The Transmission of Values From Math Teachers to Their Ninth-Grade Students: Different
Mechanisms for Different Value Dimensions?

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Abstract

Teachers can transmit their class-related values to their students and thus affect their students' academic development in regular classes. This so-called value transmission has mostly been examined with respect to emotional contagion, that is, the transmission of rather affective values (e.g., enjoyment) from teachers to their students through teachers' enthusiastic behavior during instruction. However, other transmission processes might also be at play, including other value dimensions and mediation through other instructional practices. In this study, we therefore aimed to systematically test the generalizability of such value transmission effects by examining a broad spectrum of (a) teacher values, (b) instructional practices, and (c) student values. Based on longitudinal data from 1,744 students and their 70 math teachers, cross-level mediation analyses revealed that teachers' teaching enthusiasm, math enthusiasm, as well as math utility value affected their students' values (i.e., intrinsic and utility values). Teachers' teaching enthusiasm was transmitted to students' values through both student-perceived enthusiastic behavior during instruction and through relevance-related instructional practices. Teachers' subject-related values (i.e., math enthusiasm and utility value) primarily affected students' utility value, but this transmission could not be explained by the instructional practices under investigation. Overall, our findings reveal auspicious evidence for a broader generalizability of the value transmission concept and yet also show the need to differentiate between different value dimensions and the mechanisms through which they are transmitted from teachers to their students.

Keywords: value transmission, teacher values, instructional practices, student values, cross-level mediation

The Transmission of Values From Math Teachers to Their Ninth-Grade Students: Different Mechanisms for Different Value Dimensions?

Adolescents' task values (i.e., the subjective value they attach to a task as defined in expectancy-value theory; Eccles et al., 1983) are essential predictors of successful learning in school (e.g., Wigfield et al., 2016). Given their importance, the decrease in students' values during the school years, which is particularly pronounced in the domain of math (e.g., Gaspard et al., 2017), has attracted attention in research (e.g., Scherrer & Preckel, 2019; Wigfield et al., 2015). It has been argued that teachers can provide important resources that can work against the decline in student values as they shape their students' everyday school life (Eccles & Roeser, 2009; Seidel & Shavelson, 2007; Wentzel, 2009). For instance, students may be captivated by their teachers' passionate and enthusiastic behavior during instruction and may subsequently enjoy that class more (Frenzel et al., 2009, 2018). Teachers may also be capable of persuading their students that the class has value by emphasizing the usefulness of the content (e.g., Assor et al., 2002; Schmidt et al., 2019; Schreier et al., 2014). Indeed, previous research has shown that student values are affected by different teacher behaviors during instruction (e.g., Dietrich et al., 2015; Schmidt et al., 2019), which, in turn, strongly depend on teachers' own values (Kunter et al., 2008; Richardson & Watt, 2010).

Ultimately, this implies that teacher values can affect student values (e.g., Frenzel et al., 2009, 2018; Pekrun, 2006; Schiefele, 2017), which can be subsumed under *value transmission*. Underlying processes (e.g., the transmission through teachers' behavioral expressions of their values) have yet almost exclusively been studied in the realm of emotional contagion (e.g., Frenzel et al., 2009, 2018; for exceptions, see, e.g., Kunter et al., 2013; and Schiefele, 2017). Emotional contagion comprises the transmission of rather affective value dimensions (e.g., enjoyment) from teachers to their students through teachers' enthusiastic behavior during instruction as a mediating variable. However, research focusing on other predictors of student values has additionally indicated links between different

dimensions of teacher and student values, which might also be explained by instructional practices other than enthusiastic behavior (e.g., Paulick et al., 2013; Schiefele, 2017; Schmidt et al., 2019). A full investigation of the effects of teacher values on student values and their underlying processes has yet to be conducted.

We thus aimed to address the questions of *whether* and *how* the transmission of multiple value dimensions from teachers to their students occurs. To do so, first, we conceptually replicated work on emotional contagion processes (see Frenzel et al., 2018). Second, we expanded this restricted view on value transmission by also investigating the potential transmission of affective value dimensions through other instructional practices (i.e., presenting everyday life examples and relevance support). Third, we additionally examined the (indirect) impacts of other dimensions of teacher values (subject enthusiasm as well as utility value) on dimensions of student values (intrinsic and utility value) based on expectancy-value theory (EVT; Eccles et al., 1983) and research on teacher enthusiasm (e.g., Keller et al., 2016). On the basis of EVT, we thereby provide a first systematic approach for a broader investigation of value transmission effects in math classrooms by investigating different value dimensions and potential underlying mechanisms.

Conceptualization of Teacher and Student Values

To conceptualize and examine different dimensions of teacher and student values, we relied on expectancy-value theory (Eccles et al., 1983; Eccles & Wigfield, 2002), which is a prominent framework for explaining differences in both teacher (e.g., Watt & Richardson, 2007) and student motivation (e.g., Watt et al., 2012). EVT posits that a person's values ("Do I want to do it?") and expectancies ("Can I do it?") are the most proximal predictors of a person's effort, achievement performance, and choices (e.g., Wigfield et al., 2016). Eccles and colleagues furthermore postulated a comprehensive set of constructs that affect a person's values and expectancies including individual and contextual features. Values and expectancies have been shown to differentially impact achievement-related outcomes, such that values

seem to be more important for choices, and expectancies seem to be more important for achievement (see, e.g., Wigfield et al., 2017). Previous research mainly focused on student motivation, but EVT provides a model that can also be fruitfully applied to investigate teachers' motivation insofar as teachers can be assumed to be highly motivated when they value their subject and their teaching, and when they expect to be good at teaching (Watt & Richardson, 2007). Importantly, teachers' own values can be important antecedents of student values (e.g., Keller et al., 2014; Lazarides, Gaspard, et al., 2019). In this study, we focus on student and teacher values.

Student Values

According to EVT, student values are influenced by socializers' (e.g., teachers') beliefs and behaviors and especially students' interpretations of this behavior (e.g., Eccles, 2007). Eccles (2005) differentiated between four task value dimensions: intrinsic value, utility value, attainment value, and cost. In this study, we focused on *intrinsic value* because it was previously most commonly investigated in terms of transmission processes. Intrinsic value is mostly affective and reflects a person's enjoyment of a task (Eccles, 2005). It seems to be highly susceptible to a positive class context (e.g., high teacher support, see Assor et al., 2002; or positive teacher-student relations, see Wentzel, 2009), which is why we considered it to be promising for an investigation of associations between teacher variables and student values. Second, we focused on *utility value* because it is assumed to be most malleable compared with the other value components (Trautwein et al., 2013; Wigfield et al., 2017). Utility value refers to the instrumental value of a task in terms of its relevance and usefulness for achieving short-term and long-term goals (Eccles & Wigfield, 2002). Utility value is described as a means to an end rather than an end in itself and is therefore more similar to extrinsic motivation than the other value components (though it is also related to personal goals and therefore to one's sense of self; Eccles, 2005). This makes utility value also highly susceptible to external influences (Harackiewicz et al., 2014) that are of personal importance for the

student (Eccles, 2005). The conceptualizations of intrinsic and utility values thus include contrasting features. Although students' intrinsic and utility values are typically positively correlated, they can be empirically separated (Gaspard, Dicke, Flunger, Schreier, et al., 2015). Furthermore, it has been shown that students' intrinsic and utility values can be affected through targeted interventions (e.g., Gaspard, Dicke, Flunger, Brisson, et al., 2015; Hulleman et al., 2010; Hulleman & Harackiewicz, 2009). Thus, both students' intrinsic and utility values are malleable. We therefore aimed to examine whether they are susceptible to similar or different value transmission processes.

Teacher Values

In line with the conceptualization of teacher motivation within the FIT-choice framework (Watt & Richardson, 2007) and our conceptualization of student values, we also focused on teachers' intrinsic and utility values as predictors of student values. Besides their relevance in previous research, we also aimed to include teacher value scales that are as close as possible to the student scales of interest to be able to investigate value transmission processes.

Teachers' intrinsic value captures their positive affect regarding teaching. It therefore overlaps a great deal with teacher enjoyment (mostly considered in research on emotional contagion; e.g., Frenzel et al., 2009, 2018) and enthusiasm (mostly considered in research on teacher effectiveness; e.g. Kunter & Holzberger, 2014; see also Keller et al., 2016). Teacher enthusiasm has been defined as reflecting "the degree of enjoyment, excitement and pleasure that teachers typically experience in their professional activities" (Kunter et al., 2008, p. 470), which is why we view enthusiasm as an operationalization of a rather affective dimension of teacher values, similar to intrinsic value. Teacher enthusiasm can be differentiated into teachers' valuing of teaching (*teaching enthusiasm*) and of the subject (*math enthusiasm*; Kunter et al., 2008). Teachers' teaching and math enthusiasm were found to be differentially predictive of student-reported and teacher-reported quality of instructional behavior (Kunter

et al., 2008), with teaching enthusiasm being a stronger predictor for both student- and teacher-reported quality of instruction, and math enthusiasm being only related to teachers' self-reports. Kunter and colleagues thus claimed for a differentiated approach to enthusiasm, which is why we consider both dimensions of enthusiasm in this study. Overall, teacher enthusiasm has shown positive associations with students' intrinsic value (see, e.g., Carmichael et al., 2017; Fauth et al., 2019; or Keller et al., 2016, for an overview).

Teachers' math utility value, on the other hand, can be understood as the perceived value of math with respect to its usefulness for one's daily and future life. In their FIT-choice framework, Watt and Richardson (2008) postulated and empirically separated multiple facets of teachers' utility value (e.g., personal and social utility value). However, the FIT-choice framework was developed and successfully implemented to investigate a person's motivation to become a teacher (e.g., Watt et al., 2012, 2017; Watt & Richardson, 2008). It thus focuses on the usefulness of teaching rather than that of the subject, and furthermore taps multiple utility-value facets that cannot be rated in a meaningful way by persons who chose this profession for the long-term, such as the sample of experienced math teachers in our study. Besides work regarding teachers' teaching utility value, empirical evidence for teachers' utility value for the subject matter and its potential associations with student values has remained scarce (for an exception, see Han et al., 2019). Nevertheless, we assume that teachers who are convinced of the relevance and usefulness of a subject will intensify their emphasis on the subject's relevance during instruction and thus support their students in seeing the relevance of the subject for their personal goals (Harackiewicz et al., 2014; Roth, 2014). In a first attempt to examine teachers' utility value and its relevance for students' values, in a sample of 219 eighth-grade students, Han et al. (2019) found that history teachers' perceived utility value was associated with students' own utility value of history reported 6 weeks later. Hence, there is still a need for longitudinal investigations with longer time lags on the association between teachers' actual (i.e., self-reported) utility value and their students'

values in adequately sized samples that would allow researchers to investigate such value transmission processes not only at the student level but also at the class level.

