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**The “Situative Nature” of Competence and Value Beliefs and the Predictive Power of
Autonomy Support: A Multilevel Investigation of Repeated Observations**

Cora Parrisius, Hanna Gaspard, Steffen Zitzmann, Ulrich Trautwein, and Benjamin Nagengast

Hector Research Institute of Education Sciences and Psychology, University of Tübingen,
Germany

Author Note

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Correspondence concerning this article should be addressed to Cora Parrisius, Hector Research Institute of Education Sciences and Psychology, University of Tübingen, Walter-Simon-Str. 12, 72072 Tübingen. Contact e-mail: cora.parrisius@uni-tuebingen.de

Abstract

In their situated expectancy-value theory, Eccles and Wigfield (2020) assume students' competence and value beliefs to be situation-specific and thereby to be “situative” in nature. Even though motivation research has gradually been developing an understanding of this situative nature, for instance, by disentangling time-consistent and fluctuating proportions of competence and value beliefs at the analytical level of the individual, most studies still have not disentangled them at the class level. The present study sought to close this gap by applying a multilevel modeling approach based on data from 1,617 ninth-grade students in 78 classrooms across five consecutive math lessons. Our findings revealed significant proportions of trait variance and state residual variance in students' competence beliefs, value beliefs, and their perceptions of autonomy-supportive teaching behaviors at the individual and class levels. Larger amounts of variance could be attributed to the individual level compared with the class level and to fluctuating compared with time-consistent proportions (across levels). Furthermore, students' perceptions of autonomy-supportive teaching behaviors predicted their situation-specific competence and value beliefs, whereby time-consistent differences, both between students and between classes, explained more variance than fluctuations within students and within classes. Thus, our findings supported the situative nature of competence and value beliefs but also revealed that, by and large, time-consistent differences in the perceptions of autonomy-supportive teaching behaviors between students and classes had more predictive power for students' competence and value beliefs than intraindividual and intra-class fluctuations over time.

Keywords: situated expectancy-value theory, situation-specific competence and value beliefs, autonomy support, state-trait theory, multilevel states and traits

Educational Implications and Impact Statement

How heterogeneous are individual students and entire classrooms when it comes to their competence beliefs (“Can I do it?”) and value beliefs (“Why should I do it?”) regarding math? This study shows that individual students and entire classrooms differ substantially from one another in their levels of competence and value beliefs regarding math and that individual students’ competence and value beliefs fluctuate substantially from lesson to lesson. In addition, this study extends previous findings by showing that the situation-specific competence and value beliefs of entire classrooms—which have hardly been investigated yet—also fluctuate substantially from lesson to lesson. So (how) can teachers counteract motivational imbalances? This study shows that when teachers *typically* support their students’ autonomy in math class, then these individual students and the whole classroom also typically report higher competence and value beliefs.

The “Situative Nature” of Competence and Value Beliefs and the Predictive Power of Autonomy Support: A Multilevel Investigation of Repeated Observations

There has been a clear and persistent call for research on student motivation that is aimed at extending the understanding of *intraindividual* motivational processes that take place in the classroom (e.g., Eccles & Wigfield, 2020; Pintrich, 2003), but only recently has this call been heard (e.g., Patall et al., 2016; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Such research, which looks at situation-specific and *intraindividual* differences rather than only at *interindividual* differences between students and over time, is valuable because it goes beyond research that generates knowledge about students’ average levels of motivation and the general predictors and general consequences of these average levels. It is particularly important because “average” and “general” might not be the focal point of teachers’ reality in school: For them, deviations from the mean are not exceptions but rather represent the reality of teachers’ daily lives. For instance, some students might “typically” be unconvinced of their ability to master math, its relevance, or its inherent interestingness; still there might be certain lessons in which their motivation to do math tasks is very high—and the same can equally be true for whole classrooms. Indeed, previous research showed that students’ motivation varied not only between students and classrooms but also from situation to situation (e.g., Dietrich et al., 2017; Patall et al., 2016; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Consequently, it is important to identify the contextual factors that are under the control of the teachers and that explain systematic variation in students’ and classrooms’ competence and value beliefs because they might eventually enable teachers to facilitate positive enduring motivational levels and to counteract motivational low points.

Grounded in the situated expectancy-value theory (Eccles et al., 1983; Eccles & Wigfield, 2020), the aim of the present investigation is to examine the extent to which competence and value beliefs are situative (i.e., their “situative nature”; Eccles & Wigfield,

2020) and to determine whether students’ typical, time-consistent levels and situation-specific fluctuations of their competence and value beliefs are systematically predicted by their teachers’ autonomy-supportive teaching behaviors during class as perceived by the students. For this aim, we made use of a repeated-measures design over the course of five consecutive math lessons in 78 math classrooms with 1,617 ninth-graders. Deploying a three-level cross-classified modeling approach, we sought to identify whether the variance in students’ competence and value beliefs is driven more by time-consistent differences between individuals or by the situation they are exposed to. Importantly, beyond individual students, we also considered the class level and expanded on previous research by examining whether the variance in students’ competence and value beliefs is driven more by time-consistent differences between the classrooms students belong to or by the specific situation that all students in the same class are similarly exposed to. This decomposition of variance at both levels provides an opportunity to identify the extent to which students’ motivation is susceptible to individual versus shared aspects and to time-consistent versus fluctuating aspects. Finally, we sought to better understand how teachers affect their students’ competence and value beliefs with their teaching behaviors in the classroom. The findings of such an investigation would substantiate Eccles and Wigfield’s (2020) proposition of the situative nature of SEVT constructs and, equally important, would underpin their theoretical assumptions by providing concrete estimates for the decomposition of variance at the individual and class levels into time-consistent and fluctuating components. Additionally, the findings may be indicative of whether students’ individual versus shared perceptions are pivotal for the success of teachers’ autonomy support for their students’ motivation and whether autonomy-supportive teaching behaviors pay off in the immediate lesson or rather over time.

Students’ Competence and Value Beliefs

Almost 40 years ago, Eccles and her colleagues adapted classical expectancy-value theories (e.g., Atkinson, 1957; Vroom, 1964) to the educational context and described

expectancy (“Can I do it?”) and value beliefs (“Why should I do it”) as a function of an interaction between individual characteristics and the environment (Eccles et al., 1983). Since then, this theory has triggered an enormous amount of research (see Wigfield & Eccles, 2020). The most recent account of expectancy-value theory has used the label “situated expectancy-value theory” (SEVT; Eccles & Wigfield, 2020) to highlight the situative nature of expectancy and value beliefs, a term we will use throughout this article. According to SEVT, students’ expectancy and value beliefs are the most proximal predictors of their engagement in a task as well as of their achievement-related choices and, eventually, their performance (Eccles et al., 1983; Wigfield & Eccles, 2020). Students’ expectancies are defined as students’ beliefs about how well they will do in an upcoming task. Expectancies are conceptually closely related to other constructs that reflect evaluations of competence, such as self-concept and self-efficacy. Although theoretically separable (Bong & Skaalvik, 2003; Eccles et al., 1983; Eccles & Wigfield, 2020), prior research has found that these constructs are typically highly correlated (Eccles & Wigfield, 2002; Marsh et al., 2019). In the current study, we use the term *competence beliefs* as an umbrella term for these different constructs. Students’ *value beliefs* refer to the value an individual attributes to an activity or task. They are assumed to be subjective and task-specific (which is why they are also labeled subjective task values; Eccles, 2005) and, analogous to students’ competence beliefs, their unfolding is assumed to be affected by individual (e.g., gender, cognitive abilities) as well as contextual factors such as the motivation of peers or the behaviors of significant others (e.g., the teacher; Eccles, 1993, 2007; see also, e.g., Frenzel et al., 2010). Eccles and colleagues (1983; Eccles, 2005) furthermore differentiated between multiple components of students’ value beliefs: students’ utility value (i.e., the personal usefulness of a task for an individual’s current or future life), attainment value (i.e., the relevance of a task for a person’s identity), intrinsic value (i.e., the value of a task due to the enjoyment it arouses in a person), and cost (i.e., the negative value that is attached to a task due to subjectively perceived

negative consequences from engaging in it). Elaborate instruments with many items tapping the four proposed components of value beliefs have empirically supported their differentiability (e.g., Conley, 2012; Gaspard et al., 2015; Trautwein et al., 2012). However, some or all of the components that positively contribute to value beliefs (i.e., utility value, attainment value, intrinsic value) have also often been collapsed into a single measure when assessed via short batteries (e.g., Durik et al., 2006; Lauermann et al., 2017; Watt et al., 2012).

In recent decades, Eccles et al.’s SEVT model has found wide appreciation in educational psychology, not least of all because many aspects of the model (e.g., the dependency of competence and value beliefs on environmental influences; the predictive power of competence and value beliefs for effort, engagement, and achievement) have been confirmed by a wide range of longitudinal investigations (e.g., Lazarides, Gaspard, et al., 2019; Marsh et al., 2005; Meece et al., 1990; Simpkins et al., 2006). Such longitudinal studies have come along with a particular emphasis on trait-like appraisals of competence and value beliefs in a particular domain (e.g., “I like doing math”; Gaspard et al., 2015; see also Wigfield & Cambria, 2010, for an overview), which seems appropriate in view of the long time intervals studied (oftentimes spanning multiple years or even decades; such as the Childhood and Beyond Project, <http://garp.education.uci.edu/cab.html>). When measured in this way, students’ competence and value beliefs have typically shown high stabilities across time (e.g., Rieger et al., 2017; Wigfield et al., 1997). However, as a result of trait-like measures typically being used as opposed to situation-specific measures in these studies, the situative nature of competence and value beliefs as defined in SEVT (e.g., Eccles & Wigfield, 2020) has often gone unstudied.

Additionally, the focus on trait-like competence and value beliefs has typically been accompanied by a focus on interindividual associations—which means that previous research has mainly been based on the analysis of between-person variation. However, as Voelkle et al. (2014) pointed out and as is the case when recapitulating basic assumptions of most motivation

theories (e.g., within SEVT, Eccles et al., 1983), mechanisms that are specified by psychological theories typically refer to interindividual *and* intraindividual mechanisms. As such, the consideration of repeated measures of situation-specific competence and value beliefs within the same students can prove helpful as it allows for the additional investigation of intraindividual associations (e.g., Berry & Willoughby, 2017; Hamaker et al., 2015; Molenaar, 2004), for example, with situation-specific teaching behaviors.

Disentangling States and Traits at the Individual and Class Levels

According to SEVT, students develop “typical” manifestations of competence and value beliefs in different academic domains through childhood into adolescence (for an overview, see Wigfield et al., 2015). These typical levels of motivation are described in the literature as, for instance, “dispositions,” “enduring” levels, or “individual” levels of competence and value beliefs and interest (e.g., Eccles et al., 1983; Hidi & Renninger, 2006; Wigfield & Cambria, 2010), whereby these terms are used to denote the relatively stable expressions of competence and value beliefs or interest. Although terms such as dispositions imply that these constructs are not easily affected by single, specific situations, by no means do these expressions imply that motivation would be unchangeable over time. Contrarily, Eccles and Wigfield (e.g., 2002, 2020) proposed that students’ competence and value beliefs are sensitive to situations, and this sensitivity will probably even increase “with increasing social and cognitive maturity” (Wigfield & Eccles, 2020, p. 173). We address such “typical” levels and situation-specific deviations from a state-trait perspective in this article.

According to latent state-trait theory (LST theory; Steyer et al., 1992, 1999; see also, e.g., Geiser et al., 2017) and as depicted in the lower part of Figure 1, a student’s situation-specific level of a certain construct such as their competence or value beliefs (i.e., their situation-specific answering behavior, the “student-in-a-situation,” or *state*) is constituted by a composite of a time-consistent part (a *trait*) and a fluctuating aspect, that is, a part that comprises aspects of the

situation and the interaction of the student with this situation (a *state residual*).¹ Thus, the trait is assumed to determine the average level of a student's states, but a situation and the student's interaction with this situation add to the actual situation-specific level of competence and value beliefs. For instance, when a student who typically has high competence beliefs about math (trait) is confronted with a very difficult math task (situation), this student might nevertheless face some problems at this difficulty level (interaction with situation), leading to competence beliefs that are lower in this certain situation compared with typical situations (state). Though Wigfield and Eccles (2020) stressed that processes involving competence and value beliefs are “situationally sensitive (that is, influenced by the immediate situation)” (p. 166), they did not further specify the extent to which students' competence and value beliefs are a function of time-consistent and fluctuating aspects. In contrast to trait-like measures, situation-specific measures (e.g., “I like these contents”, Dietrich et al., 2017) are more sensitive to situation-specific fluctuations and consequently facilitate the investigation of the proportions of trait variance and state residual variance.

--- Insert Figure 1 here ---

Examining SEVT constructs from the perspective of states and traits provides important insights into the susceptibility of competence and value beliefs to the social context they are embedded in (e.g., Is their variance driven more by time-consistent differences between individuals or by the learning situation?). By using repeated measures and variance decomposition analyses, one can estimate the extent to which traits vary between persons (*trait variance*) and the extent to which the state residual naturally fluctuates around the trait (*state residual variance*). To achieve such a decomposition of variance, it is common in educational research to apply multilevel modeling that considers observations nested within students

¹ Strictly speaking, the composite of the trait and the state residual reflects the true score of an observed variable. According to LST, any observed variable can be decomposed into such a true score (latent state variable) and an error variable (Steyer et al., 1999), which we do not take into account in the present study.

(Nezlek, 2007).

For instance, in one of the first studies to systematically examine the situative nature of interest experience (measured by items tapping situation-specific intrinsic, utility, and attainment value), Tsai, Kunter, Lüdtke, Trautwein, & Ryan (2008) investigated the proportions of trait variance and state residual variance in students' value beliefs. Depending on the domain (math, German, or second foreign language), 55% to 64% of the variance in students' interest experience could be attributed to between-person differences (i.e., trait variance), and 36% to 45% of the variance could be attributed to intraindividual, situation-specific fluctuations (i.e., state residual variance). Since then, similar investigations were also made regarding students' competence beliefs (e.g., Tsai, Kunter, Lüdtke, & Trautwein, 2008), interest (e.g., Patall et al., 2016; Tanaka & Murayama, 2014), control and value (e.g., Goetz et al., 2020), emotions (e.g., Becker et al., 2014; Goetz, Lüdtke, et al., 2013; Mainhard et al., 2018), and (dis)engagement (e.g., Park et al., 2012; Patall et al., 2016; Patall, Steingut, et al., 2018). Thus, these authors overcame the shortcomings of trait-like measures and between-person variation analyses by using situation-specific measures, repeated observations, and multilevel modeling. Yet decomposing the variances in students' competence and value beliefs into time-consistent and fluctuating proportions disregards the classroom context and can thus be only a first step toward approximating their situative nature as we outline next.

