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The Relationship Between Teacher Support and Student Learning in Feedback Situations:

Exploring the Role of Students' Migration Backgrounds and Competence Levels and the Generalizability Across Different Countries and Subjects

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Abstract

Heterogeneity is a challenge for educational practice and research. Not only do students differ, for example, in terms of migration backgrounds or achievements, but educational contexts, such as country and subject, also characterize the teaching situation. In this environment of diversity, feedback situations and teacher support within them may vary for different students and in different contexts. To analyze teacher support in feedback situations, for example, the amount of feedback a student receives or the way that the teacher and students deal with an error (the so-called error culture) can be considered. This dissertation investigates the relationship between teacher support in feedback situations and student learning in comparative analyses and examines whether this relationship differs for students with and without migration backgrounds, with different competence levels, in different school subjects, and in different countries. Study 1 used an integrative data analysis of the PISA 2018 dataset to examine the relationship between feedback and student achievement, considering differences between students' migration backgrounds and competence levels and comparing countries. Study 2 focused on error culture and used the video dataset *Interaction* to analyze the relationship between error culture and student participation in classroom discourse, comparing students with and without migration backgrounds and in different school subjects. Overall, this dissertation shows that there is a weak relationship between teacher support in feedback situations and student learning. While there are differences between students according to their competence levels, their migration backgrounds are of little significance. In contrast, differences between subjects and countries confirm the important role of context. To further increase the potential of feedback, fixed feedback routines or the addition of automated feedback to teacher feedback could help provide tailored feedback to different students. Furthermore, the results show that there is a need for subject-specific teacher professional development programs to enable teachers to act competently in feedback situations and to provide targeted support to students with migration backgrounds.

Zusammenfassung

Heterogenität gilt als Herausforderung für Bildungspraxis und Bildungsforschung. So unterscheiden sich nicht nur Schüler*innen beispielsweise hinsichtlich des Migrationshintergrunds oder der Leistung, auch der Kontext wie das Unterrichtsfach und das Land zeichnen die Unterrichtssituation aus. Vor diesem Hintergrund der Vielfalt könnten sich Feedbacksituationen und die Lehrkraftunterstützung darin für unterschiedliche Schüler*innen und in unterschiedlichen Kontexten unterscheiden. Um die Lehrkraftunterstützung in Feedbacksituationen zu analysieren, kann beispielsweise die Menge an Feedback, die ein*e Schüler*in erhält, oder der Umgang der Lehrkraft und der Schüler*innen mit einem Fehler (die sogenannte Fehlerkultur) betrachtet werden. Diese Dissertation blickt deshalb in differenzierten Analysen auf den Zusammenhang zwischen der Lehrkraftunterstützung in Feedbacksituationen und dem Lernen der Schüler*innen und untersucht, ob sich dieser Zusammenhang für Schüler*innen mit und ohne Migrationshintergrund, unterschiedlichem Kompetenzlevel und in unterschiedlichen Schulfächern und Ländern unterscheidet. Studie 1 blickte im Rahmen einer integrativen Datenanalyse des PISA 2018 Datensatzes auf den Zusammenhang zwischen Feedback und der Schulleistung und untersuchte Unterschiede zwischen Schüler*innen mit und ohne Migrationshintergrund, Schüler*innen unterschiedlicher Kompetenzlevel und verglich Länder. Studie 2 fokussierte auf die Fehlerkultur im Unterricht und analysierte mit Hilfe des Videodatensatzes *Interaction* den Zusammenhang zwischen Fehlerkultur und der Beteiligung am Unterrichtsgespräch und verglich hierbei Schüler*innen mit und ohne Migrationshintergrund und unterschiedliche Schulfächer. Insgesamt zeigt diese Dissertation, dass ein schwacher Zusammenhang zwischen der Unterstützung der Lehrkraft in Feedbacksituationen und dem Lernen der Schüler*innen besteht. Während sich zwar Unterschiede zwischen Schüler*innen je nach Kompetenzlevel finden lassen, zeigt sich der Migrationshintergrund als wenig bedeutsam. Unterschiede zwischen Fächern und Ländern bestätigen dagegen die wichtige Rolle des Kontexts. Um das Potenzial von Feedback weiter zu erhöhen, könnten feste Feedback-Routinen oder die Ergänzung von Lehrkräftefeedback durch automatisiertes Feedback einen Beitrag leisten, um unterschiedlichen Schüler*innen passgenaues Feedback zu geben. Weiter ergibt sich aus den Ergebnissen die Notwendigkeit für fachspezifische Lehrkräftefortbildung zum kompetenten Handeln in Feedbacksituationen und der zielgerichteten Förderung von Schüler*innen mit Migrationshintergrund.

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1 Introduction

Teaching today has more faces than ever before: The ways to become a teacher are more diverse than they were a few years ago (Federal Statistical Office of Germany, 2023), a variety of new teaching methods have been established in recent years (e.g., Planinic et al., 2024), and digital media are gradually finding their way into the classroom (Bonnes et al., 2022; Fernández-Batanero et al., 2020; Scheiter, 2021). Above all, student heterogeneity and the differentiation of teaching contexts require teachers to be constantly vigilant and adaptable.

Looking at the heterogeneity of students, there are often significant differences in student backgrounds (e.g., migration background; Mang et al., 2023), achievement levels (Diedrich et al., 2023; Kastorff et al., 2023), and motivational-affective characteristics between groups of students (Hardy et al., 2019; Lazarides & Schiepe-Tiska, 2022). While teachers are predominantly positive about heterogeneity in the classroom (e.g., students with migration backgrounds; Lorenz & Müller, 2017), they also see heterogeneity as a challenge (Gebauer et al., 2013). Most do not feel prepared to teach in diverse classrooms (Arslangilay, 2018; Bryan & Atwater, 2002; Dee & Henkin, 2002). Against the backdrop of many different individuals, adapting to the needs of each student is difficult for teachers. In addition to the student heterogeneity, heterogeneity in context is also challenging for teachers. As the content and methods of teaching vary greatly across subjects and countries, a recommendation from a teacher of a different subject or from a different nation may not always be particularly helpful (Heitmann et al., 2017; Hofstede, 2011; Hofstede et al., 2010; Reusser & Pauli, 2021; Seidel & Shavelson, 2007).

Research aims to support teachers in finding effective teaching formats to deal with these challenges regarding heterogeneity. Effective teaching promotes students' multidimensional educational goals (e.g., achievement, interest, motivation; Schiepe-Tiska, 2019). An important component in various frameworks for effective teaching is teacher support—recognizing the individual needs and difficulties of students and assisting them in the learning process (Klieme et al., 2006; Kunter & Voss, 2011; Praetorius et al., 2018). Teacher support is particularly important in feedback situations when looking at past and future learning processes (Hattie & Timperley, 2007). Interestingly, empirical studies only partially support the idea that teacher support is effective for student learning (e.g., Lipowsky et al., 2009). In a research synthesis, Praetorius et al. (2018) showed that only one of nine effects of teacher support on achievement and two of six effects of teacher support on motivation were significantly positive. When we focus explicitly on one facet of teacher support—the role of feedback—nonexperimental findings also only show weak correlations between feedback and achievement (Cai et al., 2023; Ma et al., 2022).

One key to explaining these small effects of teacher support on student learning may be to account for heterogeneity. Even if there is little effect across student groups and contexts, this may not be true for all students and contexts. Consequently, theoretical models of effective

teaching include student characteristics and contexts as important determinants of effective teaching (Narciss & Alemdag, 2024; Vieluf et al., 2020). In addition, empirical studies examine the extent to which the same teaching method produces different results for different learners (aptitude-treatment interaction; Cronbach & Snow, 1977). For example, students with migration backgrounds have been shown to benefit more from teacher support (Decristan et al., 2016; Seiz et al., 2016). Therefore, adapting instruction to the needs of a group of students (Smale-Jacobse et al., 2019) or individual students (Van de Pol, 2012) is associated with positive learning outcomes.

Heterogeneity is thus an ongoing challenge for educational practice and research. This dissertation responds to this and examines the role of student characteristics (here, migration background and competence level) in the relationship between teacher support and student learning in feedback situations; it also evaluates the generalizability of the results across different contexts (here, countries and subjects). To support research and practice in dealing with heterogeneity, this dissertation employs a broad methodological spectrum (descriptive comparison, moderator analysis, integrative data analysis) and utilizes differently designed datasets (video data and questionnaire data).

This dissertation includes two studies analyzing the relationship between teacher support in feedback situations in more detail. Using the PISA 2018 dataset, Study 1 focused on the relationship between feedback and student achievement, analyzed whether student background (here, operationalized by the language spoken at home) plays a role in this relationship, and compared whether the findings were generalizable across countries.

Study 2 analyzed the video dataset *Interaction* and focused on negative feedback—more precisely, on the way teachers and students deal with errors (i.e., error culture). The relationship between error culture and one facet of student learning—student participation in classroom discourse—was examined. Furthermore, this study explored the role of student migration background and subject in the relationship between error culture and student participation.

These analyses have additional value for research and practice. Research can benefit from these findings because, first, existing frameworks of teacher support and feedback were extended to include the role of student characteristics and contexts. For example, if the low correlations between teacher support and student learning do not hold for all student groups and contexts, then student characteristics and context must be added to the models as important determinants of effective teaching. Second, these findings can inform future study design and sample composition. For example, comparative analyses can indicate whether it is important to replicate a finding in a different subject or with a different sample.

Teachers can also benefit from the results of this dissertation because they can learn whether a teaching method they have learned from a colleague or in a scientific study is appropriate for their specific students and their specific context. In addition, teachers will obtain

information on whether teacher support in feedback situations is appropriate for explicitly supporting students with migration backgrounds.

2 Theoretical Background

2.1 Teacher Support in Feedback Situations

Teacher support is a central component of effective teaching. Although there is varying terminology for teacher support (e.g., “student orientation” in Klieme et al., 2001; “supportive social climate” in Klieme et al., 2006; “constructive support” in Kunter & Voss, 2011), they all refer to similar processes in the classroom: Teachers’ actions are directed toward the needs of students. This includes helping with academic and motivational problems and ensuring integration into the classroom. To achieve these goals, teachers must be sensitive and diagnostically skilled in identifying problems and providing appropriate support to their students (Klieme et al., 2001; Kunter & Voss, 2011).

Teacher support is particularly important in situations in which students receive feedback—information about their performance or understanding—from the teacher (feedback situations; Hattie & Timperley, 2007). In accordance with Heinrichs (2015) and Steuer et al. (2013), this dissertation presents a model to characterize feedback situations with the following steps *occasion for feedback*, *giving feedback*, *peer reaction*, and *student reaction*. Figure 1 shows the process of such feedback situations. In the following section, the steps of this process and the types of teacher support that are needed in each step are described.

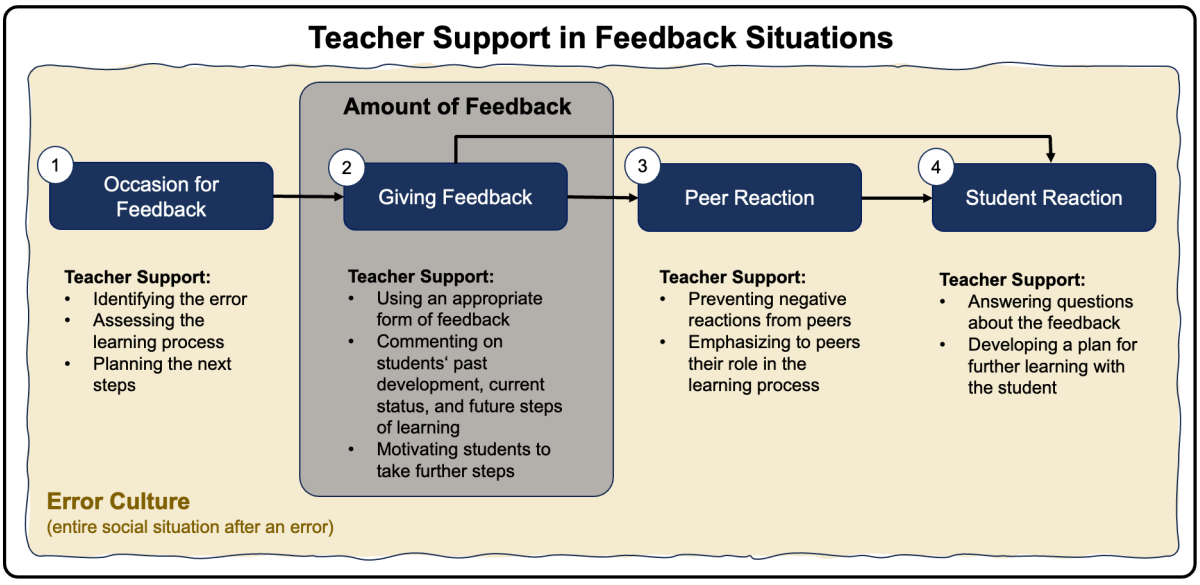

Figure 1: Four steps of feedback situations

First, the feedback situation begins with or without an *occasion* (step 1, Figure 1), for example, when a student makes an error—a statement or behavior that deviates from the norm established in the classroom (Oser et al., 1999; Prediger & Wittmann, 2009). As this definition shows, the established norm distinguishes between right and wrong. Therefore, it is the teacher’s job, first, to establish the norm and, second, to identify a deviation from the norm (i.e., an error). Alternatively, the teacher can provide feedback on the current learning process at regular intervals. In this first step, teacher support means diagnosing and predicting future steps in the learning process (see Wagner, 2025). If the error is the cause, the teacher must

recognize the error, hypothesize its cause, and choose a good way to deal with the error (Heinrichs, 2015; Prediger & Wittmann, 2009; Reiss & Hammer, 2021). If there is no specific occasion for feedback, teacher support involves diagnosing the student's strengths and weaknesses in the learning process and assessing the next steps and goals.

Second, the teacher *gives feedback* to the student (step 2, Figure 1). Here, teacher feedback has two components: instructional and emotional (see Oser et al., 1999; Pianta & Hamre, 2009; Seifried et al., 2022). Feedback and instruction are inseparable. Because feedback provides information about the learning process, it is particularly effective when combined with instruction (Hattie & Timperley, 2007). The instructional component of feedback thus emphasizes skill development (Pianta & Hamre, 2009). On the other hand, there is the emotional component. Negative feedback, which tells students what they cannot do, risks demotivating them (Oser et al., 1999; Weinert, 1999). Positive feedback, though, can be motivating by providing an incentive for future learning (Fefer & Vierbuchen, 2019). However, the direction of motivation can also be reversed; for example, students may feel encouraged to do better by their teachers' criticism (see Huber, 2019). In addition to these direct effects on motivation, feedback can also affect motivation by changing the teacher–student relationship (see Steuer et al., 2024). If students perceive negative feedback as an attack by the teacher, they may fear that the teacher does not like them. Based on this division into instructional and emotional components, teacher support means finding the right form of feedback (Wisniewski et al., 2020): Feedback can be given orally in a one-on-one conversation with the student or in front of the whole class, or it can be written as a comment on a test. Automated feedback can also provide students with information about their learning. Part of the teacher's role is to use the most appropriate form of feedback for each student. In addition, teacher support in this second step also means that feedback critically assesses past development, current status, and future steps of learning but is done in a sensitive way to motivate students' continued learning. More information about the different focuses of feedback is offered in the next section.

Third, the *peer reaction* is an important step in the feedback situation (Hattie & Gan, 2011; step 3 in Figure 1). For example, if classmates laugh at a student for making an error, the student will feel socially excluded and may be demotivated for further learning (see Deci & Ryan, 2000). Teacher support at this stage means admonishing students who laugh at other students in order to prevent such negative reactions (see Steuer, 2014). To ensure that negative reactions do not occur after class when the teacher is gone, the teacher can make students aware of the demotivating consequences of laughing at others and thus sensitize them to their behavior.

Fourth, the feedback itself and the reaction of the peers result in the *student reaction* (step 4, Figure 1). This step describes how students process teacher feedback. According to Lipnevich and Smith (2022), this includes cognitive processing (i.e., understanding feedback), affective processing (e.g., feelings about feedback), and behavioral processing (e.g., implementing the feedback). Teachers can support students through these processes by being

available to answer questions, providing explanations of the feedback, and co-constructively designing a plan for further learning with the student.

To sum up, teacher support takes on different forms during feedback situations. This dissertation examines teacher support in feedback situations in two different ways. Study 1 focuses on the second step, giving teacher feedback, and looks at the *amount of feedback* (i.e., how much feedback a teacher gives to a student). Study 2 focuses on feedback situations that have an error as an occasion, and then looks at the overall social situation of how teachers and students deal with that error (so called “error culture”; Spychiger et al., 2006; Spychiger et al., 1998; Spychiger et al., 1999; Steuer et al., 2013). Against the background of the four steps of feedback situations (Figure 1), teacher support in the sense of error culture includes acknowledging the error (step 1), presenting the error in an appreciative manner (step 2), ensuring that peers do not laugh at the student (step 3), and helping the student correct the error (step 4).

As Figure 1 and the definitions show, feedback and error culture are related constructs (Steuer & Dresel, 2019): Error culture is the social environment in which a particular type of feedback (negative feedback) is given. While feedback can also be positive (e.g., praise), error culture focuses only on negative feedback. In addition, error culture takes a broader view of the entire classroom situation, considering not only the teacher’s actions, but also the students’ reactions to an error. In summary, feedback is both a consequence and a prerequisite for a positive error culture (Steuer & Dresel, 2019).

2.1.1 The Role of Feedback in Student Learning

As just described, feedback from the teacher is a central step in teacher support in feedback situations. According to Hattie and Timperley (2007), feedback can have four different focuses, each of which has individual effects on achievement: First, the task level addresses, for example, whether an answer is correct or incorrect. Feedback at this level corrects errors, thus sparing students the laborious process of discovering errors themselves (Hattie & Gan, 2011). Second, process feedback indicates, for example, what further steps are needed in the learning process. Teachers may break up a large, seemingly insurmountable task into several smaller ones to make the learning process more efficient (Ramaprasad, 1983). Third, self-regulatory feedback provides information about, for example, what needs to be checked again in the student’s solution. Students can use this type of feedback to recognize their own mistakes and avoid making them in the future. Fourth, self-level information feedback can provide, for example, information about a student’s competency profile or skill level. This feedback can be motivating, so that students enjoy the task more (Chi et al., 2021) or have a more positive assessment of their abilities (Ma et al., 2023).

Feedback, therefore, contains a variety of information about a student’s performance level and the development of the learning process. Theoretically, this information from a teacher about the past and present learning process will improve student learning. Empirically,

the picture of the relationship between feedback and achievement is mixed: While feedback shows strong effects on student achievement in experimental settings (Hattie, 2023; Hattie & Timperley, 2007; Wisniewski et al., 2020), correlations in nonexperimental settings tend to be weak (Ma et al., 2022; Yan & Chiu, 2022). Overall, it is the information submitted in feedback that is critical for learning (Harris & Rosenthal, 1985; Hattie & Timperley, 2007; Müller et al., 2023). The lack of control over classroom conditions may explain the difference between experimental and nonexperimental studies (Yan et al., 2021). For example, it is not possible to control whether the quality of feedback from teachers is sufficient (Katsantonis et al., 2023), nor is it clear what students do with the feedback (Huber, 2019).

Another reason may be that feedback is received differently by different groups of students and in different contexts. If different student groups or countries cancel each other out, the overall correlation could be low. Study 1 of this dissertation therefore addresses the divergent findings on the role of feedback on student learning in experimental and nonexperimental settings and fills the research gap on the reasons for these findings. More specifically, whether the relationship differs across student groups (here, students with and without migration backgrounds, different competence levels) and contexts (here, countries) is examined.