Value Transmission in the Classroom: Emotional Contagion

Previous findings thus indicate that teachers can transmit their values to their students. However, the mechanisms through which such value transmission processes in the classroom can be explained are still not fully understood. For values to be transmitted, it is probably necessary for teachers to enact their values and for students to perceive this behavior (see Eccles, 2007). This would mean that it is the *perception* of the teachers' behavior (Lüdtke et al., 2009) and students' conclusions about teachers' conjectural motivational states that provoke this behavior that ultimately leads to an assimilation of values.

Indeed, students' perceptions of their teachers' enthusiastic behavior during instruction have often been investigated in association with teachers' and students' affective value dimensions (e.g., enjoyment; Frenzel et al., 2009, 2018). In contrast to the teacher's motivational inner state, that is, (experienced) teacher enthusiasm, *student-perceived* teacher enthusiasm emphasizes the behavioral and observable component of enthusiasm. The aforementioned overall phenomenon—that is, the association between teacher and student values via student-perceived enthusiasm—attracted substantial attention under the term *emotional contagion*. It comprises an individual's emotional expression that can be “caught” by another person, eventually leading these two people to converge emotionally (see Hatfield et al., 1992, 1993; Hsee et al., 1990). Several studies have demonstrated emotional contagion in situations involving a teacher-learner relationship (see Frenzel et al., 2019; and Hsee et al., 1990, for laboratory studies; and Radel et al., 2010, for a quasi-experimental field study). In cross-sectional studies, Frenzel et al. (2009) and Keller et al. (2014) showed that teachers' affective value dimensions (enjoyment in the case of Frenzel et al. and experienced enthusiasm in the case of Keller et al.) were indirectly linked to students' own affective value dimensions (again, enjoyment in the case of Frenzel et al. and interest in the case of Keller et

al.) through students' perceptions of teacher enthusiasm. Even though they found no total effect from teachers' to students' enjoyment, Frenzel et al. (2018) found that these indirect associations also held longitudinally: In classrooms in which students had not already known the teachers from previous years, teachers' enjoyment of teaching in this class and their students' enjoyment of math classes were indirectly related over time. More precisely, students' enjoyment at the beginning of the school year was associated with their teachers' enjoyment in the middle of the year through teacher-perceived student engagement, and teachers' enjoyment was additionally indirectly associated with students' later enjoyment through student-perceived teacher enthusiasm.

Overall, several studies have consistently indicated the positive association between, on the one hand, student-perceived teacher enthusiasm and, on the other, students' own level of intrinsic value (e.g., Brigham et al., 1992; Frenzel et al., 2010; Kim & Schallert, 2014; B. C. Patrick et al., 2000) or enjoyment (e.g., Keller et al., 2018; Kunter et al., 2011). Besides its relevance for students' intrinsic value, student-perceived teacher enthusiasm can also affect students' utility value: A cross-sectional study by Lazarides et al. (2018) showed that students' perceptions of their teachers' enthusiastic behavior during teaching predicted their own utility value on the individual and class levels.

Value Transmission Explained Through Instructional Practices Other Than Student-Perceived Enthusiasm

Considering previous findings, emotional contagion seems to be a well-documented phenomenon that describes one aspect of value transmission processes. Yet, value transmission could also occur through other processes than students' perception of teacher enthusiasm, including other instructional practices. Furthermore, next to the transmission of affective value dimensions, a transmission between other value dimensions such as utility value has not been in the focus of prior research.

Another instructional practice through which teachers may transmit their values to their students involves emphasizing the relevance of the material, which has been shown to be a powerful strategy for motivating students (Assor et al., 2002; Brophy, 1986; Keller et al., 2016; Kunter et al., 2008; H. Patrick et al., 2003; Wang, 2012). Teachers can try to persuade their students of the relevance and usefulness of a task or learning process by helping them to draw connections to their personal interests, goals, and values (Assor et al., 2002; Reeve et al., 2002). Previous research has supported the importance of highlighting the relevance of the material during class for students' own values. For instance, students' utility value was found to be predicted by students' concurrent perceptions of their teachers' emphasis on relevance during class (Schreier et al., 2014), and this effect remained significant when changes in utility value were investigated longitudinally. Additionally, Lazarides, Dietrich, et al. (2019) found that students with a low math motivation profile (characterized by low levels of self-concept, interest, and intrinsic and utility values) were more likely to change to a more adaptive profile if they perceived that their teacher was emphasizing relevance during class. Wang (2012) also found that instructional practices such as emphasizing relevance were associated with changes in students' task values (investigating a global measure of task values).

In a mixed-method study with four teachers and 306 students, Schmidt et al. (2019) demonstrated that the extent to which teachers pointed out the specific relevance of the material they were teaching differed substantially. Whereas some teachers frequently made statements to support the relevance of the topic they were teaching, others almost never emphasized the relevance of the content for their students' lives. The quantity of relevance-inducing statements during class was linked to students' perceived global science utility, even when students' perceived levels of competence and interest were controlled for.

Overall, previous research has supported the ideas that teachers' enthusiastic behavior while teaching and their emphasis on the relevance of the material are valuable instructional

practices that teachers can use to affect their students' values in class. Considerable strands of research rooted both in realistic mathematics education (providing everyday life examples; Freudenthal, 1968; van den Heuvel-Panhuizen & Drijvers, 2014) as well as in self-determination theory (relevance support; Ryan & Deci, 2000) have focused on emphasizing the relevance as a motivating instructional practice.

But what prerequisites are necessary for teachers to show such behavior? What kinds of values do teachers need in order to teach enthusiastically and to regularly and authentically emphasize the relevance of the content? Regarding oftentimes investigated features of teaching quality (classroom management, learning support, and cognitive activation; for an overview, see Seidel & Shavelson, 2007), an impressive body of research already investigated similar questions on antecedents of teachers' behavior during instruction (for an overview, see Praetorius et al., 2017). In terms of teacher behavior that is conceptually and empirically more closely related to students' motivation such as teachers' enthusiastic behavior during instruction, previous research has argued that teachers' own underlying affective values (e.g., experienced enthusiasm) are associated with their enthusiastic behavior during class (e.g., Keller et al., 2014; Kunter et al., 2008). Such congruency between personal values and actual behavior is described as a feature of authenticity (e.g., Kreber et al., 2010). However, being authentic—and, eventually, persuasive—in a classroom setting can be expressed in different ways than just congruency; being authentic equally involves behavior that is “in the important interest of students” (Kreber et al., 2010, p. 385). We assume that teachers' enthusiasm is an important force that makes them more perceptive of their students' needs and of what is on their students' minds—that is, what their students actually consider relevant, and to act accordingly. Teachers might thus be perceived as authentically encouraging meaningfulness in the subject matter when they themselves are enjoying it in addition to believing in its usefulness (for a similar reasoning, see Schiefele, 2009). In line with this assumption, teachers' enthusiasm has been proposed (Woolfolk Hoy, 2008) and shown to be associated

with higher quality of various instructional practices as perceived by the students (Kunter et al., 2008; also in the terminology of self-determined motivation: Roth et al., 2007).

Analogously to teachers' enthusiasm and in line with the concept of authenticity, we suspect that teachers' math utility value is a critical predictor of why teachers engage in instructional practices that are conceptually close to this underlying value—such as emphasizing the relevance of content (see Roth, 2014). Furthermore, we assume that teachers who perceive a high usefulness of math for their students not only put emphasis on relevance and importance for their students, but that it might also be easier for them to show enthusiasm while teaching math. In addition, their authentic attempts to motivate their students due to their personal perceived usefulness of math might lead to an overall high engagement during class, which might be perceived as enthusiastic teaching by the students (in fact, emphasizing relevance has previously also been conceptualized as perceived enthusiasm; e.g., H. Patrick et al., 2003; for the overall associations of different value types of teachers and their motivational strategies use during class, see, e.g., Roth et al., 2007).

Taking Students' Individual and Shared Perceptions into Account

When examining the transmission of teacher values to their students, it seems to be most appropriate to consider students' own reports of their teachers' instructional practices as mediating variables rather than other sources of data (see Lüdtke et al., 2009; see also Eccles, 2007). Although students' perspectives were taken into account in past research (e.g., Frenzel et al., 2009, 2018; Schiefele, 2017), students' idiosyncratic perceptions of the teaching were mostly neglected by reducing investigations of mediational associations to the class level (i.e., by using the class-aggregated perceptions as is done by commonly used class-level only mediation approaches; e.g., Frenzel et al., 2018; see also Preacher et al., 2010).

However, it is important to distinguish between effects of the students' individual perceptions and the additional effects of the shared perceptions of the class over and above the effects via the individual level, because they can carry different information (e.g., the shared

perceptions can carry information about group norms; see “normative effects” in Raudenbush & Bryk, 2002; see also Stapleton et al., 2016). The distinction between the individual and class levels within mediation analyses can be realized using the cross-level mediation approach proposed by Pituch and Stapleton (2012), which allows disentanglement of different sources of the indirect associations between teacher and student values: whether this indirect association is essentially equal to the indirect effect through the individual-level perceptions of instructional practices, or whether there is an additional indirect impact through the shared perceptions of the class on student values over and above the indirect effect via the individual perceptions. In other words, when simultaneously considering the individual and shared perceptions, it is possible to answer two questions: First, do teacher values affect student values through students’ individual perceptions of the instructional practices? And second, is there an additional effect of the shared perceptions of the classroom that—over and above the individual perceptions—explains the indirect association between teacher and student values?

The Present Study

In the present study, we were interested in whether and how teachers transmit different values to their students in math classrooms. To answer our questions, we drew on data from a large longitudinal study in math classrooms in which we considered both the teachers’ and students’ perspectives. Drawing on evidence for emotional contagion, we first aimed to conceptually replicate previous research on the associations between teachers’ and students’ affective value dimensions, which focused on the mediational role of student-perceived teacher enthusiasm (see Frenzel et al., 2018). We hereby focused on teachers’ self-reported (experienced) enthusiasm as an operationalization of the affective value dimensions and distinguished between their teaching and math enthusiasm because they were found to affect student ratings of teaching behavior differently (Kunter et al., 2008).

