Dealing with errors in mathematics classrooms: Structure and relevance of perceived error climate ☆

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1. Introduction

Although making errors while learning is common, it is also frequently perceived as something negative, shameful and self-threatening. These perceptions and reactions often prevent persons from seeing errors as learning opportunities (see Oser & Spychiger, 2005; Pekrun, 2009). However, making mistakes has important functions in learning processes since it helps to establish accurate mental models and, therefore, fosters learning progress (Jones & Endsley, 2000). Oser and Spychiger (2005) introduced the concept of negative knowledge (knowledge about that what does not work), which is acquired through errors and is postulated to have positive effects on performance. As an impressive body of research in the past decades has shown, the way a student will deal with errors and failure depends heavily on personal achievement motivation, especially goal-orientation and academic self-concept (for an overview see Wentzel & Wigfield, 2009).

Nevertheless, in addition to influences of personal achievement motivation, influences generated by contextual characteristics in the classroom have to be assumed (Turner & Patrick, 2008; Urdan & Schoenfelder, 2006). To describe the extent and the quality in which the environment supports or inhibits learning from errors, researchers working in educational and organizational settings introduced the concept of "error climate" or "error culture" (e.g., Oser & Spychiger, 2005; Van Dyck, Frese, Baer, & Sonnentag, 2005). Accordingly, a social learning environment which is characterized by a positive error climate fosters adaptive affective, motivational, cognitive and behavioral reactions to errors, which, in turn, ensure learning from errors. Nevertheless, no theoretical consensus has yet been reached regarding the conceptualization of the error climate in learning environments (as perceived by the learners). Open issues concern the relevant subdimensions of the perceived error climate and their relation to similar and well-established contextual characteristics, primarily the perceived classroom goal structure (for an overview see Meece, Anderman, & Anderman, 2006). Moreover, there is a lack of empirical evidence of the consequences perceived classroom error climate has on how individuals deal with errors and the quantity and quality of learning processes.

Consequently, the aim of the present work is to conceptualize perceived classroom error climate and to develop a measuring instrument to adequately assess this perceived context characteristic. Moreover, an aim of the present work is to analyze the unique effects different perceived classroom error climates have on how adaptive students react to errors and how well they learn. This goal is addressed using a sample of German secondary school students in the subject of mathematics.

1.1. Individuals' reactions to errors

In recent decades affective and motivational reactions following errors and failure have been extensively studied under different

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theoretical perspectives (for an overview see Elliot & Dweck, 2005). Primarily, an adaptive reaction pattern is distinguished from a maladaptive pattern: An adaptive reaction pattern following errors and failure maintains learning motivation and functional affects such as joy; a maladaptive pattern decreases learning motivation and increases feelings of shame and hopelessness. These two patterns subsequently lead to different learning behaviors in terms of high vs. low effort and persistence, and in terms of adaptive vs. maladaptive self-regulation of learning activities. To explain why some students show adaptive affective and motivational reactions to failure and some do not, different theoretical approaches have been proposed.

Theoretical advancement primarily resulted from achievement goal theory (e.g., Ames, 1992; Dweck, 1986; Elliot, 1999; Nicholls, 1984; for an overview see Maehr & Zusho, 2009), which accounted for inter-individual differences with respect to mastery goals (goal to enhance own competency) and performance goals (goal to demonstrate high competency or to avoid demonstrating low competency). For individuals with a strong orientation on mastery goals, failure and errors are a source of information regarding one's own learning. This is frequently accompanied by an adaptive pattern characterized by functional attributions (such as effort attributions; Weiner, 1986, 2005), as well as adequate effort, appropriate task selection, and less negative affective reactions to errors. On the other hand, for individuals with a strong performance goal orientation, failure and errors are information about lacking abilities and are therefore a threat to self-esteem. This leads to consequences such as dysfunctional attributions (such as ability attributions), reduced effort, avoidance of challenges and negative affect.

In addition to achievement goals, academic self-concept can be seen as an important predictor of affective and motivational reactions following errors and failure. It reflects individuals' beliefs about the extent of their abilities (i.e., perceived competencies) and is rather domain-specific, e.g. specific for separate school subjects (Harter, 2006; Marsh, Xu, & Martin, 2012). The quality of the self-concept highly influences an individual's causal attributions. Students with low academic self-concepts are more likely to attribute failure to internal and stable causes, such as lack of ability, which are characteristics of the maladaptive pattern following errors (e.g., Skaalvik, 1994). Therefore, a strong mastery goal orientation and a positive academic self-concept seem to protect against maladaptive reactions to errors.[1]

Beyond affective and motivational reactions to errors, cognitive and behavioral reactions, which are specifically adjusted to the error in question, have to be considered (e.g., Dresel, Schober, Ziegler, Grassinger, & Steuer, submitted for publication; Dresel & Ziegler, 2002; Tulis, Grassinger, & Dresel, 2011). These reactions could be a detailed analysis of the error in order to identify misconceptions, a self-evaluation of one's specific knowledge, or deliberately practicing the type of task in which the error occurred in order to bridge the knowledge gap that was responsible for the error. Works which addressed how students deal with errors such as, Dresel and Ziegler (2002) and Dresel et al. (2013), revealed that these cognitive-behavioral reactions to failure and errors are best conceptualized distinguished from (but nevertheless interrelated with) the affective-motivational reactions described above. Accordingly, they proposed a two component model of individuals' reactions to errors, which comprises of the adaptivity of affective-motivational error reactions ("affective-motivational adaptivity") and the adaptivity of learning actions following errors ("action adaptivity"). Affective-motivational adaptivity of error reactions is defined as the degree to which the learner maintains positive affect (e.g., joy) and motivation to learn in the face of errors. On the other hand, action adaptivity of error reactions is defined as the degree to which the learner initiates cognitive processes and behaviors aimed to specifically overcome a possible misconception underlying the present error. It can be assumed, that regulating negative affect and detriments in learning motivation potentially associated with errors, i.e. an affective-motivational adaptivity of reactions to errors, is a prerequisite of cognitive activities and learning behaviors specifically adapted to the error, i.e. an action adaptivity of error reactions (cf. Boekaerts, 1999).

Referring to the definition of action-adaptive error reactions of learners, it becomes clear that these are best conceptualized as a special class of self-regulated learning processes (e.g., Zimmerman, 2000). They encompass several cognitive and meta-cognitive processes which are located in all phases of the self-regulation process (pre-actional, actional, and post-actional phases; see Schmitz & Wiese, 2006). The conceptual difference of the action adaptivity of error reactions, in contrast to general self-regulated learning, can be seen in two aspects: First, action adaptivity of error reactions refers to a specific trigger for regulation, namely the error at hand. Errors can be seen as a prominent class of occasions for self-regulating one's learning behavior, but are by no means the only one. Depending on the theoretical position, a variety of triggers, or even no trigger, for regulation is possible in general models of self-regulated learning (see Zimmerman & Schunk, 2011, for an overview). Second, the adaptation of learning processes to this trigger is constitutive for the concept of action adaptivity and a strong action adaptivity of error reactions only exists, when this adaptation is adequate (i.e. when learners initiate learning activities well-adjusted to the error). In models of self-regulated learning focusing primarily on the quantity instead of the quality of self-regulated learning this is not the case in a similar vein (cf. Wirth & Leutner, 2008).

Until now, relatively little empirical evidence has been provided about the association of action-adaptive error reactions with other, more general aspects of students' learning. Dresel and Ziegler (2002) as well as Dresel et al. (submitted for publication) provided evidence that action-adaptive reactions to errors (such as learning activities specifically adjusted to the error in question) are interrelated to general cognitive and meta-cognitive aspects of the learning process, such as the use of learning strategies, effort, self-regulation of learning and achievement. However, the affective-motivational adaptivity of error reactions was strongly related to affective and motivational aspects, such as helplessness. Results of Dresel et al. (submitted for publication) as well as Tulis et al. (2011) indicated that the affective-motivational adaptivity of students' reactions to errors is primarily predicted by their academic self-concepts (β =.29–.40), while the action adaptivity of error reactions mainly depends on students' mastery goal orientations (β = .30–.46).

1.2. Perceived error climate in the classroom

It can be assumed that reactions to and learning from errors depend not only on individual characteristics, but also on characteristics inherent to the (learning) environment. Contextual features regarding the interpersonal handling of errors, which foster or prohibit learning from errors, are included in the concept of "error climate" or "error culture". This concept is already the subject of a larger body of research in the organizational context, where its relevance has already been demonstrated (e.g., Cannon & Edmondson, 2001; Rybowiak, Garst, Frese, & Batinic, 1999; Van Dyck et al., 2005). However, for the educational context there is little research (mainly conducted by the research group of Oser and colleagues in

[1] Other concepts interrelated with achievement goals and academic self-concepts that have to be mentioned but are not the focus of the present work are the concepts of implicit theories regarding the malleability of one's abilities (Dweck & Leggett, 1988; Dweck & Molden, 2005) and interest (cf. Schiefele, 2009).

German and Swiss contexts, e.g., Oser & Spychiger, 2005; Spychiger, Kuster, & Oser, 2006; Spychiger, Mahler, Hascher, & Oser, 1998). Founded in research on classroom climate (e.g., Anderson, Hamilton, & Hattie, 2004), we prefer the term "error climate". We define a positive error climate as the evaluation and use of errors as integral elements of the learning process in the social learning environment of the classroom.

Assumed effects of a positive error climate in the learning environment are enhancements in the quantity and quality of learning processes, stable knowledge, and better achievement (see Spychiger, Oser, Hascher, & Mahler, 1999). It can be presumed that these effects are mediated through adaptive individual reactions to errors by the learners (i.e., a strong affective-motivational adaptivity and a strong action adaptivity of error reactions in terms of the two-component model of Dresel et al., submitted for publication).