2.1.2 The Role of Error Culture in Student Learning

Errors are normal and natural situations in the learning process (Heinze et al., 2012). Surprisingly, however, only 4.72 student errors are made per lesson across the entire class (Heinze, 2004). This shows that teachers tend to avoid students' making errors, possibly because they do not have sufficient strategies for dealing with errors (Heinze et al., 2012). However, it is important for teachers to show adequate strategies as models so that students can learn how to deal with errors (Soncini et al., 2021).

Error culture (or error climate; Steuer et al., 2013) is the "evaluation and use of errors as integral elements of the learning process in the social environment of the classroom" (Steuer et al., 2013; p. 198). A positive error culture includes, for example, the teacher's tolerance of errors, the absence of negative reactions from the teacher and classmates, and the view that errors are the starting point for the learning process (Steuer et al., 2013). Therefore, error culture can be observed in participants' beliefs (e.g., whether students or teachers think errors are disruptive) and practices (e.g., how the teacher reacts on a student's mistake; Fischer & Freund, 2023).

Empirical studies show that a positive error culture, which recognizes errors as a necessary and important intermediate step in the learning process, is associated with various student outcomes. Students in a positive error culture are less afraid to make mistakes (Soncini et al., 2021; Steuer, 2014), are more motivated (Fischer & Freund, 2023), feel less helpless (Fischer & Freund, 2023), and perform better (Steuer, 2014; Steuer & Dresel, 2015, 2019). Therefore, it is theoretically possible that students who experience a positive error culture will

also be more engaged in classroom discourse because they are less afraid of making errors and perceive a lower risk of being rejected by their teacher or peers.

According to Narciss and Alemdag's (2024) model, error culture can be observed in teacher–student interactions. Therefore, this dissertation focuses on the role of error culture in teacher–student interactions and extends research on error culture in two ways: First, it remains unclear whether the lower anxiety and higher motivation of students who perceive a positive error culture (e.g., Fischer & Freund, 2023; Steuer, 2014) are reflected in students' behavior in classroom discourse. Consequently, this dissertation focuses on the relationship between error culture and student participation in classroom discourse. Second, Narciss and Alemdag's (2024) model shows that learner characteristics play an important role in interactions after an error. As a result, it is unclear whether the positive role of error culture is applicable to all students or whether certain groups of students benefit more from a positive error culture than others. It also remains to be seen whether the importance of error culture varies across subject areas. Thus, using Narciss and Alemdag's (2024) model, Study 2 of this dissertation fills this research gap by empirically examining the role of student characteristics (here, migration background) and contexts (here, subjects).

2.2 Student Participation as an Important Variable for Investigating Student Learning

Teaching often involves and aims to engage students in conversation with the whole class (classroom discourse; Grünkorn et al., 2020). According to Fredricks et al. (2004), behavioral engagement is the visible part of engagement that refers to active participation in academic and social activities. One indicator of behavioral engagement is student participation.

Following Sacher (1995) and Decristan et al. (2020), student participation can be student-controlled and teacher-controlled (Figure 2), which distinguishes who is responsible for an interaction. Student-controlled participation refers to student behaviors that lead to participation in classroom discourse (hand-raising and calling-in [i.e., speaking without permission to talk]). Teacher-controlled participation, on the other hand, refers to teacher behaviors that enable students to participate in classroom discourse (calling-on).

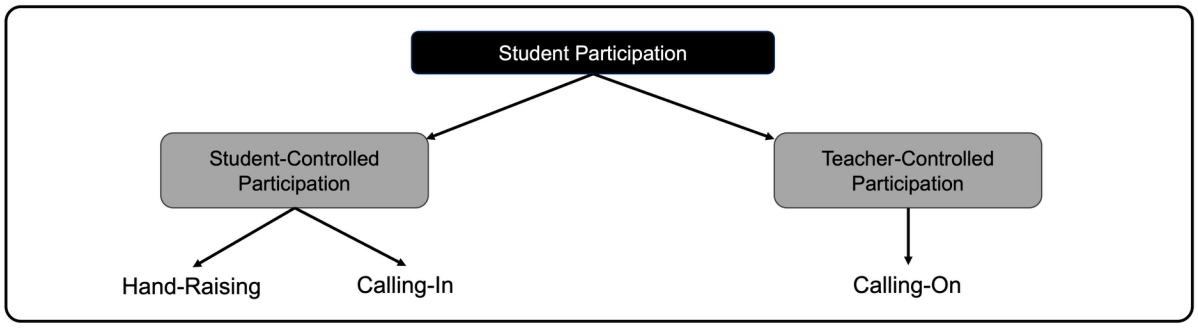

Figure 2: Distinction between student-controlled participation and teacher-controlled participation, according to Sacher (1995) and Decristan et al. (2020)

Focusing on student participation is beneficial because it is an important indicator of the learning process (e.g., Fredricks et al., 2004). For example, Böheim et al. (2020) showed that students who raised their hands at least once in class had significantly better results than students who did not raise their hands in class. In addition, hand-raising and student achievement were related, even when controlling for prior knowledge. When the number of verbal contributions is chosen instead of hand-raising to operationalize participation, this reinforces the finding that students who verbally participate more frequently in class perform better (Sedova et al., 2019).

Previous studies have also identified teacher support as a predictor of student participation (e.g., Böheim et al., 2020; Fredricks et al., 2004). In their meta-analysis, Vargas-Madriz et al. (2024) found a positive correlation (r = .30) between teacher support and student participation. More specifically, Reyes et al. (2012) showed that the classroom's emotional climate was associated with higher self-reported student participation. Similarly, Denn et al. (2019) reported that in classes where independent raters rated the classroom climate more positively, the proportion of students responding to a teacher question was also higher. Therefore, teacher support is important for student participation. In terms of these individual findings, there is a path from teacher support to student participation to student achievement. Böheim et al. (2020) confirmed this mediation.

To conclude, student participation as a result of teacher support and as an indicator of student learning may be key to the study of effective teaching. For that reason, this dissertation focuses on student participation, in addition to student achievement. First, it remains unclear from previous findings whether the positive relationship between teacher support and student participation holds true for teacher support after making a mistake. Second, it is unclear whether students choose to participate in class depending on the level of teacher support. Furthermore, whether teacher support is important for whether a student participates in classroom discourse may also depend on the context. Therefore, this dissertation addresses these research gaps and sheds light on the generalizability of the relationship between teacher support and student participation.

2.3 Investigating Heterogeneity: The Role of Student Characteristics and Context in Teacher Support in Feedback Situations

Teacher support in general and feedback in particular play important roles in teaching (Hattie, 2023; Klieme et al., 2001; Kunter et al., 2011). Despite this theoretical assumption, empirical studies often fail to confirm these relationships between teaching and learning. In their systematic review, Praetorius et al. (2018) showed that only one out of nine correlations between teacher support and achievement and two out of six correlations between teacher support and motivation were significantly positive. The authors explained these inconsistent findings by methodological differences (e.g., different ways of operationalizing teacher support, sample size) and by the lack of consideration of context (e.g., school type, school subject). Therefore, the heterogeneity of students and teaching situations should be taken into account.

The idea that learning opportunities are more or less effective for different students goes back to Cronbach and Snow (1977), who referred to this relationship between student characteristics and learning opportunities as *aptitude-treatment interactions*. Theoretical models, such as Vieluf et al.'s (2020) supply–use model, take up this idea of the role of heterogeneity in effective teaching. Vieluf et al. (2020) distinguished between supply and use regarding the processes in the classroom. Supply refers primarily to the content of the lesson and the actions of the teacher. However, the actions of students and the co-constructive collaboration between teachers and students are also considered part of the supply. This supply is now perceived and used by the students. Consequently, the second part is the use of the offer. This includes motivational and emotional experiences, as well as the student's cognitive use of the content. This use in turn leads to the achievement of multidimensional educational goals (e.g., cognitive, motivational student outcomes).

In light of these models of Cronbach and Snow (1977) and Vieluf et al. (2020), it seems necessary to explicitly consider the heterogeneity of students and contexts (see Bell et al., 2012). This dissertation therefore examines the generalizability of teacher support in feedback situations across different student groups and contexts. With regard to student groups, this dissertation considers both the proximal student characteristic of student achievement (i.e., competence level) and the distal student characteristic of migration background in order to examine student heterogeneity from different perspectives.

These two characteristics were chosen because they are particularly associated with student learning (e.g., Cooper & Allen, 1998; Decristan et al., 2020; Lorenz & Gentrup, 2017). It is therefore reasonable to assume that students also require individualized approaches to support (e.g., Tenenbaum & Ruck, 2007; Ziernwald et al., 2022) and benefit differently from the same learning opportunities (e.g., feedback). Therefore, it is worth investigating the extent to which feedback situations can be generalized for students.

In addition, feedback situations cannot be disentangled from the learning context (Bell et al., 2012; Seidel & Shavelson, 2007). Therefore, this dissertation also examines the role of

context by examining different countries and subjects. Supply–use models (e.g., Vieluf et al., 2020) and empirical studies (e.g., Praetorius et al., 2018) suggest that teaching, and thus teacher–student interactions, vary significantly across contexts (e.g., society, school, class, and subject). This dissertation investigates context by examining the heterogeneity of contexts within a school (different subjects) and across schools (different countries).

2.3.1 Migration Background

Hardly any other group of students is the subject of social and political debate as often as students with migration backgrounds. Students' migration backgrounds can be operationalized by their country of birth (i.e., students with at least one parent born abroad) or by the home language (i.e., students who are multilingual; Busse & Hardy, 2023). In this dissertation, both operationalization variants are used to describe students with migration backgrounds.

Educational research has responded to the public interest in students with migration backgrounds and the demand for evidence to inform policy decisions by regularly examining how these students perform compared to their peers without migration backgrounds. Various studies over the last few decades have shown that the achievement of students with migration backgrounds lags behind that of students without migration backgrounds (e.g., Hillmert, 2013; Mang et al., 2023; Schnepf, 2007; Weis et al., 2018), identifying five reasons that may have resulted in this achievement gap (see Figure 3).

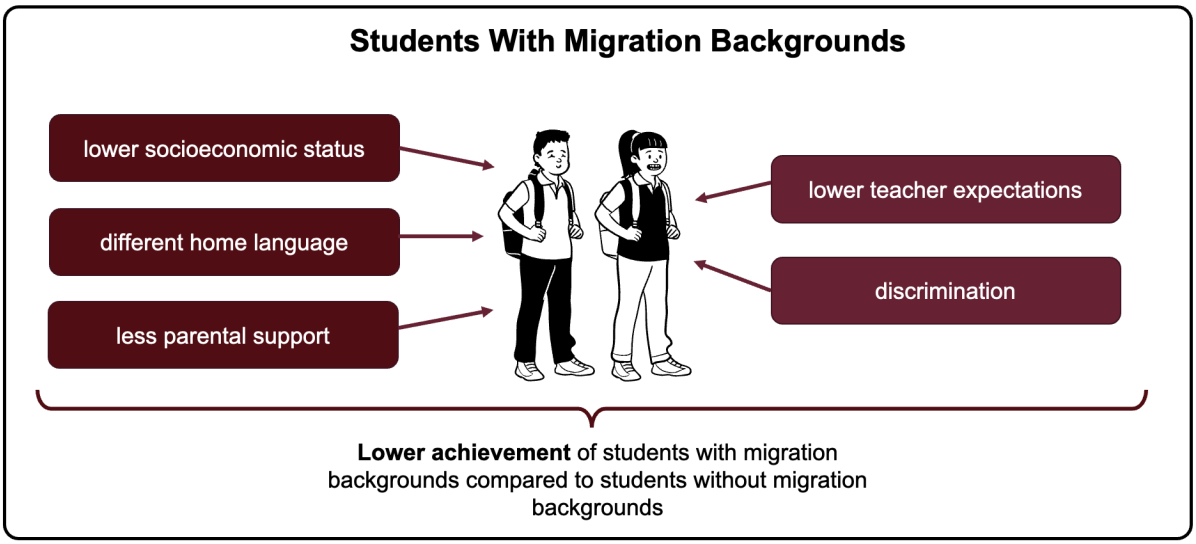

Figure 3: Empirically researched reasons for the achievement gap between students with and without migration backgrounds

First, students with migration backgrounds are characterized by a lower socioeconomic status (SES; Henschel et al., 2022; Mang et al., 2023) on average. In Germany, this difference in SES between students with and without migration backgrounds is particularly large compared to other OECD countries (Mang et al., 2023). These differences can be important for student learning, since lower parental financial resources could mean that students have less access to out-of-school educational opportunities (e.g., museums) or educational materials

(e.g., additional textbooks). Empirical evidence supports this argument, since the achievement gap between students with and without migration backgrounds is significantly reduced when SES is taken into account (Levels & Dronkers, 2008; Lüdemann & Schwerdt, 2013; Weis et al., 2018). Therefore, SES explains a significant part of the achievement gap.

Second, many students with migration backgrounds speak a different language at home than at school. Of students with migration backgrounds in Germany, 51.6% speak German at home (Mang et al., 2023). However, this varies greatly depending on the length of time spent in the country of migration: While 80.7% of students in Germany with only one foreign-born parent speak German, only 12.5% of first-generation migrants (i.e., students who were themselves born in another country) speak German at home (Mang et al., 2023). Focusing explicitly on students who speak another language at home, previous studies have shown that this group of students, on average, performs worse in school (Göbel et al., 2011; Mang et al., 2023; Müller & Stanat, 2006). It can therefore be assumed that the achievement gap between students with and without migration backgrounds can be explained to some extent by differences in language use. Empirical studies confirm this by showing that the achievement gap is reduced when the language spoken at home is controlled for (Dustmann et al., 2012; Henschel et al., 2022; Hillmert, 2013). However, the results also show subject-specific effects: The language spoken at home explains the achievement gap in reading significantly better than in Mathematics (Henschel et al., 2022).

Third, the achievement gap could also be due to less nonfinancial parental support. Educational success cannot be achieved without or against parents (Thränhardt & Weiss, 2012). As parents' education is lower on average for students with migration backgrounds (Mang et al., 2023), it is more difficult for them to help their children with homework, for example. In addition to this barrier, a language barrier can prevent parents from providing support (Göbel et al., 2011; Sattin-Bajaj et al., 2023). This does not mean that parents do not want to provide this support, but rather that various barriers prevent them from providing effective support.

Fourth, teachers seem to expect less from students with migration backgrounds (Gentrup et al., 2018; Lorenz & Gentrup, 2017; Lorenz et al., 2016; Tenenbaum & Ruck, 2007; Tobisch & Dresel, 2017; van den Bergh et al., 2010). These different expectations can lead to different actions in the classroom (Jussim, 1986; Lorenz, 2018). For example, depending on their expectations, teachers may provide different materials, offer different opportunities for different students to participate, or provide specific feedback (Harris & Rosenthal, 1985; Rosenthal, 1994). This chain from expectations to teacher actions to student achievement, also known as a self-fulfilling prophecy (Rosenthal & Jacobson, 1968), has long-term effects on educational trajectories (e.g., choice of secondary school, university studies; Birkelbach, 2011).

Fifth, it remains an open question whether the differences in expectations are due to actual differences in achievement or to discrimination. Experimental studies have shown, for example, that teachers grade a dictation with the same number of errors worse if they assume that the student has a migration background based on the first name (Bonefeld & Dickhäuser, 2018). Similarly, this has also been shown in the grading of essays and secondary school recommendations (Sprietsma, 2013). Outside of these experimental settings, however, there is no evidence of institutional discrimination (Becker & Beck, 2012; Diehl & Fick, 2016; Kiss, 2013). Compared to the other reasons for the achievement gap between students with and without migration backgrounds, discrimination appears to play a much smaller role (Kristen, 2006).

As described above, students with and without migration backgrounds differ in a number of characteristics (achievement, SES, language spoken at home, parental support, teacher expectations, and discrimination). These factors may also determine the teaching in general and the use and effect of feedback in particular. Especially in feedback situations where students receive negative feedback, their migration background might play a role. Therefore, there are three reasons why error culture might be particularly important for student participation in classroom discourse for students with migration backgrounds.

First, students with migration backgrounds show lower achievement (e.g., Weis et al., 2018), which means that making mistakes and dealing with them are more important to students with migration backgrounds. They are more likely to fear that their answers will be wrong; thus, dealing with mistakes may be more important for them. Second, students with migration backgrounds show less social integration in the classroom (Henschel et al., 2022). Therefore, they are more likely to fear being rejected by their peers after giving a wrong answer. Third, there is evidence that teachers expect less from students with migration backgrounds and sometimes discriminate against them (e.g., Bonefeld & Dickhäuser, 2018). As a result, students with migration backgrounds may have experienced discrimination and are, therefore, particularly concerned about being rejected if they make a mistake. Consequently, students with migration backgrounds would benefit more from a positive error culture.

Furthermore, feedback itself might also play a greater role in students' learning process. This dissertation therefore looks at the relationship between feedback and reading literacy as one facet of student achievement. Since knowledge of a language is particularly important in reading, students' migration backgrounds are operationalized with the language spoken at home in Study 1. These students, who speak a different language at home than at school, might benefit more from feedback for two reasons. First, they are characterized by lower achievement in reading literacy (Lesaux & Kieffer, 2010; Yan & Chiu, 2022). Students, therefore, need to plan and regulate a much longer learning process to achieve good results. Teacher support may be particularly important here. Second, students who speak a different language at home receive less support from their parents (Göbel et al., 2011; Sattin-Bajaj et al., 2023). Therefore, teacher feedback may be even more important, as parents may not be

able to provide helpful feedback. Overall, feedback could be more important for the achievement of students who speak a different language at home.

2.3.2 Students with Different Competence Levels

Of course, students do not only differ in terms of their migration backgrounds. With ongoing evaluation processes, student achievement is also at the center of teachers' attention. In research, student achievement is considered both as an outcome of the learning process and a predictor of interaction. The role of student achievement as an outcome of the learning process (i.e., the positive relationship between student participation and student achievement; Böheim et al., 2020; Sedova et al., 2019) has already been discussed in Section 2.2. However, if student achievement is used as a predictor for interaction, several studies indicate that teachers engage with students with varying competence levels differently (Decristan et al., 2020; Jurik et al., 2013; Lipowsky et al., 2007). For example, Lipowsky et al. (2007) showed that opportunities to participate in the classroom are unevenly distributed and that high-achieving students are more frequently involved in the classroom. In addition to the frequency, the quality of the interactions also varies, as shown by Bouton et al. (2025). While students with a lower competence level are more involved in simple interactions (e.g., repeating, solving simple tasks), students with higher competence levels are more likely to engage in more difficult, elaborate interactions that require deeper engagement with the learning content.

This dissertation builds on these findings by considering student achievement from two perspectives: it considers student achievement as a learning outcome and as a predictor of classroom interactions. With the differences in interactions between students with different competence levels that have been investigated thus far (e.g., Bouton et al., 2025; Lipowsky et al., 2007), it can be assumed that competence level plays an important role in feedback processes. Two reasons suggest that teachers do not distribute feedback evenly among students. First, feedback is often given more quickly to students with high competence levels, since high achievers often only need to be confirmed, while feedback for students with low competence levels often involve a lengthy process of error correction (see Oser & Spychiger, 2005). However, feedback is more important for students with low competence levels, as they need more support in structuring their learning process (see Hattie & Timperley, 2007). Teachers may give more feedback to this group of students because they feel that they need it. This dissertation aims to empirically test both arguments and investigates whether students of different competence levels receive different amounts of feedback.

