for their support and encouragement throughout my life. Thank you to my parents for always believing in me, to my sister for being my best friend, and to my brother for being someone I could look up to and learn from. My deepest gratitude goes out to my wife, Sarah, for her love, patience, moral support and unconditional kindness. Thank you for your faithful support during this and many other journeys of our life.

Abstract

Student hand-raising is a salient behavior in everyday classrooms. Students who want to participate in classroom discourse and share their thoughts and ideas are commonly required to first raise their hands. Therefore, hand-raising represents students' gateway to enter and co-regulate the social interaction process with teachers and peers. To gain a better understanding of this everyday classroom behavior, this dissertation investigates central antecedents, facilitators, and outcomes of student hand-raising. The present dissertation is embedded in the multidimensional framework of student engagement (see Fredricks et al., 2004). Following the call for an increased implementation of behavioral measures in engagement research, student hand-raising is introduced and investigated as an observable measure of behavioral engagement. The aim of this dissertation is to investigate student hand-raising as an indicator of behavioral engagement and its relations with student motivation (an antecedent of engagement), teacher emotional support (a contextual factor that facilitates engagement), students' cognitive strategy use (as an indicator of cognitive engagement), and academic achievement (as an outcome of engagement).

The research findings from this dissertation are published in two associated journal articles that are based on two different studies. In both studies, observational data on students' hand-raising behavior was derived from videotaped lessons in high school classrooms. Students' perceptions of motivational and cognitive learning experiences were measured with self-reports. The objective of the first journal article ($N = 397$) was to explore the variance in hand-raising and its relation to student motivation. Results suggest that motivation accounts for significant variance in student hand-raising. Moreover, hand-raising was positively related to students' intrinsic motivation while the association was negative for students' external regulation of motivation. Domain-specific analyses revealed that students' self-concept played a central role for students' hand-raising in Mathematics while situational interest was found to be especially important for students' hand-raising in German Language Arts. The objective of the second journal article ($N = 266$) was to investigate student hand-raising and its relation to student learning and teacher emotional support. Results show that students who raise their hands more often, report more cognitive strategy use and obtain higher academic achievement. Moreover, findings indicate that hand-raising is responsive to perceived teacher emotional support and that it serves as a mediator between this contextual factor and academic achievement. Taken together, the present dissertation contributes to a better understanding of what motivates and supports students to engage in hand-raising and shows that this behavior matters for student learning. The dissertation underlines the potential of student hand-raising to serve as a useful indicator of behavioral engagement that allows engagement researchers to collect behavioral data on students' engagement.

Zusammenfassung

Schülermeldungen spielen in alltäglichen Unterrichtsinteraktionen eine zentrale Rolle. Schülerinnen und Schüler, die sich im Unterricht aktiv beteiligen wollen, müssen sich in aller Regel zuerst melden. Durch das Meldeverhalten können Lernende ihren Beitrag zum kollektiven Lernprozess im Unterrichtsgespräch selbst steuern. Die vorliegende Dissertation untersucht Melden als ein wichtiges Schülerverhalten und dessen Zusammenhang zu motivational-affektiven Lernvoraussetzungen, kognitiver Lernaktivität und Lernleistung. Das in der internationalen Forschung weit verbreitete Modell zur Konzeptualisierung von aktiver Schülerbeteiligung (dem *student engagement framework*; siehe Fredricks et al., 2004) bildet den theoretischen Rahmen zur vorliegenden Untersuchung. In Anlehnung an dieses Modell werden Schülermeldungen als ein beobachtbarer Verhaltensindikator für aktive Beteiligung im Unterricht untersucht (dem sog. *behavioral engagement*). Die Untersuchungsergebnisse dieser Dissertation wurden in zwei Publikationen veröffentlicht, in denen zwei unterschiedliche Studien berichtet werden. In beiden Studien wurden Schülermeldungen anhand von Videoaufnahmen im Gymnasium analysiert. Individuelle Lernvoraussetzungen wurden mittels Fragebogen erhoben. In der ersten Publikation ($N = 397$) wird die Variation in der Meldehäufigkeit und der Zusammenhang von Meldungen und Motivation untersucht. Die Ergebnisse zeigen, dass ein substantieller Anteil der Varianz in diesem Schülerverhalten auf die Motivation zurückzuführen ist. Dabei zeigt sich, dass Schülermeldungen in einem positiven Zusammenhang mit intrinsischen (interessensbezogenen) motivationalen Variablen stehen, während ein negativer Zusammenhang mit fremdbestimmter Motivation besteht. Ein Fächervergleich zeigt, dass im Mathematikunterricht das Selbstkonzept und im Deutschunterricht das situationale Interesse besonders zur Varianzaufklärung beiträgt. In der zweiten Publikation ($N = 266$) wird der Zusammenhang von Schülermeldungen mit dem Lernerfolg und der sozio-emotionalen Unterstützung der Lehrperson untersucht. Die Ergebnisse deuten darauf hin, dass eine höhere Meldehäufigkeit mit besserer Schülerleistung und mehr kognitiver Lernaktivität einhergeht. Zudem zeigt sich, dass eine als emotional unterstützend wahrgenommene Beziehung zur Lehrperson die Meldehäufigkeit positiv beeinflusst und dass die Meldehäufigkeit den Zusammenhang zwischen dieser sozio-emotionalen Kontextvariable und der Lernleistung mediiert. Die vorliegende Untersuchung zeigt, dass Schülermeldungen einen Ausdruck von Motivation darstellen, durch sozio-emotionale Unterstützung gefördert werden und im Zusammenhang mit Lernleistung stehen. Schülermeldungen scheinen daher einen geeigneten Verhaltensindikator für aktive Beteiligung im Unterricht darzustellen. Die vorliegende Dissertation leistet einen Beitrag zur Student-Engagement-Forschung, indem aufgezeigt wird, wie aktive Beteiligung im Unterricht durch beobachtbares Schülerverhalten erfasst werden kann.

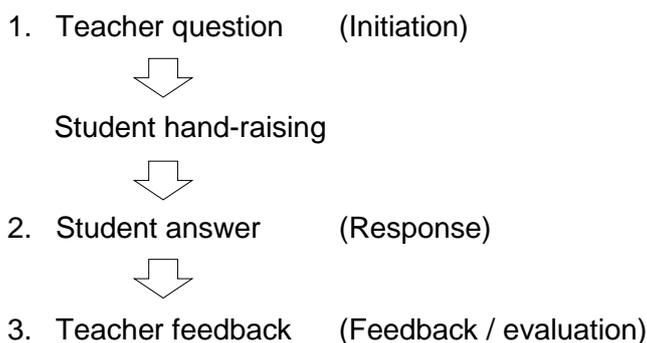
Table of contents

Acknowledgements	2
Abstract	3
Zusammenfassung	4
1. Introduction	7
2. Theoretical Background	11
2.1 Engagement theory as the overarching framework for the empirical investigation of student hand-raising	11
2.1.1 The engagement construct and its relation to the behavior of hand-raising	11
2.1.2 Student hand-raising as an observable measure of behavioral engagement	13
2.2 Theoretical perspectives on the interplay between context, engagement and outcomes	15
2.3 Motivation as an antecedent of student engagement	16
2.3.1 The dissertation's motivational framework	19
2.3.2 The influence of student motivation on behavioral engagement and its implications for the behavior of student hand-raising	23
2.4 Teacher emotional support as a facilitator of students' classroom engagement	25
2.5 Student hand-raising and its role in classroom learning	27
2.6 Variation in students' hand-raising behavior during classroom discourse	30
3. The Present Research	32
4. Methodology	33
4.1 Coding students' hand-raising behavior	35
4.2 Statistical Analyses	36
5. Descriptive Statistics of Coding Students' Hand-raising	37
6. Summary of Associated Publications	40
6.1 Investigating student hand-raising from a motivational perspective (Journal Article A)	41
6.1.1 Aim and research questions	41
6.1.2 Participants and procedures	42
6.1.3 Results and brief discussion	43
6.2 Investigating student hand-raising and its role in student learning (Journal Article B)	45

6.2.1 Aim and research questions	45
6.2.2 Participants and procedures	46
6.2.3 Results and brief discussion	46
7. Discussion.....	48
7.1 Discussion of central results	48
7.1.1 Empirical findings on students' hand-raising behavior	48
7.1.2 The potential of student hand-raising as a useful measure of behavioral engagement	52
7.2 Implications for practice	55
7.3 Limitations and further directions	56
7.4 Conclusion.....	58
8. References	60
Appendix	76

1. Introduction

Students commonly need to raise their hands in order to engage in classroom discourse and share their thoughts and ideas. This dissertation aims to investigate student hand-raising as one of the most salient student behaviors in everyday classroom interactions. Teachers dedicate a large amount of class time to teacher-centered classroom discourse (Alexander, 2008; Hiebert et al., 2003; Seidel & Prenzel, 2006), in which teachers and students interact verbally and students must typically first raise their hands to make a verbal contribution (Dixon et al., 2009). Research into classroom discourse shows that most interaction patterns follow a three-step-process, in which teachers initiate an interaction (i.e., by asking a question), students provide answers and teachers follow with feedback—often referred to as the IRF or IRE pattern (initiation, response, feedback / evaluation) (Alexander, 2018; Howe & Abedin, 2013; Mercer & Dawes, 2014). Although not addressed in this literature, it should be noted that hand-raising is central to this triadic interaction pattern because it represents students' gateway to enter and co-regulate the interaction process. In order to share thoughts and ideas, raise questions and stimulate class discussions, students need to engage in hand-raising.



Students who raise their hands signal that they *want* to become actively involved in the ongoing learning process and exchange their thinking with teachers and peers (Böheim, Knogler et al., 2020). Therefore, every student who raises his or her hand should be seen as an active participant in classroom discourse. Needless to say, that some students who raise their hand will not have the opportunity to speak because teachers usually do not call on all students with a raised hand. However, this does not change the fact, that all students who engage in hand-raising *want* or *intend* to become actively involved in the ongoing discursive learning process. In previous research on classroom discourse students' active engagement has commonly been conceptualized in terms of students' verbal participation (e.g., Jurik et al., 2013; Kelly, 2007; O'Connor et al., 2017; Pauli & Lipowsky, 2007; Sedova et al., 2019; Webb et al., 2014). However, using verbal participation as an indicator of students' engagement overlooks students who raised their hands but were not called on. The present dissertation argues that every student with a raised hand should be regarded as an active participant in

classroom discourse (regardless of whether the student gets the opportunity to talk). Moreover, there is an important difference between the group of students who are engaged verbally and the group of students who raise their hands. Students who raise their hands volunteer to be engaged in the learning process, while some students who engage verbally did not do so voluntarily. Teachers commonly try to spread participation across all students and therefore also call on students who did not raise their hands (Altermatt et al., 1998; Kelly, 2007). Therefore, verbal participation captures both students' individual engagement (i.e., students who volunteered to participate) and teachers' regulation of students' engagement (i.e., students who were called on without volunteering). In contrast, student hand-raising may more accurately reflect students' engagement because it is the students who decide if and how often they want to engage in this behavior.

In the engagement literature, there is a strong call for an increased implementation of behavioral measures because current research predominately relies on self-reports (Fredricks et al., 2019; Fredricks & McColskey, 2012; Renninger & Bachrach, 2015). It is often argued that observations of students' classroom behavior are important to advance this field of research because classroom observations are more objective compared to student self-reports (Fredricks & McColskey, 2012; Sinatra et al., 2015). However, using observational methods to capture students' engagement often raises concerns about observer bias, reliability of (high-inference) observer ratings and the overall time-consuming process of data collection and analyses (Fredricks et al., 2019). The present dissertation contributes to the engagement literature by introducing hand-raising as an observable measure of students' behavioral engagement. The behavior of student hand-raising is easy to observe, comes at a reasonable cost concerning observer training and analysis, and can be collected from large samples. Student hand-raising may thus serve as a promising behavioral measure for engagement researchers, especially during classroom discourse wherein this behavior is very frequent.

Aim of dissertation. The objective of this dissertation is to explore central antecedents, facilitators, and outcomes of student hand-raising. Results from this dissertation aim to contribute to a better understanding of what motivates and supports students to engage in this classroom behavior and clarify whether this behavior is related to student learning. Research and theory on student engagement (see Fredricks et al., 2004) provide a well-suited framework for the empirical investigation of students' hand-raising behavior. To gain more information about this particular classroom behavior and its potential to act as an indicator of behavioral engagement, this dissertation investigates relations with student motivation (an antecedent of engagement), perceived teacher emotional support (a contextual factor that

facilitates engagement), students' cognitive strategy use (an indicator of cognitive engagement), and academic achievement (an outcome of engagement).

The dissertation first examines the relationship between hand-raising and students' motivation. Student motivation is considered to be a key predictor of hand-raising because hand-raising reflects on students' personal investment and choice (i.e., students chose if and how often they engage in this behavior). Being an intentional behavior, it seems likely that the decision to raise one's hand is related to students' motivation in the classroom. The relation between student motivation and hand-raising is investigated based on a motivational model that comprises situational and more enduring (stable) factors of student motivation (Hidi & Renninger, 2006; Krapp & Prenzel, 2011; Schiefele, 2009). In addition, the dissertation investigates the importance of teacher emotional support as a salient contextual factor that facilitates students' active classroom engagement (Fredricks et al., 2004; Roorda et al., 2011; Skinner, Kindermann, Connell et al., 2009). Next to examining motivational-affective and contextual antecedents of students' hand-raising, the dissertation further investigates whether hand-raising is linked to cognitive aspects of student learning and whether it is associated with academic achievement. Drawing upon constructivist learning theories (Loyens & Gijbels, 2008; Windschitl, 2002), it is assumed that hand-raising relates to students' cognitive learning during classroom interactions.

The present dissertation is guided by the model depicted in Figure 1. In line with current literature, student engagement is conceptualized as a multidimensional "meta"-construct that includes distinct yet interrelated dimensions of engagement (Christenson et al., 2012; Fredricks et al., 2004) of which behavioral and cognitive engagement are relevant to this dissertation. The behavior of hand-raising is classified as an indicator of behavioral engagement. Based on theoretical assumptions from the engagement literature, motivational factors and perceptions of the learning environment can be construed as predictors of student engagement (i.e., student hand-raising), while student engagement is assumed to be associated with subsequent academic learning outcomes (Connell & Wellborn, 1991; Reeve, 2013; Skinner et al., 2008; Skinner, 2016). Although all depicted relationships in Figure 1 are likely to be reciprocal, the current dissertation focuses on the directionality indicated by the larger arrows. In this dissertation, the investigation of student hand-raising was conducted in a specific classroom setting. Students were observed during teacher-centered classroom discourse, wherein teachers ask questions and students provide answers or ask questions themselves. Further, students were observed across specific subject-domains including Mathematics, Language Arts and Science which allows to compare results across academic domains and draw subject-specific conclusions for research and practice.

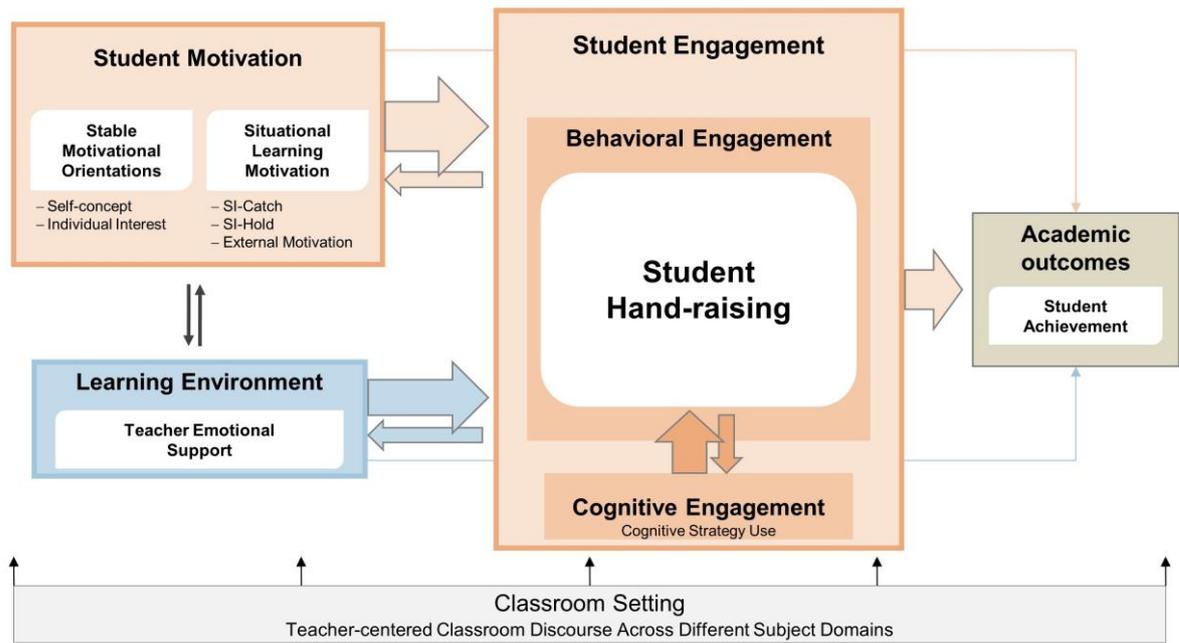


Figure 1. Conceptual study framework of the present dissertation.

2. Theoretical Background

2.1 Engagement theory as the overarching framework for the empirical investigation of student hand-raising

Student engagement holds great value for students' academic development during school education (Christenson et al., 2012). To acquire knowledge and competencies, students must actively engage in learning activities both inside and outside of school. In recent years, engagement has become one of the most prominent constructs among educational researchers, policy makers and educators because of its importance for academic progress and student learning (Appleton et al., 2008; Christenson et al., 2012; Fredricks et al., 2016; Fredricks et al., 2019; Skinner et al., 2008). Engagement is a relatively new construct, and it was not until the 1980s that the term 'engagement' first appeared in the academic literature (Appleton et al., 2008). Since the turn of the century, there has been an explosion of research on engagement which is mirrored in more than 22,000 peer reviewed journal articles that include the term "engagement" in their abstract in the last 20 years (according to a literature search on ERIC as of September 2020). This increase in research can be explained by accumulating evidence which links student engagement to important educational outcomes such as academic achievement, school completion and reduced problem behavior (Appleton et al., 2008; Finn, 1993; Fredricks et al., 2004; Jang et al., 2012; Marks, 2000; Wang & Fredricks, 2014). In addition, motivational research emphasizes that students experience higher levels of motivation when they are deeply engaged in their academic learning tasks (Reeve, 2013; Renninger & Bachrach, 2015; Skinner et al., 1990).

Skinner and Pitzer (2012) differentiate four levels in which engagement has been previously studied. According to their taxonomy, engagement can be studied at the institutional level (e.g., schools), the school level (e.g., curricular and extracurricular school activities), the classroom level (e.g., teacher–student interactions or relationships with peers) and finally the fine-grained level of a particular learning activity. The present dissertation investigates students' engagement at the classroom level that focuses on students' active participation in domain and lesson-specific learning processes.

2.1.1 The engagement construct and its relation to the behavior of hand-raising

Although engagement has been prominent in the field of educational psychology for more than 20 years, there is surprisingly little consensus about the concrete definition of the engagement construct (Sinatra et al., 2015). Researchers have used many different terms for the engagement construct including student engagement, academic engagement, school engagement or engagement in schoolwork (for a review, see Appleton et al., 2008). On the most general level, engagement draws on the idea of commitment, investment, involvement,

participation and active student behavior for promoting academic progress (e.g., performance, graduation) as well as social and emotional learning outcomes (Reschly & Christenson, 2012). Skinner, Kindermann, Connell et al. (2009), define engagement as “students’ constructive, enthusiastic, willing, cognitively-focused participation in learning activities” (p. 226). Marks (2000) focuses more on the internal psychological processes that involve the “attention, interest, investment, and effort students expend in the work of learning” (p. 155). In recent years, researchers have reached consensus that student engagement is multidimensional with distinct yet interrelated dimensions (Christenson et al., 2012). However, across different engagement models, there has been considerable variation in the number, type and operationalization of each dimension. Earlier models differentiate between students’ active behavior (e.g., participation, effort, attendance) and an additional affective component (e.g., interest, belonging, identification, positive emotions) (Finn, 1993; Marks, 2000; Skinner & Belmont, 1993). Recent models additionally include cognitive engagement as a third dimension that describes students’ strategic thinking and self-regulation during task involvement to capture the quality and the extent of students’ cognitive investment with the learning activity (Appleton et al., 2008; Fredricks et al., 2004). Again other scholars have included a fourth dimension, such as social engagement (Finn & Zimmer, 2012), academic engagement (Appleton et al., 2006) or agentic engagement (Reeve et al., 2020; Reeve & Tseng, 2011). The most prevalent model of student engagement in recent literature comprises behavioral, emotional and cognitive engagement (Fredricks et al., 2004). This three-dimensional model emerged from a review conducted by Fredricks et al. (2004)—one of the most influential papers in the engagement literature, yielding more than 3,000 citations in Scopus and more than 8,500 citations in Google Scholar (as of September 2020). The authors introduce engagement as a meta-construct that systematically combines different literatures to conceptualize how students act (behavioral engagement), feel (emotional engagement) and think (cognitive engagement) during academic learning.