Following a core view of social constructivism, we assume that the origin of these effects lies in the learners' subjective perceptions of the error climate, which may vary between learners within the same learning environment. As earlier research indicates, environmental characteristics such as climate are often constructed to a considerable degree in the eye of the beholder (e.g., Martin, Bobis, Anderson, Way, & Vellar, 2011). Individual learners' perceptions of the error climate can be conceptualized as resulting from a compound of the "objective" error climate (i.e. perceptual bottom-up processes) and biased processing of information regarding the learning environment (i.e. perceptual top-down processes). It is important to recognize that both components are psychologically relevant and are considered to have effects on subsequent learning, although referring to different sources and having different implications (e.g., regarding the improvement of perceived error climates in learning environments).

We assume that the perceived error climate refers to a bundle of interrelated, but nevertheless distinguishable aspects of the learning environment (Spychiger et al., 1998). Based on prior research in different fields, primarily work on error climate and negative knowledge (Oser & Spychiger, 2005; Spychiger et al., 1998), work on error orientation in organizations (Rybowiak et al., 1999; Tjosvold, Yu, & Hui, 2004; Van Dyck et al., 2005), and video-based analyses which focus on instructional processes (e.g., Meyer, Seidel, & Prenzel, 2006), we presume eight subdimensions of perceived error climate in the classroom.

Four of the presumed subdimensions focus on the teacher in a narrow sense. (1) *Error tolerance by the teacher*: This aspect comprises a potential error avoidance attitude on the part of the teacher, i.e. the intolerance or tolerance shown by the teacher towards mistakes made by students (e.g., manifested in explicit verbal statements that errors are to be avoided, or in addressing questions only to students from whom the teacher expects correct answers). It is relevant because an instructional approach based mainly on the prevention of errors minimizes the chances to learn from mistakes (Oser & Spychiger, 2005; Van Dyck et al., 2005). (2) *Irrelevance of errors for assessment:* This subdimension refers to the extent to which student errors do or do not, regularly result in bad assessments of student performance (i.e. grades). It is based on research conducted by Meyer et al. (2006), who found that mixing learning and performance situations is an indicator of a negative error climate and has unfavorable consequences on students' motivation. A more functional approach would be a strict separation of learning phases, in which errors are allowed and helpful, from performance situations, in which accurate work is the main goal. (3) *Teacher support following errors:* This facet refers to the extent assistance is offered by the teacher if student mistakes occur, and includes explanations, patience and help (Oser & Spychiger, 2005). (4) *Absence of negative teacher reactions:* This subdimension refers to the amount of disapproving (verbal and non-verbal) teacher reactions that are displayed in response to mistakes (Oser & Spychiger, 2005). This includes demonstrations of anger, annoyance, and ridiculing students. Research in organizational psychology also shows this to be an important aspect: Edmondson (1999) showed that psychological safety within teams is important for learning from mistakes and Tjosvold et al. (2004) found that "blame-orientated interaction" (p. 1224) does not lead to learning from errors.

Two of the eight presumed subdimensions of perceived error climate in the classroom focus on the reactions of classmates. (5) *Absence of negative classmate reactions*: Negative reactions by classmates including laughing, taunting and making fun of the one who made the mistake are assumed to elicit negative emotions (such as shame) and error avoidance behavior, which inhibit learning activities. Meyer et al. (2006) attempted to asses negative classmate reactions using video-based observations of instructional sequences (see also Spychiger et al., 1998). (6) *Taking the error risk:* This subdimension describes whether or not the prevailing classroom climate supports students who dare to say something without being completely sure if it is correct. In other words, the classroom environment allows students to take the risk of making a mistake (Clifford, 1991). Hence, a positive error climate is characterized by the absence of fear and shame. This aspect was also discussed in prior research (e.g., Oser & Spychiger, 2005; Spychiger et al., 2006; see also Rybowiak et al., 1999).

Finally, the last two of our presumed subdimensions of the error climate in the classroom refer to the social processes of learning from errors in a narrower sense. (7) *Analysis of errors*: Research in the field of organizational psychology has revealed that analyses of errors and communication about these errors are important factors (e.g., Van Dyck et al., 2005). Accordingly, open problem solving within teams leads to learning from errors (Cannon & Edmondson, 2001; Tjosvold et al., 2004). With respect to the instructional handling of errors in the classroom, up to now the analysis of errors has not been conceptualized as a separate subdimension of error climate. (8) *Functionality of errors for learning:* This subdimension refers to the extent to which errors, in general, are starting points for learning processes in the classroom. It seems obvious that several preconditions must be met before mistakes can be used to initiate learning. Thus, it can be assumed that most of the other facets described above must be established first. Until now, this subdimension of error climate was only described in organizational contexts (e.g., Rybowiak et al., 1999; Van Dyck et al., 2005).

Against the background of the manifold nature of the aspects covered, we presume that the described subdimensions are distinguishable, but nevertheless closely interrelated subdimensions of students' perceptions of the error climate in their classrooms. We assume that each of these subdimensions contributes to the perception of the overall error climate in the classroom. Hence, we assume that the perceptions of the eight subdimensions vary rather consistently between learners and that one superordinate uniform factor of error climate perceptions can be conceptualized.

1.3. Overlapping and unique aspects of perceived error climate and perceived classroom goal structure

Beyond the relative lack of secure empirical evidence regarding the effects of a positive or negative error climate in the classroom on individual learning, an important and unresolved question concerns the discriminant and incremental validity of the concept of perceived error climate in relation to other, well-established concepts used to describe the characteristics of a learning environment. Here, perceived classroom goal structures are of pivotal relevance. They refer to student perceptions of the goal-related messages in the classroom and, subsequently, to the extent to which the classroom environment allows for, or determines, the pursuit of mastery and performance goals (Ames, 1992; Kaplan, Middleton, Urdan, & Midgley, 2002; for an overview see Meece et al., 2006). Similar to personal goals, perceived classroom mastery, perceived classroom performance approach and perceived classroom performance avoidance goal structures are distinguished from one another. Numerous studies have come to the robust finding that perceived classroom mastery goal structures lead to adaptive motivational and behavioral outcomes and perceived classroom performance goal structures lead to maladaptive outcomes (Meece et al., 2006).

Goal-related messages may be present in the whole universe of instructional practices including the handling of errors in the classroom. Accordingly, scales assessing perceived classroom goal structures often include some items focusing on errors. For example, part of the widely used Patterns of Adaptive Learning Scales (*PALS*; Midgley et al., 2000) are two items addressing errors: "In our class, it's OK to make mistakes as long as you are learning" and "In our class, it's important that you don't make mistakes in front of everyone".

Notwithstanding this, many other instructional practices communicate purposes of engaging in academic work which hardly relate to errors (e.g., mastery goal messages may be present in making students responsible for personal improvement and performance goal messages may be present in ability grouping; e.g., Ames, 1992). Hence, perceived classroom goal structures are a macroscopical and holistic construct that refers to all activities in the classroom setting associated with learning and performing. In contrast, the concept of perceived error climate refers specifically and in-depth to the dealing with errors within the social context of the classroom. From the definition given above, it follows that it goes beyond goal-related messages included in instructional practices associated with student errors. It focusses not only on the evaluation of errors and teachers' reactions to them, but also on the use of errors for improving subject knowledge and understanding. This becomes particularly evident in the two subdimensions "analysis of errors" and "functionality of errors for learning" which refer to learning from errors in a narrower sense, but may be ambivalent with regard to contained mastery or performance goal-related messages.

Therefore, we conceptualize perceived error climate in the classroom as a genuine feature of the learning environment that overlaps to a certain degree with the concept of perceived classroom goal structures. Hence, we assume that perceived error climate has effects on student learning above and beyond the effects of perceived classroom goal structures.

1.4. Assessing perceived error climates in classrooms

From the conceptualization of perceived error climate in classrooms described above, it directly follows that it is not sufficient to include some items in other instruments which address how errors are handled (see Van Dyck et al., 2005, for evidence on this topic in organizational contexts). Instead, a comprehensive assessment of the several subdimensions of error climate seems reasonable to ensure content validity of scores regarding the overall error-climate in the classroom.

Spychiger and colleagues' (1998) questionnaire (*S-UFS*), which reached considerable popularity in the German-speaking area, considered this claim. However, it confounds the level of the environment and the level of the person, which in our view must be separated for theoretical reasons. In this questionnaire, the "self-factors" are the predominant factors – two of the three dimensions on the short version of the questionnaire rather depict the individual handling of errors instead of the error climate (Spychiger et al., 1998). To the best of our knowledge, no instrument has been presented that comprehensively assesses perceived error climates in classrooms, and strictly distinguishes between error climate as a contextual feature and the individual handling of errors by learners as a feature of learning processes on the personal level.

1.5. Objectives

Based on prior work in educational and organizational contexts (e.g., Oser & Spychiger, 2005; Spychiger et al., 1999; Van Dyck et al., 2005), the main purpose of the present work was to conceptualize perceived error climate in the classroom and to develop a measuring instrument to assess this context characteristic. Furthermore, we aimed to analyze the effects perceived error climate has on students' individual reactions to errors and learning.

Building on the literature review presented above, we expected perceived classroom error climate to be a multidimensional characteristic of classrooms:

Hypothesis 1. Perceived error climate in the classroom has multiple, interrelated subdimensions that, in concert, constitute a superordinate and uniform overall perceived error climate. It varies between classrooms.

Generally, the dimensionalities of constructs on cluster levels is not necessarily identical with their dimensionality on the individual level – rather they are less differentiated in many cases (see Marsh et al., 2012; Muthén, 1989). Moreover there is, according to our best knowledge, no evidence regarding the dimensionality of learners' perceptions of error climates on the cluster level, i.e. on the level of shared perceptions of the "objective" error climate in the classroom. Hence, we did not make any predictions regarding the dimensionality of perceived error climate on the classroom level. Instead, we addressed this – important – issue utilizing an exploratory focus.

