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Constructive handling of mistakes in the classroom: The conjoint power of collaborative networks and self-efficacy beliefs

Lysann Zander · Madeleine Kreutzmann · Ilka Wolter

Abstract Constructive handling of mistakes enhances successful learning and involves an affective and a cognitive dimension: (a) low *fear of making mistakes* (FOM) and (b) high *positive learning orientation towards mistakes* (PLOM). We examine the role of collaborative peer networks for both dimensions of students' constructive handling of mistakes by analyzing their overall *structure* (density) and students' *embeddedness into the structure* (number of reciprocal relations). We found different patterns for the affective and cognitive dimension: Students reported lower FOM in classrooms with denser collaborative peer networks and when they were more embedded in the structure, but only to the extent that they also showed high levels of general self-efficacy. Students' PLOM was higher when they had more reciprocal collaborative relations to classmates and higher general self-efficacy. Denser collaborative networks did not predict students' PLOM. Results are discussed against the background of social cognitive theory and recent accounts of co- and self-regulated learning.

Keywords Mistakes · Errors · Social networks · Peers · Self-efficacy · Collaboration

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Dr. L. Zander (✉) · Dipl. Psych. M. Kreutzmann · Dr. I. Wolter
Department of Education and Psychology, Division of School and Teaching Research,
Freie Universität Berlin,
Habelschwerdter Allee 45,
14195 Berlin, Germany
e-mail: lysann.zander@fu-berlin.de

Dipl. Psych. M. Kreutzmann
e-mail: madeleine.kreutzmann@fu-berlin.de

Dr. I. Wolter
e-mail: ilka.wolter@fu-berlin.de

Konstruktiver Umgang mit Fehlern im Klassenzimmer: Was kollaborative Arbeitsnetzwerke und Selbstwirksamkeitsüberzeugungen bewirken

Zusammenfassung Konstruktiver Umgang mit Fehlern fördert erfolgreiche Lernprozesse und umfasst eine affektive und eine kognitive Dimension: a) geringe Fehlerangst (FA) und b) positive Orientierung, aus Fehlern zu lernen (FLO). Wir untersuchen die Rolle kollaborativer Peer-Netzwerke durch Analyse ihrer *Gesamtstruktur* (Dichte) und der *individuellen Einbindung von Schüler/innen in diese Struktur* (Anzahl wechselseitiger Beziehungen). Wir fanden differenzielle Muster für die affektive und kognitive Dimension: Schüler/innen berichteten geringere FA in Klassen mit dichteren Kollaborationsnetzwerken und wenn sie gut in diese Netzwerke eingebunden waren, jedoch nur bei hoher allgemeiner Selbstwirksamkeit. Schüler/innen zeigten höhere FLO, wenn sie stark in wechselseitige kollaborative Beziehungen eingebunden waren und wenn sie eine hohe allgemeine Selbstwirksamkeit hatten. Netzwerkdichte war kein Prädiktor höherer FLO. Die Ergebnisse werden vor dem Hintergrund der sozial-kognitiven Theorie und aktueller Ansätze ko- und selbst-regulierten Lernens diskutiert.

Schlüsselwörter Fehler · soziale Netzwerke · Peers · Selbstwirksamkeit · Zusammenarbeit

It is common knowledge that one learns from one's mistakes or errors. At the same time, making mistakes can be a distressing experience, and instill a fear of making errors that is in turn detrimental to learning (Spychiger et al. 2006). Therefore, students' constructive dealing with mistakes in academic settings is of growing interest to educational researchers. In a recent study, we examined students' constructive handling of mistakes in relation to academic self-efficacy, effort investment, and joy of learning (Kreutzmann et al. 2014). In the present study, we reanalyze that dataset to determine the extent to which students' constructive dealing with mistakes depends on the social learning context in general, and, more specifically, on the collaborative relationships among peers.

Particularly in adolescence, peers influence each other's approaches to learning and school (Wentzel et al. 2012). By exchanging school-related advice and collaborating on assignments within their social networks, for example, peers can create a social context that facilitates the constructive handling of mistakes. Conversely, not having collaborative relations to classmates can fortify negative emotions and cognitions associated with making mistakes in academic situations.

In the present study, we take a closer look at the contextual dependency of two dimensions of students' handling of mistakes: the affective dimension (i.e., *fear of making mistakes, FOM*) and the cognitive dimension (i.e., *positive learning orientation towards mistakes, PLOM*).

The first dimension, *fear of making mistakes*, is most likely catalyzed in social situations, when one fears negative evaluations by others. We therefore propose that students' fear of making mistakes is the genuinely social aspect of handling mistakes.

If fear of mistakes originates in social situations, and is caused by others, it is well plausible that relationships to and among these others can shape students' fear of making mistakes. Thus, we posit that a dense overall collaboration network in the classroom as well as students' embeddedness into this network, i.e., having mutually supportive relations to classmates, could very likely correspond with having lower levels of fear in regard to making mistakes.

Self-efficacy beliefs, defined as the conviction to cause desired results by determined action and perseverance when confronted with difficulties, are among the most central mechanisms of human agency (Bandura 2006). Applied to the present study, a student with strong self-efficacy beliefs could actively utilize existing peer structures in order to regulate and lower her/his fear of making mistakes. We therefore examined self-efficacy as a moderator of the association between collaborative peer relations and students' fear of making mistakes in class.