Most relevant to the investigation of this dissertation is the dimension of behavioral engagement. Behavioral engagement at the classroom level encompasses students’ active participation during the initiation and execution of learning activities (Fredricks et al., 2004). It refers to the extent to which students show effort, attention and concentration which is reflected in more observable behaviors during classroom interactions such as initiating questions, listening to others’ reasoning, sharing one’s own thinking, or following the lesson attentively (Appleton et al., 2008; Fredricks et al., 2004; Fredricks et al., 2019; Fredricks & McColskey, 2012). It is important to note that—in one way or another—these observable behaviors are all related to the behavior of student hand-raising. Student hand-raising can either be conceptualized as a gateway or as an indicator of most of these behaviors. For example, hand-

raising is students' gateway to ask questions or share their thinking, while it might be indicative of whether students follow the lesson attentively and listen to what is being discussed. Fredricks and McColskey (2012) reviewed 11 prominent instruments that have been developed for measuring students' engagement with upper elementary to high-school students. In their review, they summarize different items across the reviewed instruments to illustrate how different dimensions of engagement have been assessed. For the dimension of behavioral engagement, students are asked about their classroom participation, concentration, attention, adherence to classroom rules, and effort (p. 771). Again, student hand-raising is closely linked to these behaviors as it represents a gateway to classroom participation while it is indicative for the remaining aspects.

Taken together, student hand-raising can therefore be attributed to the dimension of behavioral engagement as it draws on the idea of students' active participation in the classroom. Moreover, hand-raising seems to be a representative indicator of behavioral engagement because it taps into many aspects that are covered by the conceptual definition of this dimension of engagement.

2.1.2 Student hand-raising as an observable measure of behavioral engagement

Different methods have been used for studying students' engagement including self-reports, observations, teacher-ratings, interviews, real-time measures or experience sampling methods (for a review, see Fredricks et al., 2019). Moreover, engagement can be captured from multiple perspectives, i.e., by students, teachers, or external observers. However, the overwhelming majority of engagement research relies on student self-report measures (Fredricks et al., 2019; Fredricks & McColskey, 2012; Renninger & Bachrach, 2015). In recent years, there has been an increasing trend towards a critical examination of benefits and challenges that are related to self-report measures in educational research (Fryer & Dinsmore, 2020; Pekrun, 2020). The prevalence of self-report measures in the engagement literature can be explained by its practicability concerning data-collection (Fredricks & McColskey, 2012). Another major advantage of self-report measures is that they capture students' individual perceptions and are therefore particularly useful to measure covert psychological processes which are difficult or impossible to observe (Appleton et al., 2006; Greene, 2015). However, one major concern with self-reported engagement data is the uncertainty about the extent to which reported engagement matches with students' actual engagement because of the limited objectivity of the data (Abernethy, 2015; Azevedo, 2015; Fredricks & McColskey, 2012; Greene, 2015). Common challenges include a risk of response bias (e.g., social desirability) or the fact that students are usually asked about their engagement retrospectively which may cause problems due to limited recall accuracy (Gobert et al., 2015). Measuring students'

engagement with observational methods can address these challenges, because data is collected by external coders. With multiple observers, problems associated with observer expectancy bias or inter-rater reliability are kept at a minimum (Abernethy, 2015). However, observational measures are usually time-consuming during both data-collection and analysis. The assessment of students' engagement via observational methods is therefore often limited to small sample sizes, which in turn raises concerns about the generalizability of the results (Fredricks et al., 2019).

In this dissertation, student hand-raising was observed from videotaped classroom lessons to obtain an observable measure of students' behavioral engagement. This approach addresses the previously mentioned methodological challenges as follows. First, student hand-raising is an observable behavior that is ubiquitous in everyday classrooms and can be measured from independent coders. Therefore, its engagement data is considered to be more objective as compared to the prevailing self-report measures of engagement. Second, student hand-raising represents a low-inference behavior that is easy to observe and therefore comes at a reasonable cost concerning observer training and analysis. As a result, the coding procedure is relatively time-efficient which allows researchers to collect behavioral data even from large and diverse samples.

Previous observational studies that measure behavioral engagement often capture the average engagement of all students in one class (e.g., Gregory et al., 2014; Hafen et al., 2015; Pianta, Hamre, & Mintz, 2012) or focus on specific students only (e.g., Guo et al., 2015; NICHD ECCRN, 2005). In contrast, the present dissertation collected behavioral data from all participating students which allows to adequately examine the interindividual differences of this behavioral phenomenon.

Focusing on observable behaviors such as hand-raising is not only interesting from a research perspective. Because teachers observe hand-raising in their everyday interactions with students, empirical findings on this classroom behavior are assumed to be useful for teachers as they can help them in making more sense of this behavior. For example, J. A. Cobb (1972) exclusively focused on observable classroom behaviors to assess students' engagement (e.g., talking to the teacher, talking to peers, volunteering by hand-raising) and argues that such specific behaviors are considered to have great practical relevance because they provide immediate diagnostic information on students' current level of engagement. In contrast, self-report measures commonly reflect on global conceptualizations of classroom behavior with high-inference items such as "I work hard in school" or "I participate actively in class" (Fredricks & McColskey, 2012). Research based on such general items has limited potential for informing teachers about particular behaviors that they can easily observe and possibly target in interventions.

Based on these methodological and practical reflections, student hand-raising is assumed to be an interesting behavioral measure for the engagement literature because it points at a promising opportunity to incorporate more observational data in this research field.

2.2 Theoretical perspectives on the interplay between context, engagement and outcomes

Although there seems to be a consensus that student engagement is a multidimensional construct, researchers have used different perspectives to situate student engagement in theoretical frameworks. These perspectives arise from two different traditions including research on dropout prevention and research guided by motivational theories (Eccles & Wang, 2012). The participation-identification model is one of the most prominent models that is grounded in research on high school dropout and completion (Finn, 1989; Finn & Zimmer, 2012). The model describes a cyclical process in which behavioral engagement (i.e., participation) and emotional engagement (i.e., identification with school) interact to promote academic progress. According to this model, active participation in classroom learning leads to students' bonding with school, which in turn leads to continued participation. School dropout is explained by continued behavioral and emotional disengagement over a longer period of time (Finn & Zimmer, 2012).

Most of the engagement research, however, is guided by literature and research on student motivation that draws on prominent theories such as self-determination theory (Ryan & Deci, 2000a), self-system theory (Connell & Wellborn, 1991), stage-environment fit theory (Eccles & Roeser, 2009), or expectancy-value theory (Eccles & Wigfield, 2002). One of the most influential models in engagement research is the self-system process model which is rooted in self-determination theory (Skinner et al., 2008). The model assumes that engagement serves as a mediator which links social context variables (shaped by teachers, peers and parents) to educational outcomes. More precisely, it is postulated that self-system processes—students' appraisals of how autonomous, related and competent they experience themselves within their social context—are the most proximal predictors of students' engagement. In other words, if contexts support students' intrinsic need of feeling capable to effectively interact with the environment (i.e., competence), while social interactions provide a sense of connectedness with others (i.e., need for relatedness), and students experience their actions as self-initiated (i.e. need for autonomy), students engage with learning activities which in turn leads to higher learning outcomes (Connell & Wellborn, 1991). Although focused more narrowly on the self-determination literature (Ryan & Deci, 2000a), the model highlights the central role of context in facilitating engagement which in turn promotes student learning (context–engagement–outcomes). The notion that engagement acts as a mediator between

context and outcomes has guided the engagement literature (Skinner, Kindermann, Connell et al., 2009) and is also found in other engagement models (Appleton et al., 2006; Reschly & Christenson, 2012). Recent engagement models, such as the one developed in the Check & Connect intervention program (Reschly & Christenson, 2019, p. 58), integrate the interplay between context, engagement and outcomes with the multidimensionality of the engagement construct. Taking a holistic perspective on engagement, the model postulates that contexts (shaped by families, peers, schools, teachers and communities) can support or thwart students' behavioral, emotional/affective, or cognitive engagement which in turn promote student learning and achievement (Reschly & Christenson, 2012). The model acknowledges that the relation between context and engagement is reciprocal and self-reinforcing. As students engage in classroom learning, teachers and peers can provide continued support and feedback, which promotes even greater engagement. This bidirectional relation between supportive contexts and engagement is also prevalent in other engagement models (e.g., Appleton et al., 2006; Reeve, 2013; Skinner et al., 2008).

The interplay between context, engagement and learning outcomes that has been postulated by this literature represents the theoretical underpinning for this dissertations' conceptual framework that guided the empirical investigation of students' hand-raising (see Figure 1). As shown in Figure 1, the conceptual framework puts a special emphasis on the motivational context and its relation to student behavior. In the next section, student motivation is introduced as a central antecedent of students' engagement in classroom learning. First, it is discussed how motivation and engagement can be conceptually separated from one another. Next, motivational factors relevant to this dissertation are introduced and it is explained why and how student motivation can foster student hand-raising (an indicator of behavioral engagement) during classroom learning.

2.3 Motivation as an antecedent of student engagement

Engagement and motivation are closely related constructs that are both fundamental in fostering students' academic progress. Both, motivation research and engagement research are overlapping in many ways and some researchers even use "engagement" and "motivation" interchangeably (see Christenson et al., 2012). However, there seems to be an increasing consensus among researchers that engagement and motivation are distinct constructs (Christenson et al., 2012). At the heart, engagement refers to the extent of students' active involvement and participation in a learning activity (Ainley, 2012). In contrast, motivation revolves around the question of what causes one's actions and refers to the underlying psychological processes that describe and explain the direction, intensity, persistence and quality of behavior (Maehr & Meyer, 1997; Pintrich, 2003). Thus, a simple way of differentiating

these constructs is to identify engagement as action and motivation as the underlying source of energy that drives the action (Skinner & Pitzer, 2012). There have been several attempts to disentangle motivation from engagement, but still much inconsistency remains about how researchers distinguish these constructs in their definitions and measures (Martin, 2012; Reschly & Christenson, 2012). One problem arises from the fact that researchers have used motivational constructs in their definitions and operationalizations of engagement. This is especially true for cognitive and emotional engagement. These dimensions of engagement both refer to more internal and less observable processes (Appleton et al., 2006), which might explain their conceptual similarity with internal processes that represent motivation. The most explicit overlap with motivation is found for the dimension of cognitive engagement where many scholars have included motivation as one of three subset aspects along with cognitive effort and cognitive strategy use (Fredricks et al., 2004). Reviewing 11 prominent instruments used to measure engagement, Fredricks and McColskey (2012) concluded that scales and items of cognitive engagement often “incorporate aspects of motivation” (p. 772). For example, in the Student Engagement Instrument (Appleton et al., 2006), scales that measure cognitive engagement include motivational concepts such as relevance, goals and extrinsic motivation. For emotional engagement the overlap with motivational concepts is less prevalent, even though motivational variables such as values, belonging or interest have been found in the operationalization of emotional engagement across various instruments (Fredricks & McColskey, 2012).

Including motivational concepts in variable subsets that together constitute engagement is problematic for several reasons. First and foremost, motivation and engagement are considered to be distinct constructs (Christenson et al., 2012) and therefore it is misleading when researchers include motivational concepts (i.e., the source of energy) in conceptualizations of engagement (i.e., one’s action). In addition, motivational concepts are far more differentiated and elaborated as they are portrayed in these operationalizations of engagement (Fredricks et al., 2004) which leads to inconsistencies with the current understanding of motivation. Ainley (2012), for example, points out that interest is generally considered to be a sub-category of motivation which raises the question why interest is subsumed under emotional engagement, when, motivation is classified as sub-category of cognitive engagement. In addition, Eccles (2016) notes that aspects of affect which are associated with interests or values are commonly understood as antecedents of engagement and not as part of engagement (see expectancy-value theory; Eccles & Wigfield, 2002; or interest theory Hidi & Renninger, 2006). In the same way, self-determination theory posits that internal qualities of student motivation (e.g., intrinsic and extrinsic motivation) either support or thwart student engagement (Ryan & Deci, 2000a; Ryan & Deci, 2016) and therefore it seems

puzzling why such inner motivational resources are construed as part of cognitive engagement. Taken together, there is a clear overlap between engagement and motivation in the current literature and more work is needed to help clarify and organize conceptual boundaries (Christenson et al., 2012; Eccles & Wang, 2012; Skinner, 2016; Wigfield et al., 2015).

Although in recent years researchers have paid more attention to the motivation-engagement issue (Christenson et al., 2012), the question remains, why conceptual boundaries between engagement and motivation are blurry. One reason for this may be that research and theory on student motivation have a much longer history, while it was not until the beginning of this century that engagement garnered increasing scholarly attention (Appleton et al., 2008; Skinner, 2016). Therefore, the integration of engagement and motivation frameworks may require more time while theoretical models, measures and definitions of engagement are still evolving. A second reason may be that the idea of engagement, often referred to as “action” or “motivated behavior”, has always been prevalent in the motivation literature—although perhaps more narrowly focused on behavioral aspects of engagement (or disengagement). In an overview of major motivation theories, Skinner (2016) demonstrates that, in one way or another, student engagement (as a global construct) is a central outcome across all major motivational theories (p. 153). Similarly, the idea that contexts shape students’ behavior (i.e., engagement) have always been prevalent in the motivational literature (Wentzel & Wigfield, 2009; Wigfield et al., 2015). Therefore, motivational researchers may have not recognized the need for integrating engagement constructs into their models and conceptualizations.

In general, it could seem unclear how the engagement literature can contribute to the much older and well-established field of motivation research, especially when considering that the field of engagement still struggles with definitional and conceptual issues (Eccles, 2016). However, clearly the engagement framework had a great influence on the motivational literature (e.g., Patall et al., 2016; Reeve, 2013; Skinner et al., 2008) and was beneficial for the following reasons. First, the engagement construct offers a differentiated perspective on the idea of “action” or “motivated behavior” by providing a multidimensional framework that conceptualizes how students act (behavioral engagement), feel (emotional engagement) and think (cognitive engagement) while working on a learning activity. Thus, the engagement construct offers a parsimonious and comprehensive framework for organizing students’ engagement during classroom learning (e.g., Fredricks et al., 2004). Second, based on evidence that engagement is malleable (Appleton et al., 2008; Martin, 2012), there has been a strong research focus on supportive contextual factors that go beyond the motivational dynamics of the learning environment. The CLASS framework, for example, has drawn

attention to important domains of effective teaching including classroom organization (e.g., behavior management), instructional support (e.g., content understanding) and emotional support (e.g., regard for students' perspective) (Hafen et al., 2015; Pianta, Hamre, & Allen, 2012). These dimensions of effective teaching have been identified as important facilitators of students' engagement and have guided successful intervention work such as the My Teaching Partner (MTP) intervention program (Allen et al., 2011; Gregory et al., 2014). Taking a more holistic approach, the engagement literature has therefore extended the scope from purely motivational aspects of the learning environment to other supportive aspects of the educational context.

In recent years, there have been efforts to integrate both research areas based on the idea that "there are multiple mutually beneficial reciprocal connections between work on motivation and on engagement" (Skinner, 2016, p. 146). Both research areas are central to the present dissertation which draws on interest and motivation theories for explaining student engagement in the classroom. In accordance with the recent literature, motivation and engagement are conceptualized as distinct, yet interrelated constructs wherein motivation refers to the underlying psychological processes and engagement (i.e., student hand-raising) represents the action-oriented, outward manifestation of motivation (Martin, 2012). Similar to Skinner, Kindermann, Connell et al. (2009) students' engagement is therefore understood as a "reflection of human motivation [that is] energized and directed by motivational processes" (p. 225). Thus, motivation is considered as a precursor or antecedent of engagement that helps explain why or to what extent students engage in learning (Appleton, 2012; Christenson et al., 2012; Connell & Wellborn, 1991; Skinner et al., 2008). It is important to note, that motivation represents a necessary, yet not sufficient condition for student engagement (Appleton, 2012). As argued earlier, engagement is shaped by a myriad of contextual features as well as individual learner characteristics that may include—but are not limited to—motivational aspects of the learning environment (Pianta, Hamre, & Allen, 2012; Reschly & Christenson, 2019). For example, a student might be motivated (e.g., being interested in Science), yet not engaged in classroom discourse because of an unsupportive learning environment (e.g., due to authoritative teachers).

2.3.1 The dissertation's motivational framework

Taking a motivational perspective on student engagement, this dissertation integrates crucial motivational factors into a motivational framework for conceptualizing the underlying "source of energy" that directs students' behavioral engagement (i.e., student hand-raising) during classroom learning (see Figure 1). The motivational variables examined in this dissertation are grounded in two prominent motivational theories: Self-determination theory

(Ryan & Deci, 2000b) and interest theory (Hidi & Renninger, 2006; Krapp, 2002). Self-determination theory (SDT) posits that all students possess inherent tendencies for their self-motivation towards learning and development (Ryan & Deci, 2000b; Ryan & Deci, 2016). It assumes that students have inner motivational resources that, when supported by their social environment, facilitate positive functioning and student engagement during classroom learning (Reeve, 2012; Reeve et al., 2018). The theory distinguishes between two fundamental types of motivation that include intrinsic motivation and extrinsic motivation. Students who are intrinsically motivated experience an inner desire to engage in learning which is energized by the inherent satisfaction of the learning activity itself (Ryan & Deci, 2000a). Intrinsic motivation is facilitated by students' satisfaction of basic psychological needs to feel competent, autonomous and related to others. Based on the evidence that these psychological needs are highly responsive to features of the learning environment, SDT offers clear implications on how teachers can support and nurture psychological need satisfaction, to promote intrinsic motivation which in turn leads to high-quality engagement in the classroom (Jang et al., 2016; Reeve et al., 2018; Ryan & Deci, 2016). However, in everyday classrooms students' engagement is often based on extrinsic forms of motivation that are not driven out of the sheer enjoyment of the activity itself. Students who are extrinsically motivated feel more externally controlled and pressured while reasons for engagement reflect instrumental motivation rather than enjoyment. SDT differentiates four different types of extrinsic motivation that range from highly controlled to more autonomous forms of motivated behavior (Ryan & Deci, 2000a). The least autonomous type of extrinsic motivation is labeled as external regulation and is most relevant to the present dissertation. When externally regulated, students engage in an activity to satisfy external demands, obtain a reward or avoid punishment. Students feel controlled by others because their actions are regulated by external sources while their intrinsic motivation to engage is very low. Students' experience of external regulation of classroom behavior was included to the dissertation's motivational model to contrast the motivational variables that reflect on students' intrinsic motivation to participate.

Interest is an intrinsic motivational construct (Hidi & Renninger, 2006; Krapp, 2002). According to interest theory, situational and individual interest are important antecedents of intrinsically motivated behaviors (Harackiewicz & Knogler, 2017). Thus far, there are very few empirical studies on interest that refer to the multidimensional engagement framework and vice versa (one exception here is a study conducted by Patall et al. (2016)). This may be surprising given the many similarities between both literature strands (Renninger & Bachrach, 2015). Interest is a well-established motivational variable in educational research that plays a key role in initiating and maintaining meaningful engagement (Ainley, 2012; O'Keefe & Harackiewicz, 2017) and has been linked to favorable educational outcomes of learning and

development such as academic achievement (Schiefele et al., 1992). In accordance with the person-object theory of interest, Krapp (2002) emphasizes that interest, in contrast to other motivational constructs, is object or content specific and thus refers to students' relationship with particular activities during classroom learning. Renninger and Hidi (2011) point out that interest incorporates cognitive and affective parts, which are more or less prevalent across different phases of interest development. As students develop their knowledge about a certain content (cognitive part), students simultaneously enhance their sense of content value (affective part) (Hidi & Renninger, 2006).