As argued, we assumed that perceived error climate in the classroom can be distinguished from perceived classroom goal structures, since it is characterized – aside from some overlap – through unique aspects. Moreover, as we proposed a clear theoretical distinction between aspects of how individuals handle errors on the level of the individual student and contextual aspects of the error climate on the level of the classroom, we expected that this distinction also holds true on the empirical level:

Hypothesis 2. Perceived error climate in the classroom is interrelated with perceived classroom goal structure and students' individual reactions to errors, but is a distinguishable characteristic.

Regarding the effects of perceived error climate in the classroom we expected that perceived error climate in the classroom predicts how students deal with errors (Fig. 1). As discussed, perceived classroom goal structures may be of importance, too. Moreover antecedents on the personal level of the student may and should also exist, as shown in prior motivational research – in the present study we focus on academic self-concept and mastery goal orientation (against the background of the findings described above, which indicate that these two components are of central importance). Nevertheless, we expected that perceived error climate in the classroom has unique effects on students' reactions to errors:

Hypothesis 3. Perceived error climate positively predicts how adaptive students individually react to errors above and beyond perceived classroom goal structures and personal achievement motivation (academic self-concept, mastery goal orientation).

Finally, the study pursues the question of how perceived error climate of the learning environment and the manners in which individual learners deal with errors impact characteristics of subsequent learning processes. Specifically, we focused on students'

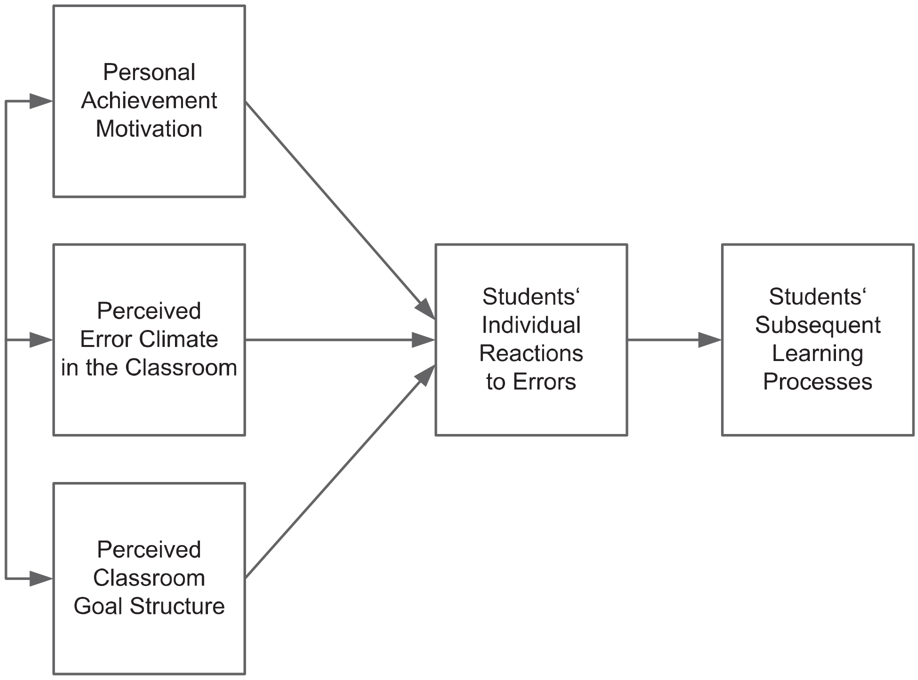

Fig. 1. Expected effects of perceived error climate.

behavioral and cognitive engagement in academic work in terms of the quantity and self-regulation of students' effort. We expected that the effects of error climate are mediated through students' individual reactions to errors (see Fig. 1):

Hypothesis 4. Perceived error climate positively predicts students' behavioral and cognitive engagement in academic work (quantity and self-regulation of students' effort) above and beyond perceived classroom goal structures and personal achievement motivation (academic self-concept, mastery goal orientation). Students' reactions to errors mediate these effects.

2. Method

2.1. Participants

We conducted a study with $N = 1116$ students from 56 sixth and seventh grade classrooms at different German secondary schools in the metropolitan areas of Augsburg and Munich. The proportion of female students was 46.4% and the average age was 13.1 years ($SD = 0.98$). Twenty-eight percent of the students had an immigrant background; for 20% of the students German was not the main spoken language in the home. Student participation was voluntarily and with parental agreement.

2.2. Measurements

Data was collected using self-report measures and all measurements were operationalized with respect to the subject of mathematics.

2.2.1. Adaptivity of individual reactions to errors

Two subscales by Dresel et al. (submitted for publication) were used to measure how adaptive students react to errors, in accordance with their two component model. First, students' affective-motivational adaptivity of error reactions (maintenance of positive affect and motivation to learn) was measured with six items (sample item: "When I can't do something in Math, the lessons in the future will still be just as fun for me as always"). Second, students' action adaptivity of error reactions (initiation of cognitive processes and behaviors aimed to specifically overcome the error) was measured with seven items ("When I can't solve a Math problem, then I practice these types of exercises on my own"). The items were presented with a 6-point Likert-type scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). Internal consistencies were satisfactory ($\alpha = .83$ and $\alpha =$, .91 respectively).

2.2.2. Perceived error climate in the classroom

In order to measure perceived error climate in accordance with the introduced conceptualization, it was assessed via student perceptions of the eight proposed error climate subdimensions depicted above. These were: Error tolerance by the teacher (sample item: "In Math our teacher doesn't like if something is done incorrectly"), irrelevance of errors for assessment ("If someone in our Math class says something wrong, it has an immediate effect on his grade"), teacher support following errors ("If someone in our Math class can't solve an exercise correctly, the teacher will help him"), absence of negative teacher reactions ("If someone in our Math class does something incorrectly, he might be mocked by the teacher"), absence of negative classmate reactions ("If someone in our Math class makes mistakes, his classmates will sometimes make fun of him"), taking the error risk ("In our Math class a lot of students don't dare to say anything because they are afraid it is wrong"), analysis of errors ("In our Math class we discuss it in detail when something is done incorrectly"), and functionality of errors for learning ("In our Math class wrong answers are often a good opportunity to really understand the material"). All items were rated on 6-point Likert-type scales which ranged from 1 (*strongly disagree*) to 6 (*strongly agree*).

The development of the measuring instrument comprised several steps. In the first step, we newly formulated 8–10 items for each error climate subdimension which were derived from the conceptual understanding of the respective subdimension (presented above in Section 1.2), and were partly based on the measuring instrument developed by Spychiger et al. (1998; for scales measuring error climate subdimensions in organizational contexts see Rybowiak et al., 1999; Tjosvold et al., 2004; Van Dyck et al., 2005). In the next step, to ensure content validity, we revised these items using feedback from three members of our research group, who are experts in the field of educational psychology, but were not involved in the initial composition of the items. In the third step, we selected six items for each error climate subdimension for the preliminary version of the error climate questionnaire which was answered by the participants of the present study. Criteria for item selection were as follows (1) best representation of the conceptual understanding of the respective subdimension (there was variation between the items in this regard) and (2) least susceptible to ceiling or floor effects.[2] Since our aim was to develop an economic and balanced instrument, in the final step we selected the four items from each subdimension that had the largest item-total correlations regarding the proposed subdimension (in the case of the dimension "taking the error risk" only three items were selected due to inadequate loading in subsequent factorial analyses; see Section 3).

The 31 items of the final instrument showed sufficient properties as analyses on the item level revealed (M = 3.10–5.09; SD = 0.94–1.58). Three of them were adaptions from items presented by Spychiger et al. (1998); the remaining 28 items were newly constructed. The final items can be found in the Appendix, accompanied by detailed information concerning their origin and psychometric properties. Analyses on the scale level also revealed sufficient properties for all error climate subscales (see Table 1). Their internal consistencies were acceptable with α = .70–.86 Bivariate correlations between the eight subscales were small to moderate (r = .09–.54).

2.2.3. Perceived classroom goal structure

We assessed perceived classroom goal structures as further contextual characteristics of the classroom. We measured perceived mastery goal structure ("In our Math class, trying hard is very important"), perceived performance approach goal structure ("In our Math class, getting good grades is the main goal") and perceived performance avoidance goal structure ("In our Math class, it's important not to do worse than the other students"), by using translated and extended versions of the relevant subscales from the "Patterns of Adaptive Learning Scales" (*PALS*, Midgley et al., 2000) with seven, six and eight items, respectively. Student responses were assessed by using Likert-type scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Internal consistencies of the three subscales were satisfactory (α = .75–.83).

2.2.4. Students' personal achievement motivation

As indicators of personal achievement motivation, two aspects were measured. First, eight items developed by Spinath, Stiensmeier-Pelster, Schöne, and Dickhäuser (2002) were presented alongside Likert-type scales ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) to assess mastery goal orientation ("My main goal in Math is to learn interesting things"). Second, academic self-concept was assessed by using five items developed by Schöne, Dickhäuser, Spinath, and Stiensmeier-Pelster (2002), which were presented with 5-point bipolar answer scales. For example, the item stem "In math, I'm ..." was presented with the two answer anchors "not intelligent" (1) and "very intelligent" (5). The two components of student personal achievement motivation were internally consistent to a sufficient degree (α = .84 – .92).