The second dimension, students' *positive learning orientation towards mistakes*, has been described as an aspect of self-regulated learning (Steuer et al. 2013) and should be predicted by high self-efficacy. PLOM, however, can also be enhanced in interaction with one's social learning environment. For example, mutual collaborative relations can serve the primary purpose to provide help and clarify difficult learning matter or mistakes, eventually through an easier access to learning relevant information (Wentzel et al. 2012). Collaborative relations in peer networks may thus provide an important platform for the constructive discussion of mistakes in the learning process. Given this, determining the degree of contextual dependency of students' positive learning orientation towards mistakes remains a question that must be empirically investigated.

1 Two aspects of handling mistakes: fear of making mistakes and positive learning orientation towards mistakes

Errors can be defined as "all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency" (Reason 1990, p. 9). This understanding presupposes a normative aspect of errors (Senders and Moray 1991), insofar as an error can only be detected if a deviation from a norm is discovered (Harteis et al. 2008). Given there can be situation- or group-specific norms regarding the acceptability and the handling of mistakes, these incorporate, additionally to a criterial norm, a social norm (e.g., Dickhäuser and Rheinberg 2003) which suggests the importance of considering a persons' handling of mistakes as contingent upon his/her social learning environment (Zander in press).

As mentioned, making mistakes can be an aversive affective experience. Spychiger et al. (2006) suggest that students' can develop and become inhibited by the fear of making mistakes in learning or performance situations, insofar as they presume that it might negatively reflect on their competence and abilities. This affective dimension of handling mistakes is fundamentally "social" in nature, as it implicitly involves an anticipated negative evaluation by others.

A positive learning orientation towards mistakes (Spychiger et al. 2006) can be understood as the cognitive dimension of students' constructive handling of mistakes.

Reflecting on the causes of mistakes, and considering possible solutions are learning processes that can help preventing mistakes in the future.

PLOM and FOM were shown to be empirically uncorrelated (Kreutzmann et al. 2014; Spychiger et al. 2006). Students who are convinced that mistakes constitute important learning opportunities, for example, might not fear making mistakes. Others, with the same conviction, might have such a fear. Both dimensions of handling mistakes, however, are strongly associated with achievement-related variables (Kreutzmann et al. 2014).

2 Handling mistakes—a matter of context?

Research on how features of the social environment attenuate fear of making mistakes, or shape students' view of mistakes as valuable learning opportunities is still scarce. Tulis (2013) as well as Kreutzmann et al. (2014) found that students reported more positive learning orientations towards mistakes the more their teachers responded openly and patiently to students' mistakes. Steuer et al. (2013) found that the aggregated perceptions of all classmates regarding the collective use of errors for learning predicted individual student's affective and cognitive reactions to mistakes. Overall, these studies confirm the importance of a contextual view of students' constructive handling of mistakes. The impact of students' peer relations, particularly collaborative relations, however, is largely unknown. We aimed to contribute to the understanding of contextual effects by systematically investigating how students' dealing with mistakes in class is associated with the existence of collaborative relationships between classmates. Furthermore, we aimed to apply an operationalization of contextual characteristics via social network procedures that does not exclusively focus on student's subjective perception of collaboration via questionnaires, but instead maps actual reciprocity of existing ties between students in the classroom.

In the present study we investigated two levels of students' peer context namely (a) the overall structure of peer relations in the classroom (network density, i.e., *intermediate context*) and (b) individual students' embeddedness into these relations (number of reciprocal collaborative relations, i.e., *immediate context*). Social network analysis allows for the modeling of peer relations on these distinctive yet interrelated levels.

We assessed the overall structure of collaborative relations by determining the density of nominations of all students in one classroom (Hanneman and Riddle 2011), because in our view, this represents an important aspect of the classroom's culture of learning and exchange. Classrooms, in which relatively many students indicate several potential collaboration partners should be characterized by an atmosphere of higher confidence in classmates as collaborators (than in classrooms with sparse collaboration networks), which likely feeds back into students' attitudes towards making mistakes and handling of mistakes once they occur.

We also assessed students' embeddedness into the overall structure as the number of reciprocal relations to those classmates who were directly linked to a student (*centrality degree*, Hanneman and Riddle 2011): Being embedded into reciprocal, reliable collaborative relations should also affect the way students handle mistakes in learning situations.

3 Contextual dependency of affective and cognitive handling of mistakes and the role of self-efficacy beliefs

Emotions are oftentimes rooted in and directed to social contexts (Parkinson 2011). Even though students can keep their fear of making mistakes to themselves, fear, as we have defined it in the present research, inevitably has a strong social aspect. Even when the emotions remain private, they concern making mistakes in a social situation, that is, in the presence of peers and/or teachers as potential evaluators. Hence, collaborative peer relations could play an important role in regulating students' fear of making mistakes. Necessary condition, however, is that the student actively approaches and utilizes these peers as a source of information (e.g., Firestone et al. 1973; Schachter 1959), or as a means to regulate negative emotions that pertain to making mistakes in learning and performance situations. This argument corresponds to one of the central tenets of social cognitive theory (Bandura 2012): the changeability of environmental impact by means of individual agency. We thus argue that there is not a straight forward effect of peer relations on students' affective approaches to mistakes. Rather, students' agentic self-efficacy beliefs, their "can-do cognitions" (Kraft et al. 2005), should moderate the beneficial impact of having positive peer relations in a learning context on students' fear of making mistakes. In other words, we posit that it is neither the dense structure of collaborative relationships in the classroom nor students' embeddedness into collaborative relationships per se that predict lower fear of making mistakes; rather these beneficial features of the learning context will have to coincide with the students' belief that he or she can act in such a way as to overcome difficulties and utilize these contextual affordances.