2.3.3 Country

In addition to student characteristics, contextual factors play an important role in effective teaching (Begrich et al., 2023). The country and culture in which lessons take place also determine learning. According to Hofstede (2011) and Hofstede et al. (2010), cultures can be classified according to several criteria, such as distribution of power (small power distance vs. large power distance). This, in turn, has an impact on teaching. While, for example, small

power distance cultures (e.g., Austria, Israel, Denmark) tend to have student-centered teaching, large power distance cultures (e.g., Malaysia, Russia, Mexico) tend to have teacher-centered teaching (Hofstede, 2011; Hofstede et al., 2010). For example, significantly more teachers in Korea used command as a teaching style than in France or Canada (Cothran et al., 2005).

These cultural differences in teaching also determine feedback processes (De Luque & Sommer, 2000; Heine et al., 2001; Hwang & Francesco, 2010; Suhoyo et al., 2014). For example, the process of seeking (De Luque & Sommer, 2000; Hwang & Francesco, 2010), giving, and receiving feedback (Yan et al., 2021) differ across cultures. Specifically, cultural differences in the relationship between feedback and reading literacy have been identified in descriptive comparisons. Yan et al. (2021) compared 12 Western and Eastern countries descriptively, Ma et al. (2022) compared 8 collectivistic and individualistic countries, and Ma et al. (2023) reported results from 75 countries. Yan et al. (2021) showed that there is a negative correlation between feedback and reading literacy in Eastern countries but not in Western countries. At the same time, the analyses by Ma et al. (2022) and Ma et al. (2023) found largely culture-independent results. The mediating role of self-concept (Ma et al., 2022) and reading enjoyment (Ma et al., 2023) in the relationship between feedback and reading literacy was found in almost all the countries studied. Following these descriptive comparisons across countries, our study builds on them by measuring, for the first time, heterogeneity across countries.

2.3.4 School Subject

Context involves more than the country. While effective teaching has a subject-independent core, the concrete arrangements differ between subjects (Praetorius & Gräsel, 2021; Reusser & Pauli, 2021; Seidel & Shavelson, 2007). Praetorius et al. (2020) developed a framework in which generic and subject-specific dimensions of teaching quality were listed. For example, “socio-emotional support” can be generic (e.g., teacher fairness) or subject-specific (e.g., managing fear or disgust when students perform dangerous experiments or examine living creatures in science classes; Praetorius et al., 2020).

Subject-specific differences result from differences in knowledge representations, methods, and forms of discourse in subjects (Reusser & Pauli, 2021). Regarding knowledge representations, it makes a big difference in teaching and learning whether students learn to prove the Pythagorean theorem, use a written language, or shoot hoops in basketball (Reusser & Pauli, 2021). Compared to languages, Mathematics is more defined and sequential (Stodolsky & Grossman, 2000), and knowledge is formed more gradually (i.e., basic knowledge acquired at the beginning is slowly expanded; Dweck, 1986). Differences in content also determine classroom discourse: For example, teacher questions in classroom discourse are either nonsubject specific (e.g., “Can anyone repeat what *A* said in their own words?”) or subject specific (e.g., “What would happen if we used y instead of x?” in Mathematics; “What

would have happened if A had done y instead of x?" in History; Pauli & Reusser, 2018). However, not only the questions but also the entire discourse can vary from subject to subject: Students find that discussions in Science are based more on facts and less on opinions, while discussions in Languages are more open (Heitmann et al., 2017).

These differences in content and discussion have implications for making and dealing with errors (Spychiger et al., 1999). First, the nature of the errors differs across subjects. For example, errors are more clearly defined and visible in Mathematics and are more dependent on the teacher in German Language Arts (Steuer et al., 2021). Second, there are differences in how errors are handled. Tulis (2013) showed that Mathematics teachers are more likely to react negatively to errors and delegate error correction to peers. In addition to these differences between subjects, there are also parallels. For example, error culture is rated equally positively in Mathematics, English, and German Language Arts (Steuer et al., 2021).

Thus, there are several differences between the subjects in terms of learning content, discussion, and error culture. Therefore, since discussions are more open and errors are more dependent on the teacher, error culture could play a greater role in German Language Arts than in Mathematics. For students, it is rather unclear whether their answers are right or wrong. Therefore, the error culture becomes more of a condition for their participation.

3 Analysis Model and Research Questions

Heterogeneity can be seen as a challenge to effective teaching, both for educational research and for educational practice. On the one hand, heterogeneity is a challenge for educational research, because general statements often do not apply to all groups of students and in all contexts. Therefore, Begrich et al. (2023) called for a focus on differential effects of teaching instead of analyzing effectiveness across the whole class. On the other hand, heterogeneity can also be seen as a challenge for educational practice. Specific statements are necessary because the situations teachers face are also specific. Comparative analyses of different student groups and contexts can show educational practice which factors to focus on in certain teaching situations and thus provide teachers with information on how to adapt lessons on the basis of empirical evidence (Begrich et al., 2023).

This dissertation provides these required comparative analyses and examines the role of student characteristics (migration background, competence level) and contexts (country, school subject) in feedback situations in order to derive statements about generalizability. These results have added value for researchers as they extend frameworks of teacher support on the role of specific student and contextual characteristics. Furthermore, researchers can use the results to gain information concerning which student and context characteristics they should emphasize when developing future studies (study design and sample). In addition, the results are important for practitioners so that they can gain insights into how to design effective teaching in specific classroom situations.

In order to sort the analyses of this dissertation, a new model that relates the investigated variables to each other is developed (see Figure 4).

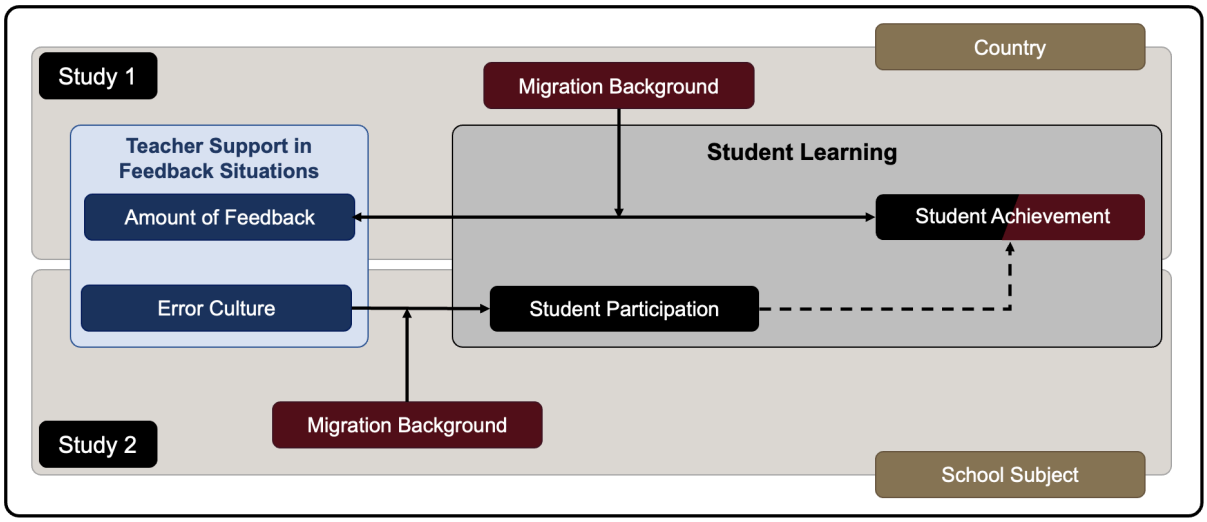

Figure 4: Analysis model of the dissertation. To illustrate the dual role of student achievement as an outcome and a predictor, the field is marked in black and red. Although the relationship between student participation and student achievement has been empirically demonstrated, it has not been examined in this dissertation (dashed arrow in the model).

In Figure 4, the blue box on the left describes *teacher support in feedback situations* (the offer, as defined by Vieluf et al., 2020). Based on previous models of teacher support and feedback (Hattie & Timperley, 2007; Kunter & Voss, 2011; Narciss & Alemdag, 2024; Pianta & Hamre, 2009), this dissertation distinguishes between error culture and the amount of feedback. Error culture focuses on the social situation in the classroom in the case of negative feedback (Kunter & Voss, 2011; Pianta & Hamre, 2009; Steuer et al., 2013). In contrast, the amount of feedback summarizes positive and negative feedback and includes the emotional and instructional aspects of feedback (Hattie & Timperley, 2007). Investigating teacher support in feedback situations by looking at the amount of feedback and the error culture allows a holistic view of feedback situations.

The gray box on the right describes *student learning* (the use and student outcome as defined by Vieluf et al., 2020). To operationalize learning, this dissertation looks at both student participation in classroom discourse, as a predictor of student achievement (Böheim et al., 2020; Sedova et al., 2019), and student achievement. Thus, we consider two important facets of the learning process by looking at learning from both the behavioral perspective (with student participation) and the cognitive perspective (with student achievement).

Based on the findings shown in Section 2, it can generally be assumed that there is a relationship between teacher support in feedback situations and student learning. Nevertheless, existing models of effective teaching suggest that this relationship varies across students and contexts (e.g., Narciss & Alemdag, 2024; Vieluf et al., 2020). Following on from research on aptitude-treatment interactions (Cronbach & Snow, 1977), student characteristics (i.e., migration background, student achievement operationalized by the competence level; red boxes in Figure 4) and context (i.e., country, subject; brown boxes in Figure 4) may be meaningful in feedback situations. Previously found differences between students with and without migration backgrounds (e.g., lower socioeconomic status, different home language, less parental support; Göbel et al., 2011; Mang et al., 2023) suggest that the role of teacher support for student learning also differs for students with and without migration backgrounds. Furthermore, various studies suggest that teacher–student interactions differ among students with different competence levels (Bouton et al., 2025; Lipowsky et al., 2007). Regarding the context (brown boxes in Figure 3), previous studies have shown differences between *countries* (e.g., in terms of culture; De Luque & Sommer, 2000; Heine et al., 2001) and school *subjects* (e.g., in terms of subject type, error handling and classroom discourse; Reusser & Pauli, 2021; Spychiger et al., 1999).

Building on this analytical model, this dissertation addresses three key research gaps: the theoretical description of feedback situations (Research Gap 1), the empirical examination of the relationship between teacher support and student learning in feedback situations (Research Gap 2), and the role of heterogeneity in feedback situations (Research Gap 3). First, this dissertation integrates insights from various research fields, combining knowledge on teacher support (Klieme et al., 2006; Klieme et al., 2001; Kunter & Voss, 2011), feedback

(Hattie & Timperley, 2007), and error culture from educational psychology (Steuer et al., 2013) and subject didactics (Prediger & Wittmann, 2009; Reiss & Hammer, 2021) into a comprehensive theoretical model of feedback situations (Figure 1). By synthesizing perspectives from different disciplines, this integrative model enables a more precise analysis of the individual stages of feedback situations—both in the empirical studies of this dissertation and in future research.

Second, this dissertation empirically investigates the relationship between teacher support and student learning in feedback situations (Research Gap 2). Given the weak correlations between teaching and learning observed in previous studies (Praetorius et al., 2018), this research explores whether the same pattern applies to feedback situations. Prior findings have established the importance of error culture for student motivation (Fischer & Freund, 2023) and academic achievement (Steuer & Dresel, 2015, 2019; Steuer et al., 2013). Based on this, it is reasonable to assume that a positive relationship also exists between error culture and student participation in classroom discussions—a hypothesis tested in Study 2. The findings contribute to refining theoretical models on the relationship between teaching and learning (e.g., Vieluf et al., 2020). Additionally, the empirical examination of the relationship between error culture and student participation offers valuable insights into the ongoing debate on the low proportion of explained variance in student behavior in the classroom (e.g., Parsons et al., 2018). Existing research indicates that student characteristics account for only a small fraction of this variance (Decristan et al., 2020; Pielmeier et al., 2018). Study 2 of this dissertation integrates student characteristics with their perceptions of classroom dynamics—specifically, error culture—and clarifies the role of these perceptions in shaping student participation in classroom discourse.

Third, it is unclear whether the relationship between error culture and student participation or between the amount of feedback and student achievement is equally strong for different groups and in different contexts (Research Gap 3). Existing theoretical models (e.g., Cronbach & Snow, 1977; Narciss & Alemdag, 2024; Vieluf et al., 2020) and empirical studies on differences between students with and without migration backgrounds (e.g., Göbel et al., 2011; Mang et al., 2023; Weis et al., 2018), students with different competence levels (e.g., Bouton et al., 2025; Lipowsky et al., 2007), subjects (e.g., Reusser & Pauli, 2021; Spychiger et al., 1999), and countries (e.g., De Luque & Sommer, 2000; Heine et al., 2001) suggest that the relationships vary. Specifically, Study 1 examined the role of migration background, student competence level, and country in the relationship between the amount of feedback and student achievement. Study 2 investigated whether the relationship between error culture and student participation can be generalized across students with migration backgrounds and across subjects. The comparative analyses in this dissertation include not only descriptive comparisons and moderator analyses, but also an integrative data analysis that allows, for example, for the first time to measure country difference and the role of the context.

To bridge the identified research gaps, this dissertation explores two research questions. The first research question is examined through Study 1, while the second research question is investigated in Study 2.

(1) How generalizable is the relationship between feedback and student achievement for different groups of students and countries?

a. What is the relationship between feedback and student achievement?
b. How do teachers distribute their feedback to students of different competence levels?
c. What role does migration background play in the relationship between feedback and student achievement?
d. What are the differences between the countries regarding the above questions?

(2) How generalizable is the relationship between error culture and student participation in classroom discourse for different groups of students and subjects?

a. How are error culture and migration background related to student participation in classroom discourse?
b. What role does students' migration background play in the relationship between error culture and student participation in classroom discourse?
c. What are the differences between the subjects regarding the above questions?

4 Overview of the Studies

4.1 Study 1

Munk, S., Ziernwald, L., Heine, J.-H., & Holzberger, D. (2024). How generalizable is the relationship between feedback and reading literacy across different competence levels, multilingual learners, and countries? A meta-analytic approach. *International Journal of Educational Research Open*, *7*, 100382. https://doi.org/10.1016/j.ijedro.2024.100382

4.1.1 Research Aims

Building on the divergent findings between experimental and nonexperimental studies on the relationship between feedback and achievement (Cai et al., 2023; Hattie, 2023; Kluger & Denisi, 1996; Ma et al., 2022; Ma et al., 2023; Wisniewski et al., 2020; Yan & Chiu, 2022), this study took a closer look at the relationship between feedback and reading literacy and analyzed the extent to which the relationship varies across students (migration background, competence levels) and countries in order to provide reasons for this weak relationship in non-experimental settings. If the correlations vary for different groups of students or in different contexts, the differences may cancel each other out and result in a low overall correlation.

First, the correlation between feedback and reading literacy were calculated. Second, whether students with different competence levels perceive that they receive the same amount of feedback was examined. Previous studies on teacher behavior have shown that teachers give different amounts of attention to students depending on their competence level (Decristan et al., 2020; Lipowsky et al., 2007; Sacher, 1995). Third, the role of migration background (here, language spoken at home) in the relationship between feedback and reading literacy was examined. Since students with migration backgrounds have more needs and tend to have fewer people around them who can provide feedback, it can be assumed that they benefit more from feedback than their peers who speak the same language at home and at school. To examine differences between countries, the analyses were calculated separately for each country and then integrated meta-analytically.

4.1.2 Methodology

This study used the PISA 2018 dataset with data from 505,906 students from 75 countries. In this study, feedback was assessed through the formative assessment scale as an assessment of students. The study used the meta-analytic approach of integrative data analysis (Brunner et al., 2022).

First, the research questions were computed separately for each country (correlations between feedback and reading literacy, mean of feedback received at each competence level, interaction coefficient describing the moderating role of home language on the relationship between feedback and reading literacy). The results were then meta-analytically integrated into random-effects models. This procedure allows for the measurement of heterogeneity across countries.

4.1.3 Main Results

First, the random-effects model, which combined data from 75 countries, revealed a slight negative overall correlation ($r = -.03$, $p < .05$) between perceived feedback and reading literacy. However, there were notable differences across countries. Second, the findings showed that perceived feedback varied among students with different competence levels. Students with the highest competence level (6: $M = 0.03$, $SE = 0.02$) and those at lower levels (1a: $M = 0.06$, $SE = 0.01$; 1b: $M = 0.05$, $SE = 0.02$) felt they received more feedback compared to other groups. In contrast, students with moderate competence (e.g., level 4: $M = -0.05$, $SE = 0.01$) and those at the lowest level (below 1c: $M = -0.11$, $SE = 0.04$) perceived less feedback on average. Third, across different countries, the regression coefficient for the interaction term was nearly zero ($\beta = 0.01$, $p < .05$), indicating no significant difference in the relationship between feedback and reading literacy for students who speak another language at home. Again, the results differed across the countries. Thus, the relationship between feedback and reading literacy varies across students with different competence levels and across countries but remains consistent for students with migration backgrounds.

4.2 Study 2

Munk, S., Holzberger, D., Böheim, R., & Seidel, T. (2025). Supportive teachers, active students: Is teacher support a promising key to engaging students with and without migration backgrounds? *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1347749

4.2.1 Research Aims

Error culture is important for key indicators of the learning process (Soncini et al., 2022), such as learning effort (Steuer et al., 2013). Therefore, this study examined whether the positive relationship between error culture and student participation in classroom discourse, a predictor of student achievement (Böheim et al., 2020; Sedova et al., 2019), also exists. It can be hypothesized that students who perceive a positive error culture will have less fear of negative reactions when they make an error. This reduced anxiety might lead them to participate more in classroom discourse.

Using the model of Narciss and Alemdag (2024) in which student characteristics are a central component of interactions in the context of error culture, this study examined differences between different student groups. It can be assumed that due to the different preconditions of students with migration backgrounds (e.g., lower achievement; Henschel et al., 2022; or language problems; Mang et al., 2023; see Section 2.3.1), making mistakes is more likely to be in the foreground for them (see Spychiger et al., 2006). Thus, they are more likely to participate in classroom discourse dependent on a positive error culture.

This study also examined whether the role of error culture varies across contexts (here, school subjects). Differences between the subjects Mathematics and German Language Arts

with regard to classroom discourse (Heitmann et al., 2017), types of errors (Steuer et al., 2021), and the way teachers deal with errors (Tulis, 2013) could cause a different meaning of error culture. Therefore, the results were calculated separately for Mathematics (M) and German Language Arts (GLA).

This study developed the current knowledge on error culture by taking up the distinction between student groups suggested in the model of Narciss and Alemdag (2024) and empirically investigating the generalizability of the role of error culture across students with and without migration backgrounds. Second, the comparative analyses also extended the field of research on students with migration backgrounds. The study examined the extent to which the differences in achievement between students with and without migration backgrounds can also be found in classroom discourse and whether error culture is key to eliminating these differences.

4.2.2 Methodology

This mixed-methods study analyzed data from 20 eighth-grade classes in German academic-track secondary schools (N = 387 [GLA] and N = 381 [M]). To operationalize student participation, coding of videos of 45-minute lessons in German Language Arts was used. Following Sacher (1995) and Decristan et al. (2020), a distinction was made between student-controlled participation (hand-raising, calling-in; SCP) and teacher-controlled participation (calling-on; TCP). For each student, the numbers of SCP and TCP per lesson in German Language Arts and Mathematics were summed. Error culture was assessed through students' perceptions in a questionnaire. The students were asked about both subjects separately. For example, they were asked to what extent they agreed with the statement "The teacher is patient when a student makes a mistake in GLA." The students' migration background and the covariates of course achievement, socioeconomic status, and gender were also assessed using the questionnaire.