In the educational literature, there has been a clear distinction between two different types of interest: situational interest and individual interest (Krapp, 2002; O'Keefe & Harackiewicz, 2017; Renninger et al., 1992; Schiefele, 2009). Situational interest refers to an in-the-moment experience that is elicited by certain triggers of the learning environment (e.g., intriguing charts, texts that are connected to students lives) (Ainley, 2017). It describes a fleeting psychological state that involves heightened attention and positive affect towards an external stimulus (Krapp, 2002; Schiefele, 2009). Research has found that positive affective reactions that are aroused by situational interest have an impact on students' engagement and learning (Hidi & Renninger, 2006). In contrast, individual interest refers to a relatively stable predisposition to engage and re-engage with an object or activity of interest (Ainley, 2017; Schiefele, 2009). It reflects an enduring process that is more internal and less focused on environmental triggers (Ainley, 2017). When students develop individual interest, they develop an enduring relationship towards an object or activity that is characterized by value, positive affect, and acquired knowledge (Hidi & Renninger, 2006; Renninger & Hidi, 2016). Krapp (2002) has proposed a developmental model of interest in which he describes two types of situational interest (emerging and stabilized) that are assumed to precede individual interest. The distinction between two forms of situational interest is based on the work of Mitchell (1993) who used the terms "catch" and "hold" to highlight that activities and instructional tasks can trigger or maintain situational interest. His work shows that there are activities and instructional tasks that catch students' attention for a short period of time (such as logic puzzles or mind-teasers) while students hold or maintain a newly sparked interest if tasks and activities are meaningful, personally relevant and help facilitate further engagement. Similar to Krapp's work (Krapp, 2002; Krapp & Prenzel, 2011), Hidi and Renninger (2006) differentiate triggered situational interest from maintained situational interest that both precede the development of individual interest. Although the present dissertation does not investigate the process of interest development, it includes several interest variables that are identified by these models. The motivational model of this dissertation differentiates between situational interest and individual interest. In line with Mitchell's (1993) distinction, situational interest is further

separated in a catch and hold facet. As mentioned earlier, situational interest-catch (SI-Catch) describes a temporary motivational response (such as positive emotions) to a specific classroom event, while situational interest-hold (SI-Hold) reflects a more enduring process as students experience the underlying task content personally important and feel an impulse for further content exploration (Knogler et al., 2015). Individual interest is investigated as students' stable predisposition to engage with the learning content in a specific academic domain (e.g., Mathematics).

In this dissertation, all motivational variables investigated were classified according to their relative stability. In line with previous motivational literature (Ainley, 2017; Krapp & Prenzel, 2011; Renninger & Hidi, 2011; Schiefele, 2009), a distinction has been made between situational learning motivation and stable motivational orientations. Situational or in-the-moment experiences of student motivation were captured with both components of situational interest (SI-Catch and SI-Hold) (Knogler et al., 2015; Mitchell, 1993). In addition, students' experience of external regulation was introduced as a proxy for students' lesson specific extrinsic motivation (Ryan & Deci, 2000b; Ryan & Deci, 2016). Stable and more enduring motivational responses were conceptualized by students' individual interest (e.g., Durik et al., 2017; Schiefele, 2009) and their self-concept of ability with the academic domain (Marsh & Martin, 2011). While individual interest refers to students' valence beliefs associated with the domain of interest (e.g., subject area), self-concept refers to students' ability-related beliefs in that domain (Durik et al., 2017; Wigfield & Cambria, 2010). Academic self-concept can broadly be defined as students' self-perceptions about their abilities (i.e., strengths and weaknesses) in broader academic domains (Trautwein & Möller, 2016). Their development is shaped through experiences with the (learning) environment, which can differ across academic domains (Shavelson et al., 1976). For example, students' ability beliefs might be high in Mathematics, but rather low in Language Arts (Marsh et al., 2006). As a result, self-concept is commonly conceptualized as a multifaceted and domain-specific construct (Marsh & Martin, 2011; Shavelson et al., 1976).

Taken together, the dissertations' motivational model (see Figure 1) conceptualizes situational and stable motivational factors as fundamental sources of students' behavioral engagement (i.e., student hand-raising) in classroom interaction. Students' situational and individual interest reflect on students' intrinsic motivation to participate while students' experience of external regulation was introduced as a proxy for extrinsic motivation.

2.3.2 The influence of student motivation on behavioral engagement and its implications for the behavior of student hand-raising

Drawing on the motivational literature, there is a large body of research that links students' intrinsic motivation to active classroom behaviors including task involvement, participation, effort exertion and persistence (see O'Keefe et al., 2017; Ryan & Deci, 2009; Skinner, 2016; Wentzel & Miele, 2016; Wigfield et al., 2015). As discussed earlier, students' actions or behaviors in classrooms are central outcomes of nearly all major motivational theories, such as self-determination theory (Ryan & Deci, 2016), achievement goal theory (Anderman & Patrick, 2012), expectancy-value theory (Eccles & Wigfield, 2002), or interest theory (Hidi & Renninger, 2006; Krapp, 2002), and the link between motivation and active behavior has been supported by fairly robust empirical evidence (see Wigfield et al., 2015). In previous literature, however, few motivational researchers have used engagement frameworks for organizing "motivated actions" or "motivated behaviors", e.g. according to the different dimensions of the engagement construct. Here, research based on self-determination theory presents an exception: Researchers such as Johnmarshall Reeve or Ellen Skinner have demonstrated how SDT can be integrated with the multidimensional construct of engagement for investigating the relation between self-determined motivation and different dimensions of student engagement (Reeve, 2012, 2013; Skinner, 2016; Skinner & Pitzer, 2012). For example, Jang et al. (2016) conducted a longitudinal study with $N = 366$ high-schools students and found that students' intrinsic motivational experiences in classrooms predicted students' subsequent engagement. In their study, engagement was conceptualized as a multidimensional factor comprising behavioral, cognitive, emotional and agentic aspects of engagement. A study of Skinner et al. (2008) focused on two dimensions of student engagement (behavioral and emotional engagement) and their relation to positive motivational self-perceptions. For behavioral engagement, the authors found that the experience of intrinsic need satisfaction had a substantial influence on changes in students' active classroom behavior from fall to spring. The importance of students' need satisfaction to promote subsequent behavioral engagement is also supported by Ruzek et al. (2016), who investigated $N = 960$ middle and high-school students over the course of one school year.

Across all three studies, behavioral engagement was assessed via self-reports with items adapted from an instrument that was developed by Wellborn (1991). These items ask students to report on their attention, active listening, exerted effort, and participation in class discussions—which are all aspects that are assumed to be conceptually related to the behavior of hand-raising. As mentioned earlier, student hand-raising seems to be indicative for students' attention, listening and effort, while it represents a gateway to active participation in class discussions. Besides SDT research, there are also examples of researchers who have

integrated expectancy-value theory with the multifaceted construct of engagement. For example, Wang and Eccles (2013) analyzed data from $N = 1157$ middle school students to test the relationship between achievement motivation and students' behavioral, emotional and cognitive engagement. Their results showed that students' self-concept of ability and subjective task value predicted students' behavioral engagement at the end of the school year.

As noted by Renninger and Bachrach (2015) there are relatively few studies who have investigated interest together with a multidimensional conceptualization of the engagement construct. However, there is a consensus that interest is a central motivational source that sparks and maintains students' active engagement (Durik et al., 2017; Hidi & Renninger, 2006; O'Keefe et al., 2017; Schiefele, 2009). For example, in an experimental study, Durik and Harackiewicz (2007) found a positive link between students' situational interest and their involvement in mathematical tasks. However, interest researchers rarely understand engagement as a multidimensional construct. Exceptions are two studies conducted by Patall et al. (2016) and Linnenbrink-Garcia et al. (2013). Linnenbrink-Garcia et al. (2013) investigated how triggered and maintained situational interest relate to students' behavioral and cognitive engagement. In this study, teachers rated the extent to which students participated in class discussions or activities (behavioral engagement) and the cognitive depth of students' questions or comments (cognitive engagement). Their analysis showed that maintained situational interest was positively associated with engagement. Designed as a diary study, Patall et al. (2016) investigated students' situational interest during Science class and its influence on different dimensions of student engagement (behavioral, cognitive and agentic). The authors followed $N = 218$ high-school students over a six-week long instructional unit and found that students' experience of situational interest predicted students' behavioral engagement in class. In addition, behavioral engagement was related to a second more stable measure of interest (i.e., students' cumulative interest averaged across the six-week period). In their study, behavioral engagement was conceptualized via students' active participation in classroom discussions, exerted effort and level of attention in class. The authors of this study recommend that further research should include extrinsic motivation to contrast students' interest-based motivation.

Assuming that hand-raising either directly or indirectly relates to most of the indicators that have been used to measure behavioral engagement across these reviewed studies, this dissertation assumes similar predictive pathways. Based on the dissertations' motivational model, both stable motivational orientations (i.e., individual interest and self-concept of ability) and situational forms of motivation (SI-Catch, SI-Hold and external regulation) are investigated as central predictors of students' hand-raising behavior. In this dissertation, student hand-raising is construed as an intrinsically motivated behavior because it reflects on students'

voluntary engagement (i.e., students chose if and how often they engage in hand-raising). Therefore, students are expected to raise their hands more often when learning tasks and activities elicit students' interest (i.e., situational interest) or when students' have higher cognitive-affective orientations toward the academic domain (i.e., individual subject interest). Moreover, because hand-raising involves public exposure students' confidence in their academic abilities (i.e., self-concept of ability) is assumed to promote this behavior. In contrast, students who rate themselves as being more reliant on an external regulation of their classroom behavior (i.e., external regulation) are assumed to raise their hands less frequently.

Both, the engagement literature and the motivation literature emphasize the role of teachers in creating supportive learning environments. Students who raise their hands intend to enter an interaction process with their teachers and it is usually the teacher who provides feedback on students' statements. The next section focuses on teachers' emotional support as a central contextual factor that facilitates students' engagement and it is explained why emotionally-supportive teachers are expected to be relevant for student hand-raising.

2.4 Teacher emotional support as a facilitator of students' classroom engagement

The importance of the learning environment and its central role for students' engagement cannot be overstated (Christenson et al., 2012; Fredricks et al., 2004). There is a consensus among researchers that engagement and context cannot be separated because student engagement is malleable and therefore highly responsive to features of the learning environment (Appleton et al., 2008; Shernoff et al., 2016; Skinner & Pitzer, 2012). Sinclair et al. (2003) argue that "engagement is not conceptualized as an attribute of the student, but rather a state of being that is highly influenced by contextual factors" (p. 31). Therefore, engagement research has placed a strong focus on contextual factors (i.e., features of the learning environment) and their potential to facilitate student engagement. Among these contextual factors (e.g., teacher support, peer support, family support, community support) (Christenson et al., 2012; Fredricks et al., 2004; Reschly & Christenson, 2019), this dissertation focuses on teacher support—as a salient contextual factor that promotes student engagement in everyday classrooms (Allen et al., 2013; Roorda et al., 2011). In classrooms, it is usually the teacher who creates the conditions for student engagement and learning (Shernoff et al., 2016; Strati et al., 2017). The engagement literature has highlighted a number of effective teaching behaviors that facilitate classroom engagement and academic development (e.g., Allen et al., 2013; Fredricks et al., 2004; Gregory et al., 2014; Pianta, Hamre, & Allen, 2012; Reyes et al., 2012; Ruzek et al., 2016; Skinner et al., 2008; Wang & Eccles, 2013). Teacher emotional support is a central aspect of effective teaching that is prevalent across various teaching frameworks such as the Three Basic Dimensions framework (Praetorius et al., 2018;

Praetorius & Charalambous, 2018). One of the most prominent teaching frameworks that has been used in the engagement literature, is the Teaching Through Interactions (TTI) framework developed by Pianta and Hamre (2009). According to this framework, effective teaching behaviors can be classified into three major domains—emotional support, instructional support, and classroom organization (see, Hafen et al., 2015). According to this framework, teacher emotional support is characterized as an affective domain that describes the extent to which teachers (1) create a warm and caring emotional climate, (2) are sensitive to their students' requirements, and (3) account for their students' perspectives. In this dissertation, the measure of teachers' emotional support is conceptually similar to the first aspect (i.e., emotional climate). More precisely, teacher emotional support is conceptualized through perceived teacher caring and warmth (including liking, valuing and being noticed).

The important role of teacher emotional support and its assumed impact on student engagement is theoretically derived from attachment theories and social-motivational theories such as self-system theory or SDT (Connell & Wellborn, 1991; Davis, 2003). In SDT, for example, warm and caring relationships between teachers and students are seen as a necessary condition for nurturing students' need for relatedness (Connell & Wellborn, 1991; Ryan & Deci, 2000b; Skinner & Belmont, 1993). In the SDT literature, teachers' emotional support has been commonly labeled as affective involvement and is described as the extent to which teachers "take time for, express affection toward, enjoy interactions with, are attuned to, and dedicate resources to their students" (Skinner & Belmont, 1993, p. 573). Scales that have been used to capture students' perceptions of their teachers' affective involvement (i.e., emotional support) include items such as "my teacher likes me", "my teacher really cares about me", or "my teacher knows me well" (for more items, see Ahn et al., 2019; Skinner et al., 2008; Skinner & Belmont, 1993). These items are similar to the ones used in the present dissertation.

There is compelling empirical evidence from meta-analyses that links teachers' affective or emotional support to student engagement and academic achievement (Cornelius-White, 2007; Roorda et al., 2011). For example, Allen et al. (2013) found that classrooms with high emotional support were associated with higher levels of student achievement at the end of the school year. In accordance with the TTI framework presented earlier, emotional support comprised three different aspects, among which emotional climate (i.e., teachers' warmth and affection) had the strongest effect on achievement. In their study, emotional climate was captured via video-ratings based on the CLASS instrument—a widely used observational instrument that is based on the TTI framework (Hafen et al., 2015; Pianta & Hamre, 2009; Pianta, Hamre, & Mintz, 2012). The same instrument was used by Ruzek et al. (2016), who investigated the association between emotional support and students' behavioral engagement in classrooms. For this purpose, the authors analyzed videotapes from 68 different teachers

and found a positive link between observations of emotional support in autumn and students' behavioral engagement in winter.

In this dissertation, teacher emotional support was captured from a student's perspective. In their analyses, Skinner et al. (2008) showed that students' perceptions of teachers' emotional support (or affective involvement as the authors call it) was associated with increases in students' behavioral engagement and declines in behavioral disaffection from fall to spring. Other research similarly found a measurable link between perceived teacher emotional support and students' active engagement in class (Skinner & Belmont, 1993; Skinner, Kindermann, & Furrer, 2009; Wang & Eccles, 2013). Students' perception of teachers' emotional support is assumed to be especially important for decisions related to whether students engage in hand-raising or not. Engaging in hand-raising is a rather high-stakes decision, because students expose themselves publicly and may fear consequences from giving an incorrect answer. When students perceive their teachers as warm and caring and feel that their contributions are valued and respected it seems more likely that students raise their hands even if uncertain about the correctness of their answer.

Thus far, hand-raising was discussed with respect to the dissertations' motivational-affective and contextual factors. However, as depicted in Figure 1 student hand-raising is further assumed to be linked to cognitive aspects of learning and achievement. The next section summarizes theoretical considerations and empirical findings that explain why hand-raising is assumed to be linked to students' cognitive strategy use (an indicator of cognitive engagement) and academic achievement from a constructivist perspective.

2.5 Student hand-raising and its role in classroom learning

Classroom discourse is typically conceived as a collective learning process in which teachers and students co-construct knowledge through verbal interactions (Pauli & Lipowsky, 2007). Discursive learning processes in everyday teaching require students' active participation such as sharing opinions, asking questions, or responding to teacher questions. Previous research highlights the benefits of students' active participation in classroom talk and its relation to student outcomes such as achievement or academic progress (Brophy & Good, 1970; Chi & Wylie, 2014; Decristan et al., 2019; Kelly, 2008; Resnick et al., 2015; Webb et al., 2014). While the focus of previous classroom research has been on students' verbal participation, far fewer studies have investigated the behavior of student hand-raising. Myhill (2002) investigated 144 students from different school years and found that high-achieving students were more likely to raise their hands compared to low-achieving students. Findings further indicated that girls raised their hands more frequently than boys (Burns & Myhill, 2004). A recent study by Decristan et al. (2019) investigated students' participation during whole-class

discussions in Science ($N = 681$ elementary students). To measure students' participation, the authors compared students belonging to different categories. Their results showed that students' self-initiated participation (a predictor variable that compared students who raised their hands at least once to students who did not raise their hands) predicted students' posttest achievement. Decristan et al. (2019) conclude that hand-raising should therefore be considered as a useful indicator to reflect on students' engagement. Interestingly, their study showed that students who raised their hands and had the opportunity to share their thinking did not outperform the group of students who raised their hand but were not called on.

These findings raise two important questions: (1) Why would hand-raising and student learning be related in the first place? and (2) why would students who raise their hands and speak perform just as well as students who raise their hands and are not called on? To explain the link between hand-raising and learning, the present dissertation draws on a constructivist perspective on learning. Both paradigms, cognitive constructivism as well as social constructivism, are relevant to explain why the behavior of hand-raising may be related to students' learning and achievement (P. Cobb & Yackel, 1996; Loyens & Gijbels, 2008; Palincsar, 1998; Windschitl, 2002). Students who raise their hands want to share thoughts, ideas or opinions and individuals must actively construct these thoughts, ideas or opinions before they raise their hands. It therefore seems likely that students who raise their hands are cognitively engaged with the learning content (see Figure 2). In the process of knowledge construction students often use cognitive learning strategies (Weinstein & Mayer, 1986). The literature commonly differentiates between deep-processing strategies (such as elaboration strategies) and surface-level strategies (such as rehearsing) (Ainley, 1993; Greene & Miller, 1996; Nolen, 1988), with a sense that deep learning strategies are assumed to be more likely to lead to a more profound understanding (Greene, 2015). Regardless of the cognitive depth, hand-raising may be interpreted as a sign that students have cognitively engaged with the learning material and are ready to present the current product of their thinking.

From a sociocultural perspective, hand-raising is further related to learning processes that arise from social interactions in classroom discourse. Students who raise their hand and are called upon get the opportunity to enter discursive learning processes with teachers and peers. These students are assumed to enhance their understanding because they receive scaffolds and feedback from peers and teachers that prompt students to further explain, justify or elaborate on their thinking, reflect on possible misconceptions, or integrate additional comments to refine their knowledge (Walshaw & Anthony, 2008; Webb et al., 2014). Students who raise their hands but who are not given the opportunity to speak (i.e., because teachers did not call on them) are expected to benefit from this collective learning process by active listening (Inagaki et al., 1998; Pauli & Lipowsky, 2007). Hand-raising is a behavior that is

usually elicited by a specific teacher question or instructional task and therefore it seems likely that students activate similar cognitive processes to construct their answer. Students who “prepared” a response (as indicated by their hand-raising) are assumed to learn through their peers’ contributions by listening to their explanations and learning from the provided feedback. Previous studies suggest that silent students who listen actively learn just as well as vocal students during classroom discourse (e.g., Inagaki et al., 1998; O'Connor et al., 2017; Stahl & Clark, 1987). For example, Inagaki et al. (1998) observed $N = 298$ students during a whole-class discussion on a specific mathematical procedure. Their analyses revealed no differences in students’ posttest achievement between the groups of students that were verbally engaged in this discussion compared to the group of students who remained silent and followed the discussion attentively. In an experimental study, Stahl and Clark (1987) manipulated whether students who raised their hands during classroom discussions were called on or not. Their results revealed no differences in students’ posttest achievement highlighting that vocal participation is not required for learning to take place (Stahl & Clark, 1987). The authors speculate that it is more the cognitive activity of generating a response that is related to student learning.

Taken together, the behavior of hand-raising is assumed to be related to student learning because students are expected to be engaged in cognitive processing in order to construct their response and because they benefit from social interactions during classroom discourse either by contributing verbally or by listening actively to their peers’ contributions (see Figure 2).