The cognitive dimension, students' positive orientation towards learning from mistakes, involves a proactive and agentic way of dealing with past and forthcoming mistakes. Students' self-efficacy beliefs have been theorized and shown to be of vital importance in the self-regulatory learning process (Zimmerman and Cleary 2006). Thus, students' orientation to learn from mistakes should be strongly and directly predicted by students' self-efficacy beliefs.

Only recently have researchers acknowledged collaborative peer relations' potential impact on students' individual learning motivation (e.g., Järvelä et al. 2010). We consider it plausible that the experience of constructively exchanging feedback, including the discussion and clarification of mistakes, can increase students' motivation to learn from mistakes. Learning from mistakes can, however, also take place without interacting with peers: students can be genuinely interested in learning from their mistakes without needing to draw on existing peer relations. We therefore explored whether the overall *structure* of collaborative peer relations and *embeddedness* in reciprocal collaborative relationships with peers predicted students' positive orientation towards learning from mistakes.

4 Current investigation and hypotheses

Students' fear of making mistakes should decrease with the density of collaborative networks in their classroom, and the number of reciprocal collaborative relations to

specific classmates. These associations should be moderated by student's self-efficacy: self-efficacy beliefs increase the effective use of existing peer resources for emotional self-regulation.

Also, self-efficacy should directly and positively predict learning orientation towards mistakes. As we had no directional hypothesis how positive learning orientation towards mistakes and peer relations should be linked, we independently analyzed its relation with density of collaborative peer relations and students' embeddedness into reciprocal peer relations.

5 Method

5.1 Statistical analysis

5.1.1 Hierarchical data structure

Students were nested into classrooms, so we applied multilevel methods to account for the hierarchical structure of the data (students = level 1, L1; classrooms = level 2, L2). Furthermore, multilevel regression analyses allow for the simultaneous modeling of individual (i.e., self-efficacy beliefs) and contextual (i.e., *structure* of collaborative network in the classroom) variables, as well as the modeling of cross-level interactions.

5.1.2 Analysis plan

We applied a random slope and intercept model using the statistical software MPLUS Version 5.1 (Muthén and Muthén 1998–2008). Missing data (9–22 %) were estimated using the full-information-maximum-likelihood-approach incorporated in MPLUS.

Separate multilevel regression models were conducted to test the associations between overall network structure (i.e., density of the collaborative network) as well as students' embeddedness into the collaborative network and both students' fear of making mistakes (FOM) and students' positive learning orientation towards mistakes (PLOM). According to our hypotheses, we thereby tested the role of self-efficacy beliefs as a moderator of the effect of collaborative network structure (L2) and embeddedness into the collaborative network (L1) on student's FOM. Additionally, we tested the direct effect of self-efficacy beliefs on students' PLOM. In subsequent models we controlled for students' academic achievement and gender. Variables on the individual level (except gender) and on the classroom level were centered at their grand means. Given the absence of longitudinal data, it is recommended to quantify how much bias (e.g., potential confounds, bias in the sampling process) must be present to invalidate the inference made based on the data: the relative robustness of an inference can be unequivocally quantified in terms of the difference between an estimate and a threshold, relative to the size of the estimate (Frank et al. 2013). An estimate showing which of the reported inferences is most robust with respect to bias was calculated. The estimate is expressed as a percentage value and indicates the percentage of the estimated effect that must be due to bias to invalidate the inference

that one factor affects another. The calculation takes into account sample size, *t*-ratio, and the number of predictors in the model (Frank et al. 2013) and will be reported for our focal predictors following our regression analyses.

5.2 Participants

The sample contains 448 students ($n = 239$ girls, 53.3%) from 21 primary school classrooms of 11 schools in Berlin, including 177 (39.5%) fifth graders and 271 (60.5%) sixth graders. The average age of the sample was 11 years ($M = 10.81$, $SD = 0.81$, range 9–13). Students were categorized as "having migration background" if they themselves, one, or both of their parents were born outside of Germany. 190 students (42.4%) reported having a migration background (11.6% missing).

5.3 Procedure

Data collection took place at the beginning of the school year, in the fall of 2009, during regular class hours in students' classrooms. Students were asked to fill in a questionnaire that was administered by trained research assistants. Teachers provided information about students' academic achievement (grades in mathematics and German).

Students and teachers were informed that the study aims to gain insight into students' current thoughts about school and other topics (e.g., leisure activities). Consent for the students' participation was given by each school's principal, school committee and parent-teacher association, the participants, and at least one parent of each participant.

6 Measures

6.1 Constructive handling of mistakes

We applied two subscales of a student questionnaire on classroom attitudes towards making mistakes developed by Spychiger and colleagues (2006) to measure students' FOM and PLOM on five-point Likert scales. As demonstrated in prior research (Kreutzmann et al. 2014; Spychiger et al. 2006), FOM and PLOM were uncorrelated.

6.1.1 Fear of making mistakes (FOM)

Three items measuring students' fear of making mistakes[1] in the classroom were used (e.g., "Before school I am sometimes afraid that I will make mistakes in class."; $\alpha = .70$). Higher means indicated higher FOM in the academic setting.