Nested hierarchical linear models were calculated to analyze the role of error culture and migration background in student participation. Therefore, error culture, migration background, and covariates were the independent variables, and SCP and TCP were the dependent variables. The nested data structure was corrected, but no class-level analyses were calculated. To determine whether students with migration backgrounds benefit more from a positive error culture, moderator analyses were conducted. These included error culture, migration background, and the covariates, as well as the interaction term *error culture x migration background,* as independent variables, and SCP or TCP as dependent variables. Again, the density in the data through nesting in classes was considered. All analyses were conducted separately for German Language Arts and Mathematics.

4.2.3 Main Results

The assumption that error culture plays a role in student participation in classroom discourse was only partially confirmed. Only in GLA was a significant correlation found between error culture and SCP ($\beta = 0.15$, $p < .05$). However, the correlation between error culture and TCP in GLA did not reach significance ($\beta = 0.11$, $p = .070$). In Mathematics, there was no significant correlation between error culture and either form of student participation ($\beta_{SCP} = 0.05$, $p = .319$; $\beta_{TCP} = 0.08$, $p = .125$). Students' migration backgrounds did not play a role in student participation in classroom discourse in either subject or for either form of student participation (GLA: $\beta_{SCP} = 0.09$, $p = .089$; $\beta_{TCP} = -0.01$, $p = .837$; M: $\beta_{SCP} = 0.08$, $p = .150$; $\beta_{TCP} = 0.01$, $p = .841$). The hypothesis that students with migration backgrounds would benefit more from a positive error culture could not be confirmed in any subject or for any form of student participation. The interaction coefficients of *error culture x migration background* did not reach significance (GLA: $\beta_{SCP} = 0.02$, $p = .640$; $\beta_{TCP} = 0.05$, $p = .306$; M: $\beta_{SCP} = 0.07$, $p = .169$; $\beta_{TCP} = 0.05$, $p = .252$).

Therefore, the role of error culture in student participation was subject specific. In addition, there were no significant differences between students with and without migration backgrounds—they did not show different levels of student participation in classroom discourse, nor did they benefit differently from error culture.

5 Summary and Discussion of the Research Questions

The following section summarizes the answers to the research questions from both studies and discusses these detailed results. An overarching discussion from a broader perspective that situates the findings within ongoing discourses in research and practice, independent of the structure of the research questions, can be found in Section 6.

(1) How generalizable is the relationship between feedback and student achievement for different groups of students and countries?

a. What is the relationship between feedback and student achievement?

The results of this dissertation confirm a weak relationship between feedback and reading literacy, which has been identified in other studies (Ma et al., 2022; Yan & Chiu, 2022). This is consistent with the phenomenon that feedback shows a strong experimental effect but is significantly less related to achievement in nonexperimental settings. This underscores the need to examine the relationship in more detail by answering the remaining research questions.

b. How do teachers distribute their feedback to students of different competence levels?

We considered the distribution of feedback to learn more about the generalizability of feedback situations for students with different competence levels. The results show that high- and low-performing students report receiving significantly more feedback than average or very low-performing students. This is consistent with previous studies showing that teachers behave differently toward students with varying competence levels (Decristan et al., 2020; Sacher, 1995). Thus, in terms of the amount of feedback, feedback situations are not generalizable to students across different competence levels. The reasons for these differences in teacher behavior remain unclear. Future studies could explore this in interviews with teachers and determine whether these differences in feedback are conscious or unconscious.

c. What role does migration background play in the relationship between feedback and student achievement?

Although students who speak another language at home than at school have a greater need for and less supply of feedback (see Kieffer, 2010; Lee, 2005), the relationship between feedback and reading literacy is independent of the language spoken at home. Therefore, simply providing more feedback does not appear to be an appropriate option for supporting students with migration backgrounds. Perhaps this group of students needs specific feedback rather than more feedback (see Winstone et al., 2017). For example, they may appreciate less-public feedback and to not be exposed in front of the whole class (see Zeeb et al., 2022).

Future studies could investigate which types of feedback students with migration backgrounds value and benefit from most.

d. What are the differences between the countries regarding the above questions?

The results show that the relationship between feedback and reading literacy varies significantly across countries. Thus, feedback situations appear to have a strong country-specific component. Previous research on differences in teachers' beliefs and teaching styles (Cothran et al., 2005; Triandis, 2002) across different countries can be extended to feedback situations. Theoretical reasons, such as differences in teacher professional development programs (Blömeke et al., 2012; Darling-Hammond, 2017), could be causal. Future research could investigate the reasons for these differences in more detail and examine which national or education-system characteristics (e.g., in teacher professional development programs) are causal for the identified differences.

(2) How generalizable is the relationship between error culture and participation in classroom discourse for different groups of students and subjects?

a. How are error culture and migration background related to student participation in classroom discourse?

Puzzling results emerged when looking at the role of error culture in student participation: While error culture in German Language Arts plays a role in student participation, this significance was not evident in Mathematics (subject differences are discussed later). The positive role of error culture for students' achievement (Fischer & Freund, 2023; Steuer & Dresel, 2015) did not appear to be directly transferable to students' participation and was thus in line with unclear relationships between teaching and learning (e.g., Praetorius et al., 2018). Even if participation and achievement are related (Böheim et al., 2020; Sedova et al., 2019), and we assumed that the positive correlations of error culture and achievement (Fischer & Freund, 2023; Steuer & Dresel, 2015) also apply to error culture and participation, participation and achievement obviously have other predictors.

The role of migration background is more clear: Students' migration backgrounds do not seem to play a role in their participation in classroom discourse. This is a reassuring finding, especially with regard to teacher-controlled participation, as it means that compared to previous studies (Bonefeld & Dickhäuser, 2018; Gentrup et al., 2018; Lorenz & Gentrup, 2017; Tenenbaum & Ruck, 2007), no teacher bias can be found. Students with migration backgrounds appeared to be fully assimilated into the class. These findings thus contradict the findings of Decristan et al. (2020) and Lorenz and Gentrup (2017), who found lower participation among students with migration backgrounds, and underline the findings of Decristan et al. (2023) and Jansen et al. (2022), who found no differences between students with and without

migration backgrounds in terms of participation. The sample may have caused this mixed picture: While Decristan et al. (2020) and Lorenz and Gentrup (2017) examined first-year students in primary school, Decristan et al. (2023) and Jansen et al. (2022) mostly examined older students. This dissertation involved older students from academic-track secondary schools. Students attending these high-track schools perform particularly well (Diedrich et al., 2023; Heine et al., 2023; Kastorff et al., 2023). Accordingly, compared to students with migration backgrounds in other school types, students with migration backgrounds in academic-track secondary schools have a high level of important skills (e.g., cognitive, motivational-affective) that qualify them for this school type. Thus, differences between students with and without migration backgrounds may be smaller in these schools. Future studies should focus more on the differences between students with and without migration backgrounds in other types of schools.

b. What role does students' migration background play in the relationship between error culture and student participation in classroom discourse?

Again, we saw that students with migration backgrounds did not benefit more from a positive error culture than students without migration backgrounds. This is consistent with the findings of Tetzlaff et al. (2021), who pointed out that aptitude-treatment interactions are difficult to measure. While Seiz et al. (2016) found that students with migration backgrounds benefit more from teacher support, such findings for one facet of teacher support, error culture, are not shown here. Again, this may be due to the sample: Seiz et al. (2016) included older students, but also nonacademic secondary schools, and thus evaluated a broader range of achievement, while this study focused only on academic-track secondary schools. Therefore, a differentiated assessment of students with migration backgrounds could be promising for future research.

c. What are the differences between the subjects regarding the above questions?

As expected, the above results show differences between German Language Arts and Mathematics regarding the importance of error culture. Students pay significantly more attention to a positive error culture when deciding whether to participate in German Language Arts than in Mathematics. This finding is consistent with previously found differences in the nature of the subject (e.g., content is more strongly based on each other in Mathematics; Dweck, 1986; Stodolsky & Grossman, 2000), discussions (e.g., more open discussions in German Language Arts; Heitmann et al., 2017), types of errors (e.g., more clearly defined in Mathematics; Steuer et al., 2021), and ways of dealing with errors (e.g., more negative reactions to errors in Mathematics classes; Tulis, 2013). As theoretically hypothesized, these differences could be at the root of the differences found: Students in German Language Arts are less certain whether their answer is correct or not, and therefore make their participation more dependent on a positive error culture (see Steuer et al., 2021). Error culture should therefore also be considered as subject and context specific with regard to its relationship with participation

in classroom discourse. Future studies should therefore replicate the analyses with other subjects (e.g., History, foreign language) to further investigate the context specificity.

Interestingly, no differences in the role of migration background were found between German Language Arts and Mathematics. Both the finding that students with migration backgrounds do not participate more or less in classroom discourse and the finding that they do not benefit differently from a positive error culture can be generalized to both subjects. These findings contrast those of Henschel et al. (2022), who found subject-specific differences, at least for the achievement gap between students with and without migration backgrounds (i.e., a larger achievement gap in German Language Arts than in Mathematics). For student participation, however, the results suggest that this does not appear to be the case. The role of migration background in participation does not seem to vary across subjects.

6 Overarching Discussion

After presenting and discussing the results of the research questions, this section will take a broader view of ongoing discourses in research and practice and therefore departs from the structure of the research questions. First, the results are placed in the analysis model, and the central messages of this dissertation are derived. Then, the limitations and implications of these central messages for practice and research are identified.

The aim of this dissertation was to shed light on the heterogeneity in feedback situations and to develop statements about the generalizability of the findings across student groups and contexts using comparative analyses. Various theoretical models of effective teaching and feedback already take into account the role of student characteristics and context (e.g., Narciss & Alemdag, 2024; Vieluf et al., 2020). Using these models, this dissertation aims to empirically test the role of student characteristics (here, migration background and competence level) and context (here, country and subject). Figure 5 shows the analysis model including the results of this dissertation.

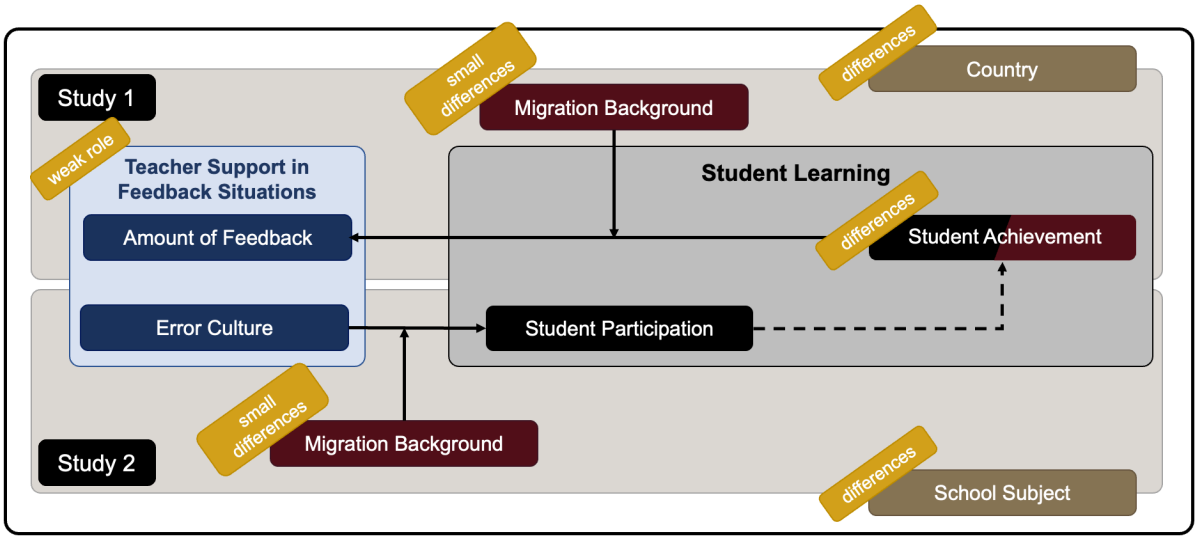

Figure 5: Analysis model including results of the dissertation

Figure 5 shows that the assumption that teacher support in feedback situations plays a role in student learning, both in terms of the error culture and the amount of feedback, was basically confirmed, even if the role is weak. Looking at the role of student characteristics and contexts, there are differences between students with different competence levels; however, there are hardly any differences between students with and without migration backgrounds. In contrast, as expected, context (i.e., country and subject) emerges as an important factor in feedback situations.

6.1 Weak Relationships Between Teacher Support in Feedback Situations and Student Learning

The results of this dissertation show that teacher support in feedback situations plays a role in the learning process. Nevertheless, only weak relationships can be found for students' participation in classroom discourse and their achievement (here, reading literacy). This result makes an important contribution to the debate on the weak correlation between teaching and learning (Praetorius et al., 2018) and confirm the pattern for feedback situations. A closer look at this relationship (e.g., in the TALIS video study; Grünkorn et al., 2020) shows that *students' use of the offer* is a likely mediating factor in the path from the teaching offer (e.g., teacher support) to student learning (e.g., motivation, achievement; see Figure 6).

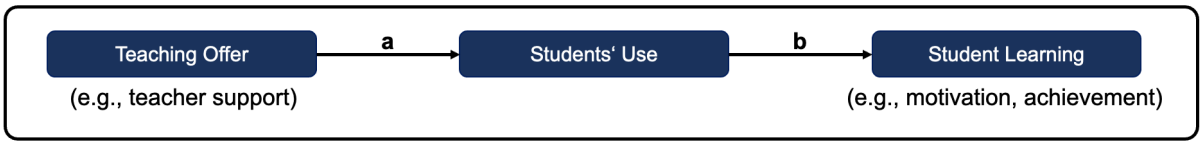

Figure 6: Path from teaching offer to student learning via students' use

Grünkorn et al. (2020) showed a correlation between students' use and learning outcomes (here, motivation, interest, and achievement; see **b** in Figure 6). At the same time, there seems to be little correlation between what is offered (e.g., teacher support) and how it is used (see **a** in Figure 6). This makes it clear that the pipeline between the teaching offer and student learning is leaking when it comes to students' use. Often, the offer is not used by the students. As a result, the offer cannot be meaningful for learning. Thus, the theoretically assumed potential of teacher support has not been empirically demonstrated. This underlines the need for improvement (Grünkorn et al., 2020).

6.1.1 Implications for Practice

Teacher support in feedback situations is important for student learning; however, according to the differences between the experimental and nonexperimental results, the full potential of teacher support in feedback situations has not been realized in practice. In terms of the steps of feedback situations in Figure 1, teacher feedback (step 2) does not always seem to elicit the desired response from students (step 4). So, what would teacher professional development programs fully exploiting the potential of feedback situations look like?

A promising approach could involve the development of video-based teacher professional development programs (e.g., Kiemer et al., 2015; Pehmer et al., 2015). Using the program structure by Kiemer et al. (2015) and Pehmer et al. (2015), teachers could first be presented with empirical findings on feedback situations in a kickoff session. They would then be given the opportunity to apply their newly acquired knowledge and film their lessons over several weeks. Excerpts from these videos could be discussed in a follow-up workshop with small groups of teachers who could reflect on their experiences together.

With this video-based approach, teachers could see which students they interact with and how often. This would provide teachers with an overview of teacher support in the form of giving feedback (step 2, Figure 1). Particularly in view of the findings of this dissertation—that teachers pay different amounts of attention to students (Bouton et al., 2025; Lipowsky et al., 2007)—it would seem helpful if teachers could observe, on video, this unequal behavior regarding their feedback, to sensitize them to it. In addition, teachers could see in detail how students react after receiving feedback (steps 3 and 4, Figure 1). Thus, the videos would provide a way for teachers to evaluate their own teaching behaviors and analyze their verbal and nonverbal microinteractions between with students.

This approach is also promising because it promotes teacher collaboration, an important building block for effective teacher professional development programs (Darling-Hammond et al., 2017; Gore et al., 2017; Krol et al., 2008). Since feedback situations and classroom heterogeneity affect all teachers, collaborative working methods offer a good opportunity to learn from each other and discuss difficulties. Based on the results of this dissertation, teachers could, for example, discuss in subject-specific groups how they deal with certain types of student error and provide adaptive feedback to all students. Sharing these best practice examples on a regular basis can provide a new impetus for feedback situations in one's own classroom.

6.1.2 Limitations and Implications for Research

Considering the result of this dissertation that teacher support in feedback situations is weakly related to student learning, the operationalization of the *teacher support in feedback situations* variable was one limitation. For example, the measure of error culture in the *Interaction* dataset was not taken immediately after the videotaped lesson, but at the end of the school year (Jurik et al., 2015). This means that the students' error culture assessments were based on many lessons, and specific features of the videotaped lesson may not have been captured. The correlations between student ratings and behavior could be significantly stronger if there were no time difference between observing and rating the behavior. Previous research has shown that, for example, teacher support is relatively stable (Praetorius et al., 2014) and is also rated as relatively stable by students over the course of a school year, regardless of the subject (Blanck, 2020). Thus, the time difference between the measurement of behavior and the assessment may have only a minor effect. However, to counteract this limitation, the time of the assessment in future studies should be close to the lesson so that the memory is fresh and focused only on the specific lesson, as was done in TALIS (Grünkorn et al., 2020).

In addition to the timing of the measurement, the focus of the items should also be mentioned as a limitation. For example, the formative assessment scale of the PISA dataset does not differentiate between different types of feedback (e.g., "feed-up", "feed-back", "feed-forward" according to Hattie & Timperley, 2007) or only includes teacher feedback and no other

important forms (e.g., peer feedback, Double et al., 2020; online feedback, Lv et al., 2021; van der Kleij et al., 2015). Because the type of feedback is critical to effectiveness (Wisniewski et al., 2020), comparative analyses that include various forms of feedback but analyze effectiveness separately are important. This dissertation encourages future research to take a differentiated look not only at the role of feedback situations (as in this dissertation) but also at the feedback situation itself.

To conclude, this dissertation advances research on feedback and effective teaching (e.g., Hattie & Timperley, 2007; Klieme et al., 2001) by addressing key gaps: describing feedback situations (Research Gap 1) and empirically examining their role in student learning (Research Gap 2). By introducing the integrative model of feedback situations (Figure 1), it provides a strong theoretical foundation for further empirical research in this area. The weak correlations between teacher support and student learning in feedback situations found in this dissertation should be further investigated in future research based on this model of feedback situations. For example, individual steps of the feedback situation can be manipulated in experimental settings to investigate their specific role on student learning.

6.2 Weak Role of Student Characteristics in Feedback Situations

Various models of effective teaching and feedback situations position student characteristics as an important factor influencing student learning (e.g., Narciss & Alemdag, 2024; Vieluf et al., 2020). With this theoretical background, it was assumed that students' competence levels and migration backgrounds also play an important role in teacher support in feedback situations. Interestingly, this assumption could only be partially confirmed.

As expected, students with different competence levels perceived different amounts of feedback. This result can be interpreted in two ways. On the one hand, teachers could simply overlook certain groups of students and thus deny them an important learning opportunity. On the other hand, the findings could also be interpreted as adaptive teaching. Teachers may focus on certain groups of students, assuming that others are making progress without their help. Which of the two interpretations is correct remains an open question that future research must clarify (see Section 6.2.2).

In addition, the results of this dissertation show that the student's migration background barely plays a role in feedback situations; therefore, having a migration background is not automatically a disadvantage. Although this dissertation found few differences in teacher–student interactions between students with and without migration backgrounds, the achievement gap remains. To reduce these differences regarding academic achievement, it is important to take a differentiated view of students with migration backgrounds: What type(s) of support do they need? Some benefit from language support, and others from financial support to participate in

extracurricular learning opportunities. Support must be tailored to the individual, as simply doing more of the same does not seem to lead to success.