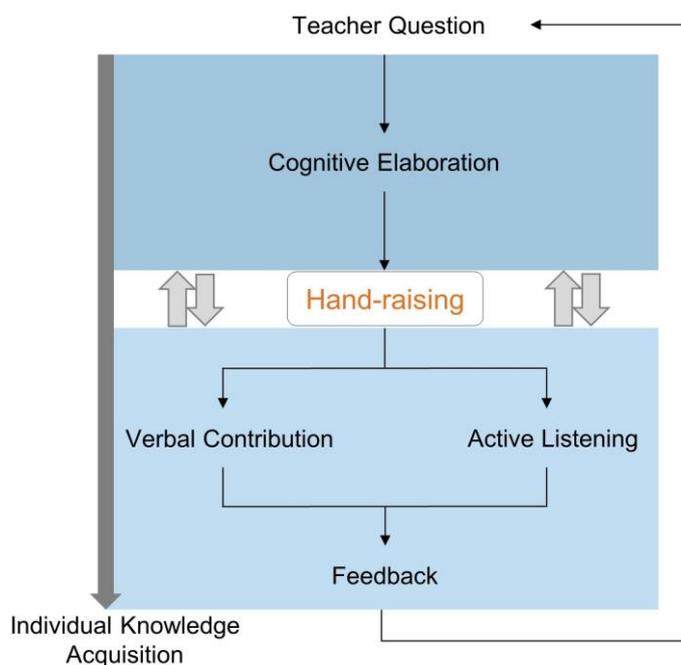


Figure 2. Theorized relation between hand-raising and student learning.

2.6 Variation in students' hand-raising behavior during classroom discourse

Several studies found substantial variability in student participation during classroom discourse. A recent study conducted by Sedova et al. (2019) examined the amount of talk time as well as the number of students' utterances during whole-class teaching during two observed lessons. Within their sample of 639 secondary students, the authors found large between-student variations with some students remaining silent during both lessons. Similarly, O'Connor et al. (2017) found that the number of spoken words varied greatly between individual students during whole-class discussions. Empirical research reaching back to the 1970s has repeatedly drawn the attention to the large variations in student participation during classroom discourse (e.g., Black, 2004; Brophy & Good, 1970; Clarke et al., 2016; Jurik et al., 2013; Kelly, 2007; Lipowsky et al., 2007). Although these studies mainly focus on students' verbal participation, results are likely to be similar for students' hand-raising behavior because hand-raising usually precedes verbal engagement. One study that provides some evidence for this assumption is the study conducted by Sacher (1995) who investigated a total of 28 lessons from 9 different classrooms in Science, Mathematics or Language Arts. His analyses revealed that roughly one third of students did not raise their hands while the maximum number of hand-raising per student reached 40 hand-raising in one lesson. However, Sacher's work does not only draw attention to the large variations between individual students but also between the 28 observed lessons. Based on these and previous findings, student hand-raising is therefore expected to be a behavior that varies greatly between students and classrooms.

Previous engagement research suggests that, in general, girls tend to show higher levels of engagement than boys (Lietaert et al., 2015; Skinner, Kindermann, & Furrer, 2009; Wang & Eccles, 2012b). However, when it comes to students' participation during classroom discourse boys seem to show more verbal contributions in Mathematics or Science classrooms (Jurik et al., 2013; Pauli & Lipowsky, 2007) as well as Language Arts classrooms (Kelly, 2008). Studies investigating gender and student hand-raising report inconsistent findings. While some studies did not find any gender effects for students' hand-raising (Brophy & Good, 1970; Decristan et al., 2019), Sacher (1995) reports that in the majority of observed classrooms boys seemed to raise their hands more frequently than girls. One explanation for this finding may be that boys have higher perceptions of their abilities and are therefore less hesitant to share their thinking publicly (Marsh et al., 2005; OECD, 2013). Regarding students' prior achievement, studies commonly report that low-achieving students are less likely to contribute to classroom discourse and may therefore be at risk of being excluded from the interactive learning (Decristan et al., 2019; Jurik et al., 2013; Kelly, 2008). Both students' gender and prior achievement were included as covariates when investigating relations to student hand-raising.

The present dissertation attempts to describe and explain some of the variance in student hand-raising by investigating student motivation, students' perceived teacher emotional support, and students' cognitive strategy use as predictors of this behavior. Needless to say that there are numerous personal and contextual factors that may be related to differences in student participation. Although not investigated in this dissertation, individual student characteristics such as socio-economic status (Decristan et al., 2019; Kelly, 2008), personality traits (Komarraju & Karau, 2005) or academic emotions (Pekrun & Linnenbrink-Garcia, 2012) as well as aspects of instructional quality such as instructional support, classroom management or cognitive activation (e.g., Pianta, Hamre, & Allen, 2012; Praetorius et al., 2018) are likely to explain additional variance in students' hand-raising behavior.

3. The Present Research

Student hand-raising is a salient student behavior in everyday classrooms. During classroom discourse, hand-raising represents students' main possibility to enter and contribute to the social interaction process with peers and teachers. So far, hand-raising has received little research attention in the context of student engagement and therefore important questions remain unanswered: What motivates and supports a student to raise his or her hand? Is hand-raising related to student learning and achievement? The present dissertation seeks to provide new empirical insights into this behavioral phenomenon and investigate its potential to serve as a useful indicator for the student engagement literature. The objective of this dissertation is to investigate student hand-raising as an observable indicator of behavioral engagement during teacher-centered classroom discourse and explore its relation to student motivation (an antecedent of engagement), teacher emotional support (a facilitator of engagement), cognitive strategy use (an indicator of cognitive engagement), and student achievement (an outcome of engagement). In line with the engagement literature, student hand-raising is conceptualized as a mediator between contextual factors and educational outcomes (see Figure 1).

The research questions of the present dissertation were investigated in two journal articles associated with this dissertation (for detailed information, see section 6). The focus of the first journal article was to explore the relation between student hand-raising and student motivation. In this article, hand-raising is construed as an intrinsically motivated behavior that is related to students' situational and more enduring (stable) motivational factors. The article first investigates the variation in students' hand-raising behavior and then seeks to explore this variation from a motivational perspective across two different subject domains. The second associated journal article investigates students' perceptions of teacher support as a key facilitator of students' hand-raising behavior in classroom interactions. Moreover, based on a constructivist perspective, student hand-raising is investigated in respect to student learning. It is assumed that students who raise their hands more often report more cognitive strategy use and obtain higher levels of academic achievement.

Besides providing new empirical insights into the behavior of student hand-raising and its relation to antecedents, facilitators, and outcomes both articles introduce student hand-raising as novel indicator of behavioral engagement and discuss its potential to contribute to engagement research.

4. Methodology

The present dissertation was embedded in two research projects that were funded by the German Research Foundation. Data for the first associated journal article (see 6.1) were obtained from the *Interaction* project (Grant No. SE1397/7-1), and data for the second associated journal article (see 6.2) were collected as part of the *Dialogue II* project (Grant No. SE1397/5-3). These projects were chosen for the present dissertation because both projects were designed to capture teacher–student interactions during classroom discourse via video recordings. These video recordings were used to code students’ hand-raising behavior. It should be mentioned that the targeted student behavior of this dissertation (i.e., hand-raising) was not an initial research focus of these projects. Students’ hand-raising behavior in the *Dialogue II* project was exclusively coded for the purpose of this dissertation with the author of this dissertation being responsible for the coding procedure.

In order to match students’ observed hand-raising behavior with students’ individual perceptions, the present dissertation used students’ self-reports that were administered as part of these projects (such as reports of perceived motivation, teacher emotional support and cognitive strategy use). Both projects were conducted with students from German academic-track secondary schools. For the videotaped lessons, teachers were instructed to give a regular lesson that was typical for their everyday teaching.

Data for the *Interaction* project were collected in the school year 2013/2014 and the project’s focus was to gain more information about students’ diverse learner characteristics and their influence on teacher–student interactions in everyday classrooms (Huber & Seidel, 2018; Jurik et al., 2015). The sample consisted of $N = 20$ eighth grade classrooms that were investigated in two different subject domains. Students were videotaped twice—once in Mathematics and once in German Language Arts (GLA). Hand-raising data was derived from $N = 397$ videotaped students in Mathematics and $N = 387$ videotaped students in German Language Arts. Each classroom was videotaped at the middle of the school year (see Figure 3). In addition, self-report data was obtained from two different questionnaires. The first questionnaire was distributed at the beginning of the school year and the second questionnaire was distributed after the videotaped lesson in the middle of the school year.

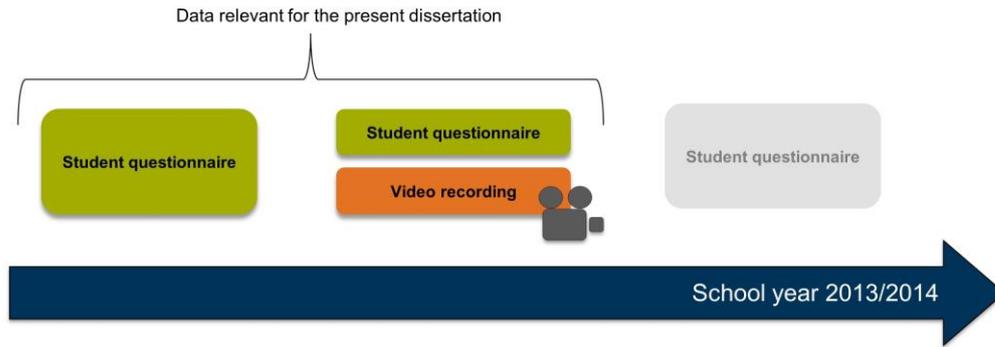


Figure 3. Data used in the present dissertation in the context of the Interaction project for the present dissertation.

In an additional qualitative study, the author of this dissertation further designed and conducted interviews with $N = 14$ eight-grade students from a German high school ($M_{Age} = 13.9$, $SD = 0.83$). The interview study was designed to gain a more in-depth understanding of what motivates students to raise their hands and thus complement the quantitative analyses on the relation between hand-raising and motivation (see 6.1). In accordance with the subject domains investigated in the *Interaction* project, students were first asked about their mathematics-specific hand-raising behavior and then, in a second interview, students were asked about their GLA-specific hand-raising behavior. The average interview duration was 24 minutes (range: 14 – 34 min.).

The *Dialogue II* project aimed to shed more light on the effects of teachers' dialogic classroom discourse (Schindler et al., submitted; Weil et al., 2020). For this purpose, teachers and their students were videotaped during the school year 2016/2017. Participating teachers attended a 1-year professional development program that was designed to help them adopt a more dialogic discourse practice. Data (video recordings and self-reports) for the present dissertation was obtained from pre-test data of this larger professional development project at the beginning of the school year (see Figure 4). Students' achievement data was collected at the end of the first school semester. For this dissertation, a subsample of $N = 266$ students from 14 different classrooms was selected. Nine classrooms were observed during one lesson in Science and five classrooms were observed during one lesson in Mathematics.

As part of the *Dialogue II* project, participating teachers were videotaped again in the following semester in spring, roughly six months after the first videotaping. Although this data was not used to investigate the research questions from this dissertation, the video data was used to obtain a second measurement of students' hand-raising to gain some information about the reliability (i.e., stability) of this behavioral measure (see * in Figure 4).

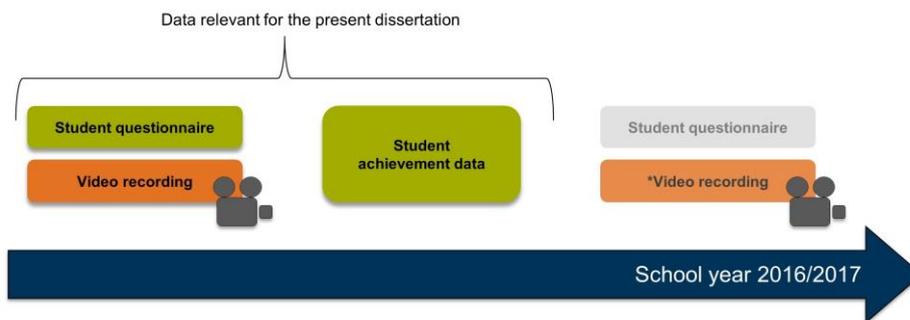


Figure 4. Data used from the present dissertation in the context of the *Dialogue II* project.

4.1 Coding students' hand-raising behavior

As argued in the introduction, hand-raising is expected to be an objective measure of students' engagement because it represents a low-inference behavior that can be directly observed by researchers. However, one challenge is that hand-raising often has a short duration and occurs simultaneously among several students. It therefore seems likely that hand-raising events may be missed when data is collected through in situ observations. The present dissertation therefore used video recordings to code students' hand-raising behavior. All classroom video recordings (from both projects) were conducted by trained videographers and followed standardized guidelines that were originally developed for the IPN Video Study (Seidel et al., 2005). The videotaped lessons were then analyzed in full length (approximately 45 minutes each) by two independent coders using the INTERACT software. Videos were divided into their interaction formats based on the following three categories: (1) silent/individual student work, (2) group work (> two students), and (3) whole-class discussion (Seidel, 2005). The coders first registered all events of students' hand-raising and teachers' questions. Every time a student raised his or her hand, and every time a teacher asked a question, a new event was coded. Following Kobarg's and Seidel's (2005) video manual, teacher questions were further coded in closed questions (e.g., the teacher wanting to hear one correct answer) or open questions (e.g., an opportunity to share differing thoughts and ideas).

To gain more descriptive information on students' hand-raising, additional codes were introduced when analyzing the video-data from the *Dialogue II* project. Here, it was coded whether students raised their hands to respond to a preceding teacher question or whether students raised their hands without being prompted by the teacher (coded as self-initiated hand-raising). In addition, it was coded whether students who raised their hands were called on and had the opportunity to make a verbal contribution. Students verbal contributions were classified into the following categories: (1) answering the teachers' question, (2) asking a content-clarifying question, (3) asking questions that express interest in the topic (i.e., asking

about additional information or further-going content), and (4) asking a content-unrelated question (e.g., organizational matters). Cohen's Kappa was calculated to measure inter-rater reliability. The video-analyses from both projects (Interaction and Dialogue II) revealed a satisfying agreement between the independent raters ($\kappa = 0.68$, inter-rater agreement: 72.7%; $\kappa = 0.63$ inter-rater agreement: 90.7%).

4.2 Statistical Analyses

The relation between hand-raising, motivation, cognitive strategy use, perceived teacher emotional support and achievement was investigated with various statistical analyses. All statistical models of the present dissertation have been estimated with *R 3.5.1* (R Development Core Team, 2018). Multiple regression models were estimated with the R package *lme4* (Bates et al., 2015) and structural equation models were estimated with the R package *lavaan* (Rosseel, 2012). Using a multilevel approach, all models accounted for nested data structures (students in classrooms). Missing values from students' self-reports were imputed with the predictive mean-matching algorithm implemented in the R package *mice* (van Buuren & Groothuis-Oudshoorn, 2011).

5. Descriptive Statistics of Coding Students' Hand-raising

Overall, the videotaped lessons observed in this dissertation pointed at teacher-centered interaction patterns, wherein teachers lead discussions and students give answers or ask questions. In line with previous research in German high schools, most of the class time was spent in whole-class teaching situations (Hiebert et al., 2003; Seidel & Prenzel, 2006). The videos analyzed in the *Interaction* project revealed that 80.1% ($SD = 0.09$) in Mathematics and $M = 75.6%$ ($SD = 0.13$) in GLA was dedicated to whole-class discussions. Similar results were found for the observed Mathematics and Science classrooms from the *Dialogue II project* (Science: $M = 85%$, $SD = 0.16$; Mathematics: $M = 87%$, $SD = 0.08$). Further, teachers asked, on average, a substantial number of questions in the videotaped lessons from the *Interaction* project ((Mathematics: $M = 56$ ($SD = 24.05$), GLA: $M = 51$ ($SD = 21.60$)) as well as in the videotaped lessons from the *Dialogue II project* ((Science: $M = 42$ ($SD = 16.78$), Mathematics: $M = 51$ ($SD = 14.94$)). As would be expected from the previous literature (Galton et al., 1999; Kobarg & Seidel, 2007; Seidel & Prenzel, 2006; Stigler et al., 1999), teachers commonly directed their students' attention into an intended direction using a closed questioning style (i.e., students are required to give a specific answer). The analyses of the videotaped lessons in the *Interaction* project, revealed 95% of closed questions in Mathematics and 74% of closed questions in GLA. Similarly, teachers' questions coded with the data from the *Dialogue* project, revealed 99% of closed questions in Mathematics and 91% of closed questions in Science.

Table 1 (adapted from Böheim, Knogler et al. (2020), and Böheim, Urdan et al. (2020)) depicts the descriptive results of students' hand-raising behavior on the student- and classroom level across both projects. The presented data in each subject domain is based on one videotaped lesson (i.e., a 45-minute observation of students' hand-raising behavior). The coded data from the *Interaction* project revealed that, on average, students raised their hands 5.16 times ($SD = 5.81$) in Mathematics and 4.88 times ($SD = 5.34$) in GLA. There were substantial variations in the frequency to which students raised their hands. In Mathematics 15% of students did not engage in hand-raising at all while one student reached up to 41 hand-raising in the videotaped lesson. Similarly, in GLA roughly 18% students did not engage in hand-raising while the maximum number of hand-raising for one student was 35. In both subject domains, there was also a certain amount of between-classroom variation as indicated by large standard deviation and the range of total hand-raising per classroom (Mathematics: 20 (min) - 203 (max); GLA: 26 (min) - 209 (max)).

Overall, the analyzed video recordings of the *Dialogue II project* revealed similar results. The average frequency of students' hand-raising in Mathematics was a bit higher ($M = 7.36$, $SD = 8.05$) compared to the observed Science classrooms ($M = 5.61$, $SD = 6.62$). In both subject domains, roughly 21% of students did not raise their hands at all during the

videotaped lesson while the maximum number of hand-raising was 32 in Mathematics and 37 in Science classrooms. Again, there was a substantial between-classroom variation in students' hand-raising behavior as indicated by the large standard deviation at the classroom level.

Table 1
Descriptive Statistics of Student Hand-Raising

Data source	Subject domain	Hand-raising per student					Hand-raising per classroom				
		<i>M</i>	<i>SD</i>	<i>Md</i>	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>SD</i>	<i>Md</i>	<i>Min</i>	<i>Max</i>
Interaction project	Mathematics (N = 20 classrooms)	5.16	5.81	3	0	41	108.10	54.24	114	20	203
	German Language Arts (N = 20 classrooms)	4.88	5.34	3	0	35	102.25	47.11	94	26	209
Dialogue II project	Mathematics (N = 5 classrooms)	7.36	8.05	5	0	32	142.80	71.00	123	55	247
	Science (N = 9 classrooms)	5.61	6.62	4	0	37	105.33	53.45	104	31	212

Note. *M* = average number of hand-raising per student/classroom; *Min* = minimum number of hand-raising across all students/classrooms; *Max* = maximum number of hand-raising across all students/classrooms; Table adapted from Böheim, Knogler et al. (2020), and Böheim, Urdan et al. (2020).

Table 2 (adapted from Böheim, Urdan et al. (2020)) shows the additional categories that have been coded in the sample from the *Dialogue II* project. Results show that most hand-raising (92%) were prompted by the teachers, meaning only 8% of students hand-raising were self-initiated. Roughly, a third of all hand-raising led to a vocal contribution (28.2%). In other words, the majority of the students who raised their hands in an average situation were not called upon. This can be explained by the fact that the student, who was first called upon, often answered the question correctly and consequently the teacher moved on with the lesson. From all students who raised their hands and were called on, in most cases students answered their teacher's question (88%). In a few events (7%) students asked a content-clarifying question. Remarkably, in only 3% of successful hand-raising did students ask a question that expressed further interest. In an additional 3%, students had a question regarding some organizational matters.

Table 2
Further Coding Results of Student Hand-Raising (Video Data from Dialogue II Project)

	Full sample (N = 266 students)	Science (N = 169 students)	Mathematics (N = 97 students)
Hand-raising <i>M (SD)</i>	6.25 (7.21)	5.61 (6.62)	7.36 (8.05)
% Teacher-prompted	92.3	93.4	91.0
% Successful	28.2	29.7	26.2
% Answering teacher question	88.1	87.5	88.8
% Content-clarifying question	6.8	5.7	8.5
% Question expressing interest	2.6	3.9	0.5
% Content-unrelated question	2.6	2.8	2.1

Note. Table adapted from Böheim, Urdan et al. (2020).

6. Summary of Associated Publications

This section summarizes the dissertation's associated publications. As part of the present dissertation, two journal articles have been published in two international journals (*Learning and Instruction* and *Contemporary Educational Psychology* (see 6.1 and 6.2)). The author of this dissertation is the first author of both articles and played the leading role in the development, conceptualization, writing, statistical data analysis, and publication-based presentation of these journal articles.