[1] For theoretical reasons, and in the interest of construct clarity we did not include two items of the original scale by Spychiger and colleagues (2006) focusing on experiences of guilt and shame in mistake situations.

6.1.2 Positive learning orientation towards mistakes (PLOM)

Students were further asked to rate their handling of mistakes in school, particularly their beliefs, that mistakes represent significant opportunities for learning (e.g. "When I am unskillful in class or do something wrong I see this as an opportunity to learn."; $\alpha = .79$). The mean of the responses to eight items was used, with higher values indicating a PLOM.

6.2 General self-efficacy beliefs

To assess students' general self-efficacy beliefs we used the scale developed by Jerusalem and Schwarzer (2001). Ten items captured the relative level of students beliefs about their own ability to perform well, even in the face of tasks that are new to them, or involve challenges or obstacles (e.g. "I am confident that I could deal efficiently with unexpected events."; $\alpha = .77$) on a four-point Likert scale. Again, higher means indicated stronger self-efficacy beliefs.

6.3 Collaborative networks

To gather information about students' collaborative networks in the classroom, we provided students with a roster of cover names for each of their classmates. We asked them to indicate those students with whom they like to collaborate on school specific tasks. Children were not limited in the number of classmates they could choose. This procedure resembles a binary measurement approach presenting all possible nominees and therefore limiting measurement error (Marsden 2011). We used the social network software UCINET 6 (Borgatti et al. 2002) to display and process the gathered data.

In the present research, we utilized two types of sociometric measures: network density as a structural feature of the (intermediate) social context; and degree centrality, i.e., reciprocal ties to specific classmates, as an indicator of embeddedness into the (immediate) social context.

6.3.1 Network density (intermediate context)

Network density characterizes a social network at the classroom level (level 2, L2). It is defined as the proportion of actual relations represented from all theoretically possible relations in a network (here: classroom; Wasserman and Faust 2007). With a range from 0 to 1, low values in density-scores indicate a low number of relations among students compared to all possible relations in a classroom. To determine network density, we used all in- and outgoing nominations of students, irrespective of the reciprocity of the nominations, which are represented in maximum symmetrized network matrixes for each classroom.

6.3.2 Degree centrality (immediate context)

This measure describes the embeddedness of a student into the collaborative (classroom) network, and is therefore displayed at the individual level (level 1, L1). Degree

centrality is defined as the share of actually present relations of one student to other students in the classroom, relatively to all theoretically possible relations of this student (Hanneman and Riddle 2011). Low values in degree centrality indicate an individual's relatively low embeddedness into the immediate social context (potential range: 0–1). Given that we were interested in determining whether a student had access to collaboration partners who were also interested in working with her/him, we calculated degree centrality based on minimum symmetrized matrices where a tie between two classmates is coded as existing only when *both* students nominate each other (Hanneman and Riddle 2011). Degree centrality is often positively skewed because it is based on a count that has a lower bound of zero and an upper bound based on the number of nodes in the network. Given the present study showed a range of 0.00 to 0.58 with a mean of only 0.15 ($SD = 0.11$), centrality degree values were square-root transformed. This procedure is commonly applied for count data (Judd et al. 2009) and specifically for centrality measures (Borgatti et al. 2013).

6.4 Demographic information and academic achievement

Students' reports about their demographic information were collected at the end of the questionnaire. Information about students' academic achievement was provided by the class teachers, and based upon school report cards in the subjects of mathematics and German from the previous academic year. Due to the strong correlation between school grades in mathematics and German ($r = .67$), and in order to obtain a joint value, we computed the mean of both school grades. We re-coded the values for better interpretability, so that higher numbers indicated better academic achievement (1 = "failed", 6 = "excellent").

7 Results

7.1 Preliminary analyses

Means and standard deviations for individual and classroom characteristics are shown in Table 1. Controlling for the hierarchical data structure, bivariate correlations yielded a weakly negative relationship between students' fear of making mistakes (FOM) and their embeddedness in collaborative networks in the classroom (i.e., degree centrality) and a moderately negative correlation between students' FOM and school grades (see Table 2). FOM was unrelated to students' general self-efficacy. Students' positive learning orientation towards mistakes (PLOM) was moderately and positively correlated with degree centrality and school grades. Also, PLOM was strongly and positively correlated with students' general self-efficacy beliefs. Students' self-efficacy beliefs and their embeddedness in reciprocal collaborative relations were marginally significant and positively related.

Table 1 Descriptive statistics of individual (L1) and classroom (L2) characteristics

				Range		
	N	*M*	*SD*	Potential	Actual	ICC
FOM	350	2.21	1.01	1–5	1.00–5.00	.02
PLOM	351	3.43	0.76	1–5	1.25–5.00	.05
General self-efficacy beliefs	406	2.94	0.44	1–4	1.40–4.00	.05
Degree centrality[a]	398	0.36	0.16	0–1	0.00–0.76	.20
School grades[b]	394	4.20	0.87	1–6	1.50–6.00	.12
Network density (L2)	21	0.26	0.07	0–1	0.15–0.39	–

FOM Fear of making mistakes, *PLOM* Positive learning orientation towards mistakes

[a]Values were transformed by taking the square root of each value (Borgatti et al. 2013)

[b]School grades (mean of grades in mathematics and German) were recoded, thus higher values indicate better academic achievement