In educational research, the nesting of students in classrooms calls for an even more sophisticated approach to the decomposition of variance in students' competence and value beliefs. When the nested data structure (along with students within the same class being more similar than students between classrooms in the constructs of interest due to the fact that they share the same educational environment) is ignored, independence assumptions are violated, which may lead to incorrect variance partitioning results (e.g., Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). Even though the consideration of students nested in classrooms via

multilevel modeling has become “one of the central research methods for applied researchers in the social sciences” (Lüdtke et al., 2008, p. 203) in recent decades, variance decomposition approaches to studying students’ motivation have not always considered such clustering, oftentimes because the sample size at the level of the clusters was not sufficient for doing so (e.g., Dietrich et al., 2017; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). However, the classroom context including the teachers’ behaviors is assumed to feed into the ontogeny of students’ motivation (Eccles, 1993, 2007). Given this context dependency, one can expect a substantial proportion of variance in students’ competence and value beliefs to be attributed to the class level.

Only in recent years has educational research interested in the situative nature of motivation started to consistently consider the class level in addition to the individual level. For instance, Patall et al. (2016) showed that students’ interest varied substantially not only from one student to another (i.e., a substantial proportion of *individual-level trait variance*; 43%) and from day to day (i.e., a substantial proportion of *individual-level state residual variance*; 46%) but also between classrooms (11%). Thus, students’ situation-specific interest appeared to be made up of shared aspects of the classroom in addition to time-consistent and fluctuating aspects of the individual (see also, e.g., Patall, Hooper, et al., 2018; Patall, Steingut, et al., 2018; Yu & Levesque-Bristol, 2020). This is particularly relevant as it reveals that teachers’ behaviors have the potential to affect their classrooms as a whole over and above individual students, emphasizing the situative nature of competence and value beliefs as postulated in SEVT.

However, an easy-to-miss though potentially relevant other aspect has commonly been neglected (but see Kärner et al., 2017; Moeller et al., 2020; Wagner et al., 2016): Whereas an individual student’s competence and value beliefs may be composed of traits and state residuals, this might equally be true for the average competence and value beliefs of all students within a classroom, meaning that the shared motivation of all students within a class may also naturally

fluctuate around a typical level of shared motivation from situation to situation (see the upper part of Figure 1). That is, the variance in students’ competence and value beliefs can be due to different sources: Whereas students’ situation-specific competence and value beliefs might vary due to time-consistent differences between students (i.e., some students are generally more motivated when it comes to math than other students), the exact same students might also differ in their competence and value beliefs from situation to situation (i.e., if one had asked the same student in another situation about their situation-specific competence and value beliefs, they might have responded differently). Additionally, the variance in students’ situation-specific reports of competence and value beliefs can be explained by the classroom a student is in (i.e., students from different classrooms can differ in their average levels of motivation). And finally, the competence and value beliefs of entire classrooms can vary due to differences in situations that the whole classroom is exposed to (i.e., the level of motivation in a class can differ from one lesson to another because, e.g., the students had to take an exam the lesson before the math lesson).

So far, only a few studies have acknowledged these time-consistent and fluctuating aspects of students’ motivation at the classroom level (i.e., in their shared motivation). For instance, Wagner and colleagues (2016) investigated the proportions of trait and state residual variance in students’ perceptions of teaching behaviors (assessed with trait-like measures of autonomy support, classroom management, and goal clarity) at the individual and class levels and predicted both students’ achievement and their self-concept with the time-consistent proportions of variance at the class level. Other studies that focused on students’ motivation either left out the individual level (e.g., Keller et al., 2018) or did not disentangle states at the class level into traits and state residuals (e.g., Stroet et al., 2015). When applying only such a multilevel structure (disentangling states and traits only at the individual but not at the class level), proportions of neglected class-level state residual variance are dispersed across the other

three variance components, most likely leading to an underestimated individual-level trait variance component and overestimated proportions of variance for the remaining components (e.g., Fielding, 2002; Luo & Kwok, 2009).

Taken together, motivation research has gradually been approaching a sound understanding of the situative nature (Eccles & Wigfield, 2020) of students’ competence and value beliefs by (a) disentangling their variances into time-consistent and fluctuating proportions at the individual level (e.g., Dietrich et al., 2017; Tsai, Kunter, Lüdtke, & Trautwein, 2008; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008) and by (b) considering the level of the class along with the individual level (e.g., Patall et al., 2016). However, prior research has typically not analogously disentangled proportions of trait and state residual variance at the class level. Yet, from a practical point of view, it would be informative to know whether students tend to respond similarly to their teachers’ behaviors and whether it is thus promising for teachers to address the whole classroom in order to support students’ motivation (rather than individual students). With the aim of closing this gap in the current literature, we sought to clarify which source (individual vs. shared perceptions; fluctuating vs. time-consistent perceptions) is most prevalent in explaining the variance in students’ situation-specific competence and value beliefs.

Motivational Teaching: Lending Strategies from SDT

In order to provide teachers with knowledge about contextual factors that explain systematic variation in their students’ individual and shared levels of situation-specific competence and value beliefs and that eventually enable them to facilitate positive enduring motivational levels, disentangling the proportions of variance in students’ competence and value beliefs can only be a first step. Additionally, it is important to identify factors that both lie in the teachers’ hands and are *systematically linked* to such variation.

Motivation research offers several promising conceptualizations of instructional behaviors that teachers can use to support students’ motivation (e.g., Eccles & Roeser, 2009;

Pianta & Hamre, 2009; Pintrich, 2003; Stroet et al., 2013). For instance, intervention research grounded in SEVT particularly singled out the support of relevance and utility as successful in promoting students’ motivation (for overviews, see, e.g., Harackiewicz et al., 2014; Lazowski & Hulleman, 2016; Priniski et al., 2018). Similarly, self-determination theorists (Deci & Ryan, 1985; Ryan & Deci, 2020) postulated that the provision of meaningful rationales is a promising approach to support students’ motivation (Ryan & Deci, 2020; see also Assor et al., 2002). Eccles and Wigfield (2020) themselves noted that their attention in the past regarding teaching behaviors that might be supportive of students’ competence and value beliefs has widely been in line with self-determination theory (SDT). Besides, beyond the provision of meaningful rationales, SDT defines a clear set of teaching strategies that can be used to foster students’ motivation and have garnered wide empirical support (Ryan & Deci, 2020). Accordingly, within the scope of this study, we borrow motivational teaching behaviors as defined in SDT as potential factors for explaining systematic variation in students’ situation-specific competence and value beliefs (for a similar approach, see, e.g., Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008).

In SDT, Ryan and Deci (2000, 2020) particularly emphasized the teaching strategy of autonomy support, which refers to a teacher’s ability to identify, nurture, and develop “students’ inner motivational resources (e.g., interests, preferences, psychological needs)” (Reeve, 2009, p. 162) in a supportive rather than controlling way. Teachers can create an autonomy-supportive climate if they provide meaningful rationales, are attentive and considerate to students’ feelings and thoughts in the classroom, nurture students’ feelings of acknowledgment make use of non-controlling language, offer meaningful choices, or provide interesting tasks or materials (see Su & Reeve, 2011, for an overview). An impressive body of research, including experimental studies, has stressed the importance of teachers’ autonomy-supportive teaching behaviors for supporting students’ motivation, competence beliefs, and engagement (e.g., Assor et al., 2002;

Patall et al., 2008; Patall, Hooper, et al., 2018; Reeve et al., 2004; Reeve & Jang, 2006; Steingut et al., 2017; Stroet et al., 2013). Most importantly, autonomy-supportive teaching behaviors such as the provision of meaningful rationales or choice have been found to be predictive of competence and value beliefs as defined within SEVT (e.g., González & Paoloni, 2015; Lazarides, Dietrich, et al., 2019; Patall, Hooper, et al., 2018; Tsai, Kunter, Lüdtke, & Trautwein, 2008; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008; Wagner et al., 2016).

The strategy of providing meaningful rationales (which shares a great deal of conceptual overlap with the attempt to foster relevance and utility; Priniski et al., 2018) is defined as one particular strategy to support autonomy (e.g., Assor et al., 2002; Reeve et al., 2002). It comprises explanations of why the engagement in a task is personally beneficial, thereby demonstrating the direct usefulness of the behavior for satisfying students' inner needs and goals (Su & Reeve, 2011). In line with findings from utility-value interventions, students' showed increases in their value beliefs and even higher effort and engagement when they perceived that their teachers were providing more meaningful rationales (e.g., Assor et al., 2002; Reeve et al., 2002; Schmidt et al., 2019; Schreier et al., 2014). Due to its potential importance in shaping students' value beliefs, in the current study, we pay special attention to the strategy of rationale provision next to the general autonomy-supportive learning climate of the classroom (created through attention to and consideration of students' feelings and thoughts in the classroom, the provision of meaningful choices, and the nurturing of students' feelings of acknowledgment).

Considering Autonomy-Supportive Teaching Behaviors at Different Levels

Students' perceptions of teaching behaviors are typically considered as constructs that are measured at the individual level. Additionally, there might exist corresponding constructs at the class level, which are frequently modeled as an aggregate of the individual-level responses (Lüdtke et al., 2009; Stapleton et al., 2016). The aggregates of all student responses are assumed to reflect common opinions regarding the assessed behaviors shared by all students in the same

classroom (i.e., shared perceptions; Lüdtke et al., 2009). However, individual appraisals of teaching behaviors might differ considerably from the shared perceptions because of students’ idiosyncratic perceptions. For instance, students might have different needs for support and thus perceive the support given by the teacher as differently helpful (leading to tendencies in individual appraisals of teaching behaviors in a certain way) or teachers might behave differently with respect to different students (leading to dyadic teacher-student effects; Göllner et al., 2018). Consequently, the individual-level variable and the class-level variable can have different meanings because the individual-level variable contains perceptions that are not shared among students in the same class, whereas the class-level construct reflects what is shared by all students. Hence, associations of individual and shared perceptions with other variables (e.g., competence or value beliefs) might have different qualities across levels, and effects of such constructs need to be studied on multiple levels to disentangle potentially concomitantly varying effects (Hamaker & Muthén, 2019; Raudenbush & Bryk, 2002; Snijders & Bosker, 1999; Stapleton et al., 2016).

For educational research and practice, it is highly relevant to know how teachers’ behaviors during instruction come to affect students. Thus, one of the major aims of this investigation was to identify the levels on which students’ situation-specific perceptions of autonomy-supportive teaching behaviors work. For instance, if fluctuating rather than time-consistent aspects of autonomy-supportive teaching behaviors as perceived by the students were found to be most predictive of their competence and value beliefs, this would indicate that it is not the teachers’ typical level of autonomy-supportive teaching behaviors that is pivotal for the students’ individual and shared motivation; rather, teachers’ fluctuating levels of autonomy-supportive teaching behaviors immediately shape students’ individual and shared situation-specific motivation (and vice versa). Additionally, if teachers’ (typical and fluctuating levels of) autonomy-supportive teaching behaviors were found to be most predictive of students’ shared

competence and value beliefs, this would indicate that teachers can reach every student in the same class in a similar way with their behaviors during class, whereas a predominant association with students’ individual motivation would be indicative of students’ idiosyncratic perceptions (which might be induced by individual tendencies or dyadic effects between teachers and their students; Göllner et al., 2018). Yet a full investigation that includes situation-specific measures of students’ motivation and their perceptions of autonomy-supportive teaching behaviors and that considers traits and state residuals for all constructs at the individual *and* class levels is still pending.

The Present Study

In the SEVT (Eccles et al., 1983; Eccles & Wigfield, 2020), students’ competence and value beliefs are assumed to be highly situation-sensitive and thereby likely to vary from one situation to another. Hence, in recent years, more and more research has been dedicated to the situative nature of competence and value beliefs and has uncovered the variability of students’ motivation as a function of traits and state residuals (e.g., Dietrich et al., 2017; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008) and even of the individual and the class (e.g., Patall et al., 2016). However, by and large, previous research has neglected to consider that the classrooms’ shared competence and value beliefs could also vary as a function of time-consistent and fluctuating levels of their shared competence and value beliefs (i.e., class-level traits and state residuals). Additionally, as situation-specific levels of students’ competence and value beliefs result not only from characteristics of the person but also from the situation and the unique interaction of the situation and the person, it is of particular interest whether and to what extent features of the social context (e.g., an autonomy-supportive climate created through corresponding teaching behaviors) contribute to the systematic variation of students’ situation-specific competence and value beliefs.

To address these gaps in the literature, we used a repeated-measures design to assess

students’ situation-specific competence and value beliefs during five consecutive math lessons from a large-scale longitudinal study including 78 classrooms with 1,617 ninth-grade students. This study thus offered the unique opportunity to apply a multilevel modeling approach that allowed us to disentangle the interwoven aspects of traits and state residuals at the individual and class levels. Thus, in the present study, first, we examined the amount of variance in students’ situation-specific competence and value beliefs (i.e., importance, intrinsic value, and cost) that could be attributed to fluctuating or time-consistent components at the individual level (e.g., Dietrich et al., 2017; Patall et al., 2016; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008) and to the class level. By considering states and traits at the class level, we expanded upon typical studies on students’ motivation (see Moeller et al., 2020, for a similar suggestion). Similarly, we also applied this approach to students’ perceptions of autonomy-supportive teaching behaviors. Second, we were interested in whether students’ perceptions of their teachers’ autonomy-supportive teaching behaviors contributed to the variation in students’ situation-specific competence and value beliefs (e.g., Patall, Hooper, et al., 2018; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). We therefore considered teachers’ autonomy support in terms of the situation-specific autonomy-supportive learning climate as reported by the students (Su & Reeve, 2011) and the provision of meaningful rationales (Reeve et al., 2002).