The first journal article (Journal Article A) was submitted to the peer-reviewed journal *Learning and Instruction* in August 2018 and was accepted for publication in September 2019.

Böheim, R., Knogler, M., Kosel, C., & Seidel, T. (2020). Exploring student hand-raising across two school subjects using mixed methods: An investigation of an everyday classroom behavior from a motivational perspective. *Learning and Instruction*, 65, 101250. <https://doi.org/10.1016/j.learninstruc.2019.101250>

The first author played the leading role in the conceptualization, preparation, data analyses and publication-based presentation of this paper (70%), while the co-authors, Dr. Maximilian Knogler (15%) and Prof. Dr. Tina Seidel (10%) guided the development of the manuscript with critical reviews. Christian Kosel overlooked the statistical analyses (5%).

The second journal article (Journal Article B) was submitted to the peer-reviewed journal *Contemporary Educational Psychology* in October 2019 and was accepted for publication in June 2020.

Böheim, R., Urdan, T., Knogler, M., & Seidel, T. (2020). Student hand-raising as an indicator of behavioral engagement and its role in classroom learning. *Contemporary Educational Psychology*, 62, 101894. <https://doi.org/10.1016/j.cedpsych.2020.101894>

The first author played the leading role in the conceptualization, preparation, data analyses and publication-based presentation of this paper (70%), while the co-authors, Prof. Dr. Tim Urdan (15%), Dr. Maximilian Knogler (10%) and Prof. Dr. Tina Seidel (5%) guided the development of the manuscript with critical reviews.

6.1 Investigating student hand-raising from a motivational perspective (Journal Article A)

The following is a brief summary of the journal article “Exploring student hand-raising across two school subjects using mixed methods: An investigation of an everyday classroom behavior from a motivational perspective” (see, Böheim, Knogler et al., 2020). A copy of the full article is presented in the appendix (see supplement A).

6.1.1 Aim and research questions

Hand-raising is an important gateway for entering the public interaction process with teachers and peers. Hand-raising is students’ main method to regulate if and how often they want to contribute to classroom discourse. By raising their hands, students signal that they *want* to become actively involved in the ongoing (discursive) learning process and share their thoughts and ideas. Previous research that investigated students’ active participation in classroom discourse found a substantial variation between individual students (e.g., Black, 2004; Clarke et al., 2016; Kelly, 2007) and this variation was also found in students’ hand-raising behavior (Sacher, 1995). The first goal of this journal article was to investigate the frequency and variation of hand-raising across students, classrooms, and school subjects. The second goal of this journal article was to clarify what accounts for these differences. Because hand-raising reflects on students’ personal investment (students need to make a conscious decision to engage in hand-raising) and their personal choice (students choose to engage in hand-raising), variations in this behavior are likely to be related to students’ underlying motivational processes (Maehr & Meyer, 1997; Pintrich, 2003). Based on research on student motivation (Hidi & Renninger, 2006; Krapp & Prenzel, 2011; Schiefele, 2009), situational and more enduring (stable) motivational factors are considered as two fundamental sources that spark student behavior. Individual interest in the subject and student self-concept were considered as stable motivational orientations (Wigfield & Cambria, 2010) that affect student hand-raising. Students’ motivational response to what happens in class was conceptualized through situational interest and students’ externally regulated motivation. Based on the assumption that hand-raising is an intrinsically motivated behavior, situational motivation that is based on internal satisfaction (situational interest) is assumed to positively predict hand-raising while motivation that is based on external regulation of behavior is expected to show a negative prediction on student hand-raising.

The relation between hand-raising and student motivation was investigated across different subject domains. The engagement and the motivation literature highlight the role of the educational context in which students are studied (Eccles & Roeser, 2015; Fredricks & McColskey, 2012; Roeser et al., 2009). As part of the educational context, disciplinary

differences between subject domains are expected to influence the organizational structure of classroom learning (Grossman & Stodolsky, 1995). Differential effects on students' motivation and engagement are especially assumed for disparate subjects such as Mathematics and Language Arts (Dweck, 1986; Goetz et al., 2007). Mathematics instruction usually focuses on well-defined concepts and this may explain why teachers from this quantitative domain often use narrow interaction patterns and closed questioning techniques (Seidel & Prenzel, 2006; Stigler et al., 1999). Consequently, raising one's hand may be a higher-stakes decision in Mathematics because closed questions aim at a single correct answer. Taken into account that Mathematics requires a conceptual understanding of complex and challenging topics, it seems likely that a secure self-concept may be especially important because the probability of giving a wrong answer is higher. In contrast, curricula in Language Arts are often more open and usually focus on diverse and controversial topics (Grossman & Stodolsky, 1995). Based on a more open-ended culture, students may regulate their hand-raising in response to their personal interest and worry less about the correctness of their answer.

Altogether, the journal article addresses the following four research questions:

1. How does student hand-raising vary between individual students, classrooms, and school subjects?
2. Do differences in student motivation explain the variation in student hand-raising?
3. Do the relations between student motivation and student hand-raising differ across two school subjects (Mathematics and German Language Arts)?

While research questions 1 – 3 were investigated with quantitative analyses, the last research question focused on students' qualitative explanations of their hand-raising behavior. For this purpose, an additional interview study was conducted that aimed to validate and supplement quantitative findings and identify possible directions for future research.

4. How do students explain their motivation to raise their hands and what role does the teacher play in this process?

6.1.2 Participants and procedures

Four-hundred and twenty-nine German eight-grade students (57% girls, $M_{age} = 13.8$ years ($SD = 0.52$)) from academic-track secondary schools participated in this study. Hand-raising data was available for $N = 397$ students in Mathematics and $N = 387$ students in German Language Arts. The recruited students from 20 different classes were videotaped in two subjects: Mathematics and German Language Arts (GLA). To capture students' hand-raising behavior each class was videotaped during one lesson in each subject at the middle of the school year. Students' subject-specific stable motivational orientations (individual interest

and self-concept) were assessed three month prior to this lesson for each subject with well-established questionnaire scales (Hertel et al., 2014; OECD, 2014; Ramm et al., 2006). Following the videotaped lesson, students were asked to report on their situational learning motivation (situational interest-catch, situational interest-hold, and external motivation) (Seidel et al., 2005). All scales showed satisfying reliability scores: $\alpha_{range} = .78 - .92$. The relation between student motivation and student hand-raising was investigated using a hierarchal multiple regression analysis. The analyses were performed separately for Mathematics and German Language Arts.

The sample for the interview study consisted of $N = 14$ eight-grade students (50% girls, $M_{age} = 13.9$ years ($SD = 0.83$)). These students were asked to elaborate on their motivation to raise their hands in each subject (Mathematics and GLA). Interviews were transcribed and coded using the MAXQDA software.

6.1.3 Results and brief discussion

Research question 1

On average students raised their hands 5.16 times ($SD = 5.81$) in Mathematics and 4.88 times ($SD = 5.34$) in GLA across all students and classrooms. There were great differences between individual students: In Mathematics, 14% of the students engaged in more than ten hand-raising, while 15% of all students did not raise their hand ($Max = 41$). Similar results were found for GLA where 18% did not raise their hands while 14% of the students engaged in more than ten hand-raising ($Max = 35$). On the classroom level, the average number of total hand-raising was comparable across both subjects (Mathematics: $M = 108.10$ ($SD = 54.24$); GLA: $M = 102.25$ ($SD = 47.11$)). The large standard deviations indicate a great variance of total hand-raising between classes with a range between 20 (*Min*) and 203 (*Max*) in Mathematics and 26 (*Min*) to 209 (*Max*) in GLA.

Research question 2 & research question 3

Students' stable motivational orientations and situational student motivation together were able to explain 15% of students' variance in hand-raising in Mathematics and 11% of students' variance in hand-raising in GLA. All motivational variables correlated significantly with students' hand-raising (except self-concept in GLA). In the multiple regression analyses, there was no evidence for a significant contribution of students' individual interest in both subjects. Students' self-concept, however, positively predicted student hand-raising in Mathematics but not in GLA. With regard to situational motivational variables, SI-Catch positively predicted hand-raising in GLA but not in Mathematics. SI-Hold did not contribute to the explanation of students' hand-raising variance in both subjects. Students' externally regulated motivation negatively predicted hand-raising in both subjects.

Research question 4

Results from the interview study revealed that students referred to the same motivational factors that were included in the quantitative analyses when explaining their hand-raising behavior (i.e., self-concept, individual interest, situational interest and external motivation). Further, the number of students who referred to each motivational factor varied across subject-domains. Comparable to the pattern found in the quantitative results, self-concept was mentioned more frequently in Mathematics, and situational interest was mentioned more frequently in GLA. In addition, students highlighted the role of perceived teacher support as being central to their decision if and to what extent they raise their hands during classroom discourse.

Taken together, results revealed a substantial variation in the frequency to which students engaged in hand-raising which strengthens the assumption that hand-raising reflects on students' choice and personal investment (i.e., students choose if and how often they want to be actively involved in the learning process). Hand-raising may therefore be interpreted as behavioral cue for students' voluntary engagement in classroom discourse. Further, the regression analyses mainly support the idea that significant proportions of this variance are related to differences in student motivation and that these relations vary across subjects. In Mathematics, students' with a higher perception of their own abilities were more likely to raise their hands. This confirms the important role of students' self-concept for students' engagement particularly in subjects, which are perceived as challenging and typically follow a rigid and closed interaction pattern. Students' individual interest did not predict independent variance in student hand-raising in both subjects. This might be due to the fact that hand-raising is more a response to situational circumstances rather than a reflection of stable motivational preferences. In line with this assumption, student's situational interest (SI-Catch) was positively associated with hand-raising in GLA. Further, students' situational experience of externally regulated motivation was negatively associated with hand-raising in both subject-domains. This finding implies that the behavior of student hand-raising should be more considered as students' intrinsic choice to participate in classroom discourse rather than a behavior that reflects on external regulation. It is worth noting that each motivational variable, examined alone, correlates significantly with student hand-raising. In addition, data from the interview study highlight the role of supportive teachers to foster students' hand-raising. Students argued that they raise their hands more often when they feel liked, valued and cared for by their teacher.

6.2 Investigating student hand-raising and its role in student learning (Journal Article B)

The following is a brief summary of the journal article “Student hand-raising as an indicator of behavioral engagement and its role in classroom learning” (see, Böheim, Urdañ et al., 2020). A copy of the full article is presented in the appendix (see supplement B).

6.2.1 Aim and research questions

Students who raise their hands intend to contribute to the collective learning process during classroom discourse by sharing their thoughts and ideas with teachers and peers. In everyday teacher–student interactions, hand-raising is a ubiquitous behavior that is easy to observe and might serve as a useful indicator for students’ behavioral engagement. Although it seems likely that students who raise their hands are also engaged in classroom learning processes, it remains unclear whether and how hand-raising is related to students’ cognitive engagement and academic achievement. Based on a constructivist perspective on learning (P. Cobb & Yackel, 1996; Loyens & Gijbels, 2008; Windschitl, 2002), student hand-raising is expected to be associated with student learning for two reasons: First, students who raise their hands need to cognitively engage with the learning content to generate thoughts and ideas. Second, students who raise their hands engage in a collective learning process in which knowledge is co-constructed in social interactions (e.g., students built upon each other’s ideas and receive feedback). Therefore, it is expected that students who raise their hands more often are cognitively more engaged and obtain higher levels of academic achievement. Although the engagement literature does not posit any directionalities among different dimensions of engagement, students’ cognitive strategy use (an indicator of cognitive engagement) is assumed to precede student hand-raising (an indicator of behavioral engagement) because students must first generate their thoughts before they can raise their hands to share them.

Teacher emotional support is one of the most prevalent contextual factors that facilitates students’ engagement in classroom interactions (Fredricks et al., 2004; Roorda et al., 2011). The perception of emotionally supportive teachers is expected to be relevant for students’ hand-raising behavior. After all, hand-raising is a form of public exposure where caring relationships with teachers may encourage students to raise their hands even if uncertain about the correctness of their answer. Research and theory on student engagement, suggest that engagement acts as a mediator between contextual factors and academic outcomes (Appleton et al., 2008; Connell & Wellborn, 1991; Skinner et al., 2008). Because student hand-raising is investigated as an indicator of behavioral engagement, similar relations between context, hand-raising (engagement), and achievement are expected. Therefore,

students' cognitive strategy use (an indicator of cognitive engagement) and students' perceived teacher emotional support (a facilitator of engagement) were considered as antecedents of students' hand-raising behavior (see Figure 1).

The journal article addressed three research questions:

1. Is students' hand-raising behavior associated with academic achievement?
2. How does the predictive power of student hand-raising (an indicator of behavioral engagement) on achievement compare to students' cognitive strategy use (an indicator of cognitive engagement) and students' perception of teachers' emotional support (a contextual factor of engagement)?
3. Does student hand-raising mediate the associations between teacher emotional support and cognitive engagement with academic achievement?

6.2.2 Participants and procedures

In this study, 266 German high school students (50% female; $M = 14.35$ years, $SD = 1.00$) from 14 different classrooms were videotaped during one lesson at the beginning of the school year (9 classrooms were observed during Mathematics instruction and 5 classrooms were observed during Science instruction). As a proxy for students' cognitive engagement students reported on scale that captured their cognitive strategy use (OECD, 2005). Students' perceptions of their teachers' emotional support was measured with a scale that was adapted from Appleton et al. (2006). Both scales revealed good reliability values ($\alpha = 0.76$ and $\alpha = 0.72$). Data on academic achievement (course grades) were collected at the end of the semester (three months after videotaping). The relation between student hand-raising and academic achievement was investigated via hierarchical multiple regression analysis to account for the nested data. The interrelations between hand-raising, teacher emotional support, cognitive engagement and academic achievement were tested using structural equation modeling.

6.2.3 Results and brief discussion

Research question 1

The regression analyses revealed that student hand-raising had a significant effect on students' subsequent academic achievement. This effect remained significant but decreased in magnitude when adding prior achievement to the model. Consistent with previous research, this shows that student hand-raising is related to subsequent achievement (e.g., Burns & Myhill, 2004; Decristan et al., 2019), while it seems that students who raise their hands frequently also have, on average, higher prior achievement (see Kelly, 2008).

Research question 2

In line with previous literature, cognitive engagement and emotional support were both correlated with academic achievement (Christenson et al., 2012; Greene, 2015; Roorda et al., 2011). Interestingly, when effects were tested simultaneously, only the path from student hand-raising to academic achievement was significant while cognitive strategy use (an indicator of cognitive engagement) and teacher emotional support (a facilitator of engagement) did not explain independent variance in students' achievement.

Research question 3

The mediation analyses revealed that hand-raising may act as a mediator in the relation between perceived teacher support and student achievement. This findings is consistent with previous research (e.g., Roorda et al., 2017) and confirms the theoretical assumption that contextual factors and academic outcomes are linked through student engagement (Appleton et al., 2008; Fredricks et al., 2004; Skinner, 2016). Results did not seem to support such an indirect relation for the link between cognitive engagement and achievement through student hand-raising. There was a stronger relation between hand-raising and teacher emotional support than between hand-raising and cognitive engagement. This finding highlights the fact that hand-raising is a classroom behavior that is especially responsive to motivational-affective perceptions of the learning environment.

Taken together, the relation to achievement and cognitive engagement suggests that hand-raising is related to students' learning during classroom interactions. It therefore seems likely that students who raise their hands are engaged with the learning content as they use cognitive strategies to process the presented information and benefit from social learning opportunities during classroom discourse. The association between hand-raising and teacher emotional support draws attention to the role of teachers and underlines the relevance of warm and caring teachers to facilitate students' hand-raising behavior during classroom interaction. The investigated interplay between student hand-raising, teacher emotional support and achievement shows that hand-raising acts as a mediator between contextual factors and outcomes of engagement. Taken together, these findings are in line with those expected from the engagement literature and therefore support the assumption that hand-raising might serve as a useful indicator of behavioral engagement.

7. Discussion

7.1 Discussion of central results

The aim of this dissertation was to gain a better understanding of an everyday classroom behavior and investigate its potential to serve as a novel indicator of students' behavioral engagement. Embedded in the engagement literature, student hand-raising (an indicator of behavioral engagement) was assumed to be related to students' motivation (an antecedent of engagement), perceived teacher emotional support (a contextual factor that facilitates engagement), and students' cognitive strategy use (as an indicator of cognitive engagement). Moreover, based on a constructivist view on learning, student hand-raising was assumed to be related to students' academic achievement. The discussion begins by summarizing the dissertation's empirical findings on student hand-raising (7.1.1). Based on this summary and additional methodological reflections, it is then discussed why hand-raising might serve as a useful indicator of behavioral engagement (7.2.1).

7.1.1 Empirical findings on students' hand-raising behavior

Findings from the present dissertation provide new empirical insights into one of the most salient classroom behaviors in the context of whole-class discourse. The following summary of the dissertation's empirical findings is structured in two sections. The first section summarizes the investigated antecedents and facilitators that were assumed to explain some of the variance in students' hand-raising. The second section summarizes results on the relation between student hand-raising and student achievement.

The video analyses from both study samples (Böheim, Knogler et al. (2020) and Böheim, Urdan et al. (2020)), revealed a substantial variation in the frequency in which students engage in hand-raising with a large number of students who did not raise their hands at all. Consistent with earlier research on students' distribution of active participation (e.g., Brophy & Good, 1970; Clarke et al., 2016; Sacher, 1995; Sedova et al., 2019), this result draws attention to the fact that students differ substantially in their hand-raising behavior. The large variance in students' hand-raising behavior indicates that hand-raising reflects on students' choice and personal investment, i.e., students chose if and how often they want to engage in this behavior to become actively involved in the ongoing learning process.

The present dissertation explored motivation, teacher emotional support and students' cognitive strategy use as possible antecedents and facilitators to explain some of the variance in student hand-raising. Student motivation was assumed to be a central predictor of hand-raising as it is commonly understood as an underlying source that energizes classroom behavior (Ainley, 2012; Maehr & Meyer, 1997; Skinner & Pitzer, 2012). Results revealed that a substantial amount of variance in students' hand-raising was explained by situational (i.e.,

situational interest and external motivation) and stable motivational (i.e., self-concept and individual interest) factors investigated in this dissertation (see Böheim, Knogler et al., 2020). Bivariate correlations showed that hand-raising was positively related to students' interest-based motivation. Thus, hand-raising seems to be related—at least on a bivariate level—to students' in-the-moment experience triggered by learning tasks and activities (i.e., situational interest) as well as to students' stable cognitive-affective orientations towards the content covered in the respective subject domain (i.e., individual subject interest). Previous research similarly shows that students' experience of interest during classroom instruction is a particularly important elicitor of student engagement (Durik & Harackiewicz, 2007; Linnenbrink-Garcia et al., 2013; Patall et al., 2016). Results from this dissertation further revealed a significant negative correlation between hand-raising and students' external motivation, indicating that students who raise their hands more frequently experience less external regulation of their classroom behavior. This finding suggests that hand-raising is more an expression of students' agency and personal interest rather than a behavior that depends on external regulation.

When examined together in a multiple regression analysis, results revealed that only some of the motivational variables remained statistically significant predictors of student hand-raising. Next to a significant negative effect of external motivation, students' self-concept additionally predicted hand-raising in Mathematics while students' situational interest-catch was found to be a significant predictor of hand-raising in GLA. One possible explanation for this different pattern across the investigated subject domains may be related to the different nature and curricula contents typically found in these domains. In Mathematics, students generally worry about the level of task difficulty (OECD, 2013), teacher–student interactions have been found to be more rigid (Stigler et al., 1999), and contents are often complex and challenging. In addition, the video analyses of this dissertation revealed that most of the teacher questions were closed questions (95%), i.e., teachers wanted to hear a single correct answer. Based on this rigid culture it seems plausible that students' self-concept is especially important for students' hand-raising during Mathematics teaching. In contrast, GLA is a subject domain that reflects on diverse and controversial topics (Grossman & Stodolsky, 1995). Consistent with this, the video analyses of this dissertations revealed that roughly every fourth teacher questions in GLA was coded as an open-ended question (allowing multiple correct answers). This might explain why students' self-concept is less important in this domain. Without their self-concept being threatened, it seems plausible that students' contributions and engagement are more an expression of other drivers such as situational interest.