Table 2 Correlations between constructive handling of mistakes, general self-efficacy beliefs, embeddedness into collaborative networks, and control variables, taking into account the hierarchical data structure

		1	2	3	4	5	6
1.	FOM	–					
2.	PLOM	−.01	–				
3.	General self-efficacy beliefs	−.06	.47***	–			
4.	Degree centrality[a]	−.11*	.17**	.08†	–		
5.	School grades[b]	−.32**	.15*	.13*	.26***	–	
6.	Gender[c]	.04	.07	−.00	−.01	.06†	–

FOM Fear of making mistakes, *PLOM* Positive learning orientation towards mistakes

[a]Values were transformed by taking the square root of each value (Borgatti et al. 2013)

[b]School grades (mean of grades in mathematics and German) were recoded, thus higher values indicate better academic achievement

[c]Girls: 0.5, Boys: −0.5

*$p<.05$; **$p<.01$; ***$p<.001$; †$p<.10$

7.2 Multilevel regression analyses

Values for the intra-class correlation (ICC; see Table 1) were .02 for students' fear of making mistakes and .05 for students' positive learning orientation, indicating there was only little variance in the dependent measures across classrooms. However, given even very low intra-class correlations can bias regression estimates (Cohen et al. 2003; Nezlek 2008), the multilevel approach seemed appropriate for the present research questions and an accurate estimation of the effects.

In what follows, the results for *students' fear of making mistakes* – the affective aspect in students' handling of mistakes – will be presented. As hypothesized, a significant Self-efficacy beliefs (L1) X Network density (L2) crosslevel interaction emerged (see Model 1a in Table 3), demonstrating that the effect of collaborative network density was moderated by students' self-efficacy beliefs (see Fig. 1). Simple effects tests probing of the interaction (Aiken and West 1991) showed that students reported significantly less FOM the higher the collaborative network density in their classroom was, when they possessed high self-efficacy beliefs ($B=-2.53$, $SE=0.83$, $t=-3.06$, $p=.002$). In contrast, students with low self-efficacy beliefs showed sig-

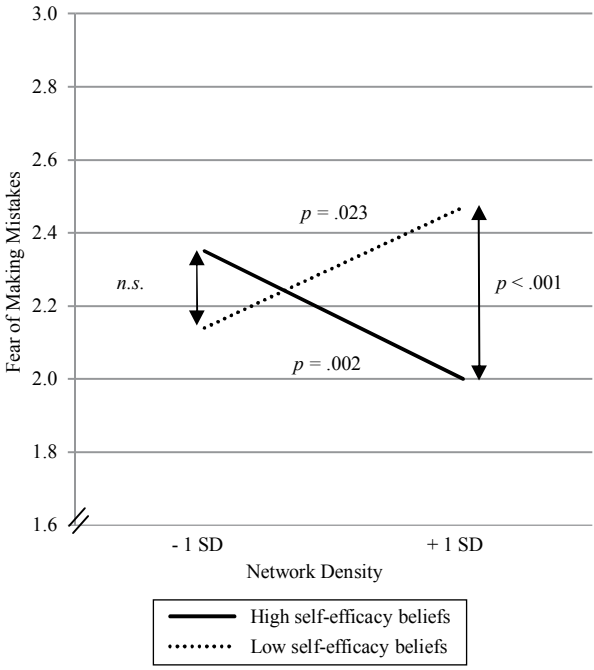

Fig. 1 Cross-level interaction of General self-efficacy beliefs X Network density predicting fear of making mistakes

nificantly more fear of making mistakes the denser the collaborative network in their classroom was ($B=2.38$, $SE=1.05$, $t=2.27$, $p=.023$). Further, results of simple difference tests indicated that in classrooms with a high density of collaborative networks, students with higher self-efficacy beliefs reported significantly less FOM than students with lower self-efficacy beliefs ($B=-0.51$, $SE=0.11$, $t=-4.57$, $p<.001$). In contrast, in classrooms with low network density, students' fear of making mistakes did not differ by their level of self-efficacy beliefs ($B=0.20$, $SE=0.12$, $t=1.64$, $p=0.100$). As suggested by Aiken and West (1991) simple effects test and simple difference tests were conducted at one standard deviation below and above the mean of the variable of interest (see Fig. 1). After controlling for students achievement level and gender, the ascertained cross-level interaction remained stable (see Model 1b in Table 3).

Using the calculations recommended by Frank et al. (2013) it is possible to further quantify how much bias there must be in our reported estimates to invalidate the inferences made based on the present data. Considering the degrees of freedom $df=448-5$ (which adjusts for the number of variables in the model) and a t-ratio of 4.52 of our analysis, as reported in Model 1b (see Table 3) we found that 56% of the estimated cross-level interaction effect between general self-efficacy beliefs and network density would have to be due to bias to invalidate the inference that the impact of the classroom's network density on students' fear of making mistakes depends on their level of self-efficacy (using statistical significance as a threshold for inference). This additional analysis suggests that the effect found for our interaction is very robust in comparison with other effects reviewed by Frank et al. (2013).