2.2.5. Students' behavioral and cognitive engagement

Finally, one central aspect of students' behavioral and cognitive engagement in learning activities was assessed, namely quantity and self-regulation of effort. As Fredericks, Blumenfeld, and Paris (2004) pointed out, the concept of effort includes primarily behavioral aspects (quantity of effort and learning processes) as well as primarily cognitive aspects (self-regulation of effort, i.e. adaptation of effort to task requirements, sustained effort in the face of difficulties). We used a scale developed by Ziegler, Dresel, Schober, and Stoeger (2005), which assesses students' effort in this breadth. It comprises of seven items assessing behavioral ("I give a lot of effort prior to Math tests") as well as cognitive ("I make particular efforts when homework problems in Math are difficult", "I carefully do my homework in Math even if I really have no desire for this") aspects of effort. Responses to the items were assessed using Likert-type scales ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). Internal consistency was satisfactory (α = .86).

2.3. Missing data

Due to economic reasons some of the data were assessed using a multi-matrix design (Munger & Loyd, 1988): Mastery goal orientation, students' effort as well as the classroom goal structure were each assessed from one half of the students. Within each classroom two groups of students were selected randomly to which the respective questionnaires were distributed. Findings from Smits and Vorst (2007) suggest that such structurally incomplete designs reveal similar values as complete datasets. Nevertheless, the core constructs of the perceived error climate and the individual reactions to errors were measured for all of the students.[3] Missing values due to the partially incomplete design and due to item nonresponse (less than 3% for all items) were imputed using the expectation-maximization algorithm (see Peugh & Enders, 2004).

3. Results

3.1. Preliminary analyses

Descriptive statistics, bivariate correlations and intraclass correlations with regard to all constructs can be found in Table 1.

3.2. Dimensionality of perceived error climate in the classroom

In order to analyze the dimensionality of perceived error climate in classrooms (Hypothesis 1), confirmatory factor analyses were performed using Mplus 6 (Muthén & Muthén, 2010). We treated all items as ordered categorical variables utilizing Means and Variance Adjusted Weighted Least Squares Estimator (WLSMV).

According to the postulated multidimensionality of perceived error climate, our first hypothesized model included one factor for each of the eight assumed subdimensions of perceived error climate with loadings of the respective items (Model 1). This model fitted acceptably to the data (χ^2 = 2543.5; df = 436; p < .001; CFI = .93; TLI = .92; RMSEA = .07). Standardized item loadings were in the range of λ = .57–.89 with one exception: One item in the subscale "taking the error risk" only had a standardized loading of λ =.34 and was excluded from all subsequent analyses and the final

[2] In order to illustrate this step of item selection, an example for an excluded item is presented here. The item "In our Math class nobody likes to admit their errors" (subdimension "taking the error risk") was formulated in the first step of instrument development because contextual support for conceding own errors is assumed to be closely related with a classroom environment that allows students to take the risk of making a mistake (the conceptual understanding of the error climate subdimension at hand). Applying criterion 1, the item was, however, excluded in the third step of instrument development because it was not precisely focused on the core of the conceptual understanding of the subdimension "taking the error risk".

[3] The two groups of participants did not significantly differ in their perceptions of the error climate in the classroom or their individual handling of errors, as a multivariate analysis of variance with all subscales of these two constructs indicated (Wilks' $\lambda = 0.992$; multivariate $F(10,1105) = 0.906$; p =.52; η^2 = .008).

scales (see Appendix). Without this item, the model was characterized through satisfactory fit indices (Table 2), satisfactory standardized loadings ($\lambda = .63 - .89$) and latent factor correlations in the range of $\phi = .09–.68$ indicating the appropriateness of an error climate conception including eight subdimensions.[4]

We additionally tested the hypothesized Model 1 against two alternative models. One of them was a one-factor model, which reflects a strictly uni-dimensional conceptualization of perceived error climate and in which all items load on one factor (Model 2). The other was a three-factor model (Model 3) with combined teacher, classmate and learning factors. Model estimation and model comparison revealed inacceptable fit indices for Models 2 and 3 and significant advantages for the hypothesized Model 1 (see Table 2).

To test our hypothesis that the eight subdimensions of perceived error climate constitute a superordinate and uniform factor reflecting the overall error climate in the classroom (Hypothesis 1), we specified another hypothesized model (Model 4): Based on Model 1 we modeled one second-order factor with loadings of all eight subfactors and eliminated correlations between subfactors. This model showed acceptable fit to the data, too (see Table 2), although slightly worse than that for Model 1. Standardized superordinate factor loadings were in the range of $\lambda = .38–.82$.[5] Again, model comparison revealed advantages over alternative models. These results indicate that it is justifiable to conceptualize perceived error climate as hierarchically structured, consisting of distinguishable subdimensions that contribute to one superordinate uniform factor of error climate perceptions.

In order to get indications regarding the dimensionality of perceived error climate on the classroom level, two-level exploratory factor analyses with Geomin rotation were performed (Muthén & Asparouhov, 2010). With the aim to determine the number of factors on the classroom-level, we estimated a series of models with eight factors on the within-level (as a result from the confirmatory factor analyses) and varying numbers of between-level factors from 1 to 8 (Table 3). We also estimated a model unrestricted at the classroom-level to obtain a reference for the fit of the previous models. The model with only one classroom-level factor already demonstrated a good fit to the data close to the fit of the unrestricted model. More complex models did not reveal substantial better fit indices and were characterized on the between-level through substantial cross-factor loadings or non-substantial loadings on postulated factors. Thus, for reasons of interpretability and parsimony we decided in favor of the model with eight within-level factors and one between-level factor. Between-level factor loadings were in the range of $\lambda = .51–.99$.[6]

3.3. Classroom differences regarding perceived error climate

As expected with Hypothesis 1, we could find significant and moderate to large differences between classrooms in all eight subdimensions, and the superordinate uniform factor of perceived error climate ($ICC1 = .10–.31$; $p < .001$; see Table 1).[7] Within classrooms, students' perceptions of the dimensions of error climate seem to be rather homogeneous ($ICC2 = .69–.90$). As Lüdtke, Robitzsch, Trautwein, and Kunter (2009) pointed out, the intraclass correlation *ICC*2 can be interpreted as a measure of the reliability of the measurement of a contextual characteristic via several individual perceptions (with values above .70 indicating a good reliability).

3.4. Differentiation and interrelations between perceived error climate in the classroom, perceived classroom goal structures, and individuals' reactions to errors

In the next step we aimed to test our assumption, explicated in Hypothesis 2, that perceived error climate in the classroom is a characteristic that is distinguishable from perceived classroom goal structures and individual reactions to errors. Due to some relatively large correlations (see Table 1), we additionally aimed to rule out concerns regarding the distinguishability of the remaining constructs. Thus, we performed a series of confirmatory factor analyses with all 84 items of the 16 scales or subscales included in the present study. Again, we treated all items as ordered categorical variables (WLSMV estimator) and used Mplus 6 for model estimation.

In the hypothesized model, we specified one factor for each of the 16 constructs with loadings of the respective items. This model demonstrated a sufficient fit to the data ($\chi^2 = 10413.8$; $df = 3365$; $p < .001$; CFI = .91; TLI = .90; RMSEA = .04). Standardized factor loadings were in the range of $\lambda = .55–.90$ (*Mdn* =.73).

With respect to the distinguishability of perceived error climate and perceived goal structures, we specified 24 alternative models. In each of these models, the items of one out of eight error climate subdimensions and one out of three goal structure dimensions loaded on one common factor. Model comparison using the robust difference testing procedure for mean and variance adjusted test statistics presented by Asparouhov and Muthén (2006) indicated that all alternative models had a worse fit to the data than the hypothesized model ($\chi^2 \geqslant 580.1$; $df = 15$; $p < .001$). These results indicated that students' perceptions of the error climate can be distinguished from their perceptions of the classroom goal structure. Students' perceptions of the subdimensions of error climate correlated small to medium in the theoretically expected directions with their perceptions of classroom goal structures (see Table 1). The same was true for the superordinate factor of classroom error climate perceptions which correlated positively with perceptions of a classroom mastery goal structure ($r = .33$) and negatively with perceptions of a classroom performance approach and a performance avoidance goal structure ($r = -0.16$ and $r = -0.22$, respectively). The respective correlations on the classroom level were of similar size (but not statistically significant) for performance approach and performance avoidance goal structure ($r = -0.09$, ns, and $r = -0.17$, ns, respectively) and somewhat larger for mastery goal structure ($r = .57$; $p < .001$). Since correlations are usually larger on higher order levels the overlap between perceived error climate and perceived mastery goal structure does not question the distinguishability of the two concepts at the classroom level.

In order to test the distinguishability of students' perceptions of the error climate and their individual reactions to errors, we analogously estimated 16 alternative models (eight error climate subdimensions x two types of the adaptivity of error reactions). As hypothesized, they fitted significantly worse to the data than the hypothesized model ($\chi^2 \geqslant 517.5$; $df = 15$; $p < .001$). The two types of the adaptivity of individual reactions to errors, affective-motivational adaptivity and action adaptivity, correlated, in small to moderate degrees, with the dimensions of perceived error climate ($r = .05–.45$; see Table 1).

Additionally, seven alternative models were estimated to rule out concerns regarding the question whether students' affective-motivational adaptivity and action adaptivity of reactions to errors can be distinguished from each another and from their academic self-concept, mastery goal orientation and effort. As expected, these models demonstrated significantly worse fits than the hypothesized model ($\chi^2 \geqslant 365.3$; $df = 15$; $p < .001$), despite partially large correlations between the constructs mentioned (see Table 1).

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[4] Complete factor loadings and correlations are available as supplementary material.

[5] Complete factor loadings are available as supplementary material.

[6] Complete between-level and within-level factor loadings are available as supplementary material.

[7] Snijders and Bosker (1999) find *ICC*1 =.05–.20 to be typical variance proportions on higher levels.