Second, extending research on emotional contagion, we furthermore investigated value transmission effects through other instructional practices than perceived teacher

enthusiasm. Previous research suggested that emphasizing the relevance of the material that is being taught affects student values (e.g., Schmidt et al., 2019; Schreier et al., 2014; Wang, 2012). Relying on different research traditions (realistic mathematics education and self-determination theory), we therefore examined the mediational roles of two relevance-related instructional practices (use of everyday life examples and relevance support). Even if students do not initially value the content intrinsically or see its relevance and usefulness, we expect them to be more likely to adopt the given rationales and finally to more likely intrinsically value the content if the teacher repeatedly points out its relevance for students' lives (Hidi & Renninger, 2006).

Finally, we extended our focus from enthusiasm and intrinsic value to teachers' utility value as well as to students' utility value on the basis of its high susceptibility to external influences compared with other task values. When teachers are convinced of the relevance of math, they might more intensively provide rationales to their students and encourage their students to internalize the same values. The students, in turn, might adopt the given rationales and ultimately see a higher usefulness in math. To our knowledge, this is the first longitudinal study to empirically explore the transmission of teachers' self-reported utility value to their students' utility value through various instructional practices (for an investigation of the transmission of student-perceived teacher utility value to their students without considering potential mediation through instructional practices, see Han et al., 2019).

Overall, we expected relations between teacher and student values as suggested in our heuristic working model in Figure 1. Given that we investigated enthusiasm, intrinsic value, and utility value, we tested for mediational associations through instructional practices that are conceptually most closely related to these value dimensions, namely, student-perceived teacher enthusiasm as well as the use of everyday life examples and relevance support.

Figure 1. Heuristic working model in which teacher values are expected to affect student values and student-perceived instructional practices are hypothesized to mediate this link.

With regard to the constructs and mechanisms under investigation, we tested the following research questions in which we first focused on the mediational model based on emotional contagion (Research Question 1), and then one at a time, we substituted different elements of this model, that is, we included other instructional practices (Research Question 2), other predictors (Research Question 3), and other outcomes (Research Question 4):

1. *Conceptually replicating findings on emotional contagion* (see Frenzel et al., 2018): Are teachers' teaching enthusiasm and students' intrinsic value prospectively related, and is this link mediated by student-perceived teacher enthusiasm?
2. *Examining transmission processes through other instructional practices*: Are the associations between teachers' teaching enthusiasm and students' intrinsic value also mediated through relevance-related instructional practices (i.e., student-perceived use of everyday life examples and relevance support)?
3. *Broadening value transmission to include other dimensions of teacher values*: Are teachers' math enthusiasm and math utility value prospectively associated with students' intrinsic value? Are these links mediated by the three student-perceived instructional practices under investigation (i.e., teacher enthusiasm, use of everyday life examples, relevance support)?

4. *Broadening value transmission to include other dimensions of student values:* Are the three dimensions of teacher values prospectively associated with students' utility value? Are these links mediated by the three student-perceived instructional practices under investigation?

Method

Approval for this study was obtained from the Ethics Committee for Psychological Research at the University of Tübingen, Germany (#2017/0724/75).

Participants and Procedure

Sample

The data stemmed from the large intervention study “Motivation in Mathematics” conducted in the 2017/2018 school year (Gaspard et al., 2020). For recruitment, 57 academic track schools (*Gymnasien*) in the German state of Baden-Württemberg and the teachers at these schools teaching math in ninth-grade classes were contacted and asked to participate in the study, and 28 schools agreed. The headmasters usually decided on behalf of their school whether they wanted to support the study. As a consequence, oftentimes, all of the teachers teaching math in ninth-grade classes at the respective schools participated in the study rather than only one teacher per school (for further information on the recruitment process, see Gaspard et al., 2020). $N_T = 70$ math teachers (44.3% female; $M_{\text{age}} = 38.7$ years, $SD_{\text{age}} = 9.8$, at the first measurement wave [T1]; $M = 10.4$ years of teaching experience, $SD = 8.5$) teaching 78 ninth-grade classes decided to participate. Only the students who had written parental consent ($N_S = 1,744$; 53.8% female adolescents; $M_{\text{age}} = 14.63$ years, $SD_{\text{age}} = 0.48$, at T1) were allowed to participate (88.7% participation rate). One of the participating classes, which was usually comprised of the same group of students in each subject, was divided into two math learning groups that were taught by two different teachers. Because our focus in this study was to examine teacher-student interactions, we treated these two learning groups as separate classes, resulting in 79 clusters on the class level. Thirty-five of these classes (44.3%) had

been instructed by the same math teacher in the previous school year or even for several years.

Study Design

The study involved three measurement waves throughout the school year. Participants were assessed a few weeks into the school year in October 2017 (T1), an average of 8 weeks later in December 2017 (T2), and an average of another 2.5 months later in February/March 2018 (T3). Between T1 and T2, some of the students received an intervention that was aimed at fostering students' motivation regarding math. Thus, data stemmed from a cluster-randomized intervention study investigating the effectiveness of this relevance intervention in the classroom. However, several robustness checks indicated that our results were not affected by the intervention (see the Results section for robustness checks). Before T1, participating teachers (and their classes) were randomly assigned to one of two intervention conditions or to a waitlist control condition. In the two intervention conditions, identical interventions were implemented; they only differed in terms of the person delivering the intervention (either the regular math teacher or trained master's students). The intervention comprised a 90-min session on the relevance of math, including a psychoeducational presentation and an individual relevance-inducing task. In this task, students were asked to evaluate quotes from interviews with young adults on the relevance of math for their current job and daily life (for more information on the intervention, see Gaspard et al., 2020). This intervention was found to foster students' utility value, whereas the math teachers and master's students differed only a little in their effectiveness in delivering the intervention (Gaspard et al., 2020). We therefore controlled for the intervention conditions in all of our analyses (see the Statistical Analyses section for more detail).

Teacher values (T1), students' perceptions of their teachers' instructional practices (T2), and student values (T1 and T3) were assessed via student and teacher questionnaires at the respective time points. Students completed their questionnaires during regular 45-min

math lessons in the presence of trained research assistants. Teachers were asked to fill out the questionnaire at the same time as their students. If they were not able to fill out the questionnaire during that time, they were asked to complete their questionnaire separately and send it via mail to the researchers conducting the study. Five of the 79 participating classes experienced a change in teachers between T2 and T3. Even though these new teachers might have had different kind of values and might have engaged in different instructional practices, we included these five classes in our analyses and used data from the teachers at T1. Students in these five classes were taught by their first teacher for at least half a school year, whereas the new teacher at T3 had only taught on average for 3.5 weeks in their class (less than half of the time period between T2 and T3). A robustness check revealed that the results were not affected by these five classes (see the Results section).

Table 1

Overview of Measures, Descriptive Statistics, Proportions of Variance between Classes (ICC₁), and the Reliabilities of the Class Means (ICC₂) for the Variables of Interest

Variable	<i>M</i>	<i>SD</i>	Range	ICC ₁ / ICC ₂	Skew- ness	Kur- tosis
<i>Teacher values</i> ^a						
T1 teachers' teaching enthusiasm	3.55	0.41	2.33–4.00	—	-.74	-.05
T1 teachers' math enthusiasm	3.15	0.51	2.00–4.00	—	-.03	-.78
T1 teachers' math utility value	3.51	0.47	2.00–4.00	—	-.97	.66
<i>Student-perceived instructional practices</i>						
T2 student-perceived teacher enthusiasm	2.87	0.74	1.00–4.00	.27/.89	-.48	-.23
T2 student-perceived use of everyday life examples	2.24	0.77	1.00–4.00	.22/.86	.11	-.65
T2 student-perceived relevance support	2.32	0.67	1.00–4.00	.16/.81	-.12	.12
<i>Student values</i>						
T1 students' intrinsic value	2.47	0.86	1.00–4.00	.03/.36	.06	-.85
T3 students' intrinsic value	2.41	0.85	1.00–4.00	.04/.46	.10	-.78
T1 students' utility value	2.83	0.50	1.00–4.00	.04/.47	-.11	-.11
T3 students' utility value	2.77	0.51	1.00–4.00	.03/.42	-.05	.00

Note. T in T1 to T3 = Time. ICC₁ = proportion of variance between classes. ICC₂ = reliability of class mean. — = not applicable. The possible range for all scales was 1 to 4.

^a It is common for teachers not to exploit the entire range in research on teacher values (e.g., Watt & Richardson, 2007) but to report high values on average (e.g., Paulick et al., 2013), accompanied by high kurtosis and skewness values for the measures (e.g., Schiefele et al., 2013). In fact, the range for teachers' teaching enthusiasm reported in this study was nearly identical to Frenzel et al.'s (2018) T1 teacher enjoyment scale.

Measures

The wordings of all of the items are presented in the supplemental material (Table S1), and their descriptive statistics, the proportion of variance between classes (ICC_1), and the reliabilities of the class means (ICC_2) are summarized in Table 1. All items were measured with a 4-point Likert-type scale ranging from 1 (*completely disagree*) to 4 (*completely agree*).

Teacher Values (T1)

To assess *teachers' teaching enthusiasm* (six items) and *math enthusiasm* (five items), we used two scales that were adapted from previous studies (e.g., Baumert et al., 1997; Kunter et al., 2011). To assess *teachers' math utility value*, we asked teachers to respond to four items that were adapted from the utility value scale for students. All three scales were internally consistent (McDonald's omega $\omega_{\text{teaching enthusiasm}} = 0.81$, $\omega_{\text{math enthusiasm}} = 0.73$, $\omega_{\text{utility value}} = 0.69$).

Student-Perceived Instructional Practices (T2)

Students were asked to report their *perceived teacher enthusiasm*, *perceived use of everyday life examples*, and *perceived relevance support*. Students' perceptions of teacher enthusiasm were measured with three items that were adapted from previous studies (e.g., Baumert et al., 2009). To assess students' perceptions of teachers' use of everyday life examples (three items), we used a student-reported scale from Baumert et al. (2009) with small adaptations of the wording. Students' perceptions of teachers' relevance support during class were assessed with five items that were partly taken from Flunger et al.'s (2019) scale to measure student-perceived provision of meaningful rationales by their teachers and partly newly developed to refer to the usefulness of math for everyday life situations and for future life specifically. All three scales showed good internal consistency (McDonald's omega $\omega_{\text{enthusiasm}} = 0.78$, $\omega_{\text{examples}} = 0.79$, $\omega_{\text{relevance support}} = 0.85$).

Student Values (T1 and T3)

We used a reduced 3-item version of the intrinsic-value scale from Gaspard et al. (2017) to assess students' *intrinsic value*. In addition, we used a slightly adapted 12-item utility-value scale from Gaspard et al. (2017) tapping multiple subfacets of utility value (general utility, utility for job, utility for daily life, and utility for school; for more information, see Gaspard, Dicke, Flunger, Schreier, et al., 2015) to assess students' *utility value*. The scales showed good internal consistency (McDonald's omega $\omega_{\text{intrinsic},T1} = 0.92/\omega_{\text{intrinsic},T3} = 0.93$, $\omega_{\text{utility},T1} = 0.86/\omega_{\text{utility},T3} = 0.88$).