Table 3 Results of multilevel regression analyses predicting students' fear of making mistakes

	Model 1a				Model 1b			
	B	*SE*	*t*	*p*	*B*	*SE*	*t*	*p*
Intercept	2.24	0.06	36.11	.000	2.24	0.05	48.27	.000
General self-efficacy beliefs	−0.15	0.10	−1.52	.128	−0.06	0.11	−0.55	.584
School grades[a]					−0.38	0.06	−6.38	.000
Gender[b]					0.14	0.09	1.66	.098
Network density (L2)	−0.07	0.84	−0.08	.936	0.31	0.71	0.44	.662
General self-efficacy beliefs X Network density (L2)	−5.56	0.97	−5.74	.000	−5.30	1.17	−4.52	.000
	Model 2a				Model 2b			
Intercept	2.23	0.07	33.63	.000	2.22	0.05	42.93	.000
General self-efficacy beliefs	−0.10	0.13	−0.82	.412	−0.01	0.13	−0.11	.913
Degree centrality[c]	−0.56	0.30	−1.87	.062	−0.06	0.28	−0.20	.844
General self-efficacy beliefs X Degree centrality[c]	−1.77	0.67	−2.65	.008	−1.99	0.61	−3.27	.001
School grades[a]					−0.37	0.07	−5.24	.000
Gender[b]					0.11	0.09	1.22	.222

L1- (except gender) and L2-predictors were centered at their grand means

[a]School grades (mean of grades in mathematics and German) were recoded, thus higher values indicate better academic achievement

[b]Girls: 0.5, Boys: −0.5

[c]Values were transformed by taking the square root of each value (Borgatti et al. 2013)

In addition to the importance of the network density in the classroom (i.e., intermediate context, L2) for students' FOM, also students' reciprocal collaborative ties (i.e., immediate context, L1) made a difference in this affective dimension in handling of mistakes, again, dependent on students' self-efficacy beliefs. As expected, our analyses confirmed that students' embeddedness in reciprocal collaborative relations to specific classmates (degree centrality, L1) was associated with their FOM, and again this correlation was moderated by students' self-efficacy beliefs (see Model 2a in Table 3). Post-hoc probing of the interaction effect between self-efficacy beliefs and degree centrality showed a pattern (see Fig. 2) analogous to the pattern of the cross-level interaction of Self-efficacy beliefs X Network density. Students with higher levels of self-efficacy beliefs reported significantly lower levels of FOM when they were embedded in reciprocal collaborative relations ($B=-1.34$, $SE=0.40$, $t=-3.34$, $p=.001$). However, when students reported low levels of self-efficacy beliefs their embeddedness in reciprocal collaborative relations did not predict their fear of making mistakes ($B=0.16$, $SE=0.42$, $t=0.37$, $p=.710$). Moreover, the simple difference tests confirmed that within the group of students who had more reciprocal collaborative relations, the ones with higher self-efficacy beliefs reported significantly lower fear of making mistakes than students with lower self-efficacy beliefs ($B=-0.37$, $SE=0.12$, $t=-2.94$, $p=.003$). On the contrary, among students with less reciprocal collaborative ties, students' level of self-efficacy beliefs was not related to their fear of making mistakes ($B=0.17$, $SE=0.19$, $t=0.90$, $p=.367$). Again, the interaction effect was replicated when students' achievement level and gender were used as covariates in the model (see Model 2b in Table 3). Following the suggestions

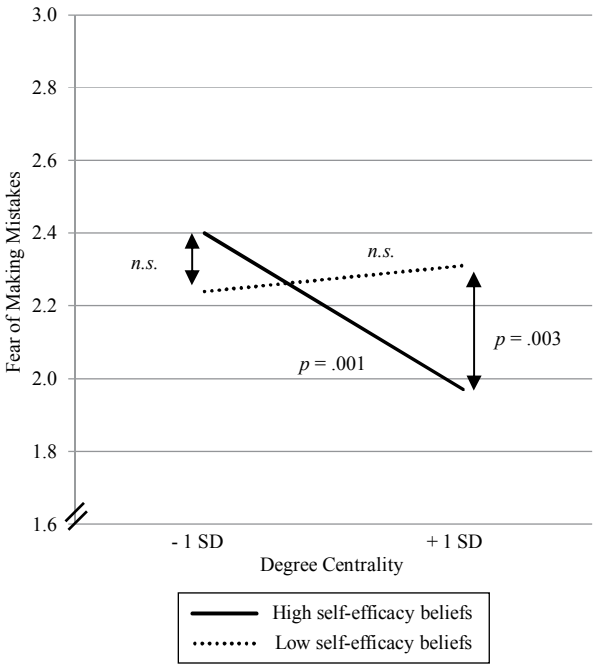

Fig. 2 Interaction of General self-efficacy beliefs X Degree centrality predicting fear of making mistakes

of Frank et al. (2013) we found that 39% of the interaction between general self-efficacy beliefs and degree centrality would have to be due to bias to invalidate the inference that the impact of students' number of reciprocal relations to classmates on their level of fear towards making mistakes depends on their level of self-efficacy (for *t*-ratio of 3.27). This is also relatively robust in comparison with other effects reviewed by Frank et al. (2013).

Concerning the cognitive aspect of students' handling of mistakes in terms of their *positive learning orientation towards mistakes (PLOM),* we recorded the following results. As expected, there was a significant main effect of general self-efficacy beliefs (see Models 3a-4b in Table 4), which means that students with higher values of self-efficacy beliefs showed a more PLOM.