Table 1
Descriptive statistics, bivariate correlations and intraclass correlations.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Adaptivity of students' reactions to errors																	
1. Affective-motivational adaptivity (6 items)																	
2. Action adaptivity (7 items)	0.45																
Perceived error climate in the classroom																	
3. Error tolerance by the teacher (4 items)	0.26	0.18															
4. Irrelevance of errors for assessment (4 items)	0.23	0.11	0.37														
5. Teacher support following errors (4 items)	0.33	0.35	0.45	0.30													
6. Absence of negative teacher reactions (4 items)	0.30	0.26	0.50	0.42	0.54												
7. Absence of negative classmate reactions (4 items)	0.22	0.12	0.19	0.30	0.18	0.38											
8. Taking the error risk (3 items)	0.30	0.05	0.23	0.24	0.17	0.30	0.37										
9. Analysis of errors (4 items)	0.27	0.37	0.31	0.25	0.53	0.31	0.12	0.08									
10. Functionality of errors for learning (4 items)	0.30	0.33	0.31	0.17	0.34	0.24	0.09	0.13	0.41								
11. Superordinate uniform factor (8 subscales)	0.45	0.35	0.66	0.58	0.70	0.75	0.56	0.54	0.59	0.54							
Perceived classroom goal structure																	
12. Mastery goal structure (7 items)	0.28	0.47	0.19	0.13	0.30	0.23	0.10	0.05	0.27	0.33	0.32						
13. Performance approach goal structure (6 items)	−0.08	0.15	−0.18	−0.19	−0.03	−0.10	−0.13	−0.20	0.09	−0.05	−0.16	0.23					
14. Performance avoidance goal structure (8 items)	−0.14	0.09	−0.21	−0.24	−0.07	−0.13	−0.17	−0.22	0.02	−0.07	−0.22	0.18	0.82				
Students' achievement motivation																	
15. Mastery goal orientation (7 items)	0.39	0.62	0.13	0.11	0.25	0.17	0.15	0.05	0.31	0.31	0.30	0.54	0.20	0.14			
16. Academic self-concept (5 items)	0.44	0.28	0.10	0.06	0.17	0.11	0.07	0.19	0.14	0.17	0.21	0.17	0.05	0.04	0.35		
Students' behavioral and cognitive engagement																	
17. Quantity and self-regulation of effort (7 items)	0.38	0.63	0.26	0.16	0.31	0.29	0.17	0.10	0.33	0.27	0.38	0.42	0.20	0.16	0.56	0.25	
M	4.16	4.37	4.23	4.75	4.72	4.75	4.09	3.22	4.13	4.15	4.26	3.94	3.25	3.15	3.77	3.39	4.11
SD	0.98	0.92	1.00	0.77	1.03	1.14	1.20	1.25	1.01	1.09	0.65	0.65	0.70	0.77	0.72	0.94	0.85
Skew	−0.30	−0.61	−0.40	−0.77	−0.91	−1.03	−0.39	0.03	−0.26	−0.56	−0.42	−0.82	0.04	−0.06	−0.72	−0.43	−0.27
α	0.83	0.91	0.72	0.70	0.81	0.82	0.86	0.81	0.80	0.80	0.76	0.81	0.75	0.83	0.84	0.92	0.86
*ICC*1	0.06	0.10	0.20	0.12	0.23	0.28	0.17	0.11	0.20	0.10	0.31	0.11	0.15	0.14	0.13	0.03	0.11
*ICC*2	–	–	0.83	0.73	0.86	0.89	0.81	0.71	0.83	0.69	0.90	0.71	0.77	0.76	–	–	–

Notes: N = 1116 students from 56 classrooms. *ICC*1 = Intraclass correlation 1 (proportion of between classroom variance on total variance), significant at $p < 0.05$ for all variables. *ICC*2 = Interclass correlation 2 (indicator of the reliability of the classroom mean ratings).
$|r| \geqslant 0.06$: $p < 0.05$.

Table 2
Results from confirmatory factor analyses of perceived error climate indicators: model fit and model comparison of hypothesized and alternative models.

Model	*df* or Δ*df*	χ^2 or $\Delta\chi^2$	RMSEA	CFI	TLI
Model fit					
Model 1: Eight factors of perceived error climate[†]	406	1205.5[*]	0.04	0.97	0.97
Model 2: One factor of perceived error climate	434	14287.6[*]	0.17	0.50	0.47
Model 3: Three factors of perceived error climate[a]	431	5233.9[*]	0.10	0.83	0.81
Model 4: Eight subfactors and one superordinate uniform factor of perceived error climate[†]	426	2743.8[*]	0.07	0.92	0.91
Model comparison					
Model 1 vs. Model 2	28	4632.9[*]			
Model 1 vs. Model 3	25	1522.2[*]			
Model 4 vs. Model 1	−20	619.8[*]			
Model 4 vs. Model 2	8	4003.7[*]			
Model 4 vs. Model 3	5	650.9[*]			

Note: *N* = 1116 students from 56 classrooms. Hypothesized models are indicated by a dagger. Analyses were performed with Mplus 6 (Muthén and Muthén, 2010). All items were treated as ordered categorical, utilizing the WLSMV estimator. Model comparisons were conducted using the robust difference testing procedure for mean and variance adjusted test statistics presented by Asparouhov and Muthén (2006).
[a] The following subdimensions were combined: (1) Teacher factor: error tolerance by the teacher, irrelevance of errors for assessment, teacher support following errors, and absence of negative teacher reactions to errors. (2) Classmate factor: absence of negative classmate reactions to errors, taking the error risk. (3) Learning factor: analysis of errors, functionality of errors for learning.
[*] $p < 0.05$.

Table 3
Results from two-level exploratory factor analyses of perceived error climate indicators: model fit of models with varying numbers of between-level factors.

Within-level factors	Between-level factors	*df*	χ^2	CFI	RMSEA
8	1	679	872.3[*]	0.98	0.02
8	2	649	801.9[*]	0.98	0.02
8	3	620	750.2[*]	0.98	0.01
8	4	592	720.1[*]	0.98	0.01
8	5	565	701.3[*]	0.98	0.02
8	6	539	677.1[*]	0.98	0.02
8	7	514	651.8[*]	0.98	0.02
8	8	490	628.5[*]	0.98	0.02
8	Unrestricted	245	365.4[*]	0.99	0.02

Note: *N* = 1116 students (within-level) from 56 classrooms (between-level). Analyses were performed with Mplus 6 (Muthén and Muthén, 2010), using Geomin rotation. All items were treated as ordered categorical, utilizing the WLSMV estimator.
[*] $p < 0.05$.

3.5. Predicting learners' individual reactions to errors

To test our hypothesis that perceived error climate in the classroom has an incremental effect on the two types of students' individual reactions to errors (action adaptivity and affective-motivational adaptivity) above and beyond the effects of perceived classroom goal structures and personal achievement motivation (Hypothesis 3), we used two-level modeling (e.g., Snijders & Bosker, 1999). Three intercept-as-outcome models were built on each other (Table 4).[8] Students' perceptions of classroom characteristics were simultaneously inserted on the classroom-level (between-level, grand-mean centered classroom means) and on the student-level (within-level, group-mean centered) in order to disentangle the effects of both, "objective" characteristics as indicated by shared perceptions of all classroom members and – therefore frequently deviating – perceptions of the individual student within classrooms. The models were estimated separately for the affective-motivational adaptivity and the action adaptivity of students' reactions to errors using HLM 6 (Raudenbush, Bryk, & Congdon, 2004) and restricted maximum likelihood estimation.

In the first step (Model 1) we inserted students' personal achievement motivation (academic self-concept and mastery goal orientation, group-mean centered) and perceived classroom goal structures as predictors. Estimation revealed that students' mastery goal orientation positively predicted how adaptive their affective-motivational reactions to errors and, with a larger coefficient, how adaptive their action reactions to errors were (see Table 4). Moreover, academic self-concept positively predicted affective-motivational adaptive reactions to errors and to a small degree also action adaptive reactions to errors. With regard to the effects of classroom characteristics, results indicated that perceived classroom goal structures on both the individual and shared perceptions levels partially predicted individuals' reactions to errors: Perceived mastery goal structure had a positive effect on both of the types of students' reactions to errors on each level. Moreover, perceived performance avoidance goal structure revealed a negative effect on affective-motivational error reactions that was limited to an effect on the level of students' individual perceptions within classrooms.

In the next step the uniform factors of the perceived error climate were added (Model 2). This resulted in substantial increases in the explained criterion variances on both, the within- and the between-levels (see Table 4). Shared as well as individual perceptions of the error climate in the classroom positively predicted adaptive affective-motivational and adaptive action reactions of students on errors above and beyond personal achievement motivation and perceived classroom goal structure (β = .13–.28).

In the third step, we sought to get information regarding the predictivity of the eight perceived error climate subdimensions as opposed to that of the superordinate uniform factor. Therefore, we replaced the uniform factor with the eight subdimensions on the within-level (Model 3). According to the results of two-level exploratory factor analyses reported above, perceived error climate on the classroom-level is best represented in a single dimension in every case – therefore the between-part was not changed. Estimation revealed multiple and differential effects (see Table 4): The adaptivity of students' affective-motivational reactions to errors was predicted by the error tolerance of the teacher, his or her support following student errors, the extent to which the risk of making errors is taken in the classroom and the functionality of errors for learning. The adaptivity of students' cognitive activities and behaviors following errors (action adaptivity) was predicted by teachers' support for errors, the absence of negative teacher reactions to student errors, and analyzing errors collectively in the classroom context. Remarkably, consideration of all eight subdimensions of perceived error climate on the level of individual perceptions did not lead to increases in the explained criterion variances.

[8] Model equations for these and all subsequent two-level models are available as supplementary material.

Table 4
Two-level prediction of the adaptivity of students' individual reactions to errors.