This is consistent with the finding that teachers need special skills to adequately teach students with migration backgrounds, as seen in the adaptation of the model of teacher competence (Baumert & Kunter, 2006) by Hachfeld et al. (2012). Against the background of the four steps of teacher support in feedback situations, it is useful to focus first on the teacher's assessment of students with migration backgrounds (step 1, Figure 1). Numerous studies have shown that teachers have more difficulty in accurately assessing the performance of students with migration backgrounds compared to students without migration backgrounds (Bonefeld et al., 2020; Paleczek et al., 2017; Wagner, 2025). Therefore, inaccurate or unhelpful diagnosis could explain why students with migration backgrounds may not benefit more from feedback. Regarding the second step of teacher support in feedback situations (*giving feedback* in Figure 1), in particular, communicative skills such as adapting technical language (Auernheimer, 2013; Blossfeld et al., 2016) are necessary to adequately support students with migration backgrounds. Teacher professional development programs are needed to provide teachers with specific skills for diagnosing and providing feedback for students with migration backgrounds.

6.2.1 Implications for Practice

The results show that not all students participate equally in feedback situations. Therefore, it is important for teachers to create regular opportunities for feedback (see step 1, Figure 1). One way to do this is through learning portfolios (Donnelly, 2010; Kilbane & Milman, 2017), in which students document their learning process and write about what they have learned and how they feel about it. These portfolios can then be discussed with the teacher on a regular basis. This feedback focuses on the content learned (task level according to the four different focuses of feedback according to Hattie & Timperley, 2007) and enables the teacher to provide feedback on personal development (self-level), motivation (self-regulatory level), and planning of further steps in the learning process (process level). The fixed implementation in the daily teaching routine ensures constant awareness of feedback and regularity.

Based on the finding that more of the same is not enough to specifically support students with migration backgrounds, the question arises as to how teacher support in feedback situations especially for students with migration backgrounds should be designed. Given the difficulties teachers have in accurately diagnosing students with migration backgrounds (e.g., Wagner, 2025), teacher professional development programs should be used to sensitize teachers to possible biases in assessment and to assist them in overcoming these difficulties through support in defining clear diagnostic criteria.

With regard to giving feedback (step 2, Figure 1), teacher support must be designed to elicit the intended response from the student (step 3, Figure 1). One approach to protecting students from the intimidating social situation of negative feedback is to use the think-pair-share method (see Seifried et al., 2022). Students are first given a task to work on

independently (“think”), and then they discuss their results with a partner (“pair”) before presenting the results in a group (“share”). This approach is an example of how to implement a good error culture, as students may initially be reluctant to present to a group of their peers. The previous pairing phase allows them to first receive feedback and correct mistakes in a less intimidating collaborative setting. Then, it might be easier for them to present their results to the teacher and the rest of the class.

As mentioned in the steps of the feedback situation, teacher support in giving feedback also involves choosing appropriate forms of feedback (step 2, Figure 1). Beyond verbal forms (e.g., a one-on-one conversation or a comment in front of the whole class), automated forms of feedback can be used, which avoid the creation of intimidating social situations. In AI-based tutoring systems, students can enter their scores and receive feedback. Such AI-based tutoring systems are available for essay writing, for example (e.g., PEER; Seßler et al., 2023). Of course, this does not replace a teacher’s correction based on experience and human sensitivity. However, it can provide low-threshold and immediate feedback on an interim result. When the feedback comes from a computer, students do not have to wonder if the teacher is angry or if an error will have a negative impact on their grades. In line with several empirical studies that underline the effectiveness of computer-based feedback (Azevedo & Bernard, 1995; Lv et al., 2021), this approach may therefore be particularly appropriate for students with migration backgrounds.

Therefore, there are different ways to provide students with migration backgrounds with learning environments specifically tailored to their needs. This concept of adaptive teaching (i.e., adjusting the instruction to students’ individual prerequisites; Hardy et al., 2019) must be communicated in teacher professional development programs (see Blossfeld et al., 2016). These programs should be based on three steps of adaptive teaching: student need diagnosis, learning methods selection, and learning opportunity implementation (see Leiss & Tropper, 2014; Wagner, 2016). First, teachers should be trained to accurately identify the learning needs of students with migration backgrounds, for example by assessing whether an achievement gap is due to a lack of language skills. Second, teacher professional development programs should support teachers in choosing appropriate methods. By discussing the strengths, weaknesses, and possible uses of different teaching methods (e.g., think-pair-share) in teacher professional development programs, teachers can make informed choices about the methods they use in their classrooms. Third, teacher professional development programs should offer support to appropriately implement different teaching methods in a classroom with students with migration backgrounds. This can be achieved, for example, through role-playing in which teachers take on the role of students with migration backgrounds and check the teacher’s language for comprehensibility (see Leisen, 2021). All these variants of teacher professional development aim to help teachers put themselves in the role of students with migration backgrounds and thus acquire the necessary insights for teaching them (Auernheimer, 2013; Bender-Szymanski, 2021).

6.2.2 Limitations and Implications for Research

The finding that students with different competences perceive different amounts of teacher feedback should be treated with caution; this finding is based on student perception, which may be biased, for example, by teacher popularity (see Fauth et al., 2016). Therefore, as a first step, future research should employ objective observation (e.g., by independent raters) to clarify whether students' subjective perceptions reflect reality. If teachers do indeed give different amounts of feedback to students with different competence levels, the question of the reasons for this behavior remains. As noted above, teachers could provide different amounts of feedback unconsciously (e.g., by overlooking certain groups of students) or consciously (e.g., because they believe that certain groups of students need more feedback than others). The PISA 2018 data cannot be used to determine which of these two variants is true. This dissertation therefore encourages researcher to survey teachers to ask whether they are aware of this differential behavior and how they justify it.

Surprisingly, student characteristics were not found to be particularly important for teacher–student interactions in feedback situations. As seen in other studies (Decristan et al., 2020; Pielmeier et al., 2018), when attempting to predict behavior using student characteristics, much of the variance remains unexplained, suggesting that there are other factors that play a role in predicting teacher–student interactions. These include stressors outside of school (e.g., students' romantic relationships, stress with parents, physical changes during adolescence; Aramcost, 1989; Fernández-Baena et al., 2014; Hellström et al., 2024), group dynamics in the classroom (e.g., peer relationships or intergroup conflicts, Bempechat et al., 2022), and situational factors (e.g., whether a school assignment was written in the previous lesson). All these factors are so individualized that they are difficult to capture in a questionnaire. Qualitative analyses are particularly well suited to exploring the multiple reasons behind behavior (Kelle, 2006). Future study designs could start here and explore the reasons for interactions outside the classroom. For example, in interviews following a videotaped lesson, students and teachers can be shown clips of the lesson and asked why they acted the way they did in those situations. It is possible that this study design and the inclusion of situational factors can help explain more variance in teachers' and students' behaviors.

In summary, this dissertation addresses a key research gap by systematically comparing different student groups (Research Gap 3). Existing theoretical models that consider the role of student characteristics in the learning process (e.g., Vieluf et al., 2020) can be expanded based on the finding that these characteristics appear to play a minor role in feedback situations. This suggests that not every measurable difference between students is reflected in teacher–student interactions. Existing models, such as the supply–use model, should be adapted to specific teaching situations to identify the student characteristics that are most relevant in each situation. A „supply–use model for feedback situations" could help pinpoint the student characteristics that empirical research has shown to determine the use of feedback. For instance, prior studies indicate that factors such as self-concept (Ma et al., 2022),

motivation (Zhang et al., 2023), emotions (e.g., enjoyment of reading; Ma et al., 2023), and subject-related attitudes (Burns et al., 2019) play a more significant role in feedback situations than factors like migration background. Therefore, a refined „supply–use model for feedback situations“ could integrate the empirical findings of this dissertation and previous research by explicitly outlining relevant student characteristics. Additionally, visual elements such as shading could indicate the role of each characteristic in feedback situations. A strong foundation for this assessment of the role of specific student characteristics could be provided by research syntheses, as they draw on large datasets and enable direct comparisons of the role of different student characteristics (see Munk et al., 2023).

Furthermore, the results have important implications for the design of future research on feedback situations. Regarding sample composition, the presence or absence of students with migration backgrounds appears to be less significant, as feedback situations tend to be generalizable across students with and without migration backgrounds. Instead, greater emphasis should be placed on considering the context in future studies.

6.3 Important Role of Context in Feedback Situations

The results of this dissertation show major differences between countries and subjects. Effective teaching must therefore be seen as culture and subject specific. In practice, this means that teachers need to pay attention to different things in different subjects. This underlines the importance of subject didactics and subject-specific teacher development programs. Therefore, one implication for research is that context is not a sidenote in sample composition but an important building block for analyses. In the debate about whether effective teaching is subject specific or generic (e.g., Praetorius & Gräsel, 2021), the analyses in this dissertation strongly emphasize the subject-specific component underscoring the importance of including context in models of instructional quality (e.g., Vieluf et al., 2020). Thus, replication studies in other subjects and countries are necessary and desirable.

6.3.1 Implications for Practice

The finding that feedback situations are context specific has important implications for the design of teacher professional development programs. According to Narciss and Alemdag’s (2024) model, teachers should have knowledge about learners’ errors to handle errors effectively. Consequently, the content of teacher professional development programs on feedback situations should also address this knowledge to improve teacher support in feedback situations. The following Mathematics example explains knowledge about and for handling errors. Suppose a student writes the following equation (Figure 7):

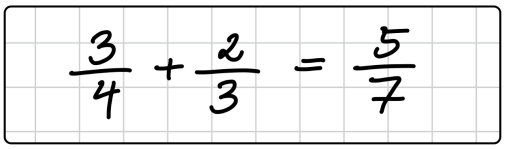

Figure 7: Typical student error in Mathematics

To deal competently with this student error, the teacher needs knowledge about the subject, subject-didactic knowledge, and pedagogical-psychological knowledge (see Baumert & Kunter, 2006). First, the teacher needs subject knowledge to recognize that this is an error (see "occasion for feedback" as step 1 of the feedback situation in Figure 1; Reiss & Hammer, 2021). In this case, the teacher must notice that the student has incorrectly and separately added the numerators and denominators instead of expanding the fractions to find the lowest common denominator. The teacher needs subject-didactic knowledge to identify commonalities in students' mistakes, derivate reasons, and use an appropriate strategy for dealing with these errors (Prediger & Wittmann, 2009; Reiss & Hammer, 2021). Here, for example, the teacher can take an enactive approach and use pizza slices to demonstrate fraction addition (see Reinhold, 2019). Finally, the teacher also needs pedagogical-psychological knowledge to recognize and account for the motivation and significance of the error in the learning process. According to the definition of error culture, teachers need to be sensitive to the situation of the error and its impact on the classroom atmosphere (see "peer reaction" [step 3] and "student reaction" [step 4] in Figure 1). For example, the teacher can decide, based on pedagogical-psychological knowledge, whether to deal with the error by correcting it immediately or by giving a tip (Santagata, 2005).

All these facets should be addressed in teacher professional development programs for feedback situations (Seifried et al., 2015). Since subject, subject-didactic, and pedagogical-psychological knowledge are often generated by different researchers, this dissertation encourages networking across disciplines. However, the results of this dissertation suggest that these three areas should be considered subject-specifically. Since typical student errors and possible strategies for dealing are vastly different across subjects (Seifried et al., 2010; Wuttke & Seifried, 2012), this dissertation calls on teacher educators to create subject-specific teacher professional development programs for feedback situations.

6.3.2 Limitations and Implications for Research

The results of this dissertation show that school country and subject are important components of feedback situations. Nevertheless, the analyses do not allow for the comparison of the importance of student characteristics and context, because the variables were never tested in the same models. Therefore, future research should examine the analysis model shown in Figure 3 (examining all student characteristics, contextual characteristics, behavioral outcomes, and achievement) in one analytical model and systematically compare the roles of the different factors. Such an analytic model could contribute to a holistic understanding of

classroom processes and pave the way of research from puzzling results from different empirical studies to a solid overview.

In summary, this dissertation's finding that context plays a crucial role in feedback situations helps to fill an important research gap (Research Gap 3). By applying innovative analytical methods, such as integrative data analysis, it is now possible to measure differences between countries for the first time. Based on these results, existing models of feedback and effective teaching (e.g., Hattie & Timperley, 2007; Narciss & Alemdag, 2024) should incorporate context as a key factor. Analogous to the supply–use model (Vieluf et al., 2020), different levels should be implemented (e.g. level 1: teacher–student interactions in the classroom, level 2: subject, level 3: country). Moreover, models that already consider student characteristics and contextual factors (e.g., Vieluf et al., 2020) can be further refined by emphasizing specific elements. For instance, the assumption of equal importance between student characteristics and context in the supply–use model should be reconsidered in light of this dissertation's findings.

Consequently, context should also be a central consideration in the design of future studies. Building on these insights, replication studies across different subjects appear both valuable and necessary. The subject in which the feedback situation takes place or the country from which a sample comes is not a sidenote, but should be carefully considered.

7 Strengths of the Dissertation and Conclusion

This dissertation addresses key research gaps by utilizing various types of data, including questionnaires, performance assessments, video data, smaller *Interaction* dataset, and a large-scale assessment. It employs innovative analytical approaches, such as integrative data analysis, to contribute both to theoretical model development and ongoing debates in educational research. In terms of theory building, this dissertation develops a model that integrates insights from different research fields, providing a strong foundation for the empirical study of feedback situations. Additionally, the empirical findings refine existing models of effective teaching by highlighting the crucial role of context and emphasizing its significance in feedback situations. Furthermore, the empirical findings contribute to ongoing debates in educational research. First, the study extends the discussion on the weak correlations between teaching and learning (e.g., Praetorius et al., 2018) by demonstrating that this pattern also applies to feedback situations. Second, it adds to the debate on the challenges of predicting student behavior, showing that students' perceptions of teaching do not significantly explain variations in their behavior.

In addition, teachers benefit from the results of the dissertation because they learn, for example, that students with migration backgrounds do not simply need more of the same, but rather special forms of support. Methods such as think-pair-share or automated feedback can be the first steps toward providing this student group—in a sense of adaptive teaching—with learning situations that are tailored to their needs. Teacher educators can also learn from the results of this dissertation and develop subject-specific formats that teach all forms of knowledge (subject-specific, subject-didactic, and pedagogical-psychological) that are necessary for competent handling of feedback situations.

Teaching has many faces—and this dissertation has looked at some of these. Interestingly, not all investigated facets of heterogeneity are equally salient in feedback situations. Aspects of context seem to be more important than, for example, the role of migration background. There is no doubt that heterogeneity is a challenge for educational practice and research; as this dissertation shows, it always requires a change of perspective, new teaching methods, and professional development for teachers (Blossfeld et al., 2016; Lipowsky & Lotz, 2015; Vock & Gronostaj, 2017). However, despite all these difficulties in everyday life, we must not forget that heterogeneity is also, or perhaps especially, an enrichment. Working together at school on a common problem from different perspectives is good practice for later life. Heterogeneity is therefore both a challenge and an opportunity (see Corno, 2008; Pevec & Schachner, 2020). Therefore, this dissertation is not intended to be the end of the debate on heterogeneity, but rather the beginning of a search for ways to deal with it.

8 References

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9 Declaration of AI Usage

According to the Artificial Intelligence Assessment Scale (https://open-publishing.org/journals/index.php/jutlp/article/view/810), AI was used in this dissertation in the following ways:

- **Level 4 (AI task completion, human evaluation)**
  The R code to generate the table in the Supplementary Material of Study 1 and suggestions for the literature search were generated using ChatGPT and then critically reviewed by the author.

- **Level 3 (AI-assisted editing)**
  The manuscripts were linguistically edited using DeepL, Grammarly, Copilot, and ChatGPT, whereby no new content was generated. All changes suggested by the AI were critically reviewed by the author.

- **Level 2 (AI-assisted idea generation and structuring)**
  ChatGPT was used to generate suggestions for the structure of the manuscripts and to brainstorm on related topics. Again, the generated material was reviewed and critiqued by the author.

- **Level 1 (no AI)**
  All further steps (in particular the writing of the manuscript and the generation of R-codes) were completed without the use of artificial intelligence.

Appendix

Appendix A – Study 1

Munk, S., Ziernwald, L., Heine, J.-H., & Holzberger, D. (2024). How generalizable is the relationship between feedback and reading literacy across different competence levels, multilingual learners, and countries? A meta-analytic approach. *International Journal of Educational Research Open*, *7*, 100382. https://doi.org/10.1016/j.ijedro.2024.100382

Simon Munk took the lead in the development and conception of the research project, the analysis, evaluation and interpretation of the data, and the drafting and revision of the manuscript (75%). The other coauthors, Lisa Ziernwald, Jörg-Henrik Heine, and Doris Holzberger, supervised the project (DH), provided feedback on the concept and manuscript (LZ, JHH, DH), and assisted in the conduct of the analyses (JHH). Co-authorship contributions are 10% (LZ), 10% (DH), and 5% (JHH).

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How generalizable is the relationship between feedback and reading literacy across different competence levels, multilingual learners, and countries? A meta-analytic approach

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ABSTRACT

Contrary to theoretical assumptions, only weak relationships have emerged between feedback and reading literacy in non-experimental settings. Our study contributes to a better understanding of those weak relationships by shedding light on generalizability across specific student groups (different competence levels, multilingual learners) and contexts (countries). Using a meta-analytic approach, we analyzed the PISA 2018 dataset with data from 505,906 students from 75 countries. Our results indicate a weak overall relationship between feedback and reading literacy, an uneven distribution of feedback across competence levels, and heterogeneity across countries. In contrast, multilingual learners do not profit differently from feedback compared to their monolingual peers. Future research should focus on the mechanisms behind these differences.

1. Introduction

Reading literacy combines various skills, such as "understanding, using, evaluating, reflecting on and engaging with texts" (OECD, 2019, p. 15). It can be seen as a door opener to education (OECD, 2019) that is related to language skills (Droop & Verhoeven, 2003; Gottardo & Mueller, 2009; Verhoeven & van Leeuwe, 2012) and fosters knowledge acquisition (Becker-Mrotzek et al., 2019) and social participation (Graham & Perin, 2007). Despite the importance of reading, international large-scale assessments such as the PISA study show that many students have low reading literacy (OECD, 2019). Multilingual learners (i.e., students who speak different languages at home than at school) are especially at risk of lower reading literacy (Yan & Chiu, 2022). Consequently, students who speak different languages at home than at school may especially depend on support from the teacher, since multilingual learners may receive less support from their parents in the teaching language (Göbel et al., 2011). A particularly helpful form of support for improving reading literacy, not only for multilingual learners, is feedback (Hattie, 2023).

Comparing two groups of students in an experiment reveals that the group receiving more feedback (experimental group) outperforms the group receiving less feedback (control group) in terms of student achievement and motivation (e.g., Wisniewski et al., 2020). Non-experimental settings, on the other hand, study students without artificially manipulating the amount of feedback. They ask retrospectively how much feedback students received in the real classroom and examine learning outcomes. These non-experimental studies show that students who receive more feedback in the real classroom do not automatically have better reading skills (Ma et al., 2022; Yan & Chiu, 2022). One reason for the weak relationship may be that the relationship is not be generalizable across students or contexts. Instead, the question of whether feedback can promote students' reading literacy may depend on different student characteristics (i.e., competence level of reading literacy, language at home; Decristan et al., 2020; Lipowsky et al., 2007) or contexts (i.e., countries; Heine et al., 2001; Yan et al., 2021).

This article, therefore, contributes to a better understanding of the weak relationship in non-experimental settings, and sheds light on the generalizability of the relationship between feedback and reading literacy. For this, we considered the distribution of feedback across students using the PISA 2018 dataset. In addition, we analyzed whether multilingual learners benefit differently from teacher feedback, as well as differences across countries. We first investigated all research

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questions separately for the different countries included, and then used a meta-analytic approach to integrate findings across countries (Brunner et al., 2022).