The mixed methods approach taken in this dissertation allowed to compare results from quantitative to qualitative analysis based on student interviews. Overall, the interview data display a similar picture with more students highlighting the role of self-concept in Mathematics

(e.g., “I usually only raise my hand, when I’m absolutely sure, that my answer is correct”), while situational interest-catch was more often referred to in Language Arts (e.g., “When I find something interesting I want to participate”).

Next to student motivation, teacher emotional support was investigated as teacher-related antecedent that facilitates students’ hand-raising behavior (see, Böheim, Urdan et al., 2020). Teacher emotional support has been identified as a central facilitator of student engagement (Fredricks et al., 2004; Ruzek et al., 2016; Skinner et al., 2008; Strati et al., 2017). The present dissertation found that variance in students’ hand-raising behavior was related to differences in students’ perceptions of teacher emotional support. One reason why teacher emotional support was considered to be especially important in the context of student hand-raising is related to the fact that hand-raising is a rather high-stakes decision. Raising one’s hand creates public exposure that may involve the threat of failure or humiliation (Abdullah et al., 2012). Therefore, it seems plausible that students who feel liked by their teacher and are certain that their contribution will be valued are more likely to raise their hands as they are less afraid of insensitive or threatening teacher feedback. Consistent with this finding, results from the interview study (see, Böheim, Knogler et al., 2020), revealed that the majority of students talked about the importance of a good relationship with their teachers when explaining their hand-raising behavior.

In addition to these motivational-affective antecedents and facilitators, students’ cognitive processing was assumed to be related to the variance in students’ hand-raising behavior (see Böheim, Urdan et al., 2020). Based on a constructivist perspective of learning (Loyens & Gijbels, 2008; Windschitl, 2002), it was assumed that students need to be cognitively active to construct thoughts and ideas before they can engage in hand-raising and share their thinking. The dissertation found a small yet statistically significant correlation between hand-raising and students’ cognitive strategy use, suggesting that students who report higher levels of cognitive activity also tend to raise their hands more often. However, students’ cognitive processing did not explain unique portions of variance in students’ hand-raising when simultaneously tested with variables of student motivation (Böheim, Knogler et al., 2020) or teacher emotional support (Böheim, Urdan et al., 2020). Therefore, findings suggest that motivational-affective learner variables play a more important role in explaining the behavior of student hand-raising. This is in line with previous research where motivational variables (including self-concept and interest) were more predictive of students’ situational engagement than students’ cognitive abilities (Lau & Roeser, 2002).

Besides investigating antecedents and facilitators of student hand-raising, the present dissertation assumed that student hand-raising would contribute to students’ learning and achievement (see, Böheim, Urdan et al., 2020). Based on a constructivist perspective of

learning, hand-raising was assumed to be related to student learning because students who raise their hands are assumed to cognitively engage with the learning content (cognitive constructivism, see Piaget, 1930; Windschitl, 2002). In addition, students who raise their hands are likely to benefit from learning processes that arise from social interactions in classroom discourse (e.g., exchanging ideas, receiving feedback) (social constructivism, see P. Cobb & Yackel, 1996; Palincsar, 1998). Consistent with these theoretical assumptions, findings from the present dissertation show that hand-raising is associated with academic achievement (i.e., course grades). This result is in line with earlier research on student hand-raising that was conducted in elementary classrooms (Burns & Myhill, 2004; Decristan et al., 2019). The relation between hand-raising and achievement remained significant even after controlling for prior achievement, suggesting that hand-raising is not merely a correlate of prior ability. However, when controlling for prior-achievement the magnitude between hand-raising and achievement decreased substantially, indicating a clear overlap between high-achieving students and students who engage in hand-raising. This confirms previous research showing that it is more likely for high-ability students to engage in classroom discourse (Decristan et al., 2019; Jurik et al., 2013; Kelly, 2008; Myhill, 2002). Although these results suggest that, on average, higher levels of student hand-raising are related with higher achievement, it should not be concluded that every student who does not engage in hand-raising is a low-achiever. As demonstrated by previous research (e.g., O'Connor et al., 2017), it seems possible that some students are just as cognitively active and learn equally well, while their (covered) learning is not reflected in an observable behavior such as hand-raising.

One interesting question is whether students who raise their hands and are called on perform better than students who raise their hands but are not called on. Here, research suggests that there are no differential effects on students' performance between the group of students who raise their hand and are called on and the group of students who raise their hands but are not called on by their teacher (Decristan et al., 2019; Stahl & Clark, 1987). As argued in the introduction (see section 2.5), all students who raise their hands are expected to benefit from social learning processes either by being verbally engaged (e.g., exchanging their ideas with teachers and peers) or through active listening (e.g., listening to their peers reasoning and comparing their peers thinking to their own ideas). It has often been argued that active listening during classroom discourse may be just as effective as being verbally engaged (Inagaki et al., 1998; O'Connor et al., 2017; Pauli & Lipowsky, 2007). Because hand-raising could be seen as a proxy for active listening it may therefore not be surprising that students who raise their hand without being called on learn just as much as students who raise their hands and are given the opportunity to share their thinking.

In addition to the antecedents investigated (i.e., motivation, teacher emotional support and cognitive strategy use) and outcomes of student hand-raising (i.e., achievement), the present dissertation further examined the interplay between contextual factors, student hand-raising and achievement. Based on the conceptual model of this dissertation (see Figure 1), student hand-raising was investigated as a mediator that links contextual factors and student achievement. Here, a recent meta-analysis provides robust evidence that engagement acts as a mediator between affective aspects of teacher–student relationships and subsequent achievement (Roorda et al., 2017). Consistent with this research, results from the present dissertation suggest that the link between perceived teacher emotional support and academic achievement is mediated through students’ hand-raising behavior. This indirect mechanism is prevalent in motivational frameworks such as self-system theory or SDT, wherein motivational-affective classroom experiences are assumed to prompt behaviors that are pivotal to student learning and achievement (e.g., Connell & Wellborn, 1991; Ryan & Deci, 2000; Skinner et al., 2008). In contrast, literature or theoretical frameworks supporting the same indirect effect for cognitive aspects of engagement are much more sparse (Li & Lerner, 2013). Although the present dissertation found a positive bivariate association between hand-raising and cognitive strategy use, this link did not hold, when teacher emotional support was accounted for. Therefore, the indirect effect of cognitive aspects of engagement and achievement through student hand-raising was not statistically significant in the mediation model (see Böheim, Urdan et al., 2020). As argued earlier, it seems that hand-raising is more responsive to motivational-affective perceptions of the learning environment, while students’ cognitive activity may be interpreted as a relevant, yet not sufficient condition for students to raise their hands.

Taken together, these findings provide new empirical insights into the relation between hand-raising, motivation, teacher emotional support, cognitive strategy use and achievement. In this dissertation, student hand-raising was introduced as a novel indicator of student engagement. The next paragraph summarizes both empirical findings from the present dissertation and methodological reflections that highlight the potential of hand-raising as a useful measure to advance the engagement literature.

7.1.2 The potential of student hand-raising as a useful measure of behavioral engagement

The investigation of students’ hand-raising behavior was embedded in the engagement literature because research and theory on student engagement provide a well-suited framework for the dissertation’s research questions. The present dissertation set out with the assumption that hand-raising would serve as a useful indicator of students’ behavioral

engagement. Based on the work of this dissertation, the following section discusses the potential of student hand-raising to serve as a valid, reliable and objective measure of behavioral engagement.

To examine the validity of this behavioral measure, construct and criterion validity are taken into account. With respect to its construct validity, student hand-raising seems to be a valid indicator of behavioral engagement because it reflects on the core definition of behavioral engagement, i.e., students' active (behavioral) participation in the learning process (see Fredricks et al., 2004). Further, student hand-raising has a substantial conceptual overlap with many aspects of behavioral engagement that have been used to operationalize this dimension of engagement in self-report measures. Self-report measures on behavioral engagement reflect on a variety of aspects such as participation, attention, concentration, effort, or adherence to classroom rules (see Fredricks & McColskey, 2012). Hand-raising incorporates several aspects subsumed under behavioral engagement because it represents a gateway to participation while it could be indicative for the remaining aspects (e.g., attention, concentration, effort, adherence to classroom rules). Therefore, hand-raising may be seen as a rather representative indicator of behavioral engagement.

With respect to its criterion validity, student hand-raising should be associated with typical outcomes (predictive validity) and correlates (concurrent validity) identified by the engagement literature. The fact that hand-raising was found to be a predictor of course grades supports the predictive validity of this behavioral measure. Student engagement is expected to be a robust predictor of important educational outcomes including academic achievement (Appleton et al., 2008; Christenson et al., 2012; Fredricks et al., 2004; Fredricks et al., 2016; Skinner & Pitzer, 2012). In line with the finding from this dissertation, previous research has found that students with higher levels of behavioral engagement achieve higher course grades (e.g., Reeve, 2013; Reyes et al., 2012; Wang & Eccles, 2012a).

In addition, correlations with student motivation, teacher emotional support and students' cognitive strategy use shed more light on the concurrent validity of this behavioral measure. According to the engagement literature, motivation is understood as a central antecedent of student engagement (Ainley, 2012; Appleton et al., 2008; Skinner, 2016; Skinner, Kindermann, Connell et al., 2009). Students' intrinsic motivational experiences have been found to effectively promote behavioral engagement (Jang et al., 2016; Linnenbrink-Garcia et al., 2013; Patall et al., 2016; Ruzek et al., 2016). Consistent with this, hand-raising seems to be an intrinsically motivated behavior that is correlated with students' perceptions of situational and individual interest. Next, different dimensions of engagement are assumed to be interrelated (Christenson et al., 2012; Fredricks et al., 2004; Skinner et al., 2008). In accordance with this, the present dissertation found that student hand-raising (as an indicator

of behavioral engagement) was correlated to the dimension of cognitive engagement (i.e., students' cognitive strategy use). Finally, student engagement is assumed to be malleable and responsive to factors of the educational context (Appleton et al., 2008; Christenson et al., 2012; Fredricks et al., 2004). The engagement literature has placed a strong focus on effective teaching behaviors that facilitate students' engagement in classroom learning (Allen et al., 2013; Fredricks et al., 2004; Pianta, Hamre, & Allen, 2012). In line with previous engagement research (Roorda et al., 2011), this dissertation found a positive correlation between students' perceptions of teacher emotional support and students' hand-raising behavior. The mediating role of hand-raising between teacher emotional support and student achievement is also consistent with the engagement literature wherein engagement is seen as a mediator by which contextual factors are linked to educational outcomes (Appleton et al., 2008; Connell & Wellborn, 1991; Skinner & Pitzer, 2012).

Taken together, the investigated relations to antecedents (motivation and teacher emotional support), and outcomes (achievement) of student hand-raising are consistent with theoretical assumptions and empirical findings from the previous engagement literature and therefore support the criterion validity of hand-raising as an indicator of behavioral engagement.

Besides providing information on its validity, this dissertation gives first insights into the reliability of hand-raising as an indicator of behavioral engagement. Results revealed significant cross-domain correlations (see Böheim, Knogler et al., 2020) and longitudinal correlations (see Böheim, Urda et al., 2020) in students' hand-raising behavior suggesting that this behavioral measure tends to be a rather stable measure of students' engagement. This stability across observations may be interpreted as a form of test-retest reliability. The magnitude of the longitudinal correlation between students' hand-raising behavior at the beginning of the school year and their hand-raising behavior at the end of the school year (see Böheim, Urda et al., 2020) is similar to those found by studies that have investigated students' behavioral engagement as a more general construct (e.g., Gregory et al., 2014; Ruzek et al., 2016). Further, as indicated by Cohen's kappa values of this dissertation, students' hand-raising seems to be a behavioral measure that can be captured with adequate interrater reliability.

Finally, hand-raising seems to be an objective measure of students' behavioral engagement as it represents a low-inference behavior that can be observed by independent coders. In contrast to high-inference classroom observations, collecting data on hand-raising is considered to be economic because it requires reasonable effort concerning observer training and analyses.

It should be mentioned that previous literature has often used verbal engagement as an observable measure of students' engagement (e.g., Jurik et al., 2013; Kelly, 2007;

O'Connor et al., 2017; Pauli & Lipowsky, 2007; Sedova et al., 2019). One advantage of analyzing students' verbal engagement is that it can provide information on the quality of students' verbal contributions. However, students' verbal participation does not accurately reflect on students' engagement for the following two reasons. First, verbal engagement is highly regulated by the teacher because the teacher calls on students and thus decides on who gets to speak. Consequently, some of the students who are considered to be engaged were actually forced to participate (i.e., students who were called on by their teacher without raising their hands). The second shortcoming is that it overlooks students who wanted to engage in classroom interaction (as indicated by a raised hand) but were not called on. Therefore, it seems that hand-raising more accurately reflects on students' engagement as it captures every student who is willing to become actively involved in the learning process. The conceptual difference to verbal engagement may also explain why this dissertation found a link between hand-raising and achievement while several studies that investigate verbal engagement (such as talk time or number of utterances) did not find a link to achievement (Flieller et al., 2016; O'Connor et al., 2017; Pauli & Lipowsky, 2007).

As current engagement research predominately relies on self-reports (Fredricks et al., 2019; Renninger & Bachrach, 2015), results from this dissertation may contribute to advance this literature by pointing at a promising behavioral measure that allows to incorporate more observational data in engagement research. Taken together, student hand-raising seems to be a promising indicator for engagement research as results from this dissertation seem to support that hand-raising acts as a valid, reliable and objective indicator of behavioral engagement.

7.2 Implications for practice

The findings from the present dissertation have a number of implications for practice as teachers experience hand-raising in their everyday interactions with students. Classrooms are social learning environments that require students' active (and voluntary) participation to jointly construct knowledge and create a shared understanding of the content. The present research provides evidence for teachers that hand-raising matters. Results suggest that hand-raising is an expression of student motivation and that it is related to student learning and achievement. Results from this dissertation draw the attention to the unequal distribution of students' hand-raising with many students not raising their hands at all. Teachers may therefore reflect on how to motivate those students who seem reluctant to raise their hands. One main implication from this dissertation is that hand-raising seems to be an intrinsically motivated behavior that is elicited by students' interest. Therefore, classroom instruction

should support and nurture students' interest development, e.g. by introducing a challenging and exciting learning task.

Moreover, as indicated by the strong association to students' self-concept, it seems likely that several students are hesitant to participate because they are not confident in the correctness of their answer and may fear their teacher's reaction when making a mistake. To avoid this barrier, that might prevent students from participating, teachers may reflect on their feedback behavior (e.g., Hattie & Timperley, 2007) and the way they articulate criticism (e.g., Skipper & Douglas, 2015). For example, they could openly communicate that mistakes are an important resource for learning and they should avoid person criticism when students do not provide a correct answer. One student from the interview study argued that she or he engages in hand-raising more frequently when the teacher "listens to [the] answer, even if it's wrong and then explains where the mistake is" (see Böheim, Knogler et al., 2020).

Finally, the present dissertation identified teacher emotional support as a central facilitator of students' hand-raising. It therefore seems promising to invest in warm and caring relationships with students that make them feel seen, liked, and valued. Similar to previous classroom research (Seidel & Prenzel, 2006; Stigler et al., 1999), this dissertation shows that classroom discourse in German high-schools is rather narrowly focused with asking and replying to closed questions being the dominant mode of interaction. In such learning environments, hand-raising may be experienced as a high-stakes decision as the probability for giving an incorrect answer is high. Here, teachers' care and warmth may act as an effective countermeasure in creating a less threatening learning environment. Research highlights that teacher' emotional involvement can also foster students' self-determined motivation which in turn is likely to promote students' active participation in classroom learning (Connell & Wellborn, 1991; Roorda et al., 2011).

7.3 Limitations and further directions

There are several limitations that should be considered when interpreting the dissertation's results and their implications for research and practice. First, across the investigated classrooms, the majority of class time was spent in teacher-centered classroom discourse, wherein teachers ask questions and students need to raise their hands to give answers or ask questions themselves. Evidently, the behavior of hand-raising is ubiquitous in this teaching setting and therefore useful to capture students' behavioral engagement. However, it should be mentioned that during lessons where students work on individual tasks or in smaller groups, other observable classroom behaviors (e.g., taking notes, time on task, talking to classmates) seem more valid for measuring student engagement.

Second, generalization is restricted to the investigated school level because all classrooms were drawn from academic-track secondary schools. Students' hand-raising behavior among high school students is likely to differ from students from elementary classrooms, given that there is an overall decline in engagement during the course of schooling (Wigfield et al., 2015). Since younger students have stronger universal interests (Schiefele, 2009) and academic self-concepts (Scherrer & Preckel, 2018; Wigfield et al., 2015) it seems plausible that students from elementary school would generally show a higher motivation to interact with their peers. The present dissertation highlights that relations between motivation and student hand-raising differ between subject domains (see Böheim, Knogler et al., 2020). Therefore, it is important to mention that the generalization of the dissertation's results are further restricted to the investigated academic domains.

Third, across both study samples the analyses of students' hand-raising rely on a single videotaped lesson in each investigated classroom. Here, multiple classroom observations would have been helpful to increase the reliability of this behavioral measure. Notwithstanding these limitations, it should be mentioned that this dissertation found a significant correlation between students hand-raising behavior at the beginning and at the end of the school year (see Böheim, Urdan et al., 2020) as well as a significant correlation between students' hand-raising in Mathematics and students hand-raising in Language Arts (see Böheim, Knogler et al., 2020). These findings suggest that hand-raising tends to be a rather stable and thus reliable behavioral variable.

Fourth, the temporal ordering of the investigated variables limits conclusions about the causal nature of the investigated associations. For example, while students' achievement was collected three month after observing students' hand-raising behavior (supporting the temporal ordering of these variables in the analyses), it should be noted that students' reports of cognitive engagement and teacher emotional support were not assessed prior to the videotaped lesson but directly after the videotaped lesson (see Böheim, Urdan et al., 2020). Therefore, information about the directionality of associations are often limited to the underlying theoretical assumptions and previous research findings based on the engagement literature. Here, longitudinal research is needed to empirically validate the causality of these relationships.

Fifth, the empirical investigation of students' hand-raising in this dissertation was mainly driven from a motivational-affective perspective. Because hand-raising was construed as a form of voluntary and intentional engagement it was assumed that its variation would be especially responsive to differences in students' motivational experiences. However, whether or not students raise their hands is a decision that is likely to be based on a complex interplay between a variety of internal and contextual factors. This complex interplay between contextual

factors, student perceptions and classroom engagement is illustrated in various teaching and learning models that are found in classroom research (e.g., Kunter & Trautwein, 2013; Seidel, 2014) as well as engagement research (e.g., Reschly & Christenson, 2012, 2019; Skinner, 2016; Wang et al., 2019). Further research could therefore account for additional internal factors (e.g., intelligence, pre-knowledge, academic emotions) and external factors (e.g., peer context, teaching context) that are likely to explain additional variance in students' hand-raising behavior. The interview study conducted in this dissertation (see Böheim, Knogler et al., 2020) gives first insights into diversity of possible teacher-related behaviors (e.g., instructional clarity, student activation) that students take into account when raising their hands.

Sixth, in this dissertation the frequency in hand-raising was summed per student to form an indicator for students' behavioral engagement during the videotaped lesson. To obtain a more in-depth understanding of the specific context that triggers this classroom behavior, future research may explore student hand-raising at the microlevel of specific educational tasks or learning activities. Insights from such research are likely to be useful for practitioners as they are based on specific situations.

Finally, it should be acknowledged that the current approach to capture students' hand-raising behavior does involve a considerable organizational effort that is needed to prepare and conduct the video recordings. Moreover, it involves a coding procedure of a behavior that is frequent, has a short duration, and often occurs simultaneously among students. In addition, setting up video cameras in classrooms can be obtrusive and distracting for students and teachers. Therefore, future research might look into recent technological advances that allow to capture student engagement in real-time (for a review, see Fredricks et al., 2019). In recent years, several devices have been developed that allow to measure student engagement based on facial expression, eye tracking or body movement (D'Mello et al., 2017). To simplify the process of collecting data on student hand-raising it seems possible that digital devices (e.g., a bracelet that recognizes movement) could also be used to measure students' hand-raising. This would increase the efficiency of data collection and analysis and would therefore allow researchers to collect behavioral data of students' engagement from larger samples with a relatively unobtrusive method.