When predicting the situation-specific levels of students’ competence and value beliefs, we additionally controlled for their trait-like competence and value beliefs (e.g., “I am good at math”), thus capturing students’ motivation with respect to the broader subject area instead of the daily lesson content. Previous research indicated that such trait-like self-reports are positively correlated with situation-specific self-reports of competence and value beliefs (Dietrich et al., 2019; Nuutila et al., 2018), and we used them as indicators of underlying motivational tendencies that might affect students’ motivational experience in a situation. Furthermore, we controlled for students’ gender and prior achievement (analogous to previous research, e.g., Patall et al., 2016;

Patall, Steingut, et al., 2018; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). These individual characteristics of the students were previously found to predict students’ competence and value beliefs in math (e.g., Dietrich et al., 2019; Gaspard et al., 2018; Marsh et al., 2005; Nagy et al., 2006).

Consequently, we posed the following research questions:

RQ1: How much of the variance in students’ individual and shared situation-specific competence and value beliefs as well as in their individual and shared perceptions of autonomy-supportive teaching behaviors can be attributed to fluctuating or time-consistent aspects?

RQ2: What is the predictive power of fluctuating and time-consistent components of autonomy-supportive teaching behaviors as perceived by the students for their situation-specific competence and value beliefs?

Method

Participants

Data for this study stemmed from the large-scale cluster-randomized trial study “MoMa 2” (Gaspard et al., 2021)² in ninth-grade math classrooms in academic-track schools in Baden-Württemberg, a federal state in Germany. The Ministry of Education and Cultural Affairs in Baden-Württemberg approved the study and the collection of the data (date of approval: July 26, 2017, file number: 31-6499.20/1105). The Ethics Committee for Psychological Research at the University of Tübingen confirmed that the procedures were in line with ethical standards of research with human subjects (date of approval: August 1, 2017, file number: 2017/0724/75).

A total of 57 academic-track schools were contacted and asked to participate. On behalf

² In addition to the Gaspard et al. (2021) study, part of these data were also used by Gaspard and Lauermaann (2021), Parrisius et al. (2020), and Piesch et al. (2020). However, none of the previous studies specifically investigated students’ situation-specific competence beliefs, situation-specific value beliefs, or students’ situation-specific perceptions of their teachers’ autonomy-supportive teaching behaviors, even though Gaspard and Lauermaann (2021) had some minor overlap regarding the items used for situation-specific competence beliefs and intrinsic value (see Appendix A for more information). However, their focus was on teachers’ and students’ shared motivational climate as indicated by teachers’ and students’ perceptions of teacher enthusiasm and student engagement during class, and they disregarded the variance in students’ perceptions at the individual level.

of their schools, 28 headmasters agreed to support the study and forwarded the recruitment information to their math teachers (for more information on the planning of the study and the recruitment process, see Gaspard et al., 2021). A total of 70 math teachers from these 28 schools decided to participate with their 78 ninth-grade classes (1 to 5 per school). There was no financial incentive for participation for the teachers or classes. One of the participating classes, which usually comprised the same group of students in each subject, was divided into two math learning groups that were taught by two different teachers. Because we sought to examine the role of students' perceptions of the teaching behaviors of their actual math teacher, we treated these two learning groups as separate classes. Additionally, in one of the classrooms, the correct allocation of individual questionnaires failed because the teacher did not hand out these questionnaires to the students as indicated by a post-it on the questionnaire, and this incorrect allocation could not be solved in retrospect, which is why we decided to exclude this class from the analyses. Our sample thus comprised a subsample of 78 classrooms.

Individual students in the participating classes were allowed to participate only when they themselves and their parents provided written consent. Along with their parents, 1,744 students (88.7% participation rate) provided written consent and therefore participated in the MoMa 2 study. We used a subsample of 78 classrooms with a total of $N = 1,617$ students (92.7%) in our analyses, which resulted from excluding the class with the incorrect allocation of questionnaires (reducing the sample to 1,722 students) and from handling missing data (see the Statistical Analyses section for more information). At the beginning of the study, students' mean age was 14.62 years ($SD = 0.46$) in our subsample, and 54% of the students were female adolescents. Of the students, 31.1% had a migration background (i.e., the students or one of their parents were not born in Germany), and 73% had at least one parent who obtained a general university entrance qualification. In terms of migration background and parents' level of education, our sample was approximately representative of academic track students in Baden-

Württemberg (Stanat et al., 2018; Statistisches Bundesamt (Destatis), 2018).

Procedure

The MoMa 2 study consists of several time points. For the current investigation, we used data from a pretest in October 2017 and from subsequent repeated measures during regular instruction (T1 through T5; see Figure 2). For the pretest, trained research assistants handed out questionnaires in which students were asked to indicate their trait-like competence and value beliefs; at the same time point, demographics were provided by the school. After the pretest, in November 2017, two randomly selected thirds of the classrooms received an intervention that was aimed at fostering students’ perceived relevance of math. Data for the current investigation were taken from a cluster-randomized controlled field trial investigating the effectiveness of this relevance intervention (for more information, see Gaspard et al., 2021). The intervention was either implemented by the regular math teachers (condition 1; for one third of the classrooms) or by trained master’s students (condition 2; for the other third of the classrooms); the delivery mode was decided randomly.

--- Insert Figure 2 here ---

The 90-min relevance intervention in these intervention condition classrooms was aimed at fostering students’ relevance of math and included a psychoeducational presentation and an individual relevance-inducing task. However, the evaluation of the efficacy of the intervention was not the focus of the current study, and results for intervention effects at posttest and follow-up can be obtained from Gaspard et al. (2021) and Piesch et al. (2020). In order to control for potential intervention effects, we used two dummy variables for the intervention conditions as covariates in our analyses (see the Statistical Analyses section). To ensure that our results were not affected by the intervention, we additionally tested for whether our results were moderated by the intervention conditions (see Table S1 in the online supplemental material). For this purpose, we tested for interactions between each variable and the two intervention conditions in

our models. Our results indicated that only four out of the 112 interactions that we tested were statistically significant (3.6%), which is even below what can be expected by chance.

After the intervention, teachers in all participating classes were handed a set of five lesson-specific repeated questionnaires for the students who were asked to indicate their situation-specific competence and value beliefs as well as their situation-specific perceptions of the teachers' autonomy-supportive teaching behaviors. Teachers were instructed to hand these to their students at the end of five consecutive math lessons (T1 through T5) but to skip the respective lesson when there were special events (e.g., a test took place). Each of the participating classes had a total of four math lessons per week (45 min each). However, because the lessons were often combined into a 90-min double session, the classes regularly had between two and four sessions per week. In this case, teachers were instructed to only administer the questionnaires at the end of a double session. Some classes were not able to complete all five questionnaires because the time frame in which teachers were able to do so was finite due to another wave of data collected in December before Christmas break. On average, the classes completed 4.55 questionnaires ($SD = 0.80$, Range: 2 to 5, Median: 5) for which it took on average 14.12 days ($SD = 3.98$, Range: 7 to 23). In the online supplemental material (Tables S2 and S3), we provide detailed information about the time slots between assessments and the number of assessments completed in different classes. From the 1,617 students who answered these questionnaires, we obtained a total of 7,023 observations.

Instruments

At T1 through T5, students were asked to report their situation-specific competence beliefs, value beliefs, and situation-specific perceptions of the autonomy-supportive teaching behaviors of their teachers with the introductory question “How was today’s math lesson for you?” We furthermore considered multiple predictor measures at pretest (trait-like measures of students’ competence and value beliefs, gender, prior achievement). The items are presented in

Appendix A. All items were assessed with a 4-point Likert-type scale ranging from 1 (*completely disagree*) to 4 (*completely agree*). We used mean scores on the respective scales for our analyses. Mean scores were computed on the valid responses under the condition that at least one item had a valid response.³ Descriptive statistics and intercorrelations are reported in Table 1.

--- Insert Table 1 here ---

Situation-Specific Competence and Value Beliefs

Students' *situation-specific competence beliefs* were measured with two items (sample item: “I could follow the lesson without any problems”; self-developed). Students' *situation-specific value beliefs* were assessed in terms of students' *importance* with four items tapping utility and attainment value (e.g., “It was important to me that I thoroughly understood the material that was covered”; partly adapted from Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008, partly self-developed). Results from two-level confirmatory factor analyses (considering situation-specific measures nested in students and constraining the factor loadings to be equal across levels) with separate factors for utility value, attainment value, intrinsic value, and cost revealed high correlations between attainment and utility value ($r_{\text{within}} = .869$, $r_{\text{between}} = .997$). These two value dimensions are also conceptually closely related (Eccles, 2005), which is why we ultimately collapsed them into a single importance factor in line with previous research (e.g., Durik et al., 2006; Lauermann et al., 2017; Watt et al., 2012; though they are separable when using elaborate instruments with many items, e.g., Conley, 2012; Gaspard et al., 2015; Trautwein et al., 2012). Furthermore, we assessed students' *intrinsic value* with two items, for instance, “The material was interesting to me” (adapted from Patall, Steingut, et al., 2018, and Tsai,

³ In other studies based on the MoMa 2 data (Gaspard & Lauermann, 2021; Gaspard et al., 2021; Parrisius et al., 2020; Piesch et al., 2020), mean scores were computed under the condition that *more than half of the items* had a valid response. For the present study, we chose a different approach as a way to handle missing data because we were not able to use the full-information maximum likelihood approach or multiple imputation (for more information, see the Missing Data section). However, the corresponding results of our analyses for which we chose the more-than-half-of-the-items condition to compute the mean scores are reported in the online supplemental material (Tables S4 and S5). These results were very similar to the results in the main paper and differed at most in the second decimal point, which did not call for a change in the interpretation of the results.

Kunter, Lüdtke, Trautwein, & Ryan, 2008). We also assessed students' subjective *cost* with two items tapping their effort required and emotional cost, for example, “I was upset because I needed to deal with this material (e.g., annoyed, anxious, and/or nervous)” (adapted from Dietrich et al., 2017, and Gaspard et al., 2015). Thus, the value items were subsumed under scales assessing importance, intrinsic value, and cost, although the items tapped all four value components as defined in SEVT. Analogous two-level confirmatory factor analyses considering only these three factors pointed to the separability of importance, intrinsic value, and cost ($\chi^2 = 812.21$, $df = 39$, CFI = .935, TLI = .907, RMSEA = .053), and the internal consistency of the scales was acceptable to good at each time point (competence beliefs: $\alpha = .82$ to .83; importance: $\alpha = .75$ to .79; intrinsic value: $\alpha = .82$ to .88; cost: $\alpha = .63$ to .68).

Situation-Specific Perceptions of Autonomy-Supportive Teaching Behaviors

Students' situation-specific perceptions of their teachers' autonomy-supportive teaching behaviors during math class were reported by the students on seven items. We partly relied on a short version of the Learning Climate Questionnaire scale to assess autonomy-supportive teaching behaviors as perceived by the students (e.g., “I felt that my teacher provided me choice and options”; e.g., Williams & Deci, 1996), which we reduced to three items as they seemed to be most appropriate for our context of ninth-grade math classrooms. Given the relevance in previous research on teaching quality (e.g., Pianta & Hamre, 2009), we partly replaced the skipped items with two items tapping the specific nurturing of students' feelings of acknowledgment (e.g., “Our teacher treated us with appreciation and respect”; self-developed). Furthermore, we aimed to consider the important role of meaningful rationales for students' perceptions of autonomy-supportive teaching behaviors, which we assessed with two items (e.g., “Our teacher explained to us why the topic of today's lesson can be relevant for us”), representing an adapted and shortened version from Flunger et al.'s (2019) scale to measure the provision of rationales. Results from two-level confirmatory factor analyses (situation-specific

measures nested in students and factor loadings constrained to be equal across levels) that considered the set of seven items revealed that *providing meaningful rationales* built a separate factor next to an *autonomy-supportive learning climate* factor ($\chi^2 = 399.49$, $df = 32$, CFI = .959, TLI = .947, RMSEA = .041; $r_{\text{within}} = .45$, $r_{\text{between}} = .66$).⁴ The internal consistencies for the two scales were satisfactory (autonomy-supportive learning climate: $\alpha = .81$ to .86; meaningful rationales: $\alpha = .68$ to .74).

Covariates

In our analyses, we considered students’ trait-like competence and value beliefs as well as their gender and prior achievement in math as covariates. Students’ *trait-like competence and value beliefs* were assessed at pretest. Their trait-like competence beliefs were measured with four items (e.g., “I am good at math”; e.g., Marsh et al., 2005). Students’ trait-like value beliefs were measured with Gaspard et al.’s (2015) scale, which was consequently refined in several studies (Gaspard et al., 2017, 2020) and slightly shortened for use in this study. The instrument allowed us to differentiate between students’ importance (i.e., analogous to the situation-specific measures, the utility and attainment dimensions were collapsed into one factor; based on 18 items; e.g., “It is important to me to be good at math”), their intrinsic value (three items; e.g., “Math is fun to me”), and their subjective cost (nine items; e.g., “Doing math makes me really nervous”). All scales showed good internal consistency (competence beliefs: $\alpha = .91$; importance: $\alpha = .91$; intrinsic value: $\alpha = .93$; cost: $\alpha = .91$). We furthermore received information about students’ *gender* and *prior achievement* (final math grades from the last report cards at the end of the previous grade level) as reported by the school. In Germany, grades range from 1 to 6 with lower values indicating better achievement. To facilitate interpretation, however, we recoded students’ grades so that higher values indicated better achievement.

⁴ When computing this model without further constraints, results revealed for one indicator a nonsignificant, negative residual variance. We thus decided to fix this residual variance to 0. The new model did not lead to estimation problems.

Statistical Analyses

For all of our analyses, we specified multilevel regression models in R (R Core Team, 2019) using the lme4 package (Bates et al., 2015). The data analysis scripts are available at the Open Science Framework (<https://osf.io/c9yze/>). In all analyses, continuous methods were applied despite the fact that the variables of interest had only four response categories. However, the application of continuous methods to four-category variables seems to be appropriate when interest lies more in structural model parameters (e.g., correlations) than in measurement model parameters (which is the case in the present investigation; Rhemtulla et al., 2012).

Decomposition of Variance

To determine the proportions of trait and state residual variance at the individual and class levels in students’ situation-specific competence beliefs, importance, intrinsic value, and cost during math class, as well as in students’ perceptions of the autonomy-supportive learning climate and the provision of meaningful rationales (RQ1), we first ran a series of multilevel regression models (without predictors). More precisely, we applied multilevel modeling in order to handle the clustering of observations in students and in lessons; additionally, we used multilevel modeling to meet the demands from students being nested in classes. Taken together, this resulted in a three-level cross-classified data structure as depicted in Figure 3, which we considered by explicitly modeling the analytical levels of the observation (Level 1), the student and the lesson (which are crossed; Level 2), and the class (Level 3; for a similar approach, see, e.g., Kärner et al., 2017). This modeling approach allowed us to disentangle proportions of individual-level trait and state residual variance (i.e., the residual variances at the levels of the student and the observation, respectively) as well as to separate proportions of class-level trait and state residual variance (i.e., the residual variances at the levels of the class and the lesson, respectively) with respect to the total variance.