Predictor	Affective-motivational adaptivity			Action adaptivity		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Intercept	0.04 (0.03)	0.04 (0.03)	0.04 (0.03)	0.05 (0.04)	0.05 (0.04)	0.05 (0.04)
Student achievement motivation (within-level)						
Mastery goal orientation	0.22* (0.04)	0.18* (0.04)	0.19* (0.04)	0.47* (0.04)	0.45* (0.04)	0.44* (0.04)
Academic self-concept	0.35* (0.03)	0.32* (0.03)	0.30* (0.03)	0.07* (0.03)	0.05* (0.03)	0.06* (0.03)
Individual perceptions of classroom goal structure (within-level)						
Mastery goal structure	0.13* (0.04)	0.07* (0.04)	0.07 (0.04)	0.21* (0.03)	0.18* (0.03)	0.15* (0.03)
Performance approach goal structure	−0.04 (0.05)	−0.01 (0.05)	0.00 (0.05)	0.02 (0.04)	0.04 (0.04)	0.03 (0.04)
Performance avoidance goal structure	−0.23* (0.05)	−0.17* (0.05)	−0.18* (0.05)	−0.07 (0.05)	−0.03 (0.05)	−0.05 (0.05)
Shared perceptions of classroom goal structure (between-level)						
Mastery goal structure	0.19* (0.03)	0.09* (0.02)	0.09* (0.02)	0.21* (0.04)	0.15* (0.04)	0.15* (0.04)
Performance approach goal structure	0.09 (0.08)	0.04 (0.08)	0.04 (0.08)	0.12 (0.10)	0.08 (0.10)	0.08 (0.10)
Performance avoidance goal structure	−0.05 (0.08)	0.02 (0.08)	0.02 (0.08)	−0.01 (0.10)	0.04 (0.11)	0.04 (0.11)
Individual perceptions of error climate in the classroom (within-level)						
Superordinate uniform factor		0.28* (0.03)			0.17* (0.04)	
Error tolerance by the teacher			0.06* (0.03)			−0.01 (0.02)
Irrelevance of errors for assessment			0.03 (0.03)			−0.03 (0.03)
Teacher support following errors			0.09* (0.04)			0.09* (0.04)
Absence of negative teacher reactions			0.06 (0.04)			0.10* (0.03)
Absence of negative classmate reactions			0.01 (0.04)			0.00 (0.03)
Taking the error risk			0.14* (0.03)			−0.05 (0.03)
Analysis of errors			0.01 (0.03)			0.11* (0.04)
Functionality of errors for learning			0.07* (0.03)			0.04 (0.03)
Shared perceptions of error climate in the classroom (between-level)						
Uniform factor		0.18* (0.03)	0.18* (0.03)		0.13* (0.05)	0.13* (0.05)
R^2_{Between}	0.39	0.70	0.70	0.39	0.46	0.46
R^2_{Within}	0.30	0.34	0.35	0.38	0.42	0.42

Note: N = 1116 students (within-level) from 56 classrooms (between-level). All variables were z-standardized prior to analyses—consequently, the coefficients of fixed effects can be interpreted similarly to standardized regression coefficients. Predictors on the within-level were modeled as fixed effects (i.e. without random slopes) and group-mean centered. Predictors on the between-level were grand-mean centered. Equations are available as Supplementary material. Presented are regression coefficients β and standard errors (in parentheses).
* $p < 0.05$.

3.6. Predicting students' quantity and self-regulation of effort

In our final set of analyses we aimed to test whether perceived error climate predicts students' behavioral and cognitive engagement in academic work (in terms of the quantity and self-regulation of students' effort) beyond perceived classroom goal structures and personal achievement motivation and, if this is the case, whether these effects are mediated through students' individual reactions to errors (Hypothesis 4). We again estimated three two-level models with students' quantity and self-regulation of effort as dependent variable with analogous specifications as in the preceding analyses (see Table 5).

To start with, estimation of Models 1 and 2 (which had identical predictors as the respective models in the preceding analyses) revealed effects of personal achievement motivation and perceived classroom goal structure widely consistent with prior findings (for an overview see Maehr & Zusho, 2009). More central for the present research questions is that adding perceived error climate led to a substantial increase of the proportions of explained variance on both, the within-level and the between-level (see Table 5). Shared as well as perceived error climate positively predicted the quantity and self-regulation of student effort (β = .13–.28), above and beyond perceived classroom goal structures, personal mastery goal orientation and academic self-concept.

In order to test the mediational function of the two types of students' individual reactions to errors, we included them grand-mean centered as predictors – since we expected that adaptive affective-motivational reactions are a prerequisite of adaptive action reactions, we added them separately (Models 3 and 4). Both types of reactions turned out to be positive predictors of the quantity and self-regulation of student effort. Formal two-level mediation testing (Krull & MacKinnon, 2001) revealed that the positive effect of adaptive affective-motivational reactions was fully mediated by adaptive action reactions (z = 3.43; p < .001). Moreover, mediation testing indicated that the adaptivity of both types of students' reactions to errors mediated the effects of shared perceptions of the classroom error climate (z > 2.34; p < .001) and individual error climate perceptions (z > 3.34; p <.001) on student effort. Nevertheless, although regression coefficients of perceived error climate were noticeably smaller for Models 3 and 4 than for Model 2, they were still statistically significant, indicating partial mediation.

4. Discussion

The purpose of the present work was to conceptualize perceived error climate in the classroom and to develop a measuring instrument for its adequate and comprehensive assessment (cf. Oser & Spychiger, 2005; Spychiger et al., 1999; Van Dyck et al., 2005). Furthermore, the incremental effects of perceived error climate on students' learning and their individual dealing with errors should be enlightened.

With respect to the conceptualization of perceived error climate, using confirmatory factor analyses it was demonstrated that student perceptions comprise of several subdimensions that refer to a considerable breadth of contextual and instructional facets associated with the evaluation and use of errors as more or less integral elements of the learning process (Hypothesis 1). Obviously, students clearly differentiate in their perceptions of classroom characteristics. This finding corresponds with the assumed multidimensionality of classroom error climate brought forward

Table 5
Two-level prediction of students' quantity and self-regulation of effort.

Predictor	Model 1	Model 2	Model 3	Model 4
Intercept	0.04 (0.04)	0.05 (0.04)	0.04 (0.03)	0.02 (0.03)
Student achievement motivation (within-level)				
Mastery goal orientation	0.44* (0.03)	0.40* (0.03)	0.38* (0.03)	0.21* (0.03)
Academic self-concept	0.05 (0.03)	0.01 (0.03)	−0.03 (0.03)	−0.02 (0.03)
Individual perceptions of classroom goal structure (within-level)				
Mastery goal structure	0.15* (0.03)	0.09* (0.03)	0.08* (0.03)	0.02 (0.03)
Performance approach goal structure	0.00 (0.05)	0.03 (0.05)	0.03 (0.05)	0.02 (0.05)
Performance avoidance goal structure	0.04 (0.05)	0.11 (0.05)	0.13 (0.05)	0.13 (0.05)
Shared perceptions of classroom goal structure (between-level)				
Mastery goal structure	0.23* (0.03)	0.16* (0.03)	0.15* (0.03)	0.10* (0.03)
Performance approach goal structure	0.21* (0.08)	0.18* (0.08)	0.17* (0.07)	0.15* (0.06)
Performance avoidance goal structure	−0.08 (0.08)	−0.04 (0.08)	−0.04 (0.08)	−0.06 (0.06)
Individual perceptions of error climate in the classroom (within-level)				
Superordinate uniform factor		0.29* (0.04)	0.25* (0.04)	0.21* (0.03)
Shared perceptions of error climate in the classroom (between-level)				
Uniform factor		0.12* (0.04)	0.10* (0.04)	0.06* (0.04)
Adaptivity of students' individual reactions to errors (within-level)				
Affective-motivational adaptivity			0.14* (0.04)	0.05 (0.04)
Action adaptivity				0.40* (0.03)
R^2_{between}	0.56	0.60	0.66	0.79
R^2_{within}	0.30	0.35	0.36	0.45

Note: $N = 1116$ students (within-level) from 56 classrooms (between-level). All variables were *z*-standardized prior to analyses—consequently, the coefficients of fixed effects can be interpreted similarly to standardized regression coefficients. Predictors on the within-level were modeled as fixed effects (i.e. without random slopes) and group-mean centered (with the exception of students' individual reactions to errors, which were grand-mean centered). Predictors on the between-level were grand-mean centered. Equations are available as Supplementary material. Presented are regression coefficients β and standard errors (in parentheses).
* $p < 0.05$.

in prior research (e.g., Spychiger et al., 1998). Although, the conceptualization with the eight subdimensions proposed in the present work differs in somewhat from earlier work, specifically with respect to the number and quality of subdimensions (more comprehensive – and as well: more eclectic – in terms of contextual dimensions in a narrower sense).

As expected – and in contrast to a strict multidimensional view – students' perceptions of the subdimensions in concert constituted one superordinate factor, which represents students' overall perceptions of the error climate in the classroom. The fit of the "eight-plus-one-model" was reasonable (in particular, if the recent discussion regarding cutoff values of acceptable fit indexes for models with large numbers of items and factors is taken into account; cf. Marsh, Hau, & Wen, 2004; Marsh et al., 2009). Although, it was somewhat worse than the fit of the eight factors model. This indicates that conceptualizing a superordinate uniform factor of students' perceptions neglects some of the students' impressions but is overall quite adequate, also in terms of theoretical parsimony (refer to the epistemic principle *lex parsimoniae*, also known as Occam's razor). It is, however, important to note that this claim by no means implies that the level of subdimensions is dispensable. We argue that only by considering the spectrum of relevant error climate subfacets an appropriate conceptualization of the construct and the development of measuring instruments assessing perceived error climate in the classroom with a sufficient content and construct validity is possible. This is also supported by the results of the two-level analyses, which indicate that most of the subdimensions of perceived error climate contribute uniquely to students' individual reactions to errors, but, altogether did not explain substantially more criterion variance than the superordinate uniform factor.