2. Theoretical background

2.1. Feedback as an important predictor of reading literacy

Since reading literacy is also a central skill for other subjects (see Becker-Mrotzek et al., 2019), feedback is especially crucial here. Feedback in the school context is the transmission of information regarding performance and goals from an agent (e.g., teacher, peer, parent) to the student in order to close the gap between the current and a target state (Hattie & Timperley, 2007). To bridge this gap, feedback can have four different foci: task, self-regulation, processing, and self as a person (Hattie & Timperley, 2007). If the focus is on the task, the student receives feedback on whether an answer is correct or not (e.g., *In your summary, the first paragraph of the text is missing.*). Feedback with a focus on self-regulation gives a hint about strategies that the student can use to achieve the set goals (e.g., *Check if you mention all key statements of the text in your summary by marking the most important parts in both texts.*). Feedback can also focus on the process level. Here the student receives concrete information on which strategies he or she can use to improve a task (e.g., *You can improve your summary if you use shorter sentences more often.*). Furthermore, feedback can also be given at the self-level: Here the student receives information about his or her abilities without reference to a task (e.g., *You are smart.*). Regardless of the focus, it is crucial that feedback provides students with information about the next steps (Hattie & Timperley, 2007). In our study, we ask for feedback on all four foci globally, but especially on this forward aspect of feedback.

Teacher feedback with different foci can be important for reading literacy by (1) helping to correct errors, (2) facilitating the planning of the learning process, and (3) motivating. First, feedback that focuses on the task is useful for error correction (Hattie & Gan, 2011; Hattie & Timperley, 2007). For example, students may misunderstand a text or overread relevant passages, making later texts challenging. Highlighting this to students at an early stage can enhance the efficiency of the learning process (Evans, 2013). Second, feedback (especially with a focus on self-regulation) facilitates the planning of the learning process (Ramaprasad, 1983). With the teacher's help, a long text or large task can be broken down into small, quickly achievable goals (Hattie & Timperley, 2007). Teachers can help students understand a text by explaining what steps are important in writing a summary (e.g., skimming text, highlighting important parts of the text), helping achieve their goals and improve their performance. Third, studies have shown that feedback motivates by enhancing reading joy (Ma et al., 2023) and positively changes students' assessments of their own abilities (Chi et al., 2021). This, for example, allows students to have more confidence and to read longer texts.

However, empirical findings that examine the overall relationship between feedback and learning outcomes only partially confirmed these reasons for the positive effect of feedback: Subject-unspecific experimental findings often showed a strong effect of feedback on learning outcomes. A series of meta-analyses that aggregated experimental findings independent of the subject under investigation found medium to strong effects of feedback on student learning (0.41, Kluger & Denisi, 1996; 0.48, Wisniewski et al., 2020). That is, student learning improves when students receive feedback, compared to when students do not receive such feedback.

On the other hand, with a specific focus on reading, several analyses conducted, for example, on the PISA 2018 dataset, indicated no or small relationships between feedback and reading literacy. Cai et al. (2023) found no significant correlation between feedback and reading literacy in the Hong Kong sample. Ma et al. (2022) looked at eight countries and found an overall correlation of $r = .03$ between feedback and reading literacy. For 75 countries combined, Ma et al. (2023) found that feedback had a small positive effect on reading literacy.

Aiming at explaining the weak relationship between feedback and learning outcomes previous meta-analyses have shown that the form of feedback may be one explanation for heterogeneity in effect sizes. For example, feedback that is linked to learning goals (Hattie, 2023), that is not overly specific (Kluger & Denisi, 1996), but that provides a lot of information (Wisniewski et al., 2020), seems to be supportive for students learning. In contrast, it may be reasonable that feedback may not work similarly for students with different characteristics or in different school contexts. With regard to student characteristics, on the one hand, it would be conceivable that teachers do not distribute their feedback equally across different competence levels, and on the other hand, the relationship between feedback and reading literacy could be different depending on students' home languages. Finally, the context (here, country) might be important as well. If the correlations differ greatly between the countries, they could also balance each other out.

Hence, our study aims to investigate potential variations in the distribution of feedback across different levels of competence (Chapter 2.2), the varying role of feedback based on home language (Chapter 2.3), and potential discrepancies among countries (Chapter 2.4). By examining these factors, we contribute to the discussion about the generalizability of the relationship between feedback and reading literacy across student characteristics and contexts, and intend to draw conclusions regarding whether these aspects account for the weak relationships observed between feedback and reading literacy.

2.2. Distribution of feedback across different competence levels

One possible reason for the weak relationship between feedback and reading literacy in the field could be an unequal distribution of feedback among students. It is well known that teachers do not treat students equally in the classroom: For example, they interact more frequently with high-performing students compared to low-performing students (Decristan et al., 2020; Jurik et al., 2013; Lipowsky et al., 2007). The reason for this could be that teachers think that they can make more progress in the classroom with the (correct) answers of high-performers (Decristan et al., 2020). Furthermore, Sacher (1995) showed that teachers pay more attention to low-performers when they call on students who did not raise their hands, perhaps because they want to explicitly include this group to ensure that they do not lose out.

These mechanisms could also be relevant for providing feedback. For example, teachers may be more likely to give feedback to high-performing students, since confirming is often easier and faster than understanding an incorrect solution and correcting a mistake (see Oser & Spychiger, 2005). At the same time, teachers might see more potential for feedback in low-performing students and, thus give feedback to this group of students more often. Therefore, as an indicator for the distribution, we examined whether students with different competence levels perceive different amounts of feedback.

2.3. Special relevance of feedback for multilingual learners

In addition to the different competence levels of students, feedback on reading tasks may be particularly important for multilingual learners. Given the multiple definitions for multilingual learners (overview in Busse & Hardy, 2023), in the present study we defined multilingual learners as students who do not predominantly speak the teaching language at home. The fact that family members often speak a different language than the teaching language may have consequences on students reading literacy: Multilingual learners have fewer people in their environment who can support them if they need help with the teaching language or who can give them spontaneous feedback regarding their language skills (Göbel et al., 2011). Second, multilingual learners have less practice speaking the language and thus often have lower oral expression skills (Droop & Verhoeven, 2003). Since oral expression skills are related to reading literacy (Droop & Verhoeven, 2003; Gottardo &

Mueller, 2009; Verhoeven & van Leeuwe, 2012), the lower expression skills are one reason for multilingual learners' lower scores in reading literacy (Kieffer, 2010; Lesaux & Kieffer, 2010; Yan & Chiu, 2022). In addition, multilingual learners can get into a vicious cycle (Wang & MacIntyre, 2021). Lower performance makes them anxious to talk and leads to stress. This extra burden leads to even worse performance regarding their oral expression skills and, in turn, their reading literacy.

Looking at these two characteristics of multilingual learners (family environment and lower reading literacy), multilingual learners might benefit more from teacher feedback based on two arguments. First, multilingual learners have a higher need for teacher feedback because their performance is, on average, lower. Therefore, they need more help with error correction and need to plan a longer learning process toward adequate performance. In addition, they may need more overview of what further steps in the learning process would be possible, and more urgently need confirmation and encouragement. Second, there are fewer people in their environment who can give them adequate feedback since fewer people speak the language at a sufficient level. Thus, multilingual learners also have less supply of helpful feedback. This double disadvantage makes teacher feedback especially crucial for multilingual learners.

Empirical results confirm these assumptions. Even if multilingual learners do not perceive feedback differently (Eryilmaz & Sandoval-Hernández, 2021; Müller et al., 2023), experimental findings showed that their writing skills benefit more from feedback compared to their monolingual peers (Biber et al., 2011). It remains unclear whether this is also true for reading literacy and in non-experimental settings. Building on existing findings that consider student characteristics as mediators (e.g., Ma et al., 2023) to unravel the relationship between feedback and reading literacy, we shed light on the generalizability of the relationship and the extent to which a student characteristic (here: home language) determines the role of feedback in reading literacy.

2.4. The situation in different countries

To further test the generalizability of our results, we also considered differences in relationships across countries. This is important because feedback and home language may have different meanings in different countries. First, feedback processes differ across countries (De Luque & Sommer, 2000; Heine et al., 2001; Hwang & Francesco, 2010; Suhoyo et al., 2014). Previous studies underlined differences between countries regarding students seeking feedback (De Luque & Sommer, 2000; Hwang & Francesco, 2010) and giving and receiving feedback (Yan et al., 2021). For example, Heine et al. (2001) showed that Japanese students are more sensitive and responsive to failure feedback compared to Canadian students. In addition, the relationship between feedback and reading literacy in PISA 2018 was also studied separately for different countries: Previous studies descriptively compared the effects of feedback on reading literacy between 12 Western and Eastern countries (Yan et al., 2021), between eight collectivistic and individualistic countries (Ma et al., 2022), or considered 75 countries (Ma et al., 2023). Our study built on this by, for the first time, systematically measuring heterogeneity across countries.

Second, the role of the home language differs across countries. For example, while in Germany multilingualism is often associated with migration, the situation is different in countries with multiple national languages. Consequently, the proportions of multilingual learners and the role of the home languages differ between countries. Empirical studies have underlined the different roles of home language across countries by suggesting that the impact of home language on achievement depends strongly on the treatment of multilingual learners at school. As a result, the influence of the home language varies considerably across different countries (see Finch et al., 2021; Levels & Dronkers, 2008). Based on these differences across countries, we hypothesized that the role of multilingual learners in the relationship between feedback and reading literacy also varies across countries.

With a meta-analytic approach (Brunner et al., 2022), our study thus extends existing research by systematically measuring heterogeneity across countries. Different directional effects in different countries could balance each other out and explain the weak overall relationship between feedback and reading literacy. Our study thus provides clues as to whether the context (here, countries) may be a reason for the weak relationship between feedback and reading literacy.

3. The present study

Contrary to theoretical assumptions (see Hattie & Timperley, 2007) and findings from experimental settings (Hattie, 2023; Kluger & Denisi, 1996; Wisniewski et al., 2020), the relationship between feedback and reading literacy in non-experimental settings is weak (Cai et al., 2023; Ma et al., 2022, 2023; Yan & Chiu, 2022). These weak relationships could be due to the fact that different student groups or countries balance each other out. With our study, we contribute to the discussion about the generalizability of findings across student groups and countries and provide hints for reasons that are causal for the low correlations between feedback and reading literacy.

First, to examine the relationship between feedback and reading literacy in more detail below, as a first step we calculated the linear relationship between the two variables. Second, on the basis of previous findings (see Decristan et al., 2020; Lipowsky et al., 2007; Sacher, 1995) we assume that teachers distribute their feedback depending on students' reading literacy levels. As an indicator for this different distribution, we thus focus on the amount of perceived feedback of students with different reading literacy levels. Third, feedback might play a greater role for multilingual learners, as they have a higher need and less supply for feedback and might therefore benefit specifically from feedback (see Göbel et al., 2011; Kieffer, 2010; Müller et al., 2023). Therefore, we assume that multilingual learners profit more from feedback and investigate whether the relationship between feedback and reading literacy is generalizable to students with different home languages.

In particular, we examine the following research questions (RQs) with the PISA 2018 dataset, where feedback is measured by students' perceptions:

1. What is the linear relationship between perceived feedback and reading literacy?
2. Does perceived feedback differ for students with different reading literacy levels?
3. Does the relationship between perceived feedback and reading literacy differ for multilingual learners?

Given that the role of feedback and the home language differ across countries (e.g., Finch et al., 2021; Heine et al., 2001), we examine the research questions for each country individually, as well as aggregated across countries. Existing findings showed differences in the relationship between feedback and reading literacy across countries, but only descriptively compare results (Ma et al., 2022, 2023; Yan et al., 2021). Using a meta-analytic approach (Brunner et al., 2022), we measure heterogeneity in the relationship and thus derive a statement about generalizability across countries on a quantitative basis.

4. Methods

4.1. Sample

To investigate the research questions, we used data from the Programme for International Student Assessment (PISA), which examined 15-year-old students every three years in Reading, Mathematics, and Science. In addition to evaluating performance, the PISA assessment included collecting background data on teaching characteristics (e.g., teacher feedback) and students' home environment (e.g., home language) through a student questionnaire. The majority of PISA country

samples were structured using a two-stage sampling procedure. First, schools in which 15-year-old students could potentially be enrolled were selected, followed by a random sampling of students within those schools (OECD, 2019). To address the variations in selection probabilities among countries and schools resulting from the sampling method, survey weights (final student weights) and 80 accompanying replication weights for the correct estimation of standard errors are provided in the PISA database. These weights must be taken into consideration in all analyses (for more information about final student weights and replication weights see OECD, 2009).

The PISA 2018 dataset used in this study is publicly available and included data from 80 initially participating countries and regions (OECD, 2019). Spain and Vietnam were excluded from the present analysis due to the unavailability of valid measures for reading literacy in the database. This lack of data is attributed to their exclusion from the official OECD reporting on reading literacy (OECD, 2019). Canada, North Macedonia, and Lebanon were excluded from the present analysis since no measures for the feedback variable are available. In addition, we excluded the students in the remaining 75 countries who had missing values in one of the analysis variables. This procedure is appropriate because the proportion of missing values is low (missing value in feedback: 5.46 %; reading literacy: 0 %; home language: 2.08 %). The final sample consisted of 505,906 (50.35 % female) students.

The proportion of multilingual learners varied greatly between countries: the proportion of multilingual learners across countries was 16.72 %, with the lowest proportion in B-S-J-Z (Beijing, Shanghai, Jiangsu, and Zhejiang in China; 0.48 %) and the highest proportion in the Philippines (94.47 %). As already mentioned, this variation can be attributed to the diverse linguistic situations in different countries. Therefore, speaking language other than the teaching language at home does not necessarily imply migration experiences. Notably, 68.03 % of multilingual learners did not have a migration background, highlighting the distinction between home language and migration background, and cautioning against using these terms interchangeably. A detailed list of the investigated countries with the proportion of multilingual learners and languages spoken at home can be found in Table A.1 in the Appendix.

4.2. Measurements

Reading literacy. "PISA 2018 defined reading literacy as understanding, using, evaluating, reflecting on and engaging with texts in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society" (OECD, 2019, p. 15). The PISA assessment design utilized a balanced and adaptive booklet design, in which students were presented with a set of reading tasks based on this approach (OECD, 2023). Consequently, each student worked on a specific subset of tasks selected from the overall task pool. The students were given authentic reading scenarios (e.g., reading an internet forum) and were then asked to complete realistic tasks (e.g., evaluating the relevance of forum posts; further information on the tasks and examples in Becker-Mrotzek et al., 2019). To derive population estimators for reading literacy, student response data were scaled using a combined latent IRT model. This model estimated a posterior proficiency distribution, considering various sources of uncertainty in the data. From this posterior distribution, 10 plausible values, which represent reading literacy, were generated for every student (OECD, 2023). Each of the 10 plausible values are metric variables with values between 0.49 and 928.6. These 10 metric plausible values representing reading literacy were transformed into categorical variables (reading literacy levels) for RQ 2. In accordance with the OECD classification, each plausible value was assigned to one of nine competence levels (under 1c, 1c, 1b, 1a, 2, 3, 4, 5, 6), with 6 representing the highest competence level (OECD, 2009, 2023).

Perceived feedback. Students rated their perceived level of feedback on three items of the scale "formative assessment" (Bayer et al., 2016) with the question, *How often do these things happen in your <test language lessons>?* (ST104; OECD, 2017, p. 28). The items included were: *The teacher gives me feedback on my strengths in this subject; The teacher tells me in which areas I can still improve*; and *The teacher tells me how I can improve my performance*. Students responded on a four-point Likert scale ranging from 1 (*never* or *almost never*) to 4 (*every lesson* or *almost every lesson*). The reliability of this scale was satisfactory (Cronbach's $\alpha = .86$). The results of the confirmatory factor analysis confirmed that the three items have similar factor loadings and therefore can form a common scale. The correlations between the items ($r = .61$ - $.73$) and the items with the overall scale ($r = .80$ - $.93$) are also high. Individual participant scores for feedback were calculated on the basis of the scores for the items considering the final student weights, as well as all replication weights. Subsequently, these individual participant scores were standardized across senate-weighted OECD countries (OECD, 2023).

Home language. To identify multilingual learners, the home language was assessed using the item: *What language do you speak at home most of the time?* (ST022; OECD, 2017, p. 21). Students were provided with a list of the most common languages in their country, while they indicated the language spoken at home. The variable was recoded as follows: 0 = *home language corresponds to the test language*, 1 = *a different language is spoken at home (multilingual learners)*.

4.3. Analysis

Following the approach of integrative data analysis (Brunner et al., 2022), our analysis was divided into two steps. First, we performed the analyses within each country (country-level results). Second, we integrated these results into an overall picture (meta-analytic integration). We used R-Version 4.3.0 (R Core Team, 2023). The R code of our analysis and the appendix with additional tables are publicly available here: https://osf.io/dbxyw/.

4.3.1. Generating country-level results

Two preparations had to be made prior to the main analysis: First, the predictor variable perceived feedback was centered on the country means (centering within cluster; Enders & Tofighi, 2007) to generate a meaningful zero point (Cohen et al., 2003) while preserving country differences (see Brunner et al., 2022). Thus, if a student had a perceived feedback score of zero, his or her rating of perceived feedback would be the same as the average rating of students in his or her country. In the second data preparation step, we prepared the single country data as separate datasets. Specifically, we created a data object of class "BIFIEdata" for each country using the function "BIFIE.data()" from the R package BIFIEsurvey (BIFIE et al., 2022), which contained all the variables needed for our subsequent analyses. This procedure ensured that the distinctive characteristics of the PISA data, including the sampling methodology and test instrument design, were methodologically accounted for by utilizing the plausible values, final student weights, and replication weights.

To investigate the relationship between perceived feedback and reading literacy (RQ 1), we calculated Pearson correlation coefficients for every country separately, based on the data prepared as described above. For the distribution of feedback across different reading literacy levels (RQ 2), we subdivided the students of one country according to their reading literacy levels. This resulted in six groups (based on six reading literacy levels) for each of the 75 countries, leading to a total of 450 subgroups. For each of these 450 subgroups, we calculated their mean value of perceived feedback to compare the perceived feedback of each reading literacy level at country level. To determine the moderating role of the language spoken at home in the relationship between feedback and reading literacy (RQ 3), we first calculated a multiple regression at the country level. Perceived feedback, language spoken at home, and the interaction term of perceived feedback and home language were included in the model to predict reading literacy. However, only the interaction term was relevant to answer RQ 3. A positive

coefficient suggests that multilingual learners benefit more from perceived feedback, while a negative coefficient suggests that monolingual learners benefit more from perceived feedback.

4.3.2. Meta-analytic integration of the results

In a second step, we integrated the country-level results into an overall picture. For RQ 1, we used the correlations between feedback and reading literacy for meta-analytic integration. For RQ 2, we used the mean values of perceived feedback per reading literacy level, and for RQ 3, we used the standardized regression coefficients of the interaction term between perceived feedback and home language. To integrate the country-level results, we chose to employ random-effects models with the package *metafor* (Viechtbauer, 2010). We used random-effects models for two reasons: First, as stated above, between-country variation (e.g., cultural differences regarding feedback or the role of multilingual learners; e.g., Heine et al., 2001; Levels & Dronkers, 2008) was expected. Therefore, we chose random-effects models to account for both, within- and between-country variation (Borenstein et al., 2010; Dettori et al., 2022). Second, we use random-effects models to draw conclusions beyond the surveyed population to the situation worldwide (Brunner et al., 2022). The restricted maximum likelihood method was used to compute the random-effects models since it is considered unbiased and efficient and is therefore recommended (Viechtbauer, 2005).