Following recommendations on the transparency of model specifications (Foster, 2010),

the mathematical equation underlying the analyses can be found in Appendix B. We computed variance partition coefficients (VPC) to gauge the relative distributions of variance in the four motivation dimensions and in the two dimensions of autonomy-supportive teaching behaviors to the respective levels of interest.

--- Insert Figure 3 here ---

Predicting Students’ Situation-Specific Competence and Value Beliefs

In a next step, we aimed to examine the predictive power of the autonomy-supportive teaching behaviors as perceived by the students for their situation-specific competence and value beliefs (RQ2). Thus, we first entered the covariates (i.e., trait-like competence and value beliefs, gender, and prior achievement) and the dummy variables for the intervention conditions into the model (Model 1). Subsequently, we entered students’ perceptions of an autonomy-supportive learning climate and the provision of meaningful rationales as predictors (Model 2). Analogous to students’ situation-specific competence and value beliefs, we sought to consider their perceptions of autonomy-supportive teaching behaviors at each level (i.e., at the level of the observation, student, lesson, and class) in order to disentangle the proportions of trait and state residual variance at both the individual level and the class level. To do so, we applied manifest disaggregation of the autonomy-supportive teaching behavior variables to the levels of interest. This means that, in addition to the autonomy-supportive teaching behavior states at the level of the observation, we added level-specific aggregates of these variables, which comprise (a) the average ratings of autonomy-supportive teaching behaviors for each student across the five lessons (i.e., students’ *individual-level trait*), (b) the average ratings of autonomy-supportive teaching behaviors regarding a specific lesson across all students within the same class (i.e., the *class-level state*), and (c) the average ratings of autonomy-supportive teaching behaviors across all students and across the five lessons within each class (i.e., the *class-level trait*). Furthermore, we applied cluster-mean centering for the autonomy-supportive teaching behavior variables at

the levels of the observation, student, and lesson as described in Equation 2 in Appendix B.

Additionally, we applied grand-mean centering for the aggregates at the level of the class as well as for the covariates (i.e., trait-like competence and value beliefs, gender, and prior achievement). All continuous variables were standardized across individuals and across time points before we ran the analyses so that all regression coefficients can be understood as standardized regression coefficients with respect to the total variance in the outcome variables. Unstandardized results are reported in the supplemental material (see Table S6).

Finally, we obtained the proportions of outcome variance explained by the respective level-specific predictors. Following suggestions by Rights and Sterba (2019), for Model 1 (i.e., when including only the covariates and the two dummy variables), we estimated the proportions of both *level-specific* outcome variance and *total* outcome variance explained by entering this group of predictors into our models. Inspired by Rights and Sterba, who handled within- and between-outcome variance, we refer to the proportions of explained level-specific outcome variance as R_l^2 and to the proportions of explained total outcome variance as R_t^2 . The larger R_l^2 and R_t^2 , the more outcome variance could be explained by entering the respective predictors into the model. For Model 2 (i.e., when additionally entering the perceptions of autonomy-supportive teaching behaviors), we report the *incremental* (i.e., additional) level-specific and total outcome variance that was explained by the level-specific predictors (ΔR_l^2 and ΔR_t^2), which we obtained by subtracting the R_l^2 and R_t^2 values in Model 1 from the corresponding R_l^2 and R_t^2 values in Model 2, respectively (Rights & Sterba, 2020).

Missing Data

As is common in longitudinal designs, missing data occurred for many reasons. The amount of missing data due to the absence of individual students at single time points (while only considering the classes that had been administered the questionnaires at the respective time points) ranged from 3.1% to 8.0%. Additionally, 0.4% to 5.4% of the missing data resulted from

nonresponses to single items (considering the students who had been administered the questionnaires). The amount of missing data for individual information that was reported by the school was 0% (gender) and 2.6% (prior achievement). We are not aware of any statistical implementations of the full-information maximum-likelihood approach or multiple imputation that are able to handle missing data with a three-level cross-classified data structure. Due to the negligible rates of missing data, we thus decided to use listwise deletion across all our analyses, which resulted in an overlapping sample of 1,617 students who constituted the basis of our analyses.⁵

Results

In the current study, we aimed to investigate the situative nature of students' competence and value beliefs by examining their decomposition of variance. Additionally, we investigated the situative nature by examining the predictive power of students' perceptions of autonomy-supportive teaching behaviors for their situation-specific competence and value beliefs within the same lesson.

Decomposition of Variance

In a first step, we were interested in the stability of individual and shared situation-specific competence beliefs, value beliefs, and perceptions of autonomy-supportive teaching behaviors over time. Thus, for RQ1, we disentangled the proportions of trait and state residual variance in the variables of interest that could be attributed to the individual and class levels using a multilevel modeling approach with the analytical levels of the observation (individual-level state), student (individual-level trait), lesson (class-level state), and class (class-level trait).

As the results revealed (see Table 2 and Figure 4), for students' competence beliefs,

⁵ When comparing the group of students who were excluded from the analyses ($N_{\text{excluded}} = 127$) with the group of students who constituted the basis of our analyses ($N = 1,617$) in all the 38 variables that we considered (situation-specific and trait-like competence and value beliefs, gender, migration background, parents' level of education, prior achievement), we mainly found no statistically significant mean differences except for six variables, for which we found only small differences (see Table S7 in the online supplemental material).

importance, intrinsic value, and cost, 52%, 40%, 49%, and 56% of the variance, respectively, were attributed to fluctuations within students over time (i.e., individual-level state residual variance); 38%, 47%, 39%, and 36%, respectively, were attributed to time-consistent differences between students (i.e., individual-level trait variance); 5%, 4%, 7%, and 5%, respectively, were attributed to fluctuations within classrooms over time (i.e., class-level state residual variance); and 5%, 8%, 6%, and 4%, respectively, were attributed to time-consistent differences between classrooms (i.e., class-level trait variance). Importance was the only one for which most of the variance was a function of time-consistent rather than fluctuating components at both levels. The variance in students’ perceptions of the autonomy-supportive learning climate was mainly attributed to time-consistent aspects at the individual level (i.e., individual-level trait variance; 46%), with an additional 37% due to fluctuations at the individual level (i.e., individual-level state residual variance), only 3% due to fluctuations at the class level (i.e., class-level state residual variance), and 13% due to time-consistent aspects at the class level (i.e., class-level trait variance). Variance in students’ perceptions of the provision of meaningful rationales, however, was mainly due to fluctuations at the individual level (i.e., individual-level state residual variance; 45%), with an additional 30% due to time-consistent aspects at the individual level (i.e., individual-level trait variance), 11% due to fluctuations at the class level (i.e., class-level state residual variance), and 13% due to time-consistent aspects at the class level (i.e., class-level trait variance).

--- Insert Table 2 here ---

--- Insert Figure 4 here ---

Overall, the results from the decomposition of variance (RQ1) revealed considerable proportions of variance located at the individual level when aggregating the proportions of state residual and trait variance, particularly for students’ competence and value beliefs (between 87% and 91%; see Table 3) but also for their perceptions of autonomy-supportive teaching behaviors

(76% and 83%). Time point-specific variance components captured more than half of the variance both at the individual and class levels (except for importance and the provision of meaningful rationales, for which they, however, still captured a substantial amount of variance). This means that students as well as classrooms fluctuated considerably in their situation-specific competence beliefs, value beliefs, and perceptions of autonomy-supportive teaching behaviors around their typical levels of these beliefs and perceptions. Yet simultaneously, there were also substantial degrees of time-consistency in all constructs under investigation as both students and classrooms also differed considerably from one another in their average levels across the time span of the five consecutive math lessons.

--- Insert Table 3 here ---

Predicting Students’ Situation-Specific Competence and Value Beliefs

For RQ2, we were interested in the predictive power of autonomy-supportive teaching behaviors as perceived by the students while controlling for individual predictors of students’ situation-specific competence and value beliefs (i.e., trait-like competence and value beliefs, gender, and prior achievement). Thus, we first entered these individual covariates along with the two dummy variables for the intervention conditions into our model (Model 1 in Table 4) before entering the actual predictors of interest (i.e., students’ perceptions of autonomy-supportive teaching behaviors; Model 2).

When considering only the covariates in our model (i.e., trait-like competence and value beliefs, gender, prior achievement, and intervention conditions), we were able to explain between 10% and 13% of the total outcome variance with predictors at the student level and between 1% and 2% of the total outcome variance with predictors at the class level. Taken together, the individual characteristics and intervention conditions accounted for 11% to 15% of the total outcome variance in students’ situation-specific competence and value beliefs (though mostly through predictors at the student level).

We then examined the predictive power of students’ perceptions of autonomy-supportive teaching behaviors (i.e., autonomy-supportive learning climate and provision of meaningful rationales). For this purpose, we considered students’ perceptions of autonomy-supportive teaching behaviors at all levels as predictors of students’ situation-specific competence and value beliefs (see Model 2 in Table 4).

--- Insert Table 4 here ---

The results revealed that, first, students’ perceptions of the autonomy-supportive learning climate significantly and positively (and for cost, negatively) predicted students’ competence beliefs and value beliefs at all levels while controlling for the provision of meaningful rationales. The regression coefficients at the level of the observation ($|0.17| \leq b_{\text{observation}} \leq |0.39|$, $ps < .001$) mean that students who perceived a more autonomy-supportive learning climate also reported higher motivation. More precisely, students who perceived a more autonomy-supportive learning climate than usual and who perceived a more autonomy-supportive learning climate than their classmates within the same lesson also reported competence and value beliefs that were higher (and for cost, lower) than usual and higher (for cost, lower) than their classmates’ within the same lesson. At the level of the student, the regression coefficients ($|0.27| \leq b_{\text{student}} \leq |0.42|$, $ps < .001$) indicated that students who typically perceived a more autonomy-supportive learning climate than their classmates also usually reported higher competence and value beliefs (and lower cost) compared with the other students in their class. The results at the level of the lesson ($|0.41| \leq b_{\text{lesson}} \leq |0.83|$, $ps < .001$) revealed that when students reported a higher level of shared perceptions of an autonomy-supportive learning climate than usual, then they also reported a higher level of shared competence and value beliefs (and for cost, lower) than usual. The coefficients at the level of the class ($|0.46| \leq b_{\text{class}} \leq |0.82|$, $ps < .001$) revealed that classrooms that reported a higher time-consistent level of shared perceptions of an autonomy-supportive learning climate compared with other classrooms also reported a higher time-consistent level of

shared competence and value beliefs (and for cost, lower).

Second, with respect to the perceptions of the provision of meaningful rationales when controlling for an autonomy-supportive learning climate, the results were less consistent. At the level of the observation, we found significant and positive regression coefficients for students' competence beliefs, importance, intrinsic value, and—in contrast to the autonomy-supportive learning climate—also for cost ($0.04 \leq b_{\text{observation}} \leq 0.20$, $ps \leq .007$). At the level of the student, students' typical perceptions of the provision of meaningful rationales were additionally significantly and positively associated with students' value beliefs (again, including higher costs; $0.18 \leq b_{\text{student}} \leq 0.42$, $ps < .001$) but not with their competence beliefs ($b_{\text{student,cb}} = -0.04$, $p = .122$). Furthermore, at the level of the lesson, levels of shared perceptions of the provision of meaningful rationales within a certain lesson were only significantly and positively associated with students' situation-specific levels of shared value beliefs in terms of their importance and intrinsic value ($0.09 \leq b_{\text{lesson}} \leq 0.17$, $ps \leq .020$) but not with their situation-specific levels of shared competence beliefs or cost ($b_{\text{lesson,cb}} = 0.04$, $p = .373$, $b_{\text{lesson,cost}} = 0.00$, $p = .954$). Finally, at the level of the class, the time-consistent levels of shared perceptions of the provision of meaningful rationales were significantly and positively associated with students' time-consistent levels of shared value beliefs (including higher costs; $0.19 \leq b_{\text{class}} \leq 0.59$, $ps \leq .033$) but not with their time-consistent shared levels of competence beliefs ($b_{\text{class,cb}} = -0.09$, $p = .380$). At all levels, the regression weights were largest for students' importance as an outcome compared with the other competence and value beliefs.

By entering students' perceptions of the autonomy-supportive teaching behaviors into our model, we were able to account for a total of additional 23 up to 33 percentage points of the total variance in students' situation-specific competence and value beliefs, with the exception of cost, for which the autonomy-supportive teaching behaviors only accounted for additional 6 percentage points of the total variance. Broken down into the respective levels, we were able to

account for 6% up to 7% (except for cost: 1%) of the total outcome variance with predictors at the level of the observation; for 6% up to 11% (except for cost: 2%) of the total outcome variance with predictors at the level of the student; for 1% up to 3% of the total outcome variance with predictors at the level of the lesson; and for 8% up to 14% (except for cost: 2%) of the total outcome variance with predictors at the level of the class.

The results for RQ2 can be summarized in the following way. First, perceptions of an autonomy-supportive learning climate consistently predicted all outcomes of interest at all levels. This means that both fluctuating aspects within students and time-consistent differences between students—as well as fluctuations within classes and time-consistent differences between classes with respect to the average level of an autonomy-supportive learning climate as perceived by the students—coincided with fluctuating and time-consistent aspects of students’ situation-specific competence and value beliefs. Second, over and above perceptions of an autonomy-supportive learning climate, students’ perceptions of the provision of meaningful rationales predicted students’ competence and value beliefs. However, this was mainly the case for importance and, when also considering the other competence and value beliefs, primarily (but not exclusively) at the individual level. Third, the simultaneous consideration of the two dimensions of autonomy-supportive teaching behaviors as perceived by the students had descriptively the highest explanatory power for importance and the least for cost (see the total amount of explained variance in Table 4). Finally, taken together, time-consistent components of the perceptions of autonomy-supportive teaching behaviors explained descriptively more variance across the individual and class levels than fluctuating components (see Figure 5).