In addition to the dimensionality of perceived error climate on the level of students' individual perceptions we also addressed its dimensionality on the classroom level. Against the background of the methodological notion that the dimensionality of constructs on cluster levels is not necessarily identical with their dimensionality on the individual level, but is instead frequently more simple (Marsh et al., 2012; Muthén, 1989), this addressed an important and, up to now, open issue. Exploratory two-level factor analyses indicated that a model assuming unidimensionality of perceived error climate on the classroom-level is appropriate. Thus, the superordinate uniform factor on the level of individual perceptions of the single student corresponds with a uniform factor of perceived error climate on the level of shared perceptions within classrooms. Again, it is important to recognize that the validity of the uniform classroom-level factor is substantiated by the bundle of subfacets on the student-level.

Regarding the variability of perceived error climate on the classroom-level – which refers to variability in shared perceptions of students and, therefore, to (more) objectified differences between classrooms – we found relatively large differences between perceived error climates of different classrooms (Hypothesis 1). These were of similar size (or apparently even somewhat larger) than those found for other contextual characteristics, in particular perceived classroom goal-structures (cf. Meece et al., 2006). These relatively large classroom differences are a fundamental precondition of the suitability of the error climate concept to describe and explain influences of the learning environment on student motivation and learning (although the size of empirically found variance proportions on the classroom level also could depend on the wording of the respective items; cf. Chan, 1998).

As hypothesized, perceptions of the error climate and perceptions of the classroom goal structure turned out to be interrelated, but clearly distinguishable (Hypothesis 2). This fortifies our theoretical analysis of the unique and overlapping aspects of both concepts. We argue that perceived classroom goal structures as a macroscopical construct refers to goal-related messages in the whole universe of instructional practices and classroom activities (including many practices and activities which are not related to student errors), while perceived error climate in the classroom specifically and in-depth refers to the dealing with errors within the social learning context. Beyond referring to the evaluation of errors and teachers' reactions to them (an aspect relatively close to the concept of perceived classroom goal structures), perceived error climate refers also to the use of errors for improving understanding and subject matter knowledge (an aspect which goes beyond perceived classroom goal structures).

Moreover, our fundamental theoretical assumption that perceived error climate as a characteristic of the learning environment is distinguishable from students' personal reactions to errors (Hypothesis 2), was clearly supported.

Regarding the prediction of learners' individual reactions to errors, it was shown that these are dependent not only on personal achievement motivation, but also to a considerable degree on contextual characteristics. Above and beyond the effects of perceived classroom goal structures (particularly perceived classroom mastery goal structure), perceived error climate predicted individuals' handling with errors (Hypothesis 3). Remarkably, this was true for both, the maintenance of positive affect and motivation (affective-motivational adaptivity of error reactions) as well as the initiation of cognitive processes and behaviors aimed to specifically overcome a possible misconception underlying the present error (action adaptivity of error reactions). Thus, perceived error climate refers – aside from some communality – to aspects of the classroom environment which are not included in the concept of perceived classroom goal structures and are uniquely predictive for students' reactions to errors.

The present findings challenge existing theoretical conceptions aiming to explain adaptive vs. maladaptive motivational and behavioral patterns following errors and failure, especially achievement goal theory (see Elliot & Dweck, 2005 and Maehr & Zusho, 2009, for overviews). Our results demonstrate that the contextual side of existing models should be extended and refined. We provided evidence that focusing on the extent errors are evaluated and used in the social learning environment of the classroom as elements of the learning process may allow for a better understanding of the adaptivity of students' individual reactions to errors. Analyzing the contributions of the subdimensions revealed significant effects, particularly for aspects of the perceived error climate that are explicitly directed towards the use of errors for improving understanding and subject matter knowledge and are, as argued above, uniquely included in the concept. For example, the degree to which students initiate cognitive processes and behaviors aimed to specifically overcome possible misconceptions underlying errors (i.e. the action-adaptivity of student reactions to errors) depended on a collective analysis of errors in the classroom context and teachers' specific support following student errors.

With respect to the effects perceived error climate and learners' individual reactions to errors have on their behavioral and cognitive engagement in academic work (in terms of the quantity and self-regulation of their effort), it was shown that this depends on both of the characteristics. Most crucial is that perceived error climate again functioned as a significant predictor above and beyond perceived classroom goal structures (Hypothesis 4). This finding emphasizes the relevance of perceived error climate as a useful concept to describe contextual influences on student learning and motivation covering unique aspects.

Moreover, the affective-motivational adaptivity and the action adaptivity of students' error reactions both predicted the quantity and self-regulation of their effort – the former fully mediated by the latter. Thus, it seems to be appropriate to consider both components of the students' individual handling of errors, in order to comprehensively describe and understand the effects errors have on subsequent learning (cf. Dresel & Ziegler, 2002; Dresel et al., submitted for publication). The pattern of results is in accordance with the assumptions that adaptive affective-motivational reactions are a prerequisite of adaptive cognitive processes and behaviors specifically adapted to the error at hand, that is, the action adaptivity of error reactions. Nevertheless, additional research on these questions is needed, particularly with respect to the causal order of the two types of error reactions. Here, a more process-oriented perspective on learning would be greatly beneficial.

Regarding the question, whether the adaptivity of individual error reactions mediates the effects of perceived error climate on the quantity and self-regulation of students' effort, the present study yielded mixed results (Hypothesis 4). On the one hand, we found indications that the effects of perceived error climate in the classroom on student effort are mediated, at least partially, through students' reactions to errors. These expected (partial) mediation effects are in line with our theoretical assumption that a positive error climate in the classroom has the proximate consequence of adaptive reactions to errors on the side of the students, which, in turn, have positive effects on subsequent learning. On the other hand, direct effects remained, which are less comprehensible. It may be that these effects are due to correlations with third variables, especially more global aspects of the classroom context. Particularly, one can suspect that characteristics of the teacher may be responsible for the remaining direct effect of shared perceptions of the error climate. One can hypothesize that teachers, who have more comprehensive professional competencies and are better motivated and more engaged, implement a more positive error climate in their classrooms, but also use several other instructional strategies to maintain and foster student engagement. Testing these assumptions is not only an interesting task for future research, but will also be beneficial in uncovering the antecedents of different error climates.

Apart from the aim of conceptualizing perceived error climate in the classroom, a starting point of the present work was the lack of an instrument that clearly distinguishes between contextual characteristics from individuals' reactions to errors. As a result, an instrument is now available that reliably and validly assesses students' perceptions of classroom error climates. Content and construct validity are ensured through considering eight relevant subfacets of the handling of errors in the classroom context. All of the subscales, as well as the superordinate uniform factor, had sufficient reliabilities in terms of internal consistencies as well as acceptable reliabilities for aggregated student perceptions on the classroom level. Confirmatory factor analyses yielded support for the factorial validity of a conception including subdimensions and a superordinate uniform factor and for the discriminant validity with respect to the distinguishability from perceived classroom goal structures and individual reactions to errors. Results regarding the unique effects of perceived error climate on students' reactions to errors and effort pointed to the incremental predictive validity of scores obtained with the newly developed measuring instrument.

Of course, the present study has some limitations. It should be mentioned, that as components of personal achievement motivation, only mastery goal orientation and academic self-concept could be included. Although prior research indicated that these two components are of central importance for the adaptivity of students' reactions to errors, an analysis with other components such as implicit theories about the malleability of own competencies or interest would complement the pattern found in the present study (cf. Dresel et al., submitted for publication). Focusing interactions between aspects of students' personal motivation and classroom error climates (such as a possible buffering effect of adaptive individual motivation against the negative effects of maladaptive error climates) may be especially fruitful in this context (cf. Murayama & Elliot, 2009). It should be, nevertheless, noted that consideration of only two components of personal achievement motivation may have led to an overestimation of the effects of individual perceptions of the classroom error climate, but not to overestimating the effects of shared perceptions of the classroom error climate which refer to (more) objective differences between classrooms. Furthermore, the cross-sectional design of the present study should be kept in mind when interpreting its results. A third limitation of the present and prospect for future research results from our focus on the school subject of mathematics, in which errors are frequently well-defined. Our results do not necessarily apply to other subjects, especially to domains were errors are less clearly defined (such as literature). It seems fruitful to address perceived error climate and students handling with errors simultaneously in different school subjects, not only in order to replicate the present findings, but also to identify domain-specific aspects of the handling with errors in the social learning environment of the classroom.

5. Conclusions

Despite these limitations, the present study allows one to derive conclusions towards a more differentiated understanding of the contextual conditions of an adaptive or maladaptive handling of errors in the classroom. It could be concluded that perceived error climate is a contextual characteristic that varies considerably between classrooms and can be best conceptualized on both, the level of the individual students and the level of the classrooms, as an essentially uniform construct which is substantiated by quite differentiated perceptions of students of a broad range of facets regarding the evaluation and use of errors as integral elements of the learning process. This enables researchers to conceptualize and analyze the effects of the error climate in classrooms in a holistic and, at the same time, parsimonious manner. Perceived classroom climate is a feature of classroom contexts that is interrelated with, but distinguishable from perceived classroom goal structures and personal reactions of students to errors. Justified through unique effects, it could be moreover concluded that considering perceived error climates of classroom contexts has the potential to advance our understanding of the adaptivity of students' reaction patterns following errors and failure.