Confirmatory Factor Analyses

To test for the separability of all the different constructs under investigation, we used a multilevel confirmatory factor analysis (CFA) with students nested within classrooms using the robust maximum likelihood estimator. For the two student values, residuals of identical items were allowed to correlate over time (Cole et al., 2007). For students' utility value in particular, residuals of the items indicating the same subfacets of utility value were also allowed to correlate (see Gaspard, Dicke, Flunger, Schreier, et al., 2015). Results from measurement invariance tests across time (for student values at T1 and T3) indicated support for weak measurement invariance (see Table S2 in the supplemental material), which is why we constrained the item loadings for these variables to be equal across time. Following recommendations from Stapleton et al. (2016), we furthermore constrained the factor loadings for identical student-reported variables (i.e., instructional practices and student values) to be equal across levels. The multilevel CFA yielded an acceptable fit (CFI = .931, TLI = .925, RMSEA = .033, SRMR_{within} = .065, SRMR_{between} = .147) and supported the assumed factor structure of the measures we used. Results for separate CFAs for teacher values, student-perceived instructional practices, and student values, can be found in the supplemental material (Table S3).

Statistical Analyses

We aimed to investigate whether and how (i.e., through which instructional practices) teachers transmit their values to their students. We include an example analysis script for our statistical approach to multilevel mediation analyses in the supplemental material. The complete set of analysis scripts that we actually used can be accessed from the Open Science Framework (<https://osf.io/ekcyz/>).

Multilevel Mediation Analyses

To examine the transmission of value from teachers to their students through students' perceptions of their teachers' instructional practices as suggested in our heuristic working model (Figure 1), we set up a series of multilevel mediation models. We investigated the links between class-level (L2) predictors (i.e., teacher values) and individual-level (L1) outcomes (i.e., student values) mediated by variables measured at the individual level (i.e., student-perceived instructional practices). More precisely, following the approach suggested by Pituch and Stapleton (2012), we specified *cross-level mediation* models (2–1–1 models with cross- and unique cluster-level mediation; see Pituch & Stapleton, 2012) in Mplus 7.31 (Muthén & Muthén, 1998-2015) via MplusAutomation 0.7-3 (Hallquist & Wiley, 2018). In contrast to commonly used class-level-only mediation approaches (see Pituch & Stapleton, 2012, for a discussion; and Preacher, Zyphur, & Zhang, 2010, for an application), cross-level mediation models are able to take both students' individual and shared perceptions into account when testing for mediational associations. Results of such models thereby provide information on whether (a) the L2 predictor has an indirect effect on the L1 outcome through a L1 mediator (cross-level indirect effect); and whether (b) there is an additional indirect impact of the L2 predictor on the outcome over and above the indirect effects via the L1 mediator (unique class-level indirect effect). That is, the latter effect contains information about the indirect impact of the environment (e.g., normative qualities of the shared perception) on the student outcome of interest that the individual perceptions of the mediator

do not capture—it could be a unique function of the respective environment (Pituch & Stapleton, 2012).

Figure 2. Cross-level mediation model for the association between teacher and student values mediated through student-perceived instructional practices, controlling for prior levels of student values and the intervention condition students were assigned to (not depicted for the sake of clarity). The total indirect effect from teacher to student values through student-perceived instructional practices is estimated by $a_2b_1 + a_2b_{cont}$ and the total effect by $c' + a_2b_1 + a_2b_{cont}$.

Subscripts: ₁ = individual-level path, ₂ = class-level path, _{cont} = contextual effect. Apostrophe: mediated direct paths between the T1 and T3 variables.

In the cross-level mediation model as depicted in Figure 2, path a_2 represents the unique impact of the class-level predictor (teacher values) on the class-level mediator (i.e., the class-level aggregate of student-perceived instructional practices). At the same time, it also represents the unique impact of the class-level predictor on the individual-level mediator (i.e., these paths are equal; see Pituch & Stapleton, 2012, for an expanded explanation). Path b_1 represents the unique impact of the individual-level mediator on the outcome (student values); and b_{cont} represents the corresponding contextual effect (i.e., the class-level effect controlled for the effect of the individual-level mediator, that is, b_1). We present the contextual effects that resulted from the cross-level mediation approach (see Pituch & Stapleton, 2012). The contextual effect represents the effect of students' shared perception of the contextual variable

while holding constant students' idiosyncratic perceptions of the same variable. This therefore provides insight into how being in a certain context influences student values over and above their individual perception of the teacher (e.g., students in classrooms with teachers who are perceived as teaching enthusiastically by the class report higher intrinsic values irrespective of their individual perceptions of enthusiastic teaching). The composite of the contextual effect (b_{cont}) and the corresponding individual-level effect (i.e., the effect of students' tendency to perceive the contextual variable in a more or less positive light compared with their classmates; or b_1) provides the class-level effect (i.e., $b_1 + b_{\text{cont}}$; see, e.g., Lüdtke et al., 2009).

The direct effect of the class-level predictor on the outcome is represented by c' . The indirect effect, also referred to as the *total indirect effect*, is a composite of two separate indirect effects that simultaneously occur through the individual level (i.e., the cross-level indirect effect) and the class level (i.e., the unique class-level indirect effect). The cross-level indirect effect is represented by the product $a_2 * b_1$ (see Pituch & Stapleton, 2012, for an expanded explanation). The additional unique class-level indirect effect in this model (i.e., the indirect effect through the class-level mediator when controlling for the indirect effect through the individual-level mediator) is represented by the product $a_2 * b_{\text{cont}}$. The total indirect effect is then given by $a_2b_1 + a_2b_{\text{cont}}$, and the total effect of the class-level predictor on the outcome is $c' + a_2b_1 + a_2b_{\text{cont}}$.

To answer our research questions, we ran a total of 18 cross-level mediation models. First, we looked at the effect of teachers' teaching enthusiasm on students' *intrinsic* value mediated by student-perceived teacher enthusiasm (i.e., one model). Second, we tested for mediational associations through student-perceived use of everyday life examples and relevance support during class, respectively (i.e., two models). Third, we ran the same analysis with math enthusiasm or math utility value as predictors (i.e., six models due to 2 predictor variables x 3 mediator variables x 1 outcome). Finally, we ran the same set of analyses with students' *utility* value as the outcome (another nine models). Student-reported

individual-level covariates (i.e., student values at T1) and mediators were grand-mean centered, and we used manifest aggregation for their class-level counterparts (see Enders & Tofghi, 2007; Pituch & Stapleton, 2012, for centering; and Marsh et al., 2009, for manifest aggregation). In order to ensure that potential associations could not be traced to the intervention, we additionally regressed student values at T3 and student-perceived instructional practices at T2 on two class-level dummy variables, each indicating one of the two intervention conditions with the waitlist control condition as the reference group.

In contrast to Frenzel et al. (2018), who reported standardized results from the Mplus output, in which between-level effects are standardized with respect to the between-level variances, we standardized all continuous variables before running the analyses so that all paths could be understood as standardized effects with respect to the *total variance* of the outcome variables (Marsh et al., 2009; Rights & Sterba, 2019). Additionally, we computed contextual effects (i.e., the unique effect of being in a class with a teacher who is more or less enthusiastic than a teacher with an average level of enthusiasm as reported by the students when controlling for students' interindividual differences in their perceptions of their teachers' enthusiasm), whereas the coefficients depicted by Frenzel et al. (2018) at the between level are L2 effects (i.e., not taking into account whether a student differs from the class-average perception of how enthusiastic their teacher's teaching is). In testing our mediation models, we controlled for the prior levels of the respective outcomes (i.e., students' intrinsic or utility value, represented by paths d_1 and d_{cont} in Figure 2) in contrast to Frenzel et al., who freely estimated the covariance between the mediator (perceived enthusiasm) and students' enjoyment at T1 due to their cross-lagged structure at the class level. These differences between our specification of multilevel mediation analyses and those used by Frenzel et al. (2018) imply that the coefficients are not directly comparable. In order to make comparability easier, we additionally ran the analyses described above regarding teachers' teaching enthusiasm, student-perceived teacher enthusiasm, and students' intrinsic value with

specifications that were identical to Frenzel et al. (i.e., a doubly latent approach with covariances between the mediator and the covariates; reporting standardized results from Mplus output).

Missing Data

Despite the longitudinal design of the present study, the amount of missing data only ranged from 3.7% to 12.5% for the student variables and from 0.0% to 2.5% for the teacher variables. Missing data occurred due to the absence of individual students at single measurement waves and nonresponses to single items. Following recommendations by Graham (2009), we used the full information maximum likelihood method implemented in Mplus, which takes all available information into account.

Results

In order to expand the understanding of value transmission effects, we examined the associations between different teacher values, student-perceived instructional practices, and student values. We report the intercorrelations resulting from the manifest variables in Table 2. In the following, we will first present the results from predicting students' intrinsic value (Table 3), followed by results for their utility value (Table 4). We will describe the respective models (labeled M1 to M18 for Models 1 to 18) in the order in which they appear in the tables.

Predicting Students' Intrinsic Value

Emotional Contagion

Our first research question addressed the replication of previous findings on emotional contagion, that is, the association between teachers' teaching enthusiasm and students' intrinsic value through students' perceptions of their teachers' enthusiastic behavior during instruction (see Frenzel et al., 2018). As demonstrated in Figure 3, teachers' teaching enthusiasm was significantly related to student-perceived teacher enthusiasm ($\beta_{a2} = 0.23, p < .001$), which in turn was significantly linked to students' intrinsic value at T3 at the

individual level ($\beta_{b1} = 0.09, p < .001$; see M1 in Table 3). There was no further contextual effect associated with student-perceived teacher enthusiasm at L2 ($\beta_{bcont} = .07, p = .175$), indicating that the association between students' shared perception and students' intrinsic value did not significantly differ from the association between students' individual perception and intrinsic value. In contrast to Frenzel et al. (2018), we furthermore found a marginally significant positive total effect of teachers' teaching enthusiasm on students' intrinsic value ($\beta_{total} = 0.04, p = .063$).

Figure 3. Results from the cross-level mediation analysis replicating findings on emotional contagion, that is, the indirect associations between teachers' teaching enthusiasm and students' intrinsic value through students' perceptions of their teachers' enthusiasm in class. See M1 in Table 3 for further results.