--- Insert Figure 5 here ---

Discussion

In a recent review of their model, Eccles and Wigfield (2020) re-emphasized the “situative nature” of competence and value beliefs and newly labeled it the *situated* expectancy-

value theory. In the present study, we aimed to develop a sound understanding of this situative nature by examining time-consistent and fluctuating components of students’ individual and shared competence and value beliefs and their sensitivity to the teaching context. To do so, we drew on repeated measures from five consecutive math lessons from 1,617 ninth-grade students and explicitly modeled states and traits at both the individual *and* class levels, and hence, we expanded upon previous research by revealing a more comprehensive picture of the distributions of the proportions of variance.

The present study revealed three major findings. First, the largest amount of variance in students’ competence beliefs, value beliefs (importance, intrinsic value, and cost), and perceptions of autonomy-supportive teaching behaviors (autonomy-supportive learning climate and provision of meaningful rationales) was attributed to the individual level rather than to the class level. Second, across the individual and class levels, fluctuating factors were mostly the predominant source of variance rather than time-consistent factors. Third, our results showed that autonomy-supportive teaching behaviors as perceived by the students predicted students’ competence and value beliefs over and above their trait-like competence and value beliefs, which we assessed with trait-like measures. More specifically, students’ as well as the classes’ time-consistent perceptions of autonomy-supportive teaching behaviors had higher explanatory power for their competence and value beliefs than fluctuating levels of these perceptions.

The Situative Nature of Competence and Value Beliefs

Our findings on the decomposition of the variance in students’ competence and value beliefs into time-consistent and fluctuating components *at the individual level* reinforce the findings from previous studies that have shown that motivation varies substantially between students and within students (e.g., Dietrich et al., 2017; Patall et al., 2016; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). Thus, students seem to differ substantially from one another in terms of their time-consistent levels of motivation. Furthermore, students’ situation-specific

competence and value beliefs fluctuate substantially around their time-consistent levels. These findings are in line with previous studies that found that occasion-specific factors accounted for 36% to 45% (Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008) and 45% to 82% (Dietrich et al., 2017) of the variance in students' values. Along with only a few other studies that have explicitly or implicitly studied the time-consistency of SEVT constructs, this finding not only substantiates Eccles and Wigfield's (2020) proposition of the situative nature of competence and value beliefs but also explicitly underpins their theoretical assumptions by providing concrete estimates of the decomposition of variance at the individual level. These estimates can be assumed to be even more reliable than the ones from the few previous studies because we were able to model the class level explicitly due to a sufficient sample size at that level and because our modeling approach prevented an incorrect dispersion of variance across too few levels (see Fielding, 2002; Luo & Kwok, 2009).

From the theoretical task- or situation-specificity of students' competence and value beliefs, Eccles and Wigfield (2020) derived a high level of similarity between intrinsic value and situational interest as defined in Hidi and Renninger's (2006) four-phase model of interest development. In alignment with this assumption and analogous to situation-specific measures of interest, our situation-specific measures of intrinsic value reflected a high degree of susceptibility to situation-specific environmental features. Additionally, and also analogous to situation-specific measures of interest (e.g., Knogler, 2017), students' intrinsic value in our study reflected to some extent a situational manifestation of students' trait-like intrinsic value (Dietrich et al., 2019; Nuutila et al., 2018). Thus, situation-specific measures of intrinsic value such as the measure we used in our study might capture both a situation-sensitive, not far-developed form of students' motivation and an internalized, enduring form that might be similar to individual interest as defined in interest theories (e.g., Hidi & Renninger, 2006; Krapp, 2002; Schiefele, 2009). In light of the remarkable situation-specificity of the other competence and value beliefs,

the analogy likening intrinsic value to situational interest (Eccles & Wigfield, 2020) could probably even be extended, and it might be reasonable to adapt it to encompass students' competence beliefs, importance, and cost. As such, competence and value beliefs could also be triggered by situations or environmental features and they might have the affordances to develop into relatively stable characteristics of a person (similar to well-developed individual interest; Hidi & Renninger, 2006).

In relation to the individual level, less variance in students' motivation was situated *at the class level* (between 9% and 13%), which is consistent with previous research (e.g., Patall et al., 2016). By and large, these proportions of variance were equally accounted for by time-consistent and fluctuating components. This means that classrooms differed substantially in their typical levels of shared competence and value beliefs due to common time-consistent characteristics; additionally, the situation-specific levels of shared competence and value beliefs of students in the same class shifted to a certain extent in sync from lesson to lesson due to common situation-specific characteristics that all students from the same classroom experienced. The findings regarding the time-consistency of students' shared intrinsic value in particular are aligned with Keller et al.'s findings regarding the decomposition of variance in students' enjoyment at the class level (40% of the class-level variance due to differences between classes and 60% due to differences within classes over time).

Beyond our findings on the task- and situation-specificity of students' competence and value beliefs, our findings provided justification for their subjectivity as well, and thus support SEVT's conceptualization of value beliefs as “*subjective* task values” (Eccles, 2005; Eccles et al., 1983). Following Eccles and Wigfield's (2020) most recent account of SEVT, not only an individual's competence and value beliefs (and their internal hierarchies) are assumed to be very much tied to the current situation but also the competence and value beliefs (and their hierarchies) of whole classrooms who experience the same classroom context, including the

teachers’ behaviors (Eccles, 1993, 2007). Consequently, one could have expected that the present study results would depict higher proportions of variance in students’ competence and value beliefs attributed to the class level. However, while competence and value beliefs are assumed to be situative in nature (from a time-consistency or contextual perspective), they are also assumed to be subjective to the individual (Eccles, 2005; Eccles et al., 1983). That is, even though the immediate situation might affect every student similarly (which should be depicted in higher proportions of variance at the class level), the interpretation of and sensitivity to different situations might vary broadly among individuals in the same class, which might be the reason why most of the variance was located at the individual level. Taken together, the findings of the present study are compatible with the theoretical assumptions of SEVT and broaden our understanding of how the assumed situative nature and subjectivity relate to each other.

In contrast to the often-used trait-like measures of students’ motivation, which are typically highly stable across time (e.g., Rieger et al., 2017; Wigfield et al., 1997), we relied on situation-specific measures of students’ competence and value beliefs because they can be assumed to be better suited to capture their situation sensitivity (see Braun et al., 2021). In our study, situation-specific proportions of variance were more pronounced than they were in studies that relied on trait-like measures. Consequently, we would not expect similar result patterns as the ones in our study if one used trait-like measures of students’ competence and value beliefs. In view of our research aim, we think it was reasonable and even a strength of the present investigation to use situation-specific measures instead of trait-like measures in order to adequately capture in-the-moment associations. However, this statement cannot be made in a general way because the time frame and specificity level of the items should always be derived theoretically and be aligned with the respective research question under investigation. Additionally, more systematic research is certainly needed to grasp a better sense of how the framing of the items (i.e., the time frame and the level of specificity) affects the decomposition

of variance and, even more importantly, the associations with other variables (see Braun et al., 2021; Lance et al., 2019; see also Goetz et al., 2016; Goetz, Bieg, et al., 2013).

The Situation-Specificity of Autonomy-Supportive Teaching Behaviors

In order to explain systematic variation in students’ competence and value beliefs, we considered students’ perceptions of their teachers’ autonomy-supportive teaching behaviors. Our findings revealed that students’ perceptions of the provision of meaningful rationales as well as an autonomy-supportive learning climate were highly situation-specific as a substantial amount of their variance was explained by a fluctuating factor. This contradicts previous findings from Wagner et al. (2016), who found that variance in students’ shared perceptions of autonomy support was predominantly due to differences between students and between classes and only marginally due to fluctuations within students and within classes over time. However, Wagner et al. used trait-like instead of situation-specific measures (which in itself can already be a reason for different proportions of variance; Braun et al., 2021; Lance et al., 2019), and consequently, the differences in the findings are not that surprising after all.

Our findings additionally revealed that students’ perceptions of the provision of meaningful rationales were more fluctuating than their perceptions of an autonomy-supportive learning climate (created through attention to and consideration of students’ feelings and thoughts in the classroom, the provision of meaningful choices, and the nurturing of students’ feelings of acknowledgment). This somehow differed from previous research (e.g., Patall, Steingut, et al., 2018) that revealed a tendency for the provision of meaningful rationales to be less fluctuating than other dimensions of autonomy-supportive teaching behaviors. This could indicate a specificity of math classes, in which the provision of rationales could hinge more on the actual topic of the respective lesson compared with other subjects. Math teachers in particular might provide more rationales when introducing a new topic compared with lessons that students must engage in predominantly to consolidate their knowledge. Our findings could reflect such

variation between the focus of the math lessons accompanied by a varying amount of rationale provision.

The Predictive Power of Autonomy-Supportive Teaching Behaviors

Overall, our results revealed that the regression coefficients for students’ shared perceptions of autonomy-supportive teaching behaviors were usually higher than—and sometimes even double the size of—the coefficients for their individual perceptions. This was also reflected in large proportions of *level-specific* variance that were explained by time-consistent and fluctuating aspects of autonomy-supportive teaching behaviors at the class level (between 15% and 66%). Based on these level-specific proportions of explained variance alone, one could reach the conclusion that the level of autonomy-supportive teaching behaviors as perceived by *all* students in the same class is more important for students’ motivation than their individual deviations from these shared perceptions. However, the overall decomposition of variance also needs to be considered when interpreting these predictive effects, as there was not as much variance in the variables of interest at the class level as there was at the individual level.

By contrast, in relation to the *total* variance in students’ competence and value beliefs, students’ time-consistent perceptions of autonomy-supportive teaching behaviors ultimately explained more variance in their competence and value beliefs (except for cost) than fluctuations from lesson to lesson—at both the individual and class levels. This means that, irrespective of the systematically higher regression coefficients at the class level compared with the individual level, by and large, time-consistent aspects of autonomy-supportive teaching behaviors accounted for more variance in students’ competence and value beliefs (except for cost) compared with fluctuating components of autonomy-supportive teaching behaviors (at both levels). Consequently, the typical level of autonomy-supportive teaching behaviors as perceived by individual students as well as by all students in the same class was more predictive for students’ motivation than individual or shared lesson-specific deviations from these perceptions

were. This finding is in line with previous research that found that higher proportions of variance in students’ motivation were explained by time-consistent rather than fluctuating components of autonomy-supportive teaching behaviors (e.g., Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008).

Regarding cost, students’ perceptions of autonomy-supportive behaviors seemed to be only slightly relevant overall (irrespective of the level). On a conceptual level, cost as a construct shares a great deal of overlap with students’ disaffection as measured in the study by Patall, Steingut, et al. (2018, e.g., “When I was in science class today, I felt bad”), with a similarly small amount of variance explained by autonomy-supportive teaching behaviors. Analogous to their study, the mere absence of autonomy-supportive teaching behaviors was not automatically reflected in higher levels of cost/disaffection. Rather, on the basis of Patall, Steingut, et al.’s findings, we speculate that, in particular, demotivating teaching behaviors such as autonomy-thwarting teaching (indicated by controlling messages, suppression, and uninteresting activities) might be able to explain the variance in students’ cost perceptions. Investigating this potential link is a task for further research.

Furthermore, students’ perceptions of the provision of meaningful rationales mostly offered additional predictive power over and above the autonomy-supportive learning climate (apart from cost). This was especially the case when predicting students’ importance perceptions. Our findings thus reiterate previous results from within-person (e.g., Patall, Steingut, et al., 2018) and between-person analyses (e.g., Assor et al., 2002; Reeve et al., 2002; Schmidt et al., 2019; Schreier et al., 2014) that pointed to the significance of meaningful rationales for students’ motivation. Importantly, expanding upon this research, our findings also provided initial evidence that students’ perceptions of the provision of meaningful rationales and their importance perceptions covary not only regarding students’ time-consistent individual and shared levels over time but also with their fluctuating levels at each time point.

This study thus adds to previous findings that already linked SDT constructs such as

autonomy support to SEVT constructs (e.g., González & Paoloni, 2015; Tsai, Kunter, Lüdtke, Trautwein, & Ryan, 2008). In line with Eccles (2005) who carved out conceptual overlaps between value beliefs and motivation as defined in SDT, our findings suggested similar positive associations of autonomy-supportive teaching behaviors with importance and intrinsic value to associations reported in the literature with autonomous motivation (see Stroet et al., 2013, for an overview).

Practical Implications

Our findings draw a highly relevant picture for educational practice. The findings on the variability of competence and value beliefs emphasize what teachers perceive regularly—namely, that their classes are truly heterogeneous when it comes to students’ motivation. In our study, students in the same class were not identical in terms of their situation-specific competence and value beliefs and, consequently, might differ in what they need to support their motivation. Additionally, they differed from lesson to lesson. Given that also the average level of motivation varied from classroom to classroom as well as from lesson to lesson, teachers seem to be confronted with changing conditions in every situation of their work day, and a maximum level of sensitivity is likely needed to adapt appropriately to changes in their students’ individual and shared motivation.

However, as our findings on the predictive power of autonomy-supportive teaching behaviors also revealed, teachers are not without means to counteract motivational imbalances. Indeed, our study showed that individual students and even entire classrooms who perceived their teachers to support their autonomy also reported higher competence and value beliefs. This was particularly the case for students’ typical perceptions of autonomy and their typical levels of motivation. Teachers’ autonomy-supportive teaching behaviors in single lessons, however, should not be neglected, even though they did not explain much variance in students’ situation-specific competence and value beliefs. Yet not only does every lesson contribute to the typical

level of autonomy-supportive teaching behaviors, but additionally, deviations from the typical level of autonomy-supportive teaching behaviors were still highly associated with students’ situation-specific competence and value beliefs if they occurred. Consequently, even if teachers typically instruct in an autonomy-supportive way, it appears important to prevent one-time low points in their autonomy-supportive teaching behaviors as this substantially coincided with lower levels of students’ situation-specific competence and value beliefs.

Given that autonomy-supportive teaching behaviors were of similar predictive power for students’ competence and value beliefs at the individual and class levels, this could indicate that teachers are able to equally well support their students’ motivation with autonomy-supportive teaching behaviors that are tailored to the individual students as with autonomy-supportive teaching behaviors that are focused on the entire classroom. Results from studies that have evaluated theory-based training programs to enhance teachers’ autonomy support have suggested that teachers can be supported to create such a climate in school (e.g., Aelterman et al., 2014; Cheon et al., 2018; Cheon & Reeve, 2015) and, thus, our findings reinforce the benefit of the goals that such training programs pursue. However, research based on intervention studies that compare targeting individual students versus the entire classroom is necessary to put these indications on a solid basis. Furthermore, we speculate that providing meaningful rationales during math class is particularly promising for the support of the shared motivation in class because students seem to more strongly agree upon their perceptions of the provision of meaningful rationales compared with their perceptions of an autonomy-supportive learning climate (as indicated by the higher class-level ICC for the provision of meaningful rationales).