7.4 Conclusion

The present dissertation revealed important insights into an everyday classroom behavior that contribute to both classroom research and engagement research. Student hand-raising is one of the most salient student behaviors as it represents students' gateway to verbal participation and collective sense making. Despite its pivotal role, student hand-raising has received little research attention in recent years. The present dissertation therefore contributes

to classroom research by shedding new light on central antecedents and facilitators that contribute to a better understanding of what motivates and supports students to engage in this classroom behavior. Student hand-raising seems to be an intrinsically motivated behavior that is responsive to motivational-affective perceptions of the learning environment. Relations to cognitive engagement and academic achievement underline the relevance of this behavior for student learning. The dissertation further contributes to engagement research because hand-raising was introduced and investigated as an observable indicator of behavioral engagement. Taken together, findings from the present dissertation highlight the potential of student hand-raising to serve as a useful indicator for the engagement literature. As a response to the call for an increased implementation of observable measures in engagement research, this dissertation draws attention to the behavior of student hand-raising as an opportunity to incorporate more observational data in this research field.

8. References

- Abdullah, M. Y., Bakar, N. R. A., & Mahbob, M. H. (2012). Student's participation in classroom: What motivates them to speak up? *Procedia - Social and Behavioral Sciences*, 51, 516–522. <https://doi.org/10.1016/j.sbspro.2012.08.199>
- Abernethy, M. (2015). Self-reports and observer reports as data generation methods: An assessment of issues of both methods. *Universal Journal of Psychology*, 3(1), 22–27.
- Ahn, I., Patrick, H., Chiu, M. M., & Levesque-Bristol, C. (2019). Measuring teacher practices that support student motivation: Examining the factor structure of the teacher as social context questionnaire using multilevel factor analyses. *Journal of Psychoeducational Assessment*, 37(6), 743–756. <https://doi.org/10.1177/0734282918791655>
- Ainley, M. (1993). Styles of engagement with learning: Multidimensional assessment of their relationship with strategy use and school achievement. *Journal of Educational Psychology*, 85(3), 395–405. <https://doi.org/10.1037/0022-0663.85.3.395>
- Ainley, M. (2012). Students' interest and engagement in classroom activities. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 283–302). Springer.
- Ainley, M. (2017). Interest: Knows, unknowns, and basic processes. In P. A. O'Keefe & J. M. Harackiewicz (Eds.), *The science of interest* (pp. 3–24). Springer International Publishing.
- Alexander, R. (2008). *Towards dialogic teaching: Rethinking classroom talk* (4th ed.). Dialogos.
- Alexander, R. (2018). *Towards dialogic teaching: Rethinking classroom talk* (5th ed.). Dialogos.
- Allen, J. P., Gregory, A., Mikami, A. Y., Lun, J., Hamre, B. K., & Pianta, R. C. (2013). Observations of effective teacher-student interactions in secondary school classrooms: Predicting student achievement with the classroom assessment scoring system–secondary. *School Psychology Review*, 42(1), 76–98. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5602545/>
- Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science*, 333(6045), 1034–1037. <https://doi.org/10.1126/science.1207998>
- Altermatt, E. R., Jovanovic, J., & Perry, M. (1998). Bias or responsiveness? Sex and achievement-level effects on teachers' classroom questioning practices. *Journal of Educational Psychology*, 90(3), 516–527. <https://doi.org/10.1037/0022-0663.90.3.516>

- Anderman, E. M., & Patrick, H. (2012). Achievement goal theory, conceptualization of ability / intelligence, and classroom climate. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 173–191). Springer.
- Appleton, J. J. (2012). Systems consultation: Developing the assessment-to-intervention link with the student engagement instrument. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 725–742). Springer.
- Appleton, J. J., Christenson, S. L., & Furlong, M. J. (2008). Student engagement with school: Critical conceptual and methodological issues of the construct. *Psychology in the Schools, 45*(5), 369–386. <https://doi.org/10.1002/pits.20303>
- Appleton, J. J., Christenson, S. L., Kim, D., & Reschly, A. L. (2006). Measuring cognitive and psychological engagement: Validation of the Student Engagement Instrument. *Journal of School Psychology, 44*(5), 427–445. <https://doi.org/10.1016/j.jsp.2006.04.002>
- Azevedo, R. (2015). Defining and measuring engagement and learning in science: Conceptual, theoretical, methodological, and analytical issues. *Educational Psychologist, 50*(1), 84–94. <https://doi.org/10.1080/00461520.2015.1004069>
- Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software, 67*(1). <https://doi.org/10.18637/jss.v067.i01>
- Black, L. (2004). Differential participation in whole-class discussions and the construction of marginalised identities. *The Journal of Educational Enquiry, 5*(1), 34–54.
- Böheim, R., Knogler, M., Kosel, C., & Seidel, T. (2020). Exploring student hand-raising across two school subjects using mixed methods: An investigation of an everyday classroom behavior from a motivational perspective. *Learning and Instruction, 65*, 101250. <https://doi.org/10.1016/j.learninstruc.2019.101250>
- Böheim, R., Urdan, T., Knogler, M., & Seidel, T. (2020). Student hand-raising as an indicator of behavioral engagement and its role in classroom learning. *Contemporary Educational Psychology, 62*, 101894. <https://doi.org/10.1016/j.cedpsych.2020.101894>
- Brophy, J. E., & Good, T. L. (1970). Teachers' communication of differential expectations for children's classroom performance: Some behavioral data. *Journal of Educational Psychology, 61*(5), 365–374. <https://doi.org/10.1037/h0029908>
- Burns, C., & Myhill, D. (2004). Interactive or inactive? A consideration of the nature of interaction in whole class teaching. *Cambridge Journal of Education, 34*(1), 35–49. <https://doi.org/10.1080/0305764042000183115>
- Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243. <https://doi.org/10.1080/00461520.2014.965823>

- Christenson, S. L., Reschly, A. L., & Wylie, C. (Eds.). (2012). *Handbook of research on student engagement*. Springer.
- Clarke, S. N., Howley, I., Resnick, L., & Penstein Rosé, C. (2016). Student agency to participate in dialogic science discussions. *Learning, Culture and Social Interaction, 10*, 27–39. <https://doi.org/10.1016/j.lcsi.2016.01.002>
- Cobb, J. A. (1972). Relationship of discrete classroom behaviors to fourth-grade academic achievement. *Journal of Educational Psychology, 63*(1), 74–80. <https://doi.org/10.1037/h0032247>
- Cobb, P., & Yackel, E. (1996). Constructivist, emergent, and sociocultural perspectives in the context of developmental research. *Educational Psychologist, 31*(3-4), 175–190. <https://doi.org/10.1080/00461520.1996.9653265>
- Connell, J. P., & Wellborn, J. G. (1991). Competence, autonomy, and relatedness: A motivational analysis of self-system processes. In M. R. Gunnar & L. A. Sroufe (Eds.), *The Minnesota symposia on child psychology, Vol. 23. Self processes and development* (pp. 43–77). Lawrence Erlbaum Associates, Inc.
- Cornelius-White, J. (2007). Learner-centered teacher-student relationships are effective: A meta-analysis. *Review of Educational Research, 77*(1), 113–143. <https://doi.org/10.3102/003465430298563>
- Davis, H. A. (2003). Conceptualizing the role and influence of student-teacher relationships on children's social and cognitive development. *Educational Psychologist, 38*(4), 207–234. https://doi.org/10.1207/S15326985EP3804_2
- Decristan, J., Fauth, B., Heide, E. L., Locher, F. M., Troll, B., Kurucz, C., & Kunter, M. (2019). Individuelle Beteiligung am Unterrichtsgespräch in Grundschulklassen: Wer ist (nicht) beteiligt und welche Konsequenzen hat das für den Lernerfolg? [Students' differential participation in classroom discourse in primary schools: Who participates (not), and what are the consequences for student learning?]. *Zeitschrift Für Pädagogische Psychologie/German Journal of Educational Psychology, 5*, 1–16. <https://doi.org/10.1024/1010-0652/a000251>
- Dixon, J. K., Egendoerfer, L. A., & Clements, T. (2009). Do they really need to raise their hands? Challenging a traditional social norm in a second grade mathematics classroom. *Teaching and Teacher Education, 25*(8), 1067–1076. <https://doi.org/10.1016/j.tate.2009.04.011>
- D'Mello, S., Dieterle, E., & Duckworth, A. (2017). Advanced, analytic, automated (AAA) measurement of engagement during learning. *Educational Psychologist, 52*(2), 104–123. <https://doi.org/10.1080/00461520.2017.1281747>

- Durik, A. M., & Harackiewicz, J. M. (2007). Different strokes for different folks: How individual interest moderates the effects of situational factors on task interest. *Journal of Educational Psychology, 99*(3), 597–610. <https://doi.org/10.1037/0022-0663.99.3.597>
- Durik, A. M., Lindeman, M. H., & Coley, S. L. (2017). The power within: How individual interest promotes domain-relevant task engagement. In P. A. O'Keefe & J. M. Harackiewicz (Eds.), *The science of interest* (pp. 125–148). Springer International Publishing.
- Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist, 41*(10), 1040–1048. <https://doi.org/10.1037/0003-066X.41.10.1040>
- Eccles, J. S. (2016). Engagement: Where to next? *Learning and Instruction, 43*, 71–75. <https://doi.org/10.1016/j.learninstruc.2016.02.003>
- Eccles, J. S., & Roeser, R. W. (2009). Schools, academic motivation, and stage-environment fit. In *Handbook of Adolescent Psychology* (pp. 404–434). John Wiley & Sons, Inc. <https://doi.org/10.1002/9780470479193.adlpsy001013>
- Eccles, J. S., & Roeser, R. W. (2015). School and community influences on human development. In M. H. Bornstein & M. E. Lamb (Eds.), *Developmental science: An advanced textbook* (pp. 645–728). Psychology Press.
- Eccles, J. S., & Wang, M.-T. (2012). So what is student engagement anyway? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 133–145). Springer.
- Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109–132. <https://doi.org/10.1146/annurev.psych.53.100901.135153>
- Finn, J. D. (1989). Withdrawing from school. *Review of Educational Research, 59*(2), 117–142. <https://doi.org/10.3102/00346543059002117>
- Finn, J. D. (1993). *School engagement and students at risk*. National Center for Education Statistics.
- Finn, J. D., & Zimmer, K. S. (2012). Student Engagement: What Is It? Why Does It Matter? In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 97–132). Springer.
- Flieller, A., Jarlégan, A., & Tazouti, Y. (2016). Who benefits from dyadic teacher–student interactions in whole-class settings? *The Journal of Educational Research, 109*(3), 311–324. <https://doi.org/10.1080/00220671.2014.950718>
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. <https://doi.org/10.3102/00346543074001059>

- Fredricks, J. A., Filsecker, M., & Lawson, M. A. (2016). Student engagement, context, and adjustment: Addressing definitional, measurement, and methodological issues. *Learning and Instruction, 43*, 1–4. <https://doi.org/10.1016/j.learninstruc.2016.01.009>
- Fredricks, J. A., Hofkens, T., & Wang, M.-T. (2019). Addressing the challenge of measuring student engagement. In K. A. Renninger & S. E. Hidi (Eds.), *Cambridge handbook on motivation and learning* (pp. 689–712). Cambridge University Press.
- Fredricks, J. A., & McColskey, W. (2012). The measurement of student engagement: A comparative analysis of various methods and student self-report instruments. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 763–782). Springer.
- Fryer, L. K., & Dinsmore, D. L. (2020). The promise and pitfalls of self-report. *Frontline Learning Research, 8*(3), 1–9. <https://doi.org/10.14786/flr.v8i3.623>
- Galton, M., Hargreaves, L., Comber, C., Wall, D., & Pell, T. (1999). Changes in patterns of teacher interaction in primary classrooms: 1976-96. *British Educational Research Journal, 25*(1), 23–37. <https://doi.org/10.1080/0141192990250103>
- Gobert, J. D., Baker, R. S., & Wixon, M. B. (2015). Operationalizing and detecting disengagement within online science microworlds. *Educational Psychologist, 50*(1), 43–57. <https://doi.org/10.1080/00461520.2014.999919>
- Goetz, T., Frenzel, A. C., Pekrun, R., Hall, N. C., & Lüdtke, O. (2007). Between- and within-domain relations of students' academic emotions. *Journal of Educational Psychology, 99*(4), 715–733. <https://doi.org/10.1037/0022-0663.99.4.715>
- Greene, B. A. (2015). Measuring cognitive engagement with self-report scales: Reflections from over 20 years of research. *Educational Psychologist, 50*(1), 14–30. <https://doi.org/10.1080/00461520.2014.989230>
- Greene, B. A., & Miller, R. B. (1996). Influences on achievement: Goals, perceived ability, and cognitive engagement. *Contemporary Educational Psychology, 21*(2), 181–192. <https://doi.org/10.1006/ceps.1996.0015>
- Gregory, A., Allen, J. P., Mikami, A. Y., Hafen, C. A., & Pianta, R. C. (2014). Effects of a professional development program on behavioral engagement of students in middle and high school. *Psychology in the Schools, 51*(2), 143–163. <https://doi.org/10.1002/pits.21741>
- Grossman, P. L., & Stodolsky, S. S. (1995). Content as context: The role of school subjects in secondary school teaching. *Educational Researcher, 24*(8), 5–23. <https://doi.org/10.3102/0013189X024008005>
- Guo, Y., Sun, S., Breit-Smith, A., Morrison, F. J., & Connor, C. M. (2015). Behavioral engagement and reading achievement in elementary-school-age children: A longitudinal

- cross-lagged analysis. *Journal of Educational Psychology*, 107(2), 332–347. <https://doi.org/10.1037/a0037638>
- Hafen, C. A., Hamre, B. K., Allen, J. P., Bell, C. A., Gitomer, D. H., & Pianta, R. C. (2015). Teaching through interactions in secondary school classrooms: Revisiting the factor structure and practical application of the classroom assessment scoring system-secondary. *The Journal of Early Adolescence*, 35(5-6), 651–680. <https://doi.org/10.1177/0272431614537117>
- Harackiewicz, J. M., & Knogler, M. (2017). Interest: Theory and application. In A. J. Elliot, C. S. Dweck, & D. S. Yeager (Eds.), *Handbook of competence and motivation: Theory and application* (2nd ed., pp. 334–352). Guilford Publications.
- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81–112. <https://doi.org/10.3102/003465430298487>
- Hertel, S., Hochweber, J., Mildner, D., Steinert, B., & Jude, N. (2014). *PISA 2009 Skalenhandbuch*. Waxmann.
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4
- Hiebert, J., Gallimore, R., Garnier, K., Bogard Givvin, K., Hollingsworth, J., Jacobs, J., Chui, A. M. Y., Wearne, D., Smith, M., Kersting, N., Manaster, A., Tseng, E., Etterbeek, W., Manaster, C., Gonzales, P., & Stigler, J. W. (2003). *Teaching mathematics in seven countries. Results from the TIMSS 1999 video study*. U.S. Department of Education.
- Howe, C., & Abedin, M. (2013). Classroom dialogue: A systematic review across four decades of research. *Cambridge Journal of Education*, 43(3), 325–356. <https://doi.org/10.1080/0305764X.2013.786024>
- Huber, S. A., & Seidel, T. (2018). Comparing teacher and student perspectives on the interplay of cognitive and motivational-affective student characteristics. *PloS One*, 13(8), e0200609. <https://doi.org/10.1371/journal.pone.0200609>
- Inagaki, K., Hatano, G., & Morita, E. (1998). Construction of mathematical knowledge through whole-class discussion. *Learning and Instruction*, 8(6), 503–526. [https://doi.org/10.1016/S0959-4752\(98\)00032-2](https://doi.org/10.1016/S0959-4752(98)00032-2)
- Jang, H., Kim, E. J., & Reeve, J. (2012). Longitudinal test of self-determination theory's motivation mediation model in a naturally occurring classroom context. *Journal of Educational Psychology*, 104(4), 1175–1188. <https://doi.org/10.1037/a0028089>
- Jang, H., Kim, E. J., & Reeve, J. (2016). Why students become more engaged or more disengaged during the semester: A self-determination theory dual-process model. *Learning and Instruction*, 43, 27–38. <https://doi.org/10.1016/j.learninstruc.2016.01.002>

- Jurik, V., Gröschner, A., & Seidel, T. (2013). How student characteristics affect girls' and boys' verbal engagement in physics instruction. *Learning and Instruction, 23*, 33–42. <https://doi.org/10.1016/j.learninstruc.2012.09.002>
- Jurik, V., Häusler, J., Stubben, S., & Seidel, T. (2015). Interaction: Erste Ergebnisse einer vergleichenden Videostudie im Deutsch- und Mathematikunterricht. *Zeitschrift Für Pädagogik, 61*(5), 692–711.
- Kelly, S. (2007). Classroom discourse and the distribution of student engagement. *Social Psychology of Education, 10*(3), 331–352. <https://doi.org/10.1007/s11218-007-9024-0>
- Kelly, S. (2008). Race, social class, and student engagement in middle school English classrooms. *Social Science Research, 37*(2), 434–448. <https://doi.org/10.1016/j.ssresearch.2007.08.003>
- Knogler, M., Harackiewicz, J. M., Gegenfurtner, A., & Lewalter, D. (2015). How situational is situational interest? Investigating the longitudinal structure of situational interest. *Contemporary Educational Psychology, 43*, 39–50. <https://doi.org/10.1016/j.cedpsych.2015.08.004>
- Kobarg, M., & Seidel, T. (2005). Coding manual – Process-oriented teaching. In T. Seidel, M. Prenzel, & M. Kobarg (Eds.), *How to run a video study: Technical report of the IPN Video Study* (pp. 108–144). Waxmann.
- Kobarg, M., & Seidel, T. (2007). Process-oriented teaching – Video analyses in high school physics instruction [Prozessorientierte Lernbegleitung - Videoanalysen im Physikunterricht der Sekundarstufe I]. *Unterrichtswissenschaft, 35*(2), 148–168.
- Komarraju, M., & Karau, S. J. (2005). The relationship between the big five personality traits and academic motivation. *Personality and Individual Differences, 39*(3), 557–567. <https://doi.org/10.1016/j.paid.2005.02.013>
- Krapp, A. (2002). Structural and dynamic aspects of interest development: theoretical considerations from an ontogenetic perspective. *Learning and Instruction, 12*(4), 383–409. [https://doi.org/10.1016/S0959-4752\(01\)00011-1](https://doi.org/10.1016/S0959-4752(01)00011-1)
- Krapp, A., & Prenzel, M. (2011). Research on interest in science: Theories, methods, and findings. *International Journal of Science Education, 33*(1), 27–50. <https://doi.org/10.1080/09500693.2010.518645>
- Kunter, M., & Trautwein, U. (2013). *Psychologie des Unterrichts. StandardWissen Lehramt: Vol. 3895*. Ferdinand Schöningh.
- Lau, S., & Roeser, R. W. (2002). Cognitive abilities and motivational processes in high school students' situational engagement and achievement in science. *Educational Assessment, 8*(2), 139–162. https://doi.org/10.1207/S15326977EA0802_04

- Li, Y., & Lerner, R. M. (2013). Interrelations of behavioral, emotional, and cognitive school engagement in high school students. *Journal of Youth and Adolescence*, 42(1), 20–32. <https://doi.org/10.1007/s10964-012-9857-5>
- Lietaert, S., Roorda, D. L., Laevers, F., Verschueren, K., & Fraine, B. d. (2015). The gender gap in student engagement: The role of teachers' autonomy support, structure, and involvement. *The British Journal of Educational Psychology*, 85(4), 498–518. <https://doi.org/10.1111/bjep.12095>
- Linnenbrink-Garcia, L., Patall, E. A., & Messersmith, E. E. (2013). Antecedents and consequences of situational interest. *The British Journal of Educational Psychology*, 83, 591–614. <https://doi.org/10.1111/j.2044-8279.2012.02080.x>
- Lipowsky, F., Rakoczy, K., Pauli, C., Reusser, K., & Klieme, E. (2007). Gleicher Unterricht - gleiche Chancen für alle? Die Verteilung von Schülerbeiträgen im Klassenunterricht. *Unterrichtswissenschaft*, 35(2), 125–147.
- Loyens, S. M. M., & Gijbels, D. (2008). Understanding the effects of constructivist learning environments: Introducing a multi-directional approach. *Instructional Science*, 36(5), 351–357. <https://doi.org/10.1007/s11251-008-9059-4>
- Maehr, M. L., & Meyer, H. A. (1997). Understanding motivation and schooling: Where we've been, where we are, and where we need to go. *Educational Psychology Review*, 9(4), 371–409. <https://doi.org/10.1023/A:1024750807365>
- Marks, H. M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. *American Educational Research Journal*, 37(1), 153–184.
- Marsh, H. W., & Martin, A. J. (2011). Academic self-concept and academic achievement: Relations and causal ordering. *The British Journal of Educational Psychology*, 81(Pt 1), 59–77. <https://doi.org/10.1348/000709910X503501>
- Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development*, 76(2), 397–416. <https://doi.org/10.1111/j.1467-8624.2005.00853.x>
- Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2006). Integration of multidimensional self-concept and core personality constructs: Construct validation and relations to well-being and achievement. *Journal of Personality*, 74(2), 403–456. <https://doi.org/10.1111/j.1467-6494.2005.00380.x>
- Martin, A. J. (2012). Motivation and engagement: Conceptual, operational, and empirical clarity. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 303–311). Springer.