*** $p < .001$.

Table 2

Bivariate Correlations among the Manifest Variables under Investigation on the Individual and Class Levels

	1	2	3	4	5	6	7	8	9	10
1. T1 Teachers' teaching enthusiasm		—	—	—	—	—	—	—	—	—
2. T1 Teachers' math enthusiasm	.36		—	—	—	—	—	—	—	—
3. T1 Teachers' math utility value	.29	.29		—	—	—	—	—	—	—
4. T2 Student-perceived teacher enthusiasm	.37	(.06)	(.06)		.45	.47	.18	.24	.19	.23
5. T2 Student-perceived use of everyday life examples	.31	(.03)	.26	.61		.70	.18	.24	.23	.29
6. T2 Student-perceived relevance support	.38	(.00)	.25	.62	.91		.26	.33	.32	.41
7. T1 Students' intrinsic value	(-.05)	(.02)	(-.03)	(.10)	.21	(.18)		.74	.48	.41
8. T3 Students' intrinsic value	(.10)	(.01)	(-.01)	.34	.29	.27	.68		.39	.52
9. T1 Students' utility value	.21	(.06)	.29	.30	.35	.36	.41	.44		.61
10. T3 Students' utility value	.24	(.18)	.34	.34	.43	.46	.36	.53	.71	

Note. Correlations for the individual-level variables are presented above the diagonal, and correlations for the class-level variables are presented below the diagonal. Correlations in parentheses were not statistically significant. All other correlations were significant at $p < .05$. — = not applicable.

Table 3

*Standardized Estimates and 95% Confidence Intervals for Selected Path Coefficients, Indirect Effects, Total Indirect Effects, and Total Effects in the Nine Cross-Level Mediation Models for Students' **Intrinsic Value** for Different Predictors (Teachers' Teaching Enthusiasm, Math Enthusiasm, and Math Utility Value) and Mediators (Student-Perceived Teacher Enthusiasm, Use of Everyday Life Examples, and Relevance Support)*

	Teachers' teaching enthusiasm			Teachers' math enthusiasm			Teachers' math utility value		
	M1	M2	M3	M4	M5	M6	M7	M8	M9
	Enthusiasm	Examples	Relevance	Enthusiasm	Examples	Relevance	Enthusiasm	Examples	Relevance
	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]
Path coefficients									
Individual level									
T1 students' IV $\rightarrow$ T3 students' IV	.72*** [.69,.76]	.72*** [.68,.76]	.70*** [.66,.74]	.72*** [.69,.76]	.72*** [.68,.76]	.70*** [.66,.74]	.72*** [.69,.76]	.72*** [.68,.76]	.70*** [.66,.74]
T1 students' IV $\rightarrow$ Mediator	.18*** [.14,.23]	.18*** [.13,.23]	.26*** [.21,.32]	.18*** [.14,.23]	.18*** [.13,.23]	.26*** [.21,.32]	.18*** [.14,.23]	.18*** [.13,.23]	.26*** [.21,.32]
Mediator $\rightarrow$ T3 students' IV	.09*** [.05,.13]	.11*** [.07,.14]	.14*** [.10,.18]	.09*** [.05,.13]	.11*** [.07,.14]	.14*** [.10,.18]	.09*** [.05,.13]	.11*** [.07,.14]	.14*** [.10,.18]
Class level									
T1 students' IV $\rightarrow$ T3 students' IV	.01 [-.17,.18]	.01 [-.17,.20]	.03 [-.16,.21]	.01 [-.16,.18]	.00 [-.18,.18]	.02 [-.16,.20]	.01 [-.17,.18]	.00 [-.19,.18]	.01 [-.17,.20]
T1 students' IV $\rightarrow$ Mediator	.30 [-.07,.66]	.49* [.10,.88]	.42* [.09,.75]	.23 [-.13,.59]	.43* [.05,.80]	.35* [.03,.67]	.23 [-.13,.60]	.45* [.07,.82]	.37* [.04,.69]
Mediator $\rightarrow$ T3 students' IV	.07 [-.03,.17]	.01 [-.08,.10]	-.01 [-.11,.09]	.07 [-.02,.16]	.02 [-.06,.11]	.00 [-.09,.10]	.07 [-.02,.16]	.03 [-.06,.12]	.01 [-.09,.11]
T1 teacher values $\rightarrow$ Mediator	.23*** [.13,.33]	.19*** [.09,.28]	.20*** [.11,.28]	.02 [-.09,.14]	.02 [-.09,.13]	.01 [-.09,.11]	.04 [-.06,.15]	.14** [.04,.25]	.12** [.04,.21]
T1 teacher values $\rightarrow$ T3 students' IV	.00 [-.04,.04]	.02 [-.02,.05]	.01 [-.02,.05]	-.01 [-.04,.03]	.00 [-.04,.03]	-.01 [-.04,.03]	.00 [-.04,.04]	-.01 [-.06,.03]	-.01 [-.05,.03]
Indirect, total indirect, and total effects									
Cross-level indirect effect (a_2b_1)	.02** [.01,.04]	.02** [.01,.03]	.03*** [.01,.04]	.00 [-.01,.01]	.00 [-.01,.01]	.00 [-.01,.02]	.00 [-.01,.01]	.02* [.00,.03]	.02** [.00,.03]
Unique class-level indirect effect (a_2b_{cont})	.02 [-.01,.04]	.00 [-.02,.02]	.00 [-.02,.02]	.00 [-.01,.01]	.00 [.00,.00]	.00 [.00,.00]	.00 [-.01,.01]	.00 [-.01,.02]	.00 [-.01,.01]
Total indirect effect ($a_2b_1 + a_2b_{\text{cont}}$)	.04* [.01,.07]	.02* [.00,.04]	.03* [.00,.05]	.00 [-.01,.02]	.00 [-.01,.02]	.00 [-.01,.02]	.01 [-.01,.02]	.02* [.00,.04]	.02* [.00,.04]
Total effect ($c' + a_2b_1 + a_2b_{\text{cont}}$)	.04† [.00,.07]	.04† [.00,.08]	.04* [.00,.08]	.00 [-.04,.03]	.00 [-.04,.04]	.00 [-.04,.03]	.00 [-.04,.04]	.01 [-.04,.05]	.01 [-.04,.05]

Note. Enthusiasm = student-perceived teacher enthusiasm. Examples = student-perceived use of everyday life examples. Relevance = student-perceived relevance support. CI = 95% confidence interval. IV = intrinsic value. T1 teacher values = teachers' teaching enthusiasm, math enthusiasm, and math utility value, respectively. Results are controlled for the intervention conditions. Extended results, including the effects of the intervention conditions and covariances, can be found in the supplemental material (Table S4).

[†] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4

*Standardized Estimates and 95% Confidence Intervals for Selected Path Coefficients, Indirect Effects, Total Indirect Effects, and Total Effects in the Nine Cross-Level Mediation Models for Students' **Utility Value** for Different Predictors (Teachers' Teaching Enthusiasm, Math Enthusiasm, and Math Utility Value) and Mediators (Student-Perceived Teacher Enthusiasm, Use of Everyday Life Examples, Relevance Support)*

	Teachers' teaching enthusiasm			Teachers' math enthusiasm			Teachers' math utility value		
	M10	M11	M12	M13	M14	M15	M16	M17	M18
	Enthusiasm	Examples	Relevance	Enthusiasm	Examples	Relevance	Enthusiasm	Examples	Relevance
	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]	β [CI]
Path coefficients									
Individual level									
T1 students' UV $\rightarrow$ T3 students' IV	.58*** [.54,.62]	.57*** [.52,.61]	.53*** [.48,.57]	.58*** [.54,.62]	.57*** [.52,.61]	.53*** [.48,.57]	.58*** [.54,.62]	.57*** [.52,.61]	.53*** [.48,.57]
T1 students' UV $\rightarrow$ Mediator	.19*** [.13,.25]	.23*** [.18,.29]	.32*** [.27,.37]	.19*** [.13,.25]	.23*** [.18,.29]	.32*** [.27,.37]	.19*** [.13,.25]	.23*** [.18,.29]	.32*** [.27,.37]
Mediator $\rightarrow$ T3 students' UV	.14*** [.08,.20]	.16*** [.11,.21]	.25*** [.20,.31]	.14*** [.08,.20]	.16*** [.11,.21]	.25*** [.20,.31]	.14*** [.08,.20]	.16*** [.11,.21]	.25*** [.20,.31]
Class level									
T1 students' UV $\rightarrow$ T3 students' UV	.06 [-.09,.22]	.05 [-.11,.21]	.07 [-.08,.23]	.06 [-.09,.21]	.04 [-.11,.20]	.07 [-.08,.21]	.02 [-.13,.18]	.03 [-.14,.19]	.05 [-.11,.20]
T1 students' UV $\rightarrow$ Mediator	.43* [.07,.79]	.53* [.13,.93]	.47** [.14,.80]	.57** [.19,.94]	.63** [.23,1.03]	.58** [.24,.92]	.58** [.22,.93]	.54** [.14,.95]	.50** [.16,.84]
Mediator $\rightarrow$ T3 students' UV	-.04 [-.14,.06]	-.03 [-.13,.07]	-.08 [-.20,.04]	-.04 [-.14,.06]	-.03 [-.13,.07]	-.09 [-.20,.02]	-.04 [-.14,.06]	-.04 [-.13,.06]	-.10 [†] [-.21,.02]
T1 teacher values $\rightarrow$ Mediator	.20*** [.09,.31]	.15** [.04,.25]	.16** [.06,.26]	.01 [-.09,.12]	.01 [-.10,.11]	.00 [-.10,.09]	-.01 [-.10,.09]	.09 [†] [-.02,.20]	.08 [†] [-.01,.16]
T1 teacher values $\rightarrow$ T3 students' UV	.00 [-.05,.05]	.00 [-.05,.05]	-.01 [-.05,.04]	.05* [.01,.08]	.05* [.01,.08]	.05* [.01,.08]	.04 [†] [.00,.09]	.03 [-.01,.08]	.04 [-.01,.08]
Indirect, total indirect, and total effects									
Cross-level indirect effect (a_2b_1)	.03** [.01,.04]	.02* [.01,.04]	.04** [.02,.07]	.00 [-.01,.02]	.00 [-.02,.02]	.00 [-.02,.02]	.00 [-.01,.01]	.02 [.00,.03]	.02 [.00,.04]
Unique class-level indirect effect (a_2b_{cont})	-.01 [-.03,.01]	.00 [-.02,.01]	-.01 [-.03,.01]	.00 [-.01,.00]	.00 [.00,.00]	.00 [-.01,.01]	.00 [.00,.00]	.00 [-.01,.01]	-.01 [-.02,.01]
Total indirect effect ($a_2b_1 + a_2b_{\text{cont}}$)	.02 [†] [.00,.04]	.02* [.00,.04]	.03* [.00,.05]	.00 [-.01,.01]	.00 [-.01,.01]	.00 [-.02,.02]	.00 [-.01,.01]	.01 [.00,.03]	.01 [.00,.03]
Total effect ($c' + a_2b_1 + a_2b_{\text{cont}}$)	.02 [-.03,.07]	.02 [-.03,.07]	.02 [-.03,.07]	.05* [.01,.09]	.05* [.01,.09]	.05* [.01,.08]	.04 [†] [.00,.09]	.05 [†] [.00,.09]	.05* [.00,.09]

Note. Enthusiasm = student-perceived teacher enthusiasm. Examples = student-perceived use of everyday life examples. Relevance = student-perceived relevance support. CI = 95% confidence interval. UV = utility value. T1 teacher values = teachers' teaching enthusiasm, math enthusiasm, and math utility value, respectively. Results are controlled for the intervention conditions. Extended results, including the effects of the intervention conditions and covariances, can be found in the supplemental material (Table S5).