Limitations and Future Research

Despite its novel approach to the situative nature of students’ competence and value beliefs, our study also has several limitations, some of which might constitute starting points for future research. First, we interpreted the associations between students’ competence and value

beliefs with autonomy-supportive teaching behaviors in line with theory, assuming that students’ perceptions of the learning context affected their motivation (e.g., Eccles, 1993; Ryan & Deci, 2000). However, even though we controlled for relevant covariates, interpretations of these associations directed the opposite way as well as associations via other motivational variables (e.g., needs; Yu & Levesque-Bristol, 2020) cannot be ruled out.

Second, this study was based on student reports not only of their motivation but also of their perceptions of autonomy-supportive teaching behaviors. Students are seen as “experts on different modes of teaching” (Kunter & Baumert, 2006, p. 232), and their ratings can be assumed to be more important for their individual development (Clausen, 2002) because their subjective interpretations are focal for their inner attitudes and behaviors rather than any kind of objective indicator. In our opinion, students’ self-reports were therefore best suited for the purposes of this study. Student reports are particularly with respect to the research focus of the current study—intraindividual associations between students’ teaching appraisals and their motivation—indispensable. However, future research might try additionally capturing teacher (or also observer) ratings of autonomy-supportive teaching behaviors in order to subsequently link them to students’ competence and value beliefs (but see, e.g., Stroet et al., 2015, who did not find any associations between observer ratings of autonomy support and students’ self-reported motivation).

Third, our study relied on data from an intervention study, which was aimed at fostering students’ motivation. However, other studies investigating similar research questions have also drawn on data from intervention studies (e.g., Wagner et al., 2016) and have handled this circumstance similarly (i.e., by controlling for the intervention in all models). Even though an impact of the intervention on the study results can never be ruled out completely, our robustness checks did not indicate differences in the associations between perceptions of autonomy-supportive teaching behaviors and students’ competence and value beliefs in the different

intervention groups.

Fourth, special attention has to be drawn to the referents in the student ratings of the autonomy-supportive teaching behaviors. Whereas both items used for the provision of meaningful rationales provided the class as the referent (“*Our* teacher explained to *us* how...”), the referents in the items for measuring an autonomy-supportive learning climate were intermixed, also including items in which the individual was presented as the referent (“*I* felt understood by *my* instructor.”). Though research on this topic is rare, referring to either a group or the individual might initiate different response processes in the students (Jaekel et al., 2020), which could be reflected in the slightly varying decompositions of variance that we observed in these two constructs. Yet it does not appear likely that the intermixed use of referents affected our results (Jaekel et al., 2020; but see also den Brok et al., 2006) and, indeed, additional analyses of the two subscales of an autonomy-supportive learning climate using the class or the student as the referent revealed only negligible differences in the ICCs of the two subscales (see Tables S8 and S9 in the online supplemental material). However, future research might want to explore further whether and how referring to the class or the individual affects the appraisal of autonomy-supportive teaching behaviors.

Finally, the extent to which our findings generalize to other domains and age groups has yet to be determined. With respect to trait-like measures of motivation and teaching behaviors, however, previous research has provided a fairly consistent picture in which students’ motivation and perceptions of teaching behaviors were relatively stable across time, grade levels, and school subjects (e.g., Gaertner & Brunner, 2018; Wigfield et al., 1997). Additionally, links between student motivation and global ratings of teaching behaviors seem to be consistent between subjects from similar domains (e.g., Blömeke & Olsen, 2019). However, research has yet to determine the extent to which such findings from studies using trait-like measures are transferable to the stability of situation-specific measures and, particularly, to their associations

at different levels.

Conclusion

Are students’ competence and value beliefs sensitive to situation specificities? And what constitutes the situation specificities that eventually lead to their situation-specific competence and value beliefs during class? Answering these questions is key for both research and educational practice as they provide valuable information about whether and how teaching might be linked to students’ competence beliefs, beliefs about the importance of math, their intrinsic value, and the subjective costs of engaging in math. With the current study, we provided evidence of the situative nature of high-school students’ math competence and value beliefs and pointed to the highly predictive power of teachers’ autonomy-supportive teaching behaviors as reported by the students. Our findings furthermore revealed that especially differences in time-consistent perceptions of teaching behaviors between students and between classes contributed to the variance in students’ competence and value beliefs (rather than differences within students or classrooms). Thus, our findings supported the situative nature of competence and value beliefs but also revealed that, by and large, typical levels of autonomy–supportive teaching behaviors are more predictive of students’ competence and value beliefs than situation-specific fluctuations.

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Table 1*Means, Standard Deviations, and Bivariate Correlations among the Measures of Interest at the Levels of the**Observation, Student, Lesson, and Class*

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11	12
<i>Level of the observation</i>														
1. Competence beliefs			—											
2. Importance			.41	—										
3. Intrinsic value			.55	.61	—									
4. Cost			-.55	-.12	-.32	—								
5. Autonomy-supportive learning climate			.46	.50	.52	-.26	—							
6. Meaningful rationales			.21	.49	.35	-.03	.45	—						
<i>Level of the student</i>														
1. Competence beliefs	2.97	0.56	—											
2. Importance	2.68	0.53	.45	—										
3. Intrinsic value	2.68	0.58	.59	.69	—									
4. Cost	1.96	0.54	-.66	-.13	-.33	—								
5. Autonomy-supportive learning climate	2.93	0.54	.52	.57	.60	-.32	—							
6. Meaningful rationales	2.25	0.62	.26	.61	.47	-.04	.56	—						
7. Trait-like competence beliefs	2.78	0.77	.48	.22	.30	-.36	.23	.16	—					
8. Trait-like importance	2.85	0.49	.34	.49	.39	-.15	.31	.26	.44	—				
9. Trait-like intrinsic value	2.48	0.86	.42	.35	.46	-.29	.28	.23	.71	.57	—			
10. Trait-like cost	2.12	0.69	-.46	-.20	-.30	.45	-.27	-.14	-.72	-.34	-.64	—		
11. Gender (m = 0)	0.54	0.50	-.06	-.05	-.02	-.03	.05	-.11	-.17	-.06	-.07	.07	—	
12. Prior achievement	4.23	0.98	.34	.14	.19	-.27	.21	.10	.59	.23	.41	-.50	.08	—
<i>Level of the lesson</i>														
1. Competence beliefs			—											
2. Importance			.42	—										
3. Intrinsic value			.67	.72	—									
4. Cost			-.77	-.12	-.42	—								
5. Autonomy-supportive learning climate			.51	.61	.62	-.32	—							
6. Meaningful rationales			.22	.59	.42	-.05	.53	—						
<i>Level of the class</i>														
1. Competence beliefs			—											
2. Importance			.36	—										
3. Intrinsic value			.61	.77	—									
4. Cost			-.78	.01	-.29	—								
5. Autonomy-supportive learning climate			.53	.62	.63	-.33	—							
6. Meaningful rationales			.27	.71	.51	-.03	.66	—						

Note. For prior achievement, higher values indicate better achievement. Bivariate correlations in italics are not significant at $p < .05$. All other correlations are significant at $p < .05$. m = male.

Table 2

Absolute Proportions of Variance, Variance Partition Coefficients, and the Total Variance in Students' Situation-Specific Competence Beliefs, Value Beliefs, and Perceptions of Autonomy-Supportive Teaching Behaviors

Variable	Individual level				Class level				Total
	State residual		Trait		State residual		Trait		Var
	Var	VPC	Var	VPC	Var	VPC	Var	VPC	
Competence beliefs	0.29	0.52	0.22	0.38	0.03	0.05	0.03	0.05	0.57
Importance	0.17	0.40	0.20	0.47	0.02	0.04	0.04	0.08	0.43
Intrinsic value	0.30	0.49	0.24	0.39	0.04	0.07	0.04	0.06	0.62
Cost	0.32	0.56	0.20	0.36	0.03	0.05	0.02	0.04	0.57
Autonomy-supportive learning climate	0.16	0.37	0.20	0.46	0.02	0.03	0.06	0.13	0.44
Meaningful rationales	0.34	0.45	0.23	0.30	0.08	0.11	0.10	0.13	0.75

Note. Var = variance; VPC = variance partition coefficient.

Table 3*Proportions of Relative Variance Across State/Trait Components and Across Levels*

Variable	Across state/trait components		Across levels	
	Individual-level	Class-level	State residuals	Traits
	Σ VPC	Σ VPC/ ICC	Σ VPC	Σ VPC
Competence beliefs	0.90	0.10	0.56	0.44
Importance	0.87	0.13	0.45	0.55
Intrinsic value	0.87	0.13	0.56	0.44
Cost	0.91	0.09	0.60	0.40
Autonomy-supportive learning climate	0.83	0.17	0.41	0.59
Meaningful rationales	0.76	0.24	0.57	0.43

Note. The coefficients in the first column are a sum of the proportions of individual-level state residual variance and individual-level trait variance; analogously, the coefficients in the second column are a sum of the proportions of class-level state residual variance and class-level trait variance. The coefficients in the third column are a sum of the proportions of state residual variance at both the individual and class levels; analogously, the coefficients in the fourth column are a sum of the proportions of trait variance at both the individual and class levels. The coefficients from each set of two columns within each row add up to 1 (except for inaccuracies caused by rounding). VPC = variance partition coefficient; ICC = intraclass correlation coefficient.

Table 4

Multilevel Models Regressing Students' Competence or Value Beliefs on Students' Individual Characteristics and the Intervention Conditions (Model 1) and Additionally on the Perceptions of Autonomy-Supportive Teaching Behaviors (Model 2)

Variable	Competence beliefs				Importance				Intrinsic value				Cost			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Fixed effects																
	Est.	SE		SE	Est.	SE		SE	Est.	SE		SE	Est.	SE		SE
Intercept	-0.01	0.06			-0.12	0.06	*		-0.10	0.04	*		-0.03	0.06		
Level of the observation																
Autonomy-sup. learning climate ^a			0.39	0.02	***				0.26	0.01	***			0.35	0.02	***
Meaningful rationales ^a			0.05	0.02	***				0.20	0.01	***			0.09	0.01	***
Level of the student																
Autonomy-sup. learning climate ^a			0.42	0.02	***				0.27	0.02	***			0.40	0.02	***
Meaningful rationales ^a			-0.04	0.03					0.42	0.03	***			0.20	0.03	***
Respective trait-like measure	0.33	0.02	***		0.25	0.02	***		0.24	0.02	***		0.33	0.02	***	
Gender (m = 0)	-0.04	0.03			-0.08	0.03	*		0.02	0.03			0.01	0.03		
Prior achievement	0.06	0.02	**		0.05	0.02	**		0.03	0.02			0.01	0.02		
Level of the lesson																
Autonomy-sup. learning climate ^a			0.62	0.06	***				0.53	0.05	***			0.83	0.06	***
Meaningful rationales ^a			0.04	0.04					0.17	0.03	***			0.09	0.04	*
Level of the class																
Autonomy-sup. learning climate			0.82	0.10	***				0.48	0.08	***			0.73	0.09	***
Meaningful rationales			-0.09	0.10					0.59	0.08	***			0.19	0.09	*
Teacher condition	-0.04	0.08			-0.04	0.07			0.14	0.06	*		0.05	0.08		
Master's student condition	0.01	0.08			0.04	0.07			0.15	0.06	*		-0.02	0.08		
Random effects																
	Est.		Est.		Est.				Est.				Est.		Est.	
σ ² _e (individual-level state residual)	.520		.455		.404				.344				.487		.428	
σ ² _{r(2)} (individual-level trait)	.248		.181		.334				.197				.280		.166	
σ ² _{r(3)} (class-level state residual)	.048		.031		.043				.023				.071		.033	
σ ² _u (class-level trait)	.059		.044		.061				.027				.048		.033	
Number of observations	6987		6914		7001				6922				6998		6922	

Table 4 (*continued*)

Variable	Competence beliefs				Importance				Intrinsic value				Cost			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Explained variance ^b															
	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2
Level of the observation	.00	.00	.14	.07	.00	.00	.17	.06	.00	.00	.14	.06	.00	.00	.02	.01
Level of the student	.34	.13	.19	.06	.29	.13	.30	.11	.27	.10	.30	.10	.28	.10	.07	.02
Level of the lesson	.00	.00	.36	.02	.00	.00	.45	.02	.00	.00	.51	.03	.00	.00	.15	.01
Level of the class	.17	.01	.54	.08	.22	.02	.65	.14	.14	.01	.66	.11	.28	.01	.25	.02
Total		.14		.23		.15		.33		.11		.30		.11		.06

Note. All continuous variables were standardized beforehand across individuals and across time points, and thus, all regression coefficients can be understood as standardized regression coefficients. For prior achievement, higher values indicate better achievement. Results were based on the analysis of 1,617 students, 360 separate lessons, and 78 classrooms. Unstandardized results are reported in Table S6 in the online supplemental material. m = male; Est. = estimated regression coefficient; R_l^2 = proportion of *level-specific* outcome variance explained by level-specific predictors; R_t^2 = proportion of *total* outcome variance explained by level-specific predictors.

^a Scales were centered on the cluster means.

^b Explained variance (R_l^2 and R_t^2) was estimated by using the model-implied total variance by following the recommendations of Rights and Sterba (2019, 2020).

Incremental explained variance (ΔR_l^2 and ΔR_t^2) was obtained by subtracting the proportions of variance explained by Model 1 from the corresponding proportions of variance explained by Model 2.

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

Figure 1

Simplified Illustration of the Constitution of States at the Individual Level and the Class Level

Figure 2*Time Points from the MoMa 2 Study Design*

Note. For the current investigation, data from the pretest and the five consecutive lessons (T1 to T5) were used. Some students experienced an intervention between pretest and T1, which we controlled for in our statistical analyses.

Figure 3
Diagram Depicting the Structure of the Three-Level Cross-Classified Data

Note. C = class, S = student, L = lesson, O = observation.