We found no correlation between the intermediate social context (network density, L2) and students' PLOM; nor was there moderation through self-efficacy beliefs in the correlation between the network density (intermediate context on classroom level) and students' PLOM (see Model 3a in Table 4). These results lead to the conclusion that although a PLOM is strongly related to students' self-efficacy beliefs, it proves to be rather stable across intermediate contexts (i.e., network density on classroom level). Furthermore, the correlation between general self-efficacy beliefs and PLOM remained significant, even when controlled for students' academic achievement and gender (see Model 3b in Table 4). As tested in Model 4a (see Table 4), the results confirmed a positive and direct effect of students' embeddedness in classroom networks (immediate context, L1) on students' PLOM. That means, the more reciprocal collaborative relations students had, the more positive were their learning orientations towards mistakes. Again, the interaction between students' self-efficacy

Table 4 Results of multilevel regression analyses predicting students' positive learning orientation towards mistakes

	Model 3a				Model 3b			
	B	*SE*	*t*	*p*	*B*	*SE*	*t*	*p*
Intercept	3.41	0.04	85.37	.000	3.41	0.04	80.16	.000
General self-efficacy beliefs	0.79	0.09	8.58	.000	0.77	0.09	8.43	.000
School grades[a]					0.09	0.05	2.00	.046
Gender[b]					0.10	0.07	1.44	.149
Network density (L2)	0.24	0.43	0.56	.574	0.17	0.45	0.38	.703
General self-efficacy beliefs X Network density (L2)	0.95	0.91	1.03	.302	0.87	0.91	0.96	.336
	Model 4a				Model 4b			
Intercept	3.42	0.04	79.58	.000	3.42	0.05	76.58	.000
General self-efficacy beliefs	0.78	0.09	8.26	.000	0.76	0.09	8.33	.000
Degree centrality[c]	0.65	0.24	2.68	.007	0.58	0.24	2.42	.016
General self-efficacy beliefs X Degree centrality[c]	0.20	0.48	0.41	.682	0.27	0.47	0.57	.572
School grades[a]					0.07	0.04	1.55	.122
Gender[b]					0.11	0.07	1.61	.108

L1- (except gender) and L2-predictors were centered at their grand means

[a]School grades (mean of grades in mathematics and German) were recoded, thus higher values indicate better academic achievement

[b]Girls: 0.5, Boys: −0.5

[c]Values were transformed by taking the square root of each value (Borgatti et al. 2013)

beliefs and their degree of embeddedness in collaborative networks was not significant in predicting students' PLOM (see Model 4a in Table 4). This finding confirms that both students' self-efficacy beliefs and their embeddedness in collaborative relations significantly, yet independently, predicted their PLOM. Adjusting for students' school grades and gender, the correlation between self-efficacy beliefs and PLOM and the correlation between the degree centrality (i.e., embeddedness in collaborative networks) and students' PLOM remained stable and significant (see Model 4b in Table 4).

Also PLOM we calculated an estimate to quantify the robustness of our inference. Results were mixed. For the association of general self-efficacy beliefs as a predictor of PLOM the inference is highly robust: 75% of this effect would have to be due to bias to invalidate the inference, based on a *t*-ratio of 8.43 taken from Model 3b. But the robustness of inference for the correlation of degree centrality with PLOM (taken from Model 4b) is much weaker: If only 19% of this effect were due to bias (e.g., unmeasured confounding variables, alternate sample) we could no longer confidently infer that students would be more orientated towards learning from mistakes to the extent they have more reciprocal collaborative relations to classmates (for *t*-ratio of 2.42).[2]

[2]These can be compared against the average of 36% bias necessary to invalidate the inferences published in Education, Evaluation and Policy Analysis on-line July 24, 2012 (as reported in Frank et al. 2013). In fact, the 75% figure for self-efficacy is higher than 14 of 15 observational studies reviewed by Frank et al., whereas the 19% is weaker than all but two.

8 Discussion

Enhancing learning processes by constructively handling mistakes is of growing interest in educational research. The current study complements recent efforts (Steuer et al. 2013; Tulis 2013) to investigate the role that social learning contexts play in helping students to acquire and improve their ability to deal with their mistakes constructively. The major objective of the present research was to advocate a contextualized view of students' handling of mistakes that does not rely solely on self-reported measures of social contexts. We therefore used sociometric measures to assess overall collaborative structures (network density) of the classroom as well as individual students' reciprocal embeddedness (centrality degree) within these structures. We found distinct patterns for both the affective and cognitive dimensions of handling mistakes, i.e., for students' fear of making mistakes as well as their positive learning orientation towards mistakes.

Students' fear of making mistakes varied as a function of the overall collaborative structure as well as a function of an individual students' embeddedness. But importantly, these associations were shaped by the students' level of self-efficacy. In classrooms with high collaborative network density, those students who had high levels of self-efficacy reported lower fear of making mistakes. Likewise, students with more reciprocal collaborative ties, and particularly those students with high levels of self-efficacy, reported lower fear of making mistakes. In our view, self-efficacy beliefs, *because* they reflect the belief of an individual to be able to control challenging environmental demands by means of taking adaptive action, allow students to make more effective use of interpersonal relationships and classroom peer networks to cope with negative or inhibiting affective associations. Parallels to the dynamic that is at work here, can be found in the classic research carried out by Schachter (1959) demonstrating that people who were given the choice to wait by themselves or in company of another person for a study in which they would allegedly receive painful shocks, show an increased desire for affiliation with other people who were anticipating the same fate. People, who anticipate negative outcomes, and are in the need for affiliation, can use others as anchoring references and obtain social comparison information (Schachter 1959) which helps to understand the source of their own anxiety and discover ways to overcome it (Firestone et al. 1973). Also, Hill (1987) argued that a central reason of affiliation is the need for emotional support, for example, when seeking relief in a stressful situation. More recently, social appraisal theorists (Mumenthaler and Sander 2012) have argued that emotions are not only occasioned by our social environment, but also shape our interactions, and are regulated by interpersonal relationships. Our research complements these findings in that it identifies self-efficacy as a relevant condition shaping the association of interpersonal relations and fear related to mistakes in academic situations. Our findings suggest that students' fear of making mistakes can be alleviated when students are encouraged to act with initiative in *approaching* their classmates to regulate their fearful reactions.