[†] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

The significant links between teachers' teaching enthusiasm and student-perceived teacher enthusiasm as well as student-perceived teacher enthusiasm and students' intrinsic value at T3 resulted in a significant positive total indirect effect from teachers' teaching enthusiasm to students' intrinsic value through perceived teacher enthusiasm ($\beta_{\text{total indirect}} = 0.04, p = .018$). This finding supported our hypothesis from Research Question 1, and replicated the findings from Frenzel et al. (2018). Our findings furthermore revealed that this total indirect effect was primarily due to the indirect effect through students' individual perception of teacher enthusiasm; there was no additional indirect impact through the shared perception of teacher enthusiasm over and above the indirect effect via the individual-level mediator. Thus, teachers' teaching enthusiasm was indirectly associated with students' intrinsic value through teachers' enthusiastic behavior during instruction as individually reported by the students.

When we evaluated the same association by applying multilevel structural equation modeling with model specifications equivalent to Frenzel et al. (2018), we mostly found results that were comparable to Frenzel and colleagues regarding both the size and the direction of the coefficients (for the coefficients, see the supplemental material, Table S6). Importantly, in line with Frenzel et al., we found a statistically significant indirect effect from teachers' teaching enthusiasm to students' intrinsic value through student-perceived teacher enthusiasm in this model ($\beta = 0.24, 95\% \text{ CI } [.01, .47], p = .040$).

The Impact of Other Instructional Practices

We further expected the link between teachers' and students' affective value dimensions to also be mediated through relevance-related instructional practices (see Research Question 2). That is, we were interested in whether teachers' enthusiasm about teaching became evident not only in enthusiastic behavior during instruction but also in relevance-related strategy use (i.e., use of everyday life examples and relevance support). We furthermore tested whether these relevance-related instructional practices, in turn, were

prospectively associated with students' own intrinsic value. Students' perceptions of teachers' use of everyday life examples (e.g., $\beta_{\text{total indirect}} = 0.02, p = .044$) and relevance support (e.g., $\beta_{\text{total indirect}} = 0.03, p = .023$) also mediated the link between teachers' teaching enthusiasm and students' intrinsic value (see M2 and M3), meaning that these results were similar to those for the transmission via enthusiastic behavior. Again, these total indirect effects were mainly driven by the indirect effects via the individual level rather than a contextual indirect effect through the additional information students' shared perceptions hold in comparison to individual ratings.

Examining Other Teacher Values

To address our third research question, we investigated teachers' math enthusiasm as well as math utility value as potential predictors of students' intrinsic value, thereby checking each association for a mediational relation through student-perceived teacher enthusiasm, use of everyday life examples, or relevance support. We therefore tested six additional models. We found no significant total effects from teachers' math enthusiasm to students' intrinsic value at T3 in any of the three models in which we investigated teachers' math enthusiasm as the predictor (M4 to M6). There were also no significant paths from teachers' math enthusiasm to the three instructional practices we investigated, nor were there total indirect effects from teachers' math enthusiasm to students' intrinsic value at T3 through any of the three mediators under investigation.

For teachers' math utility value, we also found no significant total effects on students' intrinsic value at T3 (M7 to M9). However, the results indicated significant effects of teachers' utility value on students' perceptions of both relevance-related instructional practices ($\beta_{a2,M8} = 0.14, p = .007$; $\beta_{a2,M9} = 0.12, p = .004$) when controlling for students' initial intrinsic value, leading to significant total indirect effects on students' intrinsic value at T3 ($\beta_{\text{total indirect},M8} = 0.02, p = .047$; $\beta_{\text{total indirect},M9} = 0.02, p = .027$). This means that the more teachers perceived math to be relevant and useful, the more they emphasized its relevance

during class as perceived by the students, which in turn affected how much students intrinsically valued math class.

Predicting Students' Utility Value

For Research Question 4, we tested the predictive value of teachers' teaching enthusiasm, math enthusiasm, and math utility value on students' *utility* value (see Table 4). There were substantial paths from teachers' teaching enthusiasm to all of the three student-perceived instructional practices (M10 to M12; $0.15 \leq \beta_{a2} \leq 0.20$, $ps \leq .005$). They led to significant total indirect effects (but for student-perceived teacher enthusiasm, there was only a marginally significant effect) on students' utility value ($0.02 \leq \beta_{\text{total indirect}} \leq 0.03$, $p_{M11,M12} \leq .031$, $p_{M10} = .078$), even though there was no significant total effect from teachers' teaching enthusiasm to students' utility value ($\beta_{\text{totalS}} = 0.02$, $ps \geq .387$). The total indirect effects were completely explained by the significant cross-level indirect effects ($0.02 \leq \beta_{a2b1} \leq 0.04$, $ps \leq .012$). Consequently, students' individual perceptions of their teachers' relevance-related instructional practices were relevant for their change in utility value, and the context (i.e., the shared perceptions of the class) did not additionally contribute to the indirect effect.

Regarding teachers' math enthusiasm, we found a significant total effect on students' utility value (M13 to M15; $\beta_{\text{totalS}} = 0.05$, $ps \leq .022$). Additionally, we found that teachers' math enthusiasm significantly directly predicted students' utility value ($\beta_c's = 0.05$, $ps \leq .014$), but there were no further substantial links between teachers' math enthusiasm and any of the three mediators ($0.00 \leq \beta_{a2} \leq 0.01$, $ps \geq .795$). Reflecting on these nonsignificant relations, we found no total indirect effect from teachers' math enthusiasm to students' utility value ($\beta_{\text{total indirectS}} = 0.00$, $ps \geq .790$).

The same also applied for the last three models (M16 to M18) for which there were marginal to significant total effects from teachers' math utility value to students' utility value ($0.04 \leq \beta_{\text{total}} \leq 0.05$, $ps \leq .069$) but no further total indirect effects ($0.00 \leq \beta_{\text{total indirect}} \leq 0.01$; $ps \geq .101$). However, we found at least marginally significant paths from teachers' math utility

value to the student-perceived relevance-related instructional practices ($\beta_{a2,M17} = 0.09, p = .098$; $\beta_{a2,M18} = 0.08, p = .086$).

Taken together, teachers' teaching enthusiasm was indirectly related to students' utility value through both relevance-related instructional practices. Furthermore, teachers' math enthusiasm and (at least in one model) teachers' math utility value were associated with students' utility value, even though the instructional practices under investigation could not explain these total effects.

Robustness Checks

We carried out various robustness checks in order to draw more reliable conclusions from our findings. The overall pattern of results from the main analyses and the robustness checks were fairly consistent (see Figures S1 and S2 in the supplemental material) with only marginal variations, therefore emphasizing the robustness of the main results.

Familiarity With the Teacher

When students were already familiar with their math teachers, their initial values reported at T1 might have been affected by their teachers' values and the instructional practices students were exposed to in the previous school year. We therefore tested all our reported models with the sample split into a first group of classes that had a new math teacher at the beginning of the school year ("new teacher") and a second group of classes that had been instructed by the same teacher in the previous school year or even for multiple years ("known teacher"). As a consequence, the composition of the "new teacher" subsample was more like the Frenzel et al. (2018) study's sample composition. Results are reported in the supplemental material (Tables S7 to S12). Our findings revealed that there were no statistically significant differences in any of the reported total indirect effects or total effects between the two groups.

Effects of Changing Teachers throughout the Study

To ensure that our findings were not affected by the five classes in which students experienced a change in teachers between T2 and T3, we additionally ran all analyses with a subsample of students who did not experience a change in teachers ($N = 1,635$). Results are reported in the supplemental material (Tables S13 to S14). Correlating all 22 coefficients from the main results with the corresponding coefficients from the teacher-change results (considering one model at a time) revealed high consistencies and suggested that there were no substantial differences ($Mdn r = .99$).

Were the Results Affected by the Intervention?

To ensure that our results were not affected by the intervention (which occurred during T1 and T2 in the classes from the two intervention conditions), we additionally ran all analyses with the respective mediators assessed at T1 (instead of T2, i.e., before the intervention and therefore at the same time point as our predictors). Results are reported in the supplemental material (Tables S15 to S16) and showed overall high consistency with the main results ($Mdn r = .95$).

We additionally tested whether our results were moderated by the experimental conditions using multigroup models in which the two intervention conditions and the control condition represented the three groups (see Tables S17 to S22 in the supplemental material). We tested for statistical differences between the three groups regarding the total indirect and total effects, respectively, in each model. Only 4 out of the 108 (18 models x 3 groups x 2 coefficients) differences we tested turned out to be statistically significant.

Discussion

Drawing on an increasing body of research investigating emotional contagion as the mechanism underlying the transmission of value from teachers to their students (e.g., Frenzel et al., 2009; Lazarides et al., 2018; Lazarides, Gaspard, et al., 2019), we investigated the transmission of different value dimensions and how such transmission processes work in the

classroom. Using data from a large longitudinal study in math classrooms, we were able to replicate previous findings on the process of emotional contagion (see Frenzel et al., 2018). We found indirect longitudinal associations between teachers' teaching enthusiasm at the beginning of the school year and their students' intrinsic value throughout the school year through students' perceptions of their teachers' enthusiasm during instruction. Extending previous research, we found that the indirect association between teaching enthusiasm and intrinsic value was also explained by relevance-related instructional practices, namely, students' perceptions of their teachers' use of everyday life examples and relevance support.

We additionally extended this research by investigating other dimensions of teacher and student values. Not only teachers' math enthusiasm but also their math utility value at the beginning of the school year positively predicted students' utility value later on. Furthermore, teachers' teaching enthusiasm was indirectly related to students' utility value, and teachers' utility value was indirectly related to students' intrinsic value through different instructional practices. This study therefore makes a valuable contribution to the understanding of value transmission by expanding the focus to include important and hitherto neglected motivational and instructional constructs. In addition to emotional contagion, we were able to identify relevance-related strategies as a technique that teachers can use to promote their students' values in a meaningful way during class.