Figure 4

Graphical Representation of the Decomposition of Variance in Students' Competence and Value Beliefs

Figure 5

Graphical Representation of the Proportions of Total Explained Variance Explained by Students' Perceptions of Autonomy-Supportive Teaching Behaviors

Appendix A

Measures Used to Assess Students’ Situation-Specific Competence Beliefs, Value Beliefs, Perceptions of the Autonomy-Supportive Learning Climate, and Perceptions of the Provision of Meaningful Rationales

Scale Items	Source
Competence beliefs	
I had the impression that I could handle the demands well. ^a	Self-developed
I could follow the lesson without any problems. ^a	Self-developed
Importance	
What we learned today has meaning for me.	Self-developed
It was important to me that I thoroughly understood the material that was covered.	Adapted from Tsai, Kunter, Lüdtke, Trautwein, & Ryan (2008)
The material can be useful for me.	Adapted from Tsai, Kunter, Lüdtke, Trautwein, & Ryan (2008)
What we learned today will be useful elsewhere.	Self-developed
Intrinsic value	
The material was interesting to me. ^a	Adapted from Tsai, Kunter, Lüdtke, Trautwein, & Ryan (2008)
I enjoyed dealing with the material. ^a	Adapted from Patall, Steingut, et al. (2018)
Cost	
Dealing with the material was exhausting to me.	Adapted from Gaspard et al. (2015)
I was upset because I needed to deal with this material (e.g., annoyed, anxious, and/or nervous).	Adapted from Dietrich et al. (2017)
Autonomy-supportive learning climate as perceived by the students	
I felt that my teacher provided me choice and options.	Adapted from Williams & Deci (1996)
I felt understood by my instructor.	Adapted from Williams & Deci (1996)
My instructor conveyed confidence in my ability to do well in the course.	Williams & Deci (1996)
Our teacher tried to understand how we see things when we had any questions or complaints.	Self-developed
Our teacher treated us with appreciation and respect.	Self-developed

(continued)

Scale Items	Source
Provision of meaningful rationales as perceived by the students	
Our teacher explained to us how the material is related to our everyday lives.	Adapted from Flunger et al. (2019)
Our teacher explained to us why the topic of today's lesson can be relevant for us.	Adapted from Flunger et al. (2019)

Note. Trait-like measures of students' competence and value beliefs can be retrieved from Gaspard et al. (2021).

^a Item was also used by Gaspard and Lauermann (2021) as part of the *student engagement* scale.

Appendix B

Equations Underlying (1) the Decomposition of Variance and (2) the Multilevel Regression

Models with Separate Regression Coefficients for Each Level (Observation, Student,

Lesson, Class)

Disentangling Proportions of Variance

Applying Beretvas’ (2011) notation, the model reads:

$$Y_{i(j_1, j_2)k} = \gamma_{0000} + e_{i(j_1, j_2)k} + r_{0j_10k} + r_{00j_2k} + u_{000k}, \quad (1)$$

where $Y_{i(j_1, j_2)k}$ represents the outcome score of the i th observation reported by student j_1 in lesson j_2 for class k ; γ_{0000} represents the overall mean outcome score; $e_{i(j_1, j_2)k}$ is the random effect associated with the i th observation reported by student j_1 in lesson j_2 for class k (and the state residual variance, σ_e^2 , represents how much students fluctuate around their individual trait over time and how much students fluctuate around the class mean in the respective lesson); r_{0j_10k} is the random effect associated with the j_1 th student in class k (and the trait variance, $\sigma_{r_2}^2$, represents how much students within the same class differ from one another in their traits); r_{00j_2k} is the random effect associated with the j_2 th lesson in class k (and the state residual variance, $\sigma_{r_3}^2$, represents how much a class fluctuates around the class mean over time); u_{000k} is the random effect associated with the k th class (and the trait variance, σ_u^2 , represents how much classes differ from one another in their traits).

Predicting Students’ Situation-Specific Competence and Value Beliefs

$$Y_{i(j_1, j_2)k} = \gamma_{0000} + \quad (2)$$

$$\sum_{l=1}^2 \gamma_{000l}^b Z_{l...k} + \sum_{l=3}^4 \gamma_{000l}^b (\bar{X}_{l...k} - \bar{X}_{l,...}) +$$

$$\sum_{p=1}^2 \gamma_{00p0}^b (\bar{X}_{p,0j_2k} - \bar{X}_{p,...k}) +$$

$$\sum_{m=1}^2 \gamma_{0m00}^b (\bar{X}_{m,j_10k} - \bar{X}_{m,...k}) + \sum_{m=3}^5 \gamma_{0m00}^b (W_{m,j_1k} - \bar{W}_{m,...}) +$$

$$\sum_{n=1}^2 \gamma_{n000}^w (X_{n,i(j_1, j_2)k} - \bar{X}_{n,j_10k} - \bar{X}_{n,0j_2k}) +$$

$$e_{i(j_1,j_2)k} + r_{0j_10k} + r_{00j_2k} + u_{000k},$$

where γ_{0000} represents the situation-specific individual score of a student who was in the waitlist control condition with average scores on the individual student characteristics and an average level of perceptions of autonomy-supportive teaching behaviors; γ_{000l} (for $l = 1,2$) are the effects associated with the dummy-coded intervention conditions, $Z_{1,..k}$ and $Z_{2,..k}$ (with the control condition as reference group); γ_{000l}^b (for $l = 3,4$) are the between-effects associated with the grand-mean-centered class-level aggregates of the predictor variables, $\bar{X}_{l,..k}$ (i.e., aggregates of autonomy-supportive teaching behaviors at the level of the class), and $\bar{X}_{l,..}$ is the corresponding grand mean. Furthermore, γ_{00p0}^b (for $p = 1,2$) are the between-effects associated with the cluster-mean-centered aggregates of the predictor variables at the level of the lesson, $\bar{X}_{p,0j_2k}$ (i.e., aggregates of autonomy-supportive teaching behaviors at the level of the lesson), and $\bar{X}_{p,..k}$ is the corresponding cluster mean in class k ; γ_{0m00}^b (for $m = 1,2$) are the between-effects associated with the cluster-mean-centered student-level aggregates of the predictor variables; $\bar{X}_{m,j_10k}$ (i.e., aggregates of autonomy-supportive teaching behaviors at the level of the student), and $\bar{X}_{m,..k}$ is the corresponding cluster mean in class k ; γ_{0m00}^b (for $m = 3, \dots, 5$) are the between-effects associated with the grand-mean-centered individual characteristics; W_{m,j_1k} (i.e., trait-like measures of the respective outcome, gender, and achievement), and $\bar{W}_{m,..}$ is the corresponding grand mean; and γ_{n000}^w (for $n = 1,2$) are the within-effects associated with the cluster-mean-centered predictors at the level of the observation, $X_{n,i(j_1,j_2)k}$ (i.e., autonomy-supportive teaching behaviors).

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Table S1*Multilevel Models with Additional Interaction Terms between all Considered Variables and the Two Dummy-Coded Intervention Conditions*

Variable	Competence beliefs				Importance				Intrinsic value				Cost			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Fixed effects																
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Intercept	-0.01	0.06	-0.02	0.05	-0.12	0.06	-0.09	0.05 *	-0.03	0.06	-0.03	0.05	-0.06	0.05	-0.05	0.05
Level of the observation																
Autonomy-sup. learning climate ^a			0.39	0.03 ***			0.23	0.03 ***			0.36	0.03 ***			-0.17	0.03 ***
Meaningful rationales ^a			0.06	0.03 *			0.17	0.02 ***			0.08	0.03 **			0.05	0.03
Level of the student																
Autonomy-sup. learning climate ^a			0.41	0.04 ***			0.26	0.04 ***			0.39	0.04 ***			-0.27	0.05 ***
Meaningful rationales ^a			-0.04	0.05			0.46	0.05 ***			0.24	0.05 ***			0.10	0.05
Respective trait-like measure	0.36	0.04 ***	0.28	0.03 ***	0.41	0.03 ***	0.28	0.03 ***	0.36	0.03 ***	0.24	0.03 ***	0.36	0.03 ***	0.30	0.03 ***
Gender (m = 0)	-0.10	0.06	-0.10	0.05	-0.08	0.06	-0.01	0.05	0.02	0.06	0.06	0.05	-0.03	0.06	-0.02	0.06
Prior achievement	0.04	0.04	0.03	0.03	0.04	0.03	0.00	0.03	0.00	0.03	-0.02	0.03	0.00	0.03	0.01	0.03
Level of the lesson																
Autonomy-sup. learning climate ^a			0.68	0.12 ***			0.47	0.10 ***			0.97	0.11 ***			-0.58	0.13 ***
Meaningful rationales ^a			0.08	0.07			0.14	0.06 *			0.07	0.07			-0.06	0.08
Level of the class																
Autonomy-sup. learning climate			0.98	0.15 ***			0.34	0.13 *			0.68	0.14 ***			-0.65	0.14 ***
Meaningful rationales			-0.08	0.16			0.55	0.14 ***			0.22	0.15			0.20	0.15
Teacher condition	-0.04	0.08	-0.03	0.07	0.19	0.09 *	0.14	0.06 *	0.05	0.08	0.04	0.07	0.12	0.07	0.10	0.06
Master's student condition	0.01	0.08	0.03	0.07	0.17	0.08	0.15	0.06 *	-0.02	0.08	-0.01	0.07	0.12	0.07	0.10	0.06
Interaction with Condition 1 (i.e., variable×cond1)																
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Level of the observation																
Autonomy-sup. learning climate ^a			0.01	0.04			0.04	0.04			0.00	0.04			-0.03	0.04
Meaningful rationales ^a			-0.04	0.04			0.05	0.03			0.04	0.04			0.03	0.04

Table S1 (*continued*)

Variable	Competence beliefs				Importance				Intrinsic value				Cost			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Interaction with Condition 1 (i.e., variable×cond1)																
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Level of the student																
Autonomy-sup. learning climate ^a			0.02	0.06			0.03	0.06			0.04	0.05			-0.04	0.06
Meaningful rationales ^a			0.02	0.07			-0.07	0.07			-0.11	0.06			0.11	0.07
Respective trait-like measure	-0.04	0.05	-0.06	0.05	-0.06	0.04	-0.06	0.04	-0.02	0.04	-0.02	0.04	-0.11	0.05 *	-0.09	0.05 *
Gender (m = 0)	0.03	0.08	-0.02	0.07	0.05	0.09	0.04	0.07	-0.04	0.08	-0.09	0.07	-0.07	0.08	-0.01	0.08
Prior achievement	0.02	0.05	0.03	0.05	0.00	0.04	-0.01	0.04	0.00	0.05	0.00	0.04	-0.05	0.05	-0.05	0.05
Level of the lesson																
Autonomy-sup. learning climate ^a			-0.15	0.17			0.05	0.14			-0.28	0.17			0.16	0.19
Meaningful rationales ^a			-0.06	0.11			0.06	0.09			0.06	0.10			0.05	0.12
Level of the class																
Autonomy-sup. learning climate			0.06	0.26			0.25	0.22			0.32	0.24			-0.04	0.23
Meaningful rationales			-0.37	0.26			0.02	0.23			-0.29	0.24			0.53	0.23 *
Interaction with Condition 2 (i.e., variable×cond2)																
	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
Level of the observation																
Autonomy-sup. learning climate ^a			-0.02	0.04			0.04	0.04			-0.02	0.04			0.01	0.04
Meaningful rationales ^a			0.01	0.04			0.05	0.03			0.01	0.04			-0.03	0.04
Level of the student																
Autonomy-sup. learning climate ^a			0.00	0.06			-0.02	0.06			0.00	0.05			0.04	0.06
Meaningful rationales ^a			-0.03	0.06			-0.05	0.06			-0.01	0.06			0.09	0.07
Respective trait-like measure	-0.04	0.05	-0.02	0.05	-0.06	0.04	-0.05	0.04	-0.05	0.04	-0.02	0.04	-0.03	0.05	0.00	0.05
Gender (m = 0)	0.15	0.08	0.10	0.07	0.10	0.09	0.05	0.07	-0.01	0.08	-0.06	0.07	0.03	0.08	0.04	0.08
Prior achievement	0.04	0.05	0.02	0.04	-0.01	0.04	0.01	0.04	0.01	0.04	0.00	0.04	-0.05	0.05	-0.05	0.04
Level of the lesson																
Autonomy-sup. learning climate ^a			-0.06	0.15			0.09	0.13			-0.14	0.15			0.30	0.16
Meaningful rationales ^a			-0.07	0.09			0.02	0.08			0.02	0.09			0.11	0.10
Level of the class																
Autonomy-sup. learning climate			-0.37	0.22			0.17	0.19			-0.03	0.20			0.43	0.20 *
Meaningful rationales			0.23	0.22			0.05	0.19			0.06	0.21			-0.21	0.20

Table S1 (continued)

Variable	Competence beliefs		Importance		Intrinsic value		Cost	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
	Random effects							
	Est.	Est.	Est.	Est.	Est.	Est.	Est.	Est.
σ^2_e (individual-level state residual)	.520	.455	.404	.344	.487	.428	.557	.545
$\sigma^2_{r(2)}$ (individual-level trait)	.248	.181	.334	.198	.281	.167	.250	.224
$\sigma^2_{r(3)}$ (class-level state residual)	.048	.032	.043	.023	.071	.033	.048	.041
σ^2_u (class-level trait)	.059	.040	.061	.028	.049	.034	.035	.023
Number of observations	6987	6914	7001	6922	6998	6922	6993	6915

Note. All continuous variables were standardized beforehand across individuals and across time points, and thus, all regression coefficients can be understood as standardized regression coefficients. All continuous variables were standardized beforehand across individuals and across time points, and thus, all regression coefficients can be understood as standardized regression coefficients. For prior achievement, higher values indicate better achievement. Results were based on the analysis of 1,617 students, 360 separate lessons, and 78 classrooms. m = male; Est. = estimated regression coefficient.

^a Scales were centered on the cluster means.

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

Table S2*Average Time Lags between the Intervention and the Five Consecutive Math Lessons (in Days)*

From – to	<i>N</i>	ΔMin	ΔMax	ΔM	ΔSD
Intervention – T1	52	1	20	4.44	3.73
T1 – T2	77	1	12	3.60	2.13
T2 – T3	73	1	15	4.11	2.62
T3 – T4	68	0	7	3.49	1.86
T4 – T5	57	1	9	3.68	2.06
Intervention – T5	37	9	35	18.54	5.48
T1 – T5	57	7	23	14.12	3.98

Note. T = time point.