- Mercer, N., & Dawes, L. (2014). The study of talk between teachers and students, from the 1970s until the 2010s. *Oxford Review of Education*, 40(4), 430–445. <https://doi.org/10.1080/03054985.2014.934087>
- Mitchell, M. (1993). Situational interest: Its multifaceted structure in the secondary school mathematics classroom. *Journal of Educational Psychology*, 85(3), 424–436. <https://doi.org/10.1037/0022-0663.85.3.424>
- Myhill, D. (2002). Bad boys and good girls? Patterns of interaction and response in whole class teaching. *British Educational Research Journal*, 28(3), 339–352. <https://doi.org/10.1080/01411920220137430>
- National Institute of Child Health and Human Development Early Child Care (2005). A day in third grade: A large-scale study of classroom quality and teacher and student behavior. *The Elementary School Journal*, 105(3), 305–323. <https://doi.org/10.1086/428746>
- Nolen, S. B. (1988). Reasons for studying: Motivational orientations and study strategies. *Cognition and Instruction*, 5(4), 269–287. <http://www.jstor.org/stable/3233573>
- O'Connor, C., Michaels, S., Chapin, S., & Harbaugh, A. G. (2017). The silent and the vocal: Participation and learning in whole-class discussion. *Learning and Instruction*, 48, 5–13. <https://doi.org/10.1016/j.learninstruc.2016.11.003>
- OECD. (2005). *PISA 2003 Technical report*. PISA. OECD Publishing.
- OECD. (2013). *PISA 2012 Assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy*. OECD Publishing. <https://doi.org/10.1787/9789264190511-en>
- OECD (Ed.). (2014). *PISA 2012 technical report*. PISA. OECD Publishing.
- O'Keefe, P. A., & Harackiewicz, J. M. (Eds.). (2017). *The science of interest*. Springer International Publishing. <http://dx.doi.org/10.1007/978-3-319-55509-6> <https://doi.org/10.1007/978-3-319-55509-6>
- O'Keefe, P. A., Horberg, E. J., & Plante, I. (2017). The multifaceted role of interest in motivation and engagement. In P. A. O'Keefe & J. M. Harackiewicz (Eds.), *The science of interest* (pp. 49–67). Springer International Publishing.
- Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology*, 49, 345–375. <https://doi.org/10.1146/annurev.psych.49.1.345>
- Patall, E. A., Vasquez, A. C., Steingut, R. R., Trimble, S. S., & Pituch, K. A. (2016). Daily interest, engagement, and autonomy support in the high school science classroom. *Contemporary Educational Psychology*, 46, 180–194. <https://doi.org/10.1016/j.cedpsych.2016.06.002>

- Pauli, C., & Lipowsky, F. (2007). Mitmachen oder Zuhören? Mündliche Schülerinnen- und Schülerbeteiligung im Mathematikunterricht [Listening or joining in? Student participation in whole-class discussions and teacherstudent interactions in mathematics classrooms]. *Unterrichtswissenschaft*, 35(2), 101–124.
- Pekrun, R. (2020). Self-report is indispensable to assess students' learning. *Frontline Learning Research*, 8(3), 185–193. <https://doi.org/10.14786/flr.v8i3.637>
- Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 259–282). Springer.
- Piaget, J. (1930). *The child's conception of physical causality*. Harcourt, Brace.
- Pianta, R. C., & Hamre, B. K. (2009). Conceptualization, measurement, and improvement of classroom processes: Standardized observation can leverage capacity. *Educational Researcher*, 38(2), 109–119. <https://doi.org/10.3102/0013189X09332374>
- Pianta, R. C., Hamre, B. K., & Allen, J. P. (2012). Teacher-student relationships and engagement: Conceptualizing, measuring, and improving the capacity of classroom interactions. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 365–368). Springer.
- Pianta, R. C., Hamre, B. K., & Mintz, S. L. (2012). *Classroom Assessment Scoring System (CLASS): Secondary class manual*. University of Virginia Press.
- Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, 95(4), 667–686. <https://doi.org/10.1037/0022-0663.95.4.667>
- Praetorius, A.-K., & Charalambous, C. Y. (2018). Classroom observation frameworks for studying instructional quality: Looking back and looking forward. *ZDM*, 50(3), 535–553. <https://doi.org/10.1007/s11858-018-0946-0>
- Praetorius, A.-K., Klieme, E., Herbert, B., & Pinger, P. (2018). Generic dimensions of teaching quality: the German framework of Three Basic Dimensions. *ZDM*, 50(3), 407–426. <https://doi.org/10.1007/s11858-018-0918-4>
- R Development Core Team (2018). R: A language and environment for statistical computing (version 3.5.1) [Computer software]. <https://www.r-project.org/>
- Ramm, G. C., Prenzel, M., Baumert, J., Blum, W., Lehmann, R., Leutner, D., Neubrand, M., Pekrun, R., Rolff, H. G., Rost, J., & Schiefele, U. (Eds.). (2006). *PISA 2003: Dokumentation der Erhebungsinstrumente*. Waxmann.

- Reeve, J. (2012). A self-determination theory perspective on student engagement. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 149–172). Springer.
- Reeve, J. (2013). How students create motivationally supportive learning environments for themselves: The concept of agentic engagement. *Journal of Educational Psychology*, *105*(3), 579–595. <https://doi.org/10.1037/a0032690>
- Reeve, J., Cheon, S. H., & Yu, T. H. (2020). An autonomy-supportive intervention to develop students' resilience by boosting agentic engagement. *International Journal of Behavioral Development*, 016502542091110. <https://doi.org/10.1177/0165025420911103>
- Reeve, J., Ryan, R. M., & Deci, E. (2018). Sociocultural influences on student motivation as viewed through the lens of self-determination theory. In G. A. D. Liem & D. M. McInerney (Eds.), *Research on Sociocultural Influences on Motivation and Learning Ser. Big Theories Revisited 2* (pp. 15–40). Information Age Publishing Incorporated.
- Reeve, J., & Tseng, C.-M. (2011). Agency as a fourth aspect of students' engagement during learning activities. *Contemporary Educational Psychology*, *36*(4), 257–267. <https://doi.org/10.1016/j.cedpsych.2011.05.002>
- Renninger, K. A., & Bachrach, J. E. (2015). Studying triggers for interest and engagement using observational methods. *Educational Psychologist*, *50*(1), 58–69. <https://doi.org/10.1080/00461520.2014.999920>
- Renninger, K. A., & Hidi, S. (2011). Revisiting the conceptualization, measurement, and generation of interest. *Educational Psychologist*, *46*(3), 168–184. <https://doi.org/10.1080/00461520.2011.587723>
- Renninger, K. A., & Hidi, S. E. (2016). *The power of interest for motivation and engagement*. Routledge Taylor & Francis Group.
- Renninger, K. A., Hidi, S., & Krapp, A. (Eds.). (1992). *The role of interest in learning and development*. Erlbaum. <http://www.loc.gov/catdir/enhancements/fy0742/92002865-d.html>
- Reschly, A. L., & Christenson, S. L. (2012). Jingle, jangle, and conceptual haziness: Evolution and future directions of the engagement construct. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 3–19). Springer.
- Reschly, A. L., & Christenson, S. L. (2019). The intersection of student engagement and families: A critical connection for achievement and life outcomes. In J. A. Fredricks, A. L. Reschly, & S. L. Christenson (Eds.), *Handbook of student engagement interventions: Working with disengaged students* (pp. 57–72). Academic Press.
- Resnick, L. B., Asterhan, C. S.C., & Clarke, S. N. (Eds.). (2015). *Socializing intelligence through academic talk and dialogue*. American Educational Research Association.

- Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology, 104*(3), 700–712. <https://doi.org/10.1037/a0027268>
- Roeser, R. W., Urdan, T., & Stephens, J. M. (2009). School as a context of student motivation and achievement. In K. R. Wentzel & A. Wigfield (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 381–410). Routledge.
- Roorda, D. L., Jak, S., Zee, M., Oort, F. J., & Koomen, H. M. Y. (2017). Affective teacher–student relationships and students' engagement and achievement: A meta-analytic update and test of the mediating role of engagement. *School Psychology Review, 46*(3), 239–261. <https://doi.org/10.17105/SPR-2017-0035.V46-3>
- Roorda, D. L., Koomen, H. M. Y., Spilt, J. L., & Oort, F. J. (2011). The influence of affective teacher–student relationships on students' school engagement and achievement. *Review of Educational Research, 81*(4), 493–529. <https://doi.org/10.3102/0034654311421793>
- Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*(2). <https://doi.org/10.18637/jss.v048.i02>
- Ruzek, E. A., Hafen, C. A., Allen, J. P., Gregory, A., Mikami, A. Y., & Pianta, R. C. (2016). How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence. *Learning and Instruction, 42*, 95–103. <https://doi.org/10.1016/j.learninstruc.2016.01.004>
- Ryan, R. M., & Deci, E. L. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54–67. <https://doi.org/10.1006/ceps.1999.1020>
- Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. <https://doi.org/10.1037/0003-066X.55.1.68>
- Ryan, R. M., & Deci, E. (2009). Promoting self-determined school engagement: Motivation, learning, and well-being. In K. R. Wentzel & A. Wigfield (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 171–195). Routledge.
- Ryan, R. M., & Deci, E. (2016). Facilitating and hindering motivation, learning, and well-being in schools: Research and observations from self-determination theory. In K. R. Wentzel & D. B. Miele (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 96–119). Routledge Taylor & Francis Group.
- Sacher, W. (1995). *Meldungen und Aufrufe im Unterrichtsgespräch. Theoretische Grundlagen, Forschungsergebnisse, Trainingselemente und Diagnoseverfahren*. Wissner.

- Scherrer, V., & Preckel, F. (2018). Development of motivational variables and self-esteem during the school career: A meta-analysis of longitudinal studies. *Review of Educational Research, 89*(2), 211-258. <https://doi.org/10.3102/0034654318819127>
- Schiefele, U. (2009). Situational and individual interest. In K. R. Wentzel & A. Wigfield (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 197–222). Routledge.
- Schiefele, U., Krapp, A., & Winteler, A. (1992). Interest as a predictor of academic achievement: A meta-analysis of research. In K. A. Renninger, S. Hidi, & A. Krapp (Eds.), *The role of interest in learning and development* (pp. 183–212). Erlbaum.
- Schindler, A.-K., Seidel, T., Böheim, R., Knogler, M., Weil, M., Alles, M., & Gröschner, A. (submitted). Acknowledging teachers' individual starting conditions and zones of development in the course of professional development.
- Sedova, K., Sedlacek, M., Svaricek, R., Majcik, M., Navratilova, J., Drexlerova, A., Kychler, J., & Salamounova, Z. (2019). Do those who talk more learn more? The relationship between student classroom talk and student achievement. *Learning and Instruction, 63*, 101217. <https://doi.org/10.1016/j.learninstruc.2019.101217>
- Seidel, T. (2005). Video analysis strategies of the IPN Video Study – A methodological overview. In T. Seidel, M. Prenzel, & M. Kobarg (Eds.), *How to run a video study: Technical report of the IPN Video Study* (pp. 70–78). Waxmann.
- Seidel, T. (2014). Angebots-Nutzungs-Modelle in der Unterrichtspsychologie. Integration von Struktur- und Prozessparadigma. *Zeitschrift für Pädagogik, 60*(6), 850–866.
- Seidel, T., & Prenzel, M. (2006). Stability of teaching patterns in physics instruction: Findings from a video study. *Learning and Instruction, 16*(3), 228–240. <https://doi.org/10.1016/j.learninstruc.2006.03.002>
- Seidel, T., Prenzel, M., & Kobarg, M. (Eds.). (2005). *How to run a video study: Technical report of the IPN Video Study*. Waxmann.
- Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-Concept: Validation of construct interpretations. *Review of Educational Research, 46*(3), 407–441. <https://doi.org/10.3102/00346543046003407>
- Shernoff, D. J., Kelly, S., Tonks, S. M., Anderson, B., Cavanagh, R. F., Sinha, S., & Abdi, B. (2016). Student engagement as a function of environmental complexity in high school classrooms. *Learning and Instruction, 43*, 52–60. <https://doi.org/10.1016/j.learninstruc.2015.12.003>

- Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The challenges of defining and measuring student engagement in science. *Educational Psychologist, 50*(1), 1–13. <https://doi.org/10.1080/00461520.2014.1002924>
- Sinclair, M. F., Christenson, S. L., Lehr, C. A., & Anderson, A. R. (2003). Facilitating student engagement: Lessons learned from Check & Connect longitudinal studies. *The California School Psychologist, 8*(1), 29–41. <https://doi.org/10.1007/BF03340894>
- Skinner, E. A. (2016). Engagement and disaffection as central to processes of motivational resilience and development. In K. R. Wentzel & D. B. Miele (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 145–168). Routledge Taylor & Francis Group.
- Skinner, E. A., & Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology, 85*(4), 571–581. <https://doi.org/10.1037/0022-0663.85.4.571>
- Skinner, E. A., Furrer, C., Marchand, G., & Kindermann, T. A. (2008). Engagement and disaffection in the classroom: Part of a larger motivational dynamic? *Journal of Educational Psychology, 100*(4), 765–781. <https://doi.org/10.1037/a0012840>
- Skinner, E. A., Kindermann, T. A., Connell, J. P., & Wellborn, J. G. (2009). Engagement and disaffection as organizational constructs in the dynamics of motivational development. In K. R. Wentzel & A. Wigfield (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 223–245). Routledge.
- Skinner, E. A., Kindermann, T. A., & Furrer, C. J. (2009). A motivational perspective on engagement and disaffection: Conceptualization and assessment of children's behavioral and emotional participation in academic activities in the classroom. *Educational and Psychological Measurement, 69*(3), 493–525. <https://doi.org/10.1177/0013164408323233>
- Skinner, E. A., & Pitzer, J. R. (2012). Developmental dynamics of student engagement, coping, and everyday resilience. In S. L. Christenson, A. L. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 21–44). Springer.
- Skinner, E. A., Wellborn, J. G., & Connell, J. P. (1990). What it takes to do well in school and whether I've got it: A process model of perceived control and children's engagement and achievement in school. *Journal of Educational Psychology, 82*(1), 22–32. <https://doi.org/10.1037/0022-0663.82.1.22>
- Skipper, Y., & Douglas, K. (2015). The influence of teacher feedback on children's perceptions of student-teacher relationships. *The British Journal of Educational Psychology, 85*(3), 276–288. <https://doi.org/10.1111/bjep.12070>

- Stahl, S. A., & Clark, C. H. (1987). The effects of participatory expectations in classroom discussion on the learning of science vocabulary. *American Educational Research Journal*, 24(4), 541–555. <https://doi.org/10.3102/00028312024004541>
- Stigler, J. W., Gonzales, P., Kawanaka, T., Knoll, S., & Serrano, A. (1999). *The TIMSS videotape classroom study. Methods and findings from an exploratory research project on eighth-grade mathematics instruction in Germany, Japan, and the United States*. U.S. Department of Education. <https://nces.ed.gov/pubs99/1999074.pdf>
- Strati, A. D., Schmidt, J. A., & Maier, K. S. (2017). Perceived challenge, teacher support, and teacher obstruction as predictors of student engagement. *Journal of Educational Psychology*, 109(1), 131–147. <https://doi.org/10.1037/edu0000108>
- Trautwein, U., & Möller, J. (2016). Self-concept: Determinants and consequences of academic self-concept in school contexts. In A. A. Lipnevich, F. Preckel, & R. D. Roberts (Eds.), *The Springer Series on Human Exceptionality. Psychosocial skills and school systems in the 21st century: Theory, research, and practice* (pp. 187–214). Springer International Publishing. https://doi.org/10.1007/978-3-319-28606-8_8
- van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, 45(3), 1–67. <http://www.jstatsoft.org/v45/i03/>
- Walshaw, M., & Anthony, G. (2008). The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research*, 78(3), 516–551. <https://doi.org/10.3102/0034654308320292>
- Wang, M.-T., Degol, J. L., & Henry, D. A. (2019). An integrative development-in-sociocultural-context model for children's engagement in learning. *The American Psychologist*, 74(9), 1086–1102. <https://doi.org/10.1037/amp0000522>
- Wang, M.-T., & Eccles, J. S. (2012a). Adolescent behavioral, emotional, and cognitive engagement trajectories in school and their differential relations to educational success. *Journal of Research on Adolescence (Wiley-Blackwell)*, 22(1), 31–39. <https://doi.org/10.1111/j.1532-7795.2011.00753.x>
- Wang, M.-T., & Eccles, J. S. (2012b). Social support matters: Longitudinal effects of social support on three dimensions of school engagement from middle to high school. *Child Development*, 83(3), 877–895. <https://doi.org/10.1111/j.1467-8624.2012.01745.x>
- Wang, M.-T., & Eccles, J. S. (2013). School context, achievement motivation, and academic engagement: A longitudinal study of school engagement using a multidimensional perspective. *Learning and Instruction*, 28, 12–23. <https://doi.org/10.1016/j.learninstruc.2013.04.002>

- Wang, M.-T., & Fredricks, J. A. (2014). The reciprocal links between school engagement, youth problem behaviors, and school dropout during adolescence. *Child Development, 85*(2), 722–737. <https://doi.org/10.1111/cdev.12138>
- Webb, N. M., Franke, M. L., Ing, M., Wong, J., Fernandez, C. H., Shin, N., & Turrou, A. C. (2014). Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning. *International Journal of Educational Research, 63*, 79–93. <https://doi.org/10.1016/j.ijer.2013.02.001>
- Weil, M., Gröschner, A., Schindler, A.-K., Böheim, R., Hauk, D., & Seidel, T. (Eds.). (2020). *Dialogische Gesprächsführung im Unterricht: Interventionsansatz, Instrumente und Videokodierungen*. Waxmann Verlag GmbH. <https://doi.org/10.31244/9783830991601>
- Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (pp. 315–327). Macmillan.
- Wellborn, J. G. (1991). *Engaged and disaffected action: The conceptualization and measurement of motivation in the academic domain* [Unpublished doctoral dissertation]. University of Rochester, New York.
- Wentzel, K. R., & Miele, D. B. (Eds.). (2016). *Educational psychology handbook series. Handbook of motivation at school* (Second edition). Routledge Taylor & Francis Group.
- Wentzel, K. R., & Wigfield, A. (Eds.). (2009). *Educational psychology handbook series. Handbook of motivation at school*. Routledge.
- Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review, 30*(1), 1–35. <https://doi.org/10.1016/j.dr.2009.12.001>
- Wigfield, A., Eccles, J. S., Fredricks, J. A., Simpkins, S., Roeser, R. W., & Schiefele, U. (2015). Development of Achievement Motivation and Engagement. In *Handbook of Child Psychology and Developmental Science* (7th ed., Vol. 16, pp. 657–700). John Wiley & Sons, Inc. <https://doi.org/10.1002/9781118963418.childpsy316>
- Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research, 72*(2), 131–175. <https://doi.org/10.3102/00346543072002131>

Appendix

Supplement A:

Böheim, R., Knogler, M., Kosel, C., & Seidel, T. (2020). Exploring student hand-raising across two school subjects using mixed methods: An investigation of an everyday classroom behavior from a motivational perspective. *Learning and Instruction*, 65, 101250. <https://doi.org/10.1016/j.learninstruc.2019.101250>

Supplement B:

Böheim, R., Urdan, T., Knogler, M., & Seidel, T. (2020). Student hand-raising as an indicator of behavioral engagement and its role in classroom learning. *Contemporary Educational Psychology*, 62, 101894. <https://doi.org/10.1016/j.cedpsych.2020.101894>

Note:

For copyright reasons, supplements are not included in this online publication of the dissertation.