Replicating Research on Emotional Contagion

Our study results indicate a transmission of teachers' teaching enthusiasm to students' intrinsic value during math class through the process of emotional contagion, that is, a transmission through students' perceptions of their teachers' enthusiasm in class. Thus, we conceptually replicated the findings by Frenzel et al. (2018) using data that share several similarities with their study: We were able to incorporate the same number of assessments following a similar time line within 1 school year, relied on a similar sample in terms of sample size and context (i.e., students from intact classes from German secondary schools),

and incorporated both student and teacher reports. Regarding the analyses of teachers' impact on students' intrinsic value, we conceptually replicated the mediational approach used by Frenzel et al. (2018), including controlling for the student pretest measure. However, we used a different statistical approach in order to apply multilevel mediation (i.e., cross-level mediation), which has been recommended in the literature because of its higher power and its potential to disentangle individual and contextual effects (Pituch & Stapleton, 2012), that is, the contributions of students' individual and shared perceptions of the context to the respective indirect effects. When comparing our findings with the Frenzel et al. (2018) study, it is still important to keep in mind that the studies differed slightly in terms of age, track, and the framing of the measures that were used: Frenzel et al. relied on a more heterogeneous sample, that is, different grade levels (vs. only ninth graders) and different track schools (vs. only academic track schools). Students in the Frenzel et al. study did not know their teachers from previous school years (vs. some knew their math teachers already, others did not). Additionally, their enjoyment measures were focused on perceptions during lessons in specific classrooms only (e.g., "I enjoy teaching these students", vs. teaching in general, e.g. "I really enjoy teaching"). Thus, it seems that similar transmission processes apply to our sample of adolescents in ninth-grade math classrooms and their math teachers and that such transmission processes can also be found for teachers' general teaching enthusiasm (irrespective of the particular group of students).

Value Transmission: Different Mechanisms for Different Value Dimensions?

Overall, this study supports the value transmission processes from socializers to children, which was postulated by EVT (Eccles, 2007). Even though previous research has provided solid evidence for the transmission of values from teachers to their students in terms of emotional contagion (e.g., Frenzel et al., 2009, 2018; Keller et al., 2014), there was a clear need to broaden these findings for further value dimensions and other potential underlying mechanisms that can explain value transmission. As our findings show, the transmission of

values applied to both teachers' intrinsic value represented by their enthusiasm and math utility value. We furthermore differentiated between two instructional practices that drive the transmission of values from teachers to their students: students' perceptions of teachers' enthusiastic behavior during instruction and students' perceptions of relevance-related instructional practices (i.e., use of everyday life examples or relevance support). Even though the two relevance-related instructional practices are based in different research traditions and can be distinguished theoretically (Ryan & Deci, 2000; van den Heuvel-Panhuizen & Drijvers, 2014), our findings reveal that the students did not seem to clearly distinguish between the constructs, which is reflected both in their high correlations and the consistency in result patterns. As a consequence, we discuss them jointly in the following.

First, value transmission through the *enthusiastic behavior* during instruction applied exclusively to teachers' teaching enthusiasm. In line with Keller et al. (2014), teachers' teaching enthusiasm was evident in their enthusiastic behavior in class, meaning that teachers who were enthusiastic about the teaching-related aspects of their profession were also more likely perceived to teach with enthusiasm. In turn, this affected not only students' own intrinsic value (emotional contagion) but also their utility value. It seems that the "perceived emotional climate" (Lazarides et al., 2018, p. 7) created through teachers' enthusiastic teaching during math class played a key role in the development of various value dimensions. The association between teachers' enthusiastic behavior and students' *intrinsic* value has been the focus of prior research (see Keller et al., 2016, for an overview). However, the association between teachers' enthusiastic behavior and students' *utility* value expands upon previous research because we directly linked this instructional practice with students' utility value while simultaneously (a) testing for the impact of teacher values on these constructs and (b) adjusting for students' initial utility value (but see Lazarides et al., 2018). We assume that the perceived positive climate created through enthusiastic expressiveness during instruction led students to be more open to and more engaged in the learning process overall (H. Patrick et

al., 2003) and teachers' reasoning in particular—ultimately leading to a greater acceptance that math could indeed be useful.

Second, value transmission through the *relevance-related instructional practices* also applied to teachers' teaching enthusiasm. This means that teachers' personal, inner teaching-related motivational states were related to their active behavior such as providing rationales for the relevance of a task, as already often assumed in the literature (e.g., Schmidt et al., 2019). Our finding that students' perceptions of the relevance-related instructional practices were related to their own values furthermore confirm previous findings (Assor et al., 2002; Reeve et al., 2002; Schmidt et al., 2019; Schreier et al., 2014; Wang, 2012). As expected, students reported higher utility values when they perceived that their teachers were emphasizing the relevance of the content, even when we controlled for students' initial utility value. This finding extends previous correlational and qualitative research (e.g., Schmidt et al., 2019; Schreier et al., 2014), showing that such associations also hold longitudinally. The direct communication of relevance or guiding students to make their own connections to relevance are well established ways to foster student values through targeted interventions (for an overview, see Harackiewicz et al., 2014). Our findings indicate that similar processes also apply to natural classroom settings and lead to a higher appreciation of the content (see also Brophy, 2008).

Teachers' relevance-related instructional practices were furthermore associated with an increase in students' intrinsic value, which supports previous findings stemming from research grounded in self-determination theory (SDT; e.g., Ryan & Deci, 2017). In SDT, providing meaningful rationales is conceptualized as part of an autonomy-supportive motivational teaching style (e.g., Ryan & Deci, 2000; see also Su & Reeve, 2011), which is related to higher quality of student motivation (e.g., Assor et al., 2002). By establishing connections between students' needs and goals on the one hand and the content on the other, teachers might provide their students with rationales for engaging in a task. This can trigger

an internalization process, which is ultimately reflected in enhancements of students' personal and intrinsic valuing of the content (e.g., Deci et al., 1991; see also Vansteenkiste et al., 2018). Even though this was not the focus of this study, we nevertheless speculate that the increase in students' intrinsic value could serve as evidence for a successful internalization process in relation to teachers' relevance-related instructional practices. The repeated emphasis of the relevance of the content can additionally function as a trigger for situational interest, which in the long run can develop into individual interest (Hidi & Renninger, 2006). Emphasizing the relevance of a task thereby seems to be particularly promising when a task is uninteresting (Steingut et al., 2017).

Despite the indirect associations between teachers' enthusiasm to teach and student values, as well as between teachers' math utility value and students' intrinsic value through the instructional practices under investigation, it is important to note that the corresponding total associations between teacher values and student values were not always significant (regarding teaching enthusiasm and students' intrinsic value) or not significant (regarding teaching enthusiasm/math utility value and students' utility value/intrinsic value). In the study by Frenzel et al. (2018) that we aimed to conceptually replicate, the authors also observed positive indirect effects on students' enjoyment through student-perceived enthusiasm in combination with non-significant total effects of teacher enjoyment. In their study, the positive indirect effects were even accompanied with a negative direct effect. Although we did not observe significant negative direct effects opposing the positive indirect effects as Frenzel et al. (2018) did, the pattern of results was similar to the Frenzel et al. (2018) study and thus seems not only to apply to students' intrinsic value or enjoyment, but also to their utility value as an outcome and teachers' utility value as a predictor. Several reasons might underlie such a missing direct link between teacher and student values.

Frenzel et al. (2018) and subsequently Taxer and Frenzel (2018) provided first evidence that the non-existence of total effects from teacher enthusiasm to student values may

be due to a missing congruency between experienced and displayed motivations in some teachers. When teacher values and perceptions of their instructional practices match, positive effects on student values could indeed be observed (Keller et al., 2018). However, when the perceived instructional behavior is not aligned with the teachers' actual motivations, students may experience their teachers as being inauthentic (Kreber et al., 2010), ultimately leading to students enjoying the class less (Keller et al., 2018).

In our data, we observed only small to moderate associations between teacher values and the instructional practices under investigation (including student-perceived enthusiasm), which could indicate that the teacher was perceived as being not authentic in some classrooms. Inauthentic teaching might have arisen out of two different reasons (Frenzel et al., 2018; Keller et al., 2018). On the one hand, teachers might have up-regulated their enthusiastic or relevance-inducing behaviors compared to their actual underlying values. On the other hand, teachers' might have over-rated their actual teaching enthusiasm and math utility value due to social desirability, which would not be reflected in their teaching practices as reported by the students (for similar reasoning, see supplemental material from Frenzel et al., 2018). That is, for teaching values to be able to affect student values, they have to translate into observable behavior first (see Eccles, 2007). It appears likely that discrepancies in teacher-reported values and student-perceived instructional practices underlie the missing total associations in our study, even though other reasons for missing total links between teacher values and student values cannot be ruled out as is always the case for mediation analyses (VanderWeele & Vansteelandt, 2009); for instance, non-observed instructional practices may explain a counterbalancing negative indirect association, ultimately leading to an apparent non-association between teacher and student values.

Besides associations through the instructional practices under investigation, we also found total associations between teachers' and students' utility value. These findings regarding conceptually more cognitive constructs were in line with previous findings on the

association of rather cognitive motivational beliefs. For instance, Oppermann et al. (2019) found that teachers' science self-efficacy—the cognitive evaluation of and their confidence in their own abilities to teach science—was associated with preschool children's self-efficacy in science. However, we could not explain the associations between teachers' math values and students' utility value through the instructional practices under investigation. Hence, the mechanisms underlying this transmission process are unclear. However, as teachers' underlying beliefs regarding the usefulness of math were linked to students' utility value, they might be necessary in order to persuade their students of the usefulness, though potentially not sufficient. Recent findings from Han et al. (2019) suggest that students' perceptions of their teachers' utility value of the subject are higher when they also perceive their teachers to be emotionally supportive—that is, when the teacher behavior is also perceived as being directed to the student needs. An additional student-directed behavior (e.g., emotional support) might therefore be necessary for teachers' subject-related values to come into effect. On the other hand, teachers' utility value itself might indeed be relevant for the quality of their relevance support, whereas our measures might have just covered the mere quantity of relevance-inducing behavior—neglecting the quality thereof. It appears plausible that a single thus very convincing relevance argument (triggering a eureka moment) can initiate psychological processes leading to a change in students' utility value (a mechanisms that so called “wise interventions” also capitalize on; Yeager & Walton, 2011). Teachers who are convinced of the usefulness of math might more likely be able to initiate such a process, even though this high quality instructional behavior is not reflected in students' perceptions of their teachers' relevance support. Finally, further characteristics of the teacher (e.g., their professional knowledge) could also function as a third variable that affects both teachers' and students' perceptions of the usefulness of math (see Praetorius et al., 2017).