Table S3*Number of Lesson-Specific Repeated Assessments Completed*

# assessments completed	Frequency	%
2	3	3.8
3	6	7.7
4	14	17.9
5	55	70.5

Table S4

Absolute Proportions of Variance, Variance Partition Coefficients, and the Total Variance in Students' Competence Beliefs, Value Beliefs, and Perceptions of Autonomy-Supportive Teaching Behaviors Based on Scales That Were Built under an Alternative Rule (More Than Half of the Items Must Have a Valid Response)

Variable	Individual level				Class level				Total
	State residual		Trait		State residual		Trait		Var
	Var	VPC	Var	VPC	Var	VPC	Var	VPC/ICC	
Competence beliefs	0.29	0.51	0.22	0.38	0.03	0.05	0.03	0.05	0.57
Importance	0.17	0.40	0.20	0.47	0.02	0.04	0.04	0.08	0.43
Intrinsic value	0.30	0.49	0.24	0.39	0.04	0.07	0.03	0.06	0.62
Cost	0.31	0.55	0.20	0.36	0.03	0.05	0.02	0.04	0.57
Autonomy-supportive learning climate	0.16	0.37	0.20	0.46	0.02	0.03	0.06	0.13	0.43
Meaningful rationales	0.34	0.45	0.23	0.31	0.08	0.11	0.10	0.13	0.74

Note. Var = variance; VPC = variance partition coefficient; ICC = intraclass correlation coefficient.

Table S5*Multilevel Models Where Scales Were Built under an Alternative Rule (More Than Half of the Items Must Have a Valid Response)*

Variable	Competence beliefs				Importance				Intrinsic value				Cost									
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2							
Fixed effects																						
	Est.	SE		SE	Est.	SE		SE	Est.	SE		SE	Est.	SE		SE						
Intercept	-0.02	0.06	-0.03	0.05	-0.12	0.06	*		-0.10	0.04	*		-0.03	0.06	-0.02	0.05						
Level of the observation																						
Autonomy-sup. learning climate ^a			0.40	0.02	***				0.26	0.02	***				0.36	0.02	***					
Meaningful rationales ^a			0.05	0.02	***				0.21	0.01	***				0.09	0.02	***					
Level of the student																						
Autonomy-sup. learning climate ^a			0.41	0.02	***				0.27	0.02	***				0.39	0.02	***					
Meaningful rationales ^a			-0.04	0.03					0.41	0.03	***				0.20	0.03	***					
Respective trait-like measure	0.33	0.02	***		0.26	0.02	***		0.37	0.02	***		0.24	0.02	***		0.23	0.02	***			
Gender (m = 0)	-0.03	0.03			-0.07	0.03	*		-0.03	0.04			0.02	0.03			0.02	0.03				
Prior achievement	0.06	0.02	**		0.05	0.02	**		0.04	0.02	*		0.01	0.02			-0.02	0.02				
Level of the lesson																						
Autonomy-sup. learning climate ^a			0.61	0.06	***				0.56	0.05	***				0.81	0.06	***		-0.42	0.07	***	
Meaningful rationales ^a			0.04	0.04					0.16	0.03	***				0.10	0.04	*		0.01	0.05		
Level of the class																						
Autonomy-sup. learning climate			0.83	0.10	***				0.47	0.08	***				0.74	0.09	***		-0.45	0.09	***	
Meaningful rationales			-0.09	0.10					0.60	0.08	***				0.18	0.09	*		0.26	0.09	**	
Teacher condition	-0.03	0.09			-0.02	0.08			0.19	0.09	*		0.15	0.06	*		0.06	0.08		0.04	0.07	
Master’s student condition	0.02	0.08			0.05	0.07			0.17	0.08	*		0.15	0.06	*		-0.01	0.08		0.01	0.07	
Random effects																						
	Est.		Est.		Est.				Est.				Est.		Est.		Est.		Est.			
σ ² _e (individual-level state residual)	.516		.451		.405				.345				.488		.429		.554		.539			
σ ² _{r(2)} (individual-level trait)	.246		.179		.334				.196				.281		.167		.253		.225			
σ ² _{r(3)} (class-level state residual)	.050		.034		.044				.021				.070		.032		.050		.045			
σ ² _u (class-level trait)	.061		.046		.060				.028				.046		.032		.034		.033			
Number of observations	6728		6532		6843				6626				6801		6595		6770		6566			

Table S5 (continued)

Variable	Competence beliefs				Importance				Intrinsic value				Cost			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Explained variance ^b															
	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2
Level of the observation	.00	.00	.15	.07	.00	.00	.17	.06	.00	.00	.15	.07	.00	.00	.02	.01
Level of the student	.35	.13	.18	.05	.29	.13	.30	.10	.27	.10	.30	.10	.28	.10	.07	.02
Level of the lesson	.00	.00	.34	.02	.00	.00	.49	.02	.00	.00	.52	.03	.00	.00	.15	.01
Level of the class	.16	.01	.54	.08	.22	.02	.65	.14	.15	.01	.67	.11	.27	.01	.24	.02
Total	.14		.22		.15		.33		.11		.30		.11		.06	

Note. All continuous variables were standardized beforehand across individuals and across time points, and thus, all regression coefficients can be understood as standardized regression coefficients. For prior achievement, higher values indicate better achievement. Results were based on the analysis of 1,583 students, 360 separate lessons, and 78 classrooms. m = male; Est. = estimated regression coefficient; R_l^2 = proportion of *level-specific* outcome variance explained by level-specific predictors; R_t^2 = proportion of *total* outcome variance explained by level-specific predictors.

^a Scales were centered on the cluster means.

^b Explained variance (R_l^2 and R_t^2) was estimated by using the model-implied total variance by following the recommendations of Rights and Sterba (2019, 2020).

Incremental explained variance (ΔR_l^2 and ΔR_t^2) was obtained by subtracting the proportions of variance explained by Model 1 from the corresponding proportions of variance explained by Model 2.

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

Unstandardized Results from Multilevel Models

Variable	Competence beliefs						Importance						Intrinsic value						Cost					
	Model 1			Model 2			Model 1			Model 2			Model 1			Model 2			Model 1			Model 2		
Fixed effects																								
	Est.	SE		Est.	SE		Est.	SE		Est.	SE		Est.	SE		Est.	SE		Est.	SE		Est.	SE	
Intercept	3.00	0.05	***	4.39	0.07	***	2.60	0.04	***	3.70	0.05	***	2.67	0.05	***	4.08	0.07	***	1.87	0.04	***	1.39	0.07	***
Level of the observation																								
Autonomy-sup. learning climate ^a				0.44	0.02	***				0.26	0.01	***				0.42	0.02	***				-0.20	0.02	***
Meaningful rationales ^a				0.05	0.01	***				0.15	0.01	***				0.08	0.01	***				0.04	0.01	**
Level of the student																								
Autonomy-sup. learning climate ^a				0.48	0.03	***				0.27	0.02	***				0.47	0.03	***				-0.31	0.03	***
Meaningful rationales ^a				-0.03	0.02					0.31	0.02	***				0.18	0.02	***				0.15	0.03	***
Respective trait-like measure	0.32	0.02	***	0.25	0.02	***	0.50	0.02	***	0.33	0.02	***	0.31	0.02	***	0.21	0.01	***	0.34	0.02	***	0.30	0.02	***
Gender (m = 0)	-0.03	0.03		-0.06	0.02	*	-0.02	0.02		0.02	0.02		0.00	0.03		0.01	0.02		-0.03	0.03		0.00	0.02	
Prior achievement	0.05	0.02	**	0.04	0.01	**	0.02	0.01		0.00	0.01		0.01	0.02		-0.02	0.01		-0.03	0.01		-0.02	0.01	
Level of the lesson																								
Autonomy-sup. learning climate ^a				0.70	0.07	***				0.53	0.05	***				1.00	0.07	***				-0.47	0.08	***
Meaningful rationales ^a				0.03	0.03					0.13	0.03	***				0.08	0.04	*				0.00	0.04	
Level of the class																								
Autonomy-sup. learning climate				0.94	0.11	***				0.47	0.08	***				0.87	0.11	***				-0.53	0.11	***
Meaningful rationales				-0.07	0.08					0.44	0.06	***				0.17	0.08	*				0.22	0.08	**
Teacher condition	-0.03	0.06		-0.03	0.06		0.12	0.06	*	0.09	0.04	*	0.04	0.06		0.03	0.05		0.09	0.05		0.08	0.05	
Master's student condition	0.01	0.06		0.03	0.05		0.11	0.06	*	0.10	0.04	*	-0.01	0.06		0.00	0.05		0.08	0.05		0.06	0.05	
Random effects																								
	Est.			Est.			Est.			Est.			Est.			Est.			Est.			Est.		
σ ² _e (individual-level state residual)	.293			.257			.174			.148			.302			.265			.319			.312		
σ ² _{r(2)} (individual-level trait)	.140			.102			.144			.085			.173			.103			.144			.129		
σ ² _{r(3)} (class-level state residual)	.027			.018			.019			.010			.044			.020			.027			.024		
σ ² _u (class-level trait)	.033			.025			.026			.012			.030			.020			.019			.018		
Number of observations	6987			6914			7001			6922			6998			6922			6993			6915		

Table S6 (continued)

Variable	Competence beliefs				Importance				Intrinsic value				Cost			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
	Explained variance ^b															
	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2	R_l^2	R_t^2	ΔR_l^2	ΔR_t^2
Level of the observation	.00	.00	.14	.07	.00	.00	.17	.06	.00	.00	.14	.06	.00	.00	.02	.01
Level of the student	.34	.13	.19	.06	.29	.13	.30	.11	.27	.10	.30	.10	.28	.10	.07	.02
Level of the lesson	.00	.00	.36	.02	.00	.00	.45	.02	.00	.00	.51	.03	.00	.00	.15	.01
Level of the class	.17	.01	.54	.08	.22	.02	.65	.14	.14	.01	.66	.11	.28	.01	.25	.02
Total		.14		.23		.15		.33		.11		.30		.11		.06

Note. For prior achievement, higher values indicate better achievement. Results were based on the analysis of 1,617 students, 360 separate lessons, and 78 classrooms.

^a Scales were centered on the cluster means. m = male; Est. = estimated regression coefficient; R_l^2 = proportion of *level-specific* outcome variance explained by level-specific predictors; R_t^2 = proportion of *total* outcome variance explained by level-specific predictors.

^b Explained variance (R_l^2 and R_t^2) was estimated by using the model-implied total variance by following the recommendations of Rights and Sterba (2019, 2020).

Incremental explained variance (ΔR_l^2 and ΔR_t^2) was obtained by subtracting the proportions of variance explained by Model 1 from the corresponding proportions of variance explained by Model 2.

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

Table S7*Standardized Mean Differences between Excluded and Included Students*

Variable	Est.	SE	
<i>Situation-specific competence and value beliefs</i>			
Competence beliefs at T1	-0.14	0.12	
Competence beliefs at T2	-0.22	0.11	*
Competence beliefs at T3	-0.07	0.11	
Competence beliefs at T4	-0.06	0.13	
Competence beliefs at T5	-0.12	0.11	
Importance at T1	-0.20	0.10	*
Importance at T2	0.20	0.12	
Importance at T3	-0.05	0.11	
Importance at T4	0.08	0.12	
Importance at T5	-0.28	0.12	*
Intrinsic value at T1	0.04	0.11	
Intrinsic value at T2	0.04	0.10	
Intrinsic value at T3	0.12	0.12	
Intrinsic value at T4	-0.12	0.12	
Intrinsic value at T5	-0.02	0.11	
Cost at T1	-0.17	0.12	
Cost at T2	-0.05	0.11	
Cost at T3	-0.16	0.11	
Cost at T4	0.11	0.14	
Cost at T5	-0.18	0.10	
Autonomy-supportive learning climate at T1	-0.27	0.10	**
Autonomy-supportive learning climate at T2	-0.27	0.14	
Autonomy-supportive learning climate at T3	-0.06	0.10	
Autonomy-supportive learning climate at T4	-0.14	0.14	
Autonomy-supportive learning climate at T5	0.25	0.13	
Meaningful rationales at T1	-0.03	0.13	
Meaningful rationales at T2	0.04	0.13	
Meaningful rationales at T3	-0.17	0.13	
Meaningful rationales at T4	-0.06	0.11	
Meaningful rationales at T5	-0.01	0.13	

<i>Variable</i>	Est.	SE	
<i>Covariates</i>			
Trait-like competence beliefs	0.25	0.12	*
Trait-like importance	0.25	0.19	
Trait-like intrinsic value	0.16	0.16	
Trait-like cost	-0.18	0.12	
Gender	0.02	0.05	
Migration background	-0.08	0.06	
Parents' level of education	0.01	0.05	
Prior achievement	0.36	0.10	***

Note. Differences were investigated by running a regression analysis while taking into account the nested data structure in which students were nested in classes by correcting the standard errors. A dummy variable was used as a predictor with 0 indicating the students who were excluded from the analysis in the main manuscript. All variables were standardized beforehand so that the mean differences can be interpreted as Cohen's *d*.

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

Table S8

Absolute Proportions of Variance, Variance Partition Coefficients, and the Total Variance in Students’ Situation-Specific Perceptions of an Autonomy-Supportive Learning Climate (“I” Language Subscale and “Our” Language Subscale)

Variable	Individual level				Class level				Total
	State residual		Trait		State residual		Trait		
	Var	VPC	Var	VPC	Var	VPC	Var	VPC/ICC	
“I” language subscale	0.27	0.44	0.27	0.44	0.02	0.03	0.06	0.09	0.61
“Our” language subscale	0.18	0.41	0.19	0.42	0.01	0.03	0.06	0.13	0.45

Note. Var = variance; VPC = variance partition coefficient; ICC = intraclass correlation coefficient.

Table S9

*Proportions of Relative Variance Across State/Trait Components and Across Levels
 (“I” Language Subscale and “Our” Language Subscale)*

Variable	Across state/trait components		Across levels	
	Individual-level	Class-level	State residuals	Traits
	Σ VPC	Σ VPC/	Σ VPC	Σ VPC
	ICC			
“I” language subscale	0.88	0.12	0.47	0.53
“Our” language subscale	0.83	0.17	0.44	0.56

Note. The coefficients in the first column are a sum of the proportions of individual-level state residual variance and individual-level trait variance; analogously, the coefficients in the second column are a sum of the proportions of class-level state residual variance and class-level trait variance. The coefficients in the third column are a sum of the proportions of state residual variance at both the individual and class levels; analogously, the coefficients in the fourth column are a sum of the proportions of trait variance at both the individual and class levels. The coefficients from each set of two columns within each row add up to 1 (except for inaccuracies caused by rounding). VPC = variance partition coefficient; ICC = intraclass correlation coefficient.