To obtain information on the generalizability of our results, we examined the heterogeneity between the countries with *Q*-tests and the calculation of I^2. *Q*-tests showed whether the results of the countries differed significantly (Borenstein et al., 2009), while I^2 described the proportion of variance that remained if we could avoid the sampling error (Borenstein et al., 2017). If I^2 ranks below 40 %, heterogeneity might not be important; between 30 % and 60 %, heterogeneity is moderate; between 50 % and 90 %, heterogeneity is substantial; and between 75 % and 100 %, heterogeneity is considerable (Higgins & Thompson, 2002). We have presented the individual results of each country, along with the results of the random-effects models, using forest plots created with *metafor* (Viechtbauer, 2010). Fig. 2 was generated utilizing the package *ggplot2* (Wickham, 2016).

5. Results

5.1. Research question 1: Overall relationship between feedback and reading literacy

The random-effects model integrating the results of the 75 countries showed a small negative overall relationship ($r = -.03$, $p < .05$[c]) between perceived feedback and reading literacy. However, a significant *Q* test and a considerable proportion of variance ($I^2 = 96.51$ %) indicated significant variations across countries. Fig. 1 shows the forest plot of the results for the first research question concerning the relationship between the perceived frequency of feedback and reading literacy: Analyzing the correlations on a country-by-country basis, the correlations ranged from −.18 (Panama) to .13 (United Arab Emirates). In 49 countries, the correlation was negative (significant in 32 countries), while it was zero in one country and positive in the remaining 25 countries (significant in 12 countries).

5.2. Research question 2: Perceived feedback depending on reading literacy level

To gain more insights into the relationship between perceived feedback and reading literacy, we analyzed the perceived frequency of feedback on a descriptive level in order to investigate whether teachers distribute their feedback differently depending on student's reading literacy level. A positive value means that students at this competence level perceived more feedback than the average in their country. In the second step, these mean values for each country were integrated in a random-effects model, illustrated in Fig. 2.

The results for each reading literacy level and country level are shown in Table A.2 in the appendix. As with RQ 1, there was also great heterogeneity across the countries regarding perceived feedback for different reading literacy levels. Aggregated over all countries, the results showed that students from different reading literacy levels perceived a different amount of feedback: students of the highest competence level (6: $M = 0.03$, $SE = 0.02$) and students of two lower competence levels 1a and 1b (1a: $M = 0.06$, $SE = 0.01$; 1b: $M = 0.05$, $SE = 0.02$) perceived that they gain more feedback than the other groups. Conversely, students with moderate competence (e.g., competence level 4: $M = -0.05$, $SE = 0.01$) and students with the lowest competence level (under 1c: $M = -0.11$, $SE = 0.04$) perceived on average less feedback. Therefore, our results indicated an uneven distribution of perceived feedback across students at different competence levels.

5.3. Research question 3: Role of multilingual learners

Research question 3 explored whether the role of perceived feedback varies for multilingual learners. To investigate this, we analyzed whether home language was a moderator of the relationship between perceived feedback and reading literacy. As shown in Fig. 3, across countries, the regression coefficient for the interaction term was close to zero ($\beta = 0.01$, $p < .05$), indicating no different relationship between students' perceived frequency of feedback and reading literacy for multilingual learners. When considering the generalizability of the results across countries, a significant *Q*-test and $I^2 = 33.43$ % indicate heterogeneity. The interaction coefficients ranged from −0.10 (Morocco) to 0.09 (Philippines). A negative coefficient, indicating that monolingual learners benefit more, was observed in 24 countries (two of which are significant), while in 14 countries, the coefficient was zero, and a positive coefficient, indicating that multilingual learners benefit more, was observed in 37 countries (seven of which are significant).

6. Discussion

6.1. Weak overall relationship between feedback and reading literacy but large heterogeneity across countries (Research question 1)

The finding that the relationship between perceived feedback and reading literacy is weak underscores existing research in the field (e.g., Ma et al., 2022; Yan & Chiu, 2022), as it was also stably confirmed by the meta-analytic approach and a large amount of data. In addition, by measuring the heterogeneity across countries with a meta-analytic approach we extended previous research that compared the results of different countries descriptively (Ma et al., 2022, 2023; Yan et al., 2021). Since the results varied greatly between countries, there could be a reason for the weak overall relationship between feedback and reading literacy, as the results of different countries could balance each other out.

Two reasons could explain the differences between countries in our results: First, cultural differences in societies, and second, differences in teacher education. Regarding cultural differences between countries, Hofstede et al. (2010) established various indices that classify countries according to certain criteria (e.g., power distance, individualism vs. collectivism). Comparing our results with the categorization of countries according to Hofstede et al. (2010), the five countries with the strongest negative correlation (Panama, Israel, Croatia, Mexico, Argentina) all have a high uncertainty-avoidance index (Hofstede et al., 2010). Countries where this index is high are characterized by a strong desire for control and a low willingness for risk and uncertainty (Hofstede, 2011). It is possible that (e.g., negative) feedback from the teacher contributes to uncertainty about the further learning path if it does not

[c] The significance of the effect is primarily attributed to the large sample size and, therefore, not interpreted.

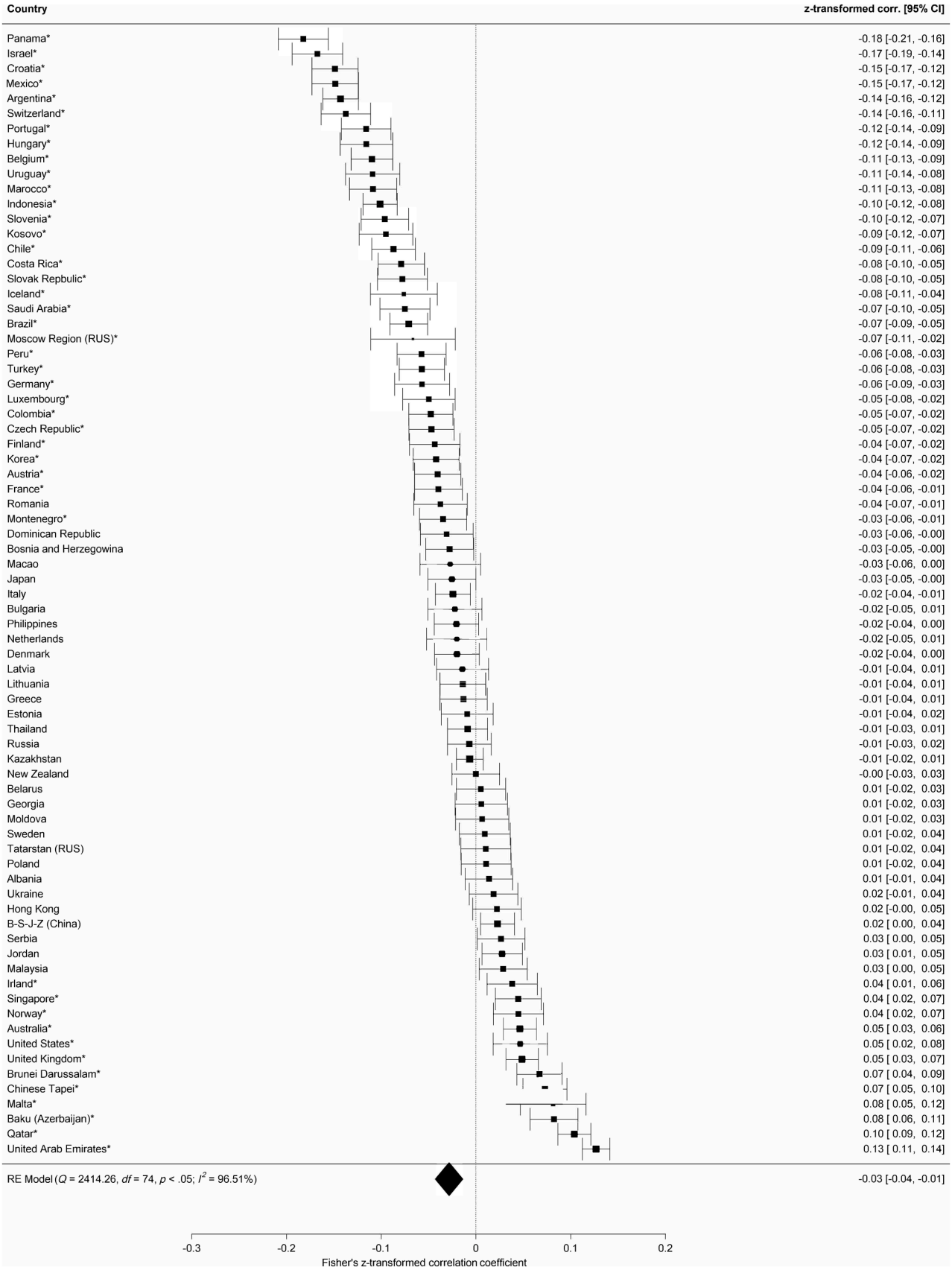

Fig. 1. Forest plot of the correlations between feedback and reading literacy (separately for each country and integrated in a random-effects model). *$p < .05$.

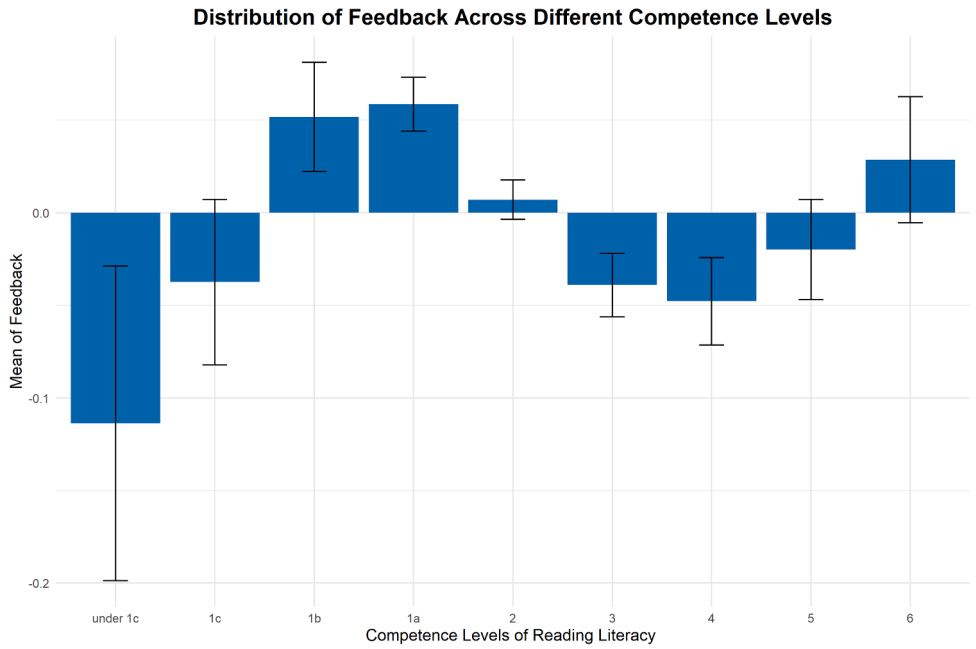

Fig. 2. Distribution of feedback across different competence levels ($N = 505{,}906$ students; 0.14 % under competence level 1c, 2.41 % in competence level 1c, 10.46 % in competence level 1b, 20.15 % in competence level 1a, 24.82 % in competence level 2, 22.03 % in competence level 3, 13.87 % in competence level 4, 5.15 % in competence level 5, and 0.95 % in competence level 6).

match the student's own view. This could lead to the finding that more feedback is associated with poorer performance in these countries.

In addition, differences between countries in the relationship between feedback and reading literacy could also be due to differences in teacher education. Countries differ in terms of recruitment, teaching standards, and teacher professional development (Biedermann & Oser, 2011; Blömeke, 2006; Darling-Hammond, 2017). If giving feedback is an essential part of teacher education in a country, the role of feedback on student achievement may also be stronger because the feedback is more supportive for learning. Further studies could compare the role of feedback practices in teacher education in different countries and thus find possible reasons for the country differences. Qualitative case studies that specifically compare, for example, a country with a high correlation and one with a low correlation between feedback and reading literacy, and describe teacher education with regard to feedback in both countries would be an interesting complementary study.

6.2. *Unequal distribution of feedback (Research question 2)*

Our results indicate that students perceive different amounts of feedback depending on their competence level: While high-performing and low-performing students perceived a high amount of feedback, very low-performing and average-performing students perceived less feedback. These findings extend existing research in two areas. First, since different competence level groups perceive different amounts of feedback, different student groups might balance each other out and mask the relationship between feedback and reading literacy. Second, this finding extends existing research on other teacher behaviors (e.g., teachers' gaze behavior, Seidel et al., 2020; calling-on in classroom discourse, Decristan et al., 2020; Sacher, 1995) by adding feedback as another teaching variable that is at least perceived to be distributed unequally.

However, this perceived unequal distribution does not necessarily imply failure. Numerous research syntheses have shown that addressing the different needs of students through differentiated instruction is effective for learning (Deunk et al., 2018; Smale-Jacobse et al., 2019; Ziernwald et al., 2022). For example, high-performing students may be given more open-ended, less structured assignments or less time to complete assignments (Tomlinson, 2001). The amount and form of feedback can also vary for students; helpful feedback for one student may not be helpful to another (Tomlinson, 2001). With this in mind, it seems logical that our results show a different distribution of feedback. Nevertheless, the reasons for this inequality in giving feedback remain unclear. Further research should therefore clarify whether teachers give feedback more often to high performers because it is easier for them to do so, or whether they believe that feedback to low-performers has particularly high potential from their point of view, and therefore they pay special attention to this group. Interviews with teachers about their motivations for giving feedback would be helpful to better understand the thought processes involved in giving feedback.

6.3. *No different relationship of feedback and reading literacy for multilingual learners (Research question 3)*

Regarding the role of multilingual learners, our results show a relatively consistent picture across PISA countries: Although multilingual learners may have a higher need and less supply for teacher feedback (see Kieffer, 2010; Lee, 2005), multilingual learners do not benefit differently from perceived feedback compared to monolingual learners. Moreover, it extends previous research on the relationship between feedback and reading literacy by indicating that the findings are generalizable across students with different home languages.

According to our results, the perceived teacher feedback does not seem to be a suitable key to cushion the lower reading literacy of multilingual learners. One reason for this could be that they need a specific type of feedback (see Winstone et al., 2017). For example, whether feedback is given publicly in front of the class or one-on-one might matter. Negative feedback in a public situation could be intimidating and could have an effect that is not conducive to learning (see Zeeb et al., 2022). Multilingual learners could therefore particularly benefit from computerized feedback (Azevedo & Bernard, 1995; Lv et al., 2021; van der Kleij et al., 2015), as this type of feedback does not involve an intimidating social situation. Therefore, further research should investigate in more detail which type of feedback is particularly appropriate for multilingual learners. Interview studies could specifically ask multilingual learners what kind and how much feedback they

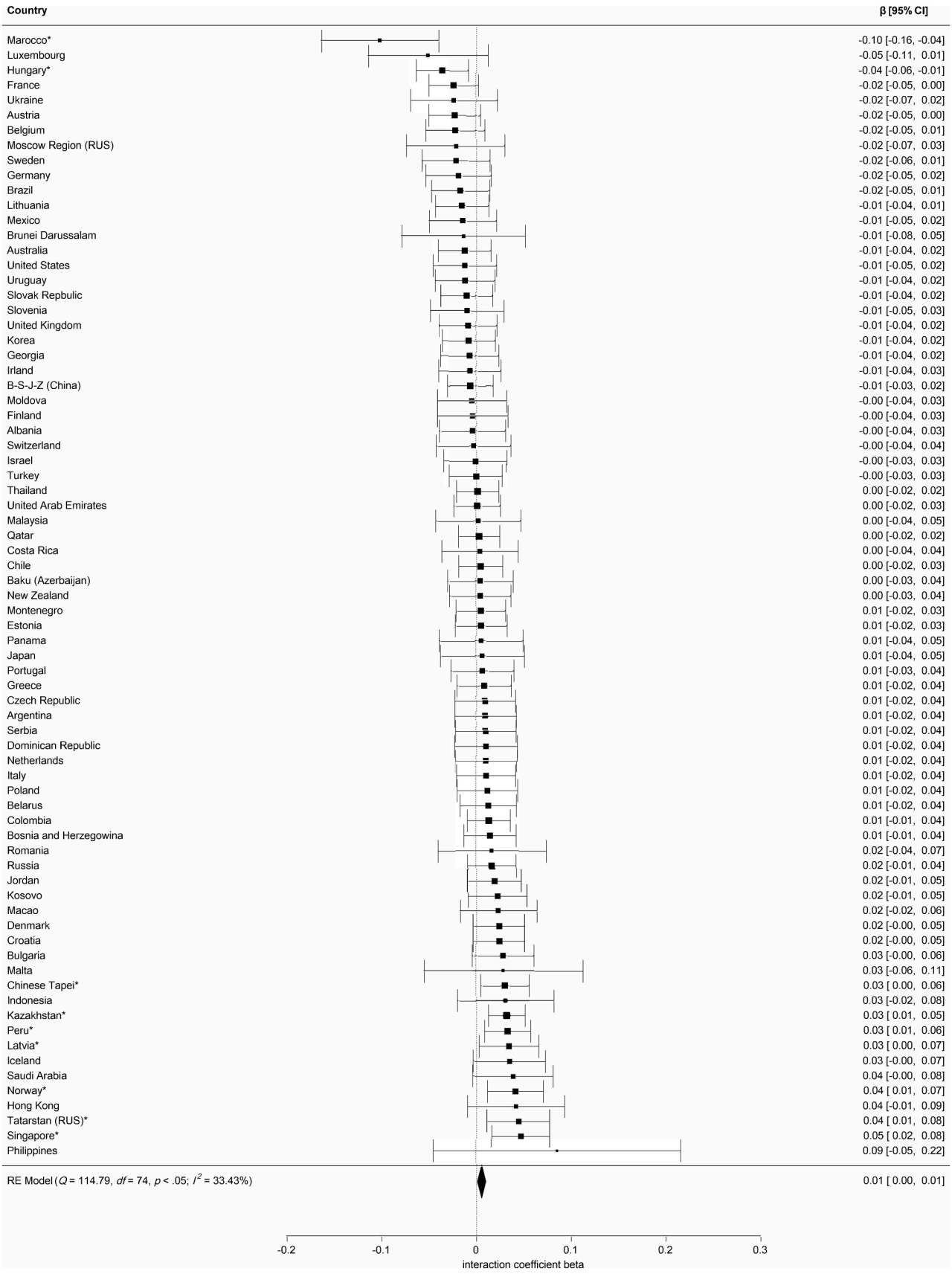

Fig. 3. Forest plot of the standardized interaction coefficients (separately for each country and integrated in a random-effects model). *$p < .05$.

would like to receive.

6.4. Implications for practice

Our findings of a weak overall relationship confirm that more perceived feedback does not automatically accompany better reading literacy (see Harris & Rosenthal, 1985). One reason why, contrary to theoretical assumptions, feedback is not related to better reading literacy might be that the quality of teacher feedback should be improved. Previous studies have underlined that the way in which feedback is delivered is crucial to its effectiveness. If feedback is too complex or detailed (Shute, 2008) or is given with a delay (van der Kleij et al., 2015), it loses its impact on student learning. With a mixture of theoretical input and practical trial phases, targeted interventions can foster the ability to provide feedback (Dekker-Groen et al., 2013; Fonseca et al., 2015; Schütze et al., 2017). In particular, training sessions in which teachers videotaped themselves giving feedback and then discussed these videos with colleagues have been effective (Hess & Lipowsky, 2019). Therefore, teachers should be specially trained to give feedback effectively so that clear effects become visible in the classroom.