Next to the instructional practices that might function as a mediator between teacher values and student values, a closer look at the associations between teacher values and

teachers' instructional practices is necessary to gain a complete picture about value transmission processes in the classroom. Several mechanisms might underlie the associations found in our data, which differ between teacher values regarding teaching (i.e., teaching enthusiasm) and regarding the subject matter (i.e., math enthusiasm and math utility value). According to Roth et al. (2007), a more affective motivation for *teaching* (they used the term autonomous motivation for teaching) involves deep understanding and leads to a deeper processing of a topic. A reason could be that teachers who are motivated to teach are also more willing to engage, to invest more effort and time preparing, and to attend in-service training (e.g., Kunter & Holzberger, 2014; Praetorius et al., 2017)—potentially also resulting in a higher awareness of what is relevant for their students. This could lead them to provide their students with more convincing and meaningful rationales to engage in math.

Regarding teachers' *subject-related values*, we speculate that teachers who experienced the actual subject matter to be useful and enjoyable, consequently (consciously or unconsciously) want their students to have similar experiences because “they understand that these types of motivations lead to a high quality of learning and increased appreciation of the subjects they teach and love” (Roth et al., 2007, p. 764). However, this reasoning for engaging in motivating instructional practices lacks one important item in the equation: the needs and goals of the students who are the actual target of the motivating behavior. Math enthusiasm and math utility value—as valuable as they are—rather focus on the self-satisfying motives for engaging in an activity. Teaching, however, involves by definition the student as the target of action, meaning that who is enthusiastic about teaching itself more likely holds motives that are directed to stimulate something within another person. These differently oriented values might be a reason for why we observed different associations between teaching enthusiasm, on the one hand, and math values, on the other, with students' perceptions of instructional practices (see also Kunter et al., 2008).

Taken together, we conclude that a transmission of value from teachers to their students takes place when teachers on the basis of their teaching enthusiasm are able to create an authentic, positive motivational climate in the classroom through their enthusiastic behavior, which, in turn, affects students' intrinsic value; and when teachers on the basis of their teaching enthusiasm correspondingly put more effort into teaching and motivating their students, leading to an overall higher quality of teaching and the application of relevance-related instructional practices (see also Praetorius et al., 2017), which, in turn, also affects students' values. Our findings furthermore provide support for the transmission of utility value from teachers to their students, although the underlying processes need to be investigated in future research. In general and for this reason in particular, more research is needed to put these speculations on a solid empirical basis, including in regard to mediating processes between teacher values and their behavioral display during instruction.

Value Transmission in the Classroom: Effect Sizes and Practical Relevance

Our findings oftentimes revealed fairly small effect sizes. However, we identified some factors that might have decreased the probability to find such effects. First, it is noteworthy that we found rather small intraclass correlations along with simultaneously high stabilities in student values throughout the school year. These stabilities provided a first indication of whether student values underwent change (the higher the stabilities, the more set), whereas the intraclass correlation indicated the maximum proportion of variance in student values that could be explained through class-level variables—in this case, through teacher values and students' shared perceptions of instructional practices. The teacher values themselves, however, were limited in variance—which is not very surprising for this specific sample of individuals who chose to become teachers after all. This is also commonly reflected in high means for teacher values (e.g., Frenzel et al., 2018; Paulick et al., 2013; Schiefele et al., 2013). With the small variances for teacher values, the high stabilities in student values, and the low intraclass correlations we found, it is all the more remarkable that our findings

indicated systematic relations between the constructs under investigation. At the same time, however, they might have covered further associations on the class level and led to supposedly small effect sizes, although it should be kept in mind that we reported contextual and not class-level effects, a difference that needs to be considered when interpreting the sizes of the coefficients (see, e.g., Lüdtke et al., 2009, for explanation). As our findings revealed, the indirect links between teacher values and student values via perceptions of instructional practices were consistently found for students' *individual* perceptions. We found no additional indirect impact of the context (i.e., the shared perceptions of the class) on student values over and above the impact of these individual perceptions.

Even though the effect sizes presented in this study appeared to be small in absolute terms, their relative meaning should be taken into account. For instance, students in classrooms with a teacher whose enthusiastic behavior was rated within the 10th percentile compared with the 90th percentile had an average difference in their change in intrinsic value of 0.38 of a standard deviation (when teachers' teaching enthusiasm was controlled for)—and this was the case after only 4 to 5 months into the school year. If these effects accumulated over time, the differences in their intrinsic value could potentially be expected to increase even more. Testing this is a task for further research.

Practical Implications

This study has several implications for educational practice. First, our investigation stresses the importance of teacher values as a dimension of professional competence already emphasized by Baumert and Kunter (2013). Not only did different dimensions of teacher values predict their strategy use during math class; these instructional practices furthermore predicted changes in students' values for math.

In motivation research, one constant concern is the question of what motivates individuals to become teachers (e.g., Richardson & Watt, 2014). Instead of asking what dimensions of motivation are relevant for making a person aspire to join the teaching

profession while implicitly assuming that higher motivation leads to better outcomes, however, we were able to shed light on the more fundamental question of which values might actually be relevant for which student learning outcomes later on. As a consequence of our findings, we conclude that being and staying motivated is one of the core concerns regarding the teaching profession. For educational practice, it appears promising to make teachers' own values a subject of discussion in teacher education and professional development, including a critical discussion of the impact and relevance of (future) teachers' values and authenticity.

Second, we identified different instructional practices that can successfully be implemented to foster student values. Both teachers' expressed enthusiasm and their emphasis on content relevance in class appeared promising for the promotion of student values. Intentionally disclosing their own values might thus help teachers reduce their students' potential inner resistance to math, initialize higher acceptance, and eventually start a motivational internalization process. Even though not new (indeed long recognized by research on effective teaching, e.g. Brophy, 2000; within the research field of modeling in math education, e.g., Greefrath & Vorhölter, 2016; by self-determination theory, Su & Reeve, 2011; or by teaching didactics in terms of realistic mathematics education, e.g., van den Heuvel-Panhuizen & Drijvers, 2014), especially the provision of meaningful rationales turned out to be beneficial for student values. Based on these findings, it seems important to focus on strategy use, including different instructional practices during teacher training and in-service training.

Limitations and Future Research

Although our study provides new insights into the transmission of value from teachers to their students on the basis of high-quality longitudinal data, it also harbors some limitations that should be kept in mind when our findings are interpreted. First, our data stemmed from an intervention study. During the intervention, students were confronted with information about the relevance of math for their current and future lives. Although this could potentially

have led to different processes occurring in the classrooms in the different intervention conditions, our robustness checks did not show such differences. However, future research might still want to investigate whether our findings can be replicated when there is no intervention.

Second, causal interpretations from mediation analyses can only be made with caution (e.g., Valeri & VanderWeele, 2013). To draw causal conclusions, the so-called *no unmeasured confounders assumption* has to hold, meaning that the predictor and further (potentially unobserved) covariates have to be uncorrelated after controlling for the mediator (VanderWeele & Vansteelandt, 2009; see also Mayer, Thoemmes, Rose, Steyer, & West, 2014). The violation of this precondition could otherwise lead to biased results. To reduce this threat, we considered baseline measures of the respective outcome variables (as recommended by Steiner et al., 2010). Despite the high stabilities of student values, we were still able to find associations between the mediator and predictor variables. However, longitudinal studies with longer time lags and potentially lower stabilities might be preferable for uncovering value transmission effects.

Third, whereas we investigated a range of instructional practices as mediators that have previously been found to be associated with student values and that are conceptually related to the value dimensions we investigated, other instructional practices (e.g., cognitive activation, supportive climate, and classroom management; see Fauth et al., 2019; Kunter et al., 2013) might also explain the relations we found. Due to our aim to systematically examine transmission processes, we opted to test for mediational associations through instructional practices that are conceptually close to the value dimensions of interest. Nevertheless, researchers conducting future studies might want to examine whether further instructional practices explain the associations between teachers' and students' utility value.

Fourth, we were not able to investigate reciprocal associations between teacher and student values (i.e., whether student values also affect teacher values) as Frenzel et al. (2018)

did because we could not draw on teacher-reported values in the middle of the semester. Nevertheless, we would generally expect teachers' values to be affected by their students' values in the long run—especially those values regarding teaching and especially when teachers experience similar motivational conditions in different classrooms. Although a few studies have examined the predictors of teacher values (e.g., Sorge, Keller, Neumann, & Möller, 2019), more research is needed on the prerequisites of teachers' own values.

Fifth, we drew our conclusions from the analysis of a rather homogeneous sample in terms of its achievement level due to the fact that we conducted the study only in German academic track schools. Frenzel et al. (2018) already provided evidence for the process of emotional contagion in middle track students, and other research has also indicated consistent associations between teaching quality constructs and students' motivation across different grades and countries (Blömeke & Olsen, 2019). Nevertheless, more research is needed on the transmission of values in environments with different levels of achievement.

Finally, the extent to which our findings generalize to other domains has yet to be determined. We were interested in math because the decline in student values during secondary school is especially prominent in this domain (e.g., Gaspard et al., 2017). Even though links between teaching quality constructs and student values seem to be consistent between subjects from similar domains (Blömeke & Olsen, 2019), it would be compelling to investigate whether our findings on value transmission also apply to other subject domains, as done by Frenzel et al. (2018) for emotional contagion.

Conclusion

The findings of this study provide support for the transmission of multiple value dimensions from teachers to their students in ninth-grade math classes and that such transmissions occur—at least regarding teaching-related teacher values—through perceptions of both teachers' enthusiastic behavior during instruction and their relevance support as reported by the students. However, teacher and student values were differently associated

with these rather affective versus cognitive instructional practices under investigation, leading to different mechanisms underlying the transmission effects for different value dimensions. Whereas student-perceived teacher enthusiasm exclusively explained the transmission of teachers' teaching enthusiasm to students' intrinsic value (also known as emotional contagion), student-perceived relevance-related instructional practices explained the transmission of both teachers' teaching enthusiasm to students' intrinsic and utility values, as well as teachers' utility value to students' intrinsic value. However, we could not explain the associations between subject-related teacher values and students' utility value through the instructional practices under investigation. Nevertheless, we were able to identify effective instructional strategies and motivational prerequisites for the promotion of student values during class, which appear to be promising for the future development of and implementation during teacher education.

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