These conclusions also have practical implications for classroom instruction. The present conceptualization of the perceived classroom error climate has the potential to provide teachers with practical clues on how they can create classroom environments that foster students' motivation and learning beyond the well-known focus on mastery. The error climate subdimensions identified may provide teachers with specific starting points to improve the evaluation and the use of errors as integral elements of the learning process in the social learning environment of their classrooms. Additionally, the newly developed measuring instrument may be useful in evaluating the error climate of individual teachers and/or classrooms and identifying specific climate subdimensions which show the most promise to achieve individual improvements.

Appendix A

Items of the final questionnaire to assess the perceived error climate in mathematics classrooms (item statistics, reliability coefficients, items origins, and original German items in parentheses; $\gamma_{XX'}$ = Spearman-brown split-half reliability coefficient; r_{it} = Item-total correlation regarding the proposed subdimension; negative Items are indicated by an asterisk).

A.1. Error tolerance by the teacher

(M = 4.02–4.67; SD = 1.24–1.45; Skew = −0.92 to −0.28; r_{it} =.39–.57; α = .72; r_{tt} = .73; Item 2 was adapted from Spychiger et al. (1998), the remaining items were newly constructed).

1. In our Math class it is okay with our teacher if the assignments are not done correctly. (Bei uns im Matheunterricht ist es für unseren Lehrer okay, wenn Aufgaben mal nicht richtig gemacht werden.)
2. In our Math class mistakes are <u>nothing</u> bad for our teacher. (Bei uns im Matheunterricht sind Fehler für unseren Lehrer nichts Schlimmes.)
3. In our Math class our teacher doesn't like if something is done incorrectly.* (Bei uns im Matheunterricht mag es der Lehrer nicht, wenn etwas falsch gemacht wird.)
4. In our Math class it is <u>not</u> at all bad for our teacher if someone says something incorrect. (Bei uns im Matheunterricht ist es für unseren Lehrer überhaupt nicht schlimm, wenn etwas Falsches gesagt wird.)

A.2. Irrelevance of errors for assessment

(M = 4.27–5.09; SD = 0.94–1.29; Skew = −1.36 to −0.50; r_{it} = .45–.52; α = .70; r_{tt} = .71; all items were newly constructed).

5. If someone in our Math class makes a mistake, he will get a bad grade.* (Wenn bei uns in Mathe jemand Fehler macht, bekommt er schlechte Bewertungen.)
6. If someone in our Math class says something wrong, it has an immediate effect on his grade.* (Wenn bei uns in Mathe jemand etwas Falsches sagt, geht das sofort in seine Note ein.)
7. If someone in our Math class does something incorrectly, he will get a bad grade.* (Wenn bei uns in Mathe jemand etwas falsch macht, bekommt er eine schlechte Note.)
8. If someone in our Math class does not do his assignment correctly, he will immediately get a bad grade.* (Wenn bei uns in Mathe jemand Aufgaben nicht richtig macht, bekommt er sofort eine schlechte Note.)

A.3. Teacher support following errors

(M = 4.38–4.97; SD = 1.14–1.42; Skew = −1.35 to −0.70; r_{it} = .59–.71; α = .81; r_{tt} = .84; all items were newly constructed; a scale measuring a similar error climate subdimension was presented by Spychiger et al. (1998)).

9. If someone in our Math class can't solve an exercise correctly, the teacher will help him. (Wenn bei uns in Mathe jemand eine Aufgabe nicht richtig löst, hilft ihm der Lehrer.)
10. If someone in our Math class does something wrong, he will get <u>very little</u> support from the teacher.* (Wenn bei uns in Mathe jemand etwas falsch macht, bekommt er <u>wenig</u> Unterstützung vom Lehrer.)
11. If someone in our Math class says something incorrect, the teacher will patiently explain the problem. (Wenn bei uns in Mathe jemand etwas Falsches sagt, erklärt der Lehrer das Problem sehr geduldig.)
12. If someone in our Math class does something wrong, he will get support from the teacher. (Wenn bei uns in Mathe jemand etwas falsch macht, bekommt er vom Lehrer Unterstützung.)

A.4. Absence of negative teacher reactions to errors

(M = 4.04–4.90; SD = 1.43–1.58; Skew = −1.87 to −0.61; r_{it} = .62–.67; α = .82; r_{tt} = .78; Item 13 was adapted from Spychiger et al. (1998), the remaining items were newly constructed).

13. If someone in our Math class does something incorrectly, he might be mocked by the teacher.* (Wenn bei uns in Mathe jemand etwas falsch macht, kann es sein, dass er vom Lehrer verspottet wird.)
14. If someone in our Math class makes mistakes, the teacher often looks annoyed.* (Wenn bei uns in Mathe jemand Fehler macht, schaut der Lehrer oft genervt.)
15. If someone in our Math class says something wrong, sometimes the teacher will embarrass him in front of the entire class.* (Wenn bei uns in Mathe jemand etwas Falsches sagt, kann es sein, dass ihn der Lehrer vor der Klasse blamiert.)
16. If someone in our Math class solves an assignment incorrectly, once in a while the teacher will become angry.* (Wenn bei uns in Mathe jemand eine Aufgabe nicht richtig löst, wird der Lehrer ab und zu wütend.)

A.5. Absence of negative classmate reactions to errors

($M = 3.69–4.53$; $SD = 1.31–1.47$; Skew = −0.72 to −0.06; $r_{it} = .64–.74$; $\alpha = .86$; $r_{tt} = .85$; Item 17 was adapted from Spychiger et al. (1998), the remaining items were newly constructed).

17. If someone in our Math class does something wrong, he will sometimes be ridiculed by his classmates.* (Wenn bei uns in Mathe jemand etwas falsch macht, wird er manchmal von Mitschülern ausgelacht.)
18. If someone in our Math class says something incorrect, he will later have to put up with teasing from his classmates.* (Wenn bei uns in Mathe jemand etwas Falsches sagt, muss er sich später blöde Sprüche von Mitschülern anhören.)
19. If someone in our Math class makes mistakes, his classmates will sometimes make fun of him.* (Wenn bei uns in Mathe jemand Fehler macht, machen sich die Mitschüler manchmal darüber lustig.)
20. If someone in our Math class solves an assignment incorrectly, his classmates will mock him.* (Wenn bei uns in Mathe jemand eine Aufgabe nicht richtig löst, verspotten ihn die Mitschüler.)

A.6. Taking the error risk

($M = 3.10–3.30$; $SD = 1.43–1.50$; Skew = 0.06–0.21; $r_{it} = .53–.73$; $\alpha = .81$; $r_{tt} = .84$; all items were newly constructed; a scale measuring a similar error climate subdimension in organizational contexts was presented by Rybowiak et al. (1999)).

21. In our Math class a lot of students would rather say nothing at all than something that is wrong.* (Bei uns in Mathe sagen viele Schüler lieber gar nichts als etwas Falsches.)
22. In our Math class a lot of students hope they will not be called on, because they are afraid they will say something wrong.* (Bei uns in Mathe hoffen viele Schüler, dass sie nicht aufgerufen werden, weil sie Angst haben, etwas Falsches zu sagen.)
23. In our Math class a lot of students don't dare to say anything because they are afraid it is wrong.* (Bei uns in Mathe trauen sich viele Schüler nicht, etwas zu sagen, weil sie befürchten, es ist falsch.)

A.7. Analysis of errors

($M = 3.85–4.42$; $SD = 1.24–1.31$; Skew = −0.68 to −0.31; $r_{it} = .59–.63$; $\alpha = .80$; $r_{tt} = .85$; all items were newly constructed; scales measuring a similar error climate subdimension in organizational contexts were presented by Rybowiak et al. (1999), Tjosvold et al. (2004), and Van Dyck et al. (2005)).

24. In our Math class we discuss it in detail when something is done incorrectly. (Bei uns in Mathe sprechen wir ausführlich darüber, wenn etwas falsch gemacht wird.)
25. In our Math class we think about it in detail when someone says something wrong. (Bei uns in Mathe denken wir genau darüber nach, wenn etwas Falsches gesagt wird.)
26. In our Math class mistakes are investigated in detail. (Bei uns in Mathe werden Fehler genau untersucht.)
27. In our Math class assignments that are done incorrectly are discussed in detail. (Bei uns in Mathe werden Aufgaben, die nicht richtig gemacht werden, genau besprochen.)

A.8. Functionality of errors for learning

($M = 4.07–4.27$; $SD = 1.32–1.46$; Skew = −0.64 to −0.57; $r_{it} = .57–.65$; $\alpha = .80$; $r_{tt} = .82$; all items were newly constructed; scales measuring a similar error climate subdimension in educational and organizational contexts were presented by Rybowiak et al. (1999), Spychiger et al. (1998), and Van Dyck et al. (2005)).

28. In our Math class the mistakes students make are often used to make sure you really understand Math. (Bei uns in Mathe dienen Fehler von Schülern oft dazu, dass man Mathe wirklich versteht.)
29. In our Math class we learn a lot from assignments that were not done correctly. (Bei uns in Mathe lernen wir viel aus Aufgaben, die nicht richtig gemacht wurden.)
30. In our Math class wrong answers on assignments are used to learn something. (Bei uns in Mathe werden falsche Aufgabenlösungen genutzt, um daraus etwas zu lernen.)
31. In our Math class wrong answers are often a good opportunity to really understand the material. (Bei uns in Mathe sind falsche Antworten häufig eine gute Gelegenheit, um den Stoff wirklich zu verstehen.)

A.9. Scoring information

First, all negative items are recoded (transformation $x' = 7 - x$). Student level: Eight subdimension scores are calculated for each student by averaging students' responses on the corresponding three or four items. One superordinate uniform score for each student is calculated by averaging the eight subdimension scores. The nine scores for each student are group-mean centered by subtracting them from their corresponding classroom mean. Classroom level: One uniform score for each classroom is calculated by averaging the classroom means of all 31 items.

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