Students' positive learning orientation towards mistakes varies as a direct function of both immediate collaborative peer relations (i.e., embeddedness) and individual levels of self-efficacy. Self-efficacy beliefs, moreover, play a crucial role in all stages of self-regulated learning. As in previous research on self-regulated learning (e.g.,

Zimmerman and Cleary 2006), we found that learning from mistakes, as a specific case of self-regulated learning, was significantly predicted by individual self-efficacy beliefs. We extended this previous research, however, by showing that reciprocal collaborative relations between specific classmates by trend amend the beneficial effects of self-efficacy beliefs. Our findings converge with the social-constructivist view which is based on the idea that students construct their knowledge through interaction and negotiation with peers (Zone of Proximal Development, Vygotsky 1978). In line with this view, our results suggest that constructive cognitive handling of mistakes is contingent upon collaboration with capable others pointing to the importance of what researchers have recently described as co-regulated learning activities (Järvelä et al. 2010). Moreover, recent work by Altermatt and Broady (2009) in which the conversations between 116 same-sex pairs of befriended elementary students were examined following an achievement-related failure. They found that children reported more adaptive responses to failure in proportion to the extent that their friends offered task-related help. Given the present data in our study, however, the degree to which the existence of reciprocated ties stems from previous constructive exchanges between two classmates cannot be determined. Additionally, in spite of its statistical significance, the interpretability of the relation between students' embeddedness in reciprocal collaborative relations and their positive learning orientation towards mistakes is limited, as indicated by our calculations quantifying the robustness of inferences (Frank et al. 2013). Further replication and, most importantly, longitudinal research designs will be necessary in order to shed further light on the interplay of students' learning orientation from mistakes and reciprocal academic work relations among peers.

In our data we did not find support for the impact of dense overall collaborative relations among peers on students' positive learning orientation towards mistakes which in our view underscores the usefulness of different types of sociometric measures as alternatives to self-reported data assessing students' perceptions. For instance, while students with a highly positive learning orientation could be likely to report a lively culture of exchange in the classroom (because they are part of it, as reflected in the reciprocal peer relations), the sociometric density measure nevertheless shows that the overall exchange culture can in fact be unrelated to students' individual learning orientation towards making mistakes. Only to the extent that the individual students are a valued part of the network, will they be more likely to feel that mistakes are important opportunities for learning.

Taken as a whole, our results suggest that the overall structure of collaborative relations in the classroom *as well as* students' embeddedness in this structure, can have a decisive impact upon the affective and partly the cognitive dimension of students' handling of mistakes in educational settings. Recognizing the different ways in which these two independent dimensions of handling of mistakes vary depending on collaborative networks is crucial when considering the design of interventions to facilitate positive learning processes.

Important limitations of the study should be addressed. First of all, our results are based on cross-sectional data. While our findings suggest that contextual features shape individual's handling of mistakes, they cannot provide a clear picture about the order of causality. Given the present design, we cannot infer whether students with

stronger networks and higher levels of efficacy can successfully regulate their fear of failure or whether those who report less fear of failure in learning situations and have high self-efficacy beliefs develop stronger networks. In fact, both paths are plausible. Longitudinal designs are needed to shed light on the interplay of these variables. Second, our research neglects the impact of other potentially important agents such as teachers, parents, or peers in other classrooms, in contributing either positively or negatively to students' learning orientation towards mistakes as well as their fear of making them. While we would argue that across subjects, classmates and thus peers are the most stable and important social environment, it is nonetheless probable that the impact of teachers is indirectly reflected in classroom collaborative networks. A third limitation pertains to the level of specificity. Analyzing the contextual contingencies of handling mistakes in specific subject domains could reveal, for example, that while peers play a crucial role in mathematics this is less so in other subjects. In subjects where students are expected to perform poorly and be more prone to mistakes (e.g., female students in mathematics, or immigrant students in languages) one might discover very different results than in learning situations where this is not the case. The presence of strongly ingrained stereotypes (e.g., Steele and Aronson 1995), might make the facilitation of collaborative relations among peers even more important and crucial to a student's ability to handle mistakes constructively.

We believe that despite these limitations the present research makes several important contributions to existing studies. First, it constitutes the first empirical examination of the association between actually existing peer relations and students' constructive handling of mistakes. Second, it describes collaborative relations in classrooms by means of social network indicators that function as measures validated by the perceptions of all classmates. Third, it formulates individual handling of mistakes as the product of the interactive contribution of students' intermediate and immediate social context and individual level variables. This theoretical perspective is familiar from the work of social cognitive theorists (Bandura 2012), but has, to the best of our knowledge, not yet been applied in this field of study. We propose that the use of sociometric measures can significantly contribute to our understanding of students' cognitions and emotions as a dynamic individual-context-interaction.

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