As discussed, the uneven distribution of feedback need not be a problem, although all students should receive at least a minimum amount. Two approaches can help teachers: Feedback processes should be firmly established and visible. First, systematic opportunities for feedback can be implemented in everyday teaching, such as fixed times for short feedback meetings (voluntary or mandatory for students) or written assessments by the teacher that are implemented equally to all students. Competency grids (Merziger & Schnack, 2016), which list the learning objectives of a teaching unit, are a promising method in which each student is assessed at regular intervals on the competencies he or she has achieved. Second, feedback processes should be visible in order to get an overview of whether feedback is evenly distributed. Digital learning portfolios (see Donnelly, 2010; Kilbane & Milman, 2017), which also record verbal feedback, can be a way for teachers to ensure that no one is forgotten.

In addition, our results show that multilingual learners do not benefit differently from feedback than monolingual learners. As mentioned earlier, this could be due to a mismatch between the form of feedback and the students' needs (Winstone et al., 2017). These differences in the preferred form of feedback have two implications for teacher education. First, teachers should provide different types of feedback and observe or ask which feedback is desired and used by students. For example, Cen and Zhang (2024) showed that incorporating different forms of feedback (e.g., peer feedback, automated feedback, teacher feedback) is particularly beneficial for motivating multilingual learners compared to their peers. Second, teacher education should provide specific insights into cultural differences in giving and receiving feedback. Because of cultural characteristics of multilingual learners, they may want more or less teacher feedback than their peers (De Luque & Sommer, 2000). Students from an individualistic country, such as the United States or the United Kingdom, tend to prefer teacher feedback over peer feedback. Students from a collectivistic country, such as China or Singapore, on the other hand, prefer peer feedback (see Hofstede et al., 2010; Hwang & Francesco, 2010). To adapt the way teachers give feedback, knowledge about these cultural differences should be part of teacher education and professional development.

6.5. Limitations

Using the PISA dataset, we were able to generate substantial evidence regarding the generalizability of the relationship between feedback and reading literacy across diverse student groups and countries, leveraging a vast database. Nonetheless, our findings are accompanied by three main limitations. First, feedback is only captured globally in PISA 2018 (see Yan & Chiu, 2022). Several studies have suggested that the form of feedback matters (e.g., Biber et al., 2011). For example, feedback is more effective when it is explanatory, rather than simply telling you what is right and wrong (Biber et al., 2011; van der Kleij et al., 2015; Wisniewski et al., 2020). The scale used in PISA does not cover these facets of feedback and therefore does not allow for concrete conclusions about which forms of feedback are already implemented profitably. In addition, the scale only covers teacher feedback. Feedback from peers (Double et al., 2020) and self-assessments (Yan et al., 2022) could also be effective in enhancing reading literacy. However, these forms of feedback are not included in PISA 2018. Therefore, further research should investigate the relationship between these two forms of feedback (peer feedback and self-assessment) and reading literacy.

Second, feedback was operationalized as students' perceived feedback. It is possible that student perceptions were biased by other factors (e.g. teacher popularity; Fauth et al., 2016). However, van der Scheer et al. (2018), for example, showed high levels of agreement between students' perceptions and objective observations. In addition, the consideration of perceived feedback is also promising from a constructivist perspective: feedback can only be effective for learning if it is perceived by students. Following these arguments, we consider students' perceptions of feedback as a valid measure of feedback.

Third, with PISA's cross-sectional design, we could only shed light on a subset of feedback processes. When considering the relationship between feedback and reading literacy, we need to distinguish between two reciprocal processes: On the one hand, teachers can influence reading literacy by providing feedback. On the other hand, teachers distribute feedback according to students' competence levels. With the study design in PISA 2018, these processes are not separable. How effective feedback is and whether changes in performance can really be attributed to feedback can only be clarified with multiple measurement points. Therefore, we encourage further research to investigate the relationship between feedback and reading literacy using a longitudinal design.

6.6. Conclusion

Why is the relationship between feedback and performance so weak in non-experimental settings? The aim of our study was to contribute to a better understanding of these weak relationships. Our results suggested that an uneven distribution of feedback across competence levels and heterogeneity across countries may be two reasons for the weak relationship. Contrary to our assumptions, the language spoken at home did not determine the relationship.

Thus, even if we found weak correlations between feedback and reading literacy, the relationship was not generalizable across students with different competence levels and in different countries. Giving and receiving feedback is therefore an individual process. Models of feedback (e.g., Hattie & Timperley, 2007) should therefore describe not only the effectiveness of different forms of feedback, but also, in a more nuanced way, the effectiveness of different forms of feedback for particular groups of students and in particular contexts (see Cronbach & Snow, 1977). For example, Hattie and Timperley's (2007) model could be extended to include different levels (e.g., contexts such as school subjects or countries) and student characteristics (e.g., achievement levels), analogous to the supply-use model (e.g., Vieluf et al., 2020). This could lead to a model that better accounts for real-world contexts and can also explain effectiveness in non-experimental settings.

Declaration of AI usage

During the preparation of this work the authors used ChatGPT in order to create the Tables in the Appendix. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

Simon Munk: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Lisa Ziernwald:** Writing – review & editing, Conceptualization. **Jörg-Henrik Heine:** Formal analysis, Data curation. **Doris Holzberger:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijedro.2024.100382.

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Appendix B – Study 2

Munk, S., Holzberger, D., Böheim, R., & Seidel, T. (2025). Supportive teachers, active students: Is teacher support a promising key to engaging students with and without migration backgrounds? *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1347749

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Supportive teachers, active students: Is teacher support a promising key to engaging students with and without migration backgrounds?

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Students with and without migration backgrounds differ in terms of their achievement. One approach to reducing the gap between the two groups may be through equal participation in classroom discourse. Here, supportive teaching behavior can be particularly important for promoting student participation. Especially teacher support after a student has made a mistake, the so-called error culture in the classroom, could pave the way for students to become active participants. In this study, we analyzed whether error culture as a facet of teacher support could be a promising key to engaging students with and without migration backgrounds. To investigate the generalizability of the process across different subjects, we examined video data from 20 eighth-grade classrooms of academic-track secondary schools in both German Language Arts and Mathematics (N = 387 students). The results from nested hierarchical linear models indicate that error culture is related to student participation in German Language Arts but not in Mathematics. Interestingly, students with and without migration backgrounds did not differ in terms of their participation in classroom discourse. Furthermore, teachers' positive error culture supported students' participation irrespective of their migration background. Therefore, we encourage teachers to continue to pay attention to their error culture as this seems relevant for all students in the classroom.

KEYWORDS

migration background, teacher support, error culture, participation, engagement

1 Introduction

Students with migration backgrounds have been an integral part of the student body for many years (Federal Statistical Office of Germany, 2014; Federal Statistical Office of Germany, 2023). Despite this long-standing development, large-scale assessments such as PISA continue to show a gap in achievement between students with and without migration backgrounds (achievement gap; Andon et al., 2014; Weis et al., 2018; Weis et al., 2019b). So far, several studies have examined the reasons for the gap by looking at student characteristics. Differences in the socio-economic status (Levels and Dronkers, 2008; Lüdemann and Schwerdt, 2013) and competence differences in language achievement of students with and without migration backgrounds (Million-Fauré, 2019) only partially explain the achievement gap. However, even when controlling for individual student characteristics, unexplained variance in the

achievement gap remains, suggesting migration-specific disadvantages (Hillmert, 2013). Against this background of unexplained differences in achievement, it seems promising to take a look at the processes in the classroom. Are students with and without migration backgrounds evenly engaged in classroom discourse? And do differences in teaching behavior account for possible differences in participation?

Student participation could be a promising key to closing the achievement gap, because active participation is regarded as one important indicator of student engagement (Böheim et al., 2020b) and, in turn, as being related to student learning and performance (Schnitzler et al., 2021). Thus, the question is whether student participation is equally distributed across students with different backgrounds. So far, studies looking at elementary schools have indicated that students with migration backgrounds participate less often in classroom discourse compared to their peers without migration backgrounds (Decristan et al., 2020). This is particularly concerning because students with migration backgrounds thus experience a double disadvantage: They start with unfavorable conditions and then experience additional differences regarding their participation—receiving less individual feedback, for example. As a result, teachers play an important role in overcoming these disparities.

Teachers can promote student participation by creating a supportive atmosphere (Böheim et al., 2020b; Denn et al., 2019; Fredricks et al., 2004). One facet of this supportive atmosphere is the way teachers and students deal with mistakes, commonly referred to as error culture (Spychiger et al., 2006; Steuer et al., 2013). When teachers show a positive and appreciative approach to mistakes, students may also become more willing to participate. In particular students with migration backgrounds, who might be more reluctant to participate due to fear of negative teacher and peer reactions after making mistakes or giving the wrong answer, could benefit from this.

With this paper, we wanted to build on this knowledge base and contribute to the discussion about how students with migration backgrounds can be promoted in the classroom and whether this process is context-specific (see Heitmann et al., 2017). In particular, we focused on one specific facet of teacher support—the error culture—and investigated whether the degree of a positive error culture can be promising for engaging students with and without migration backgrounds in the classroom discourse. Finally, we aimed to follow up on Praetorius and Gräsel's (2021) discussion of the subject-specificity of teaching behavior and to compare the processes of migration background, error culture, and student participation between German Language Arts and Mathematics.

2 Theoretical background

2.1 Differences between students with and without migration backgrounds

According to Weis et al. (2019b), a student has a migration background if at least one parent was born abroad. In addition to the already mentioned achievement gap, previous studies have found further differences between students with and without migration backgrounds: First, students with migration backgrounds are less likely to speak the official language at home (Weis et al., 2019b). A difference between the language spoken at home and at school can result in language problems that are likely to hinder learning. Second, students with and without migration backgrounds differ regarding their peer relationships. Henschel et al. (2022) showed that students with migration backgrounds felt less socially accepted compared to their peers without migration backgrounds. Third, students with migration backgrounds might struggle with culture-specific norms. For example, different understandings of the roles of students and teachers can lead to misunderstandings in teacher–student interactions (Spychiger et al., 2006). As a result, students with migration backgrounds must overcome culture-specific obstacles in addition to the cognitive load that results from the learning process. Fourth, besides these differences regarding students' perceptions, the teachers' views might also differ. Lorenz and Gentrup (2017) found evidence that teachers less often expected a correct solution from elementary school children with Turkish migration backgrounds, even when their performance was equal to that of their peers. These four arguments can result in differences between students with and without migration backgrounds regarding student participation in classroom discourse.

2.2 Student participation in classroom discourse and the possible consequences of a migration background

Student engagement is recognized as a crucial component for improving students' academic outcomes (e.g., grades and graduation rates), social development (e.g., peer relationships), and emotional skills (e.g., conflict resolution; Appleton et al., 2006). Student engagement is frequently highlighted as a key factor in preventing student dropout (Archambault et al., 2022; Finn, 1989; Reschly and Christenson, 2006) and is positively related to students' mental health (Suldo and Parker, 2022). Models of student engagement (e.g., Fredricks et al., 2004; see overview in Reschly and Christenson, 2022) typically distinguish between cognitive engagement, emotional engagement, and behavioral engagement. Within this framework, student participation in classroom discourse (i.e., students' hand raising behavior or verbal contributions during teacher-centered interactions) has been shown to be a relevant indicator of students' current level of behavioral engagement (Appleton et al., 2006; Böheim et al., 2020b; Crombie et al., 2003). Some studies conceptualize student participation by recording the amount of time a student spends talking during classroom discourse (Sedlacek and Sedova, 2020; Sedova et al., 2019). Others observe visible behaviors such as hand-raising or verbal contributions as an operationalization of participation (Böheim et al., 2020a; Decristan et al., 2020). In the present study, we focused on a conceptualization by Decristan et al. (2020) and Sacher (1995), who divided student participation in classroom discourse into student-controlled and teacher-controlled participation. With regard to student-controlled behavior, hand-raising and calling-in can be distinguished. Teacher-controlled participation refers to whether the teacher calls on students. This distinction is valuable because we examined student participation on both sides: the side of the offer by the teacher (calling-on) and the side of the use by the students (hand-raising, calling-in; Decristan et al., 2020; Seidel, 2014). Previous studies have shown that student participation is associated with a higher use of instruction (Jansen et al., 2022) and with achievement (Böheim et al., 2020b; Sedova et al., 2019). Thus,

differences in student achievement (e.g., an achievement gap) may also be due to differences in student participation.

Based on the four identified differences between students with and without migration backgrounds (language issues, peer connections, cultural norms, and lower teacher expectations; see section 2.1), students may also differ in their participation in classroom discourse, as family characteristics are considered as important for student engagement (Appleton et al., 2006). First, since students with migration backgrounds are more likely to speak a different language at home, it might be more difficult for them to follow the classroom discourse and, thus, to contribute to the discussion. Students who speak a different language at home than at school can sometimes show lower oral proficiency in the school language (Droop and Verhoeven, 2003), possibly because they have fewer opportunities to practice the language at home (see time-on-task hypothesis; Rossell and Baker, 1996). These differences in oral proficiency may imply that students with migration backgrounds have to use more cognitive resources to speak the language at school (Wang and MacIntyre, 2021). Therefore, in addition to the effort related to content, they also have to make a greater linguistic effort to participate in classroom discourse.

Second, students with migration backgrounds might feel less comfortable due to concerns about public exposure and how their peers might react if they make mistakes. Previous research shows that students with migration backgrounds are less socially integrated than students without migration backgrounds (Henschel et al., 2022). This is shown, for example, by the observation that students with migration backgrounds are less frequently mentioned when peers are asked to name their preferred seating partners (Dicataldo et al., 2023; Plenty and Jonsson, 2017). Overall, students with migration backgrounds have fewer friendships and experience less acceptance (Hamel, 2022; Hamel et al., 2022). The authors again mention the language barrier as a possible reason for this, which sometimes leads to social isolation of students with migration backgrounds (Hamel et al., 2022). In this context of threatened or actual social exclusion, students with migration backgrounds may be more reluctant to participate in classroom discourse, because they are less connected to their peers (Henschel et al., 2022).

Third, students with migration backgrounds might understand classroom practices, such as hand-raising, differently, due to cultural norms and might not participate actively out of reticence and deference to the teacher. For example, cultural norms in Germany can differ significantly from those in countries like Russia or Turkey, which are common places of origin for many students with migration backgrounds in Germany. According to Hofstede et al. (2010), cultures in Russia and Turkey can be characterized by a high level of uncertainty avoidance, which for schools can mean that teachers are assumed to know all the answers (Hofstede, 2011). In contrast, Germany has a lower level of uncertainty avoidance, which means that teachers openly say in class that they do not know everything (Hofstede, 2011; Hofstede et al., 2010). When these two cultures come together in the classroom, misunderstandings can arise. For example, students from high uncertainty avoidance countries may have difficulty dealing with open-ended questions. Cultural differences can therefore play a role in participation.

Fourth, since teachers' expectations differ depending on whether students have migration backgrounds or not (Tenenbaum and Ruck, 2007; Tobisch and Dresel, 2017), and given the strong link between expectations and behavior (Harris and Rosenthal, 1985), it can be assumed that teachers' behavior also varies accordingly between students with and without migration backgrounds. Since teachers are the gatekeepers to teacher-controlled participation, their expectations could play a role in the participation of students with migration backgrounds. If they expect less from these students, they might call on this group less because they would fear of disrupting classroom discourse. Alternatively, they could call on students with migration backgrounds more often to give them extra support and check that they have understood the content. Consequently, the difference in behavior is not necessarily negative. Adaptive teacher behavior can both mitigate and exacerbate heterogeneity (Denessen et al., 2020). Teachers can implement this adaptivity by varying the frequency or length of interactions between teacher and students with migration backgrounds.

In addition to these theoretical arguments, empirical findings from elementary schools have shown that students with and without migration backgrounds do indeed differ in their participation in classroom discourse. Students with migration backgrounds showed less student-controlled and teacher-controlled participation in classroom discourse (Decristan et al., 2020). Lorenz and Gentrup (2017) found a similar result in their study of elementary school students with migration backgrounds: Teachers called on students with migration backgrounds less often than students without migration backgrounds. Overall, interactions between teachers and students with migration backgrounds were shorter and less frequent. In contrast, Jansen et al. (2022) and Decristan et al. (2023) focused on students from different secondary school types and did not show a significant relationship between migration background and student participation in their results. Therefore, we built on these inconsistent findings across different school types and explicitly investigated students from academic-track secondary schools.

To sum up, previous studies have mainly looked at the relationship between student characteristics and student participation (see Decristan et al., 2020). However, due to the relevance of student participation, the question arises of how participation can be promoted.

2.3 Error culture as a teaching variable that fosters student participation

Hofkens and Pianta (2022) note that student engagement is not a student characteristic that students bring to school. Rather, student engagement emerges through interactions with teachers. Along with family and peers, school is an important predictor of student engagement (Appleton et al., 2006). Several studies have shown that a supportive teaching atmosphere is positively related to student participation (Böheim et al., 2020b; Fredricks et al., 2004; Reyes et al., 2012). For example, Denn et al. (2019) showed that in classes with a more positive classroom climate, student participation after a teacher question was higher. Supportive teacher behavior seems to be especially important after a student's mistake.

Error culture (sometimes called error climate; Soncini et al., 2021; Steuer et al., 2013) can be defined by teachers' and students' perceptions and activities in dealing with mistakes (Steuer et al., 2013). Error culture in a classroom can be seen, for example, in beliefs (e.g., whether students believe they are allowed to make mistakes in

class) and practices (e.g., whether an error is discussed in front of the whole class; Fischer and Freund, 2023). Fischer and Freund (2023) distinguish between a culture of error avoidance (in which errors are seen as a sign of failure and disruption and are avoided if possible; negative error culture) and a culture of error management (in which errors are seen as normal and important steps toward improvement; positive error culture).

It is worth focusing on how to deal with mistakes, as they are an integral part of the classroom (Heinze, 2004) and contribute to learning in two ways. First, errors have a content-related component. In order to structure the further learning process and to make individual progress, it is important to recognize the error. Negative knowledge, i.e., the knowledge of mistakes and "wrong ways", supports, for example, certainty or increases the quality and depth of reflection processes (Gartmeier et al., 2008; Oser and Spychiger, 2005). Second, error culture always has a motivational component (see Tulis, 2013). If teachers have a positive error culture and treat students' errors with appreciation, this can motivate students to think further. Otherwise, errors can lead to frustration and resignation. Recent studies empirically support these theoretical arguments and show the importance of (dealing with) mistakes for the learning process (e.g., Metcalfe et al., 2024; Soncini et al., 2021).

Narciss and Alemdag's (2024) model defines key components of a supportive error culture. Factors such as the characteristics of students (e.g., demographics, emotions, motivational beliefs) and teachers (e.g., knowledge of errors, strategies for dealing with errors effectively) play an important role in a supportive error culture. However, the interactions and dialogues that learners have with teachers and peers are also crucial in dealing with mistakes. In this study, we focus on this aspect of interaction and examine the role of error culture for students' participation in classroom discourse.

We hypothesize that error culture plays a role in students' participation in the classroom discourse. If there is a positive error culture in a class, i.e., if errors are treated as necessary and important prerequisites for further learning, then students are more likely to participate in classroom discourse because they will not face negative consequences if they make an error. If, on the other hand, they are afraid of being exposed by the teacher and laughed at by the class, they may be reluctant to participate. This theoretical assumption is supported by the empirical result that error culture is positively related to the amount of effort a student puts into a subject (Steuer et al., 2013). One facet of this effort could be student participation in classroom discourse.

Thus, error culture could be a promising key to promoting participation. However, since the characteristics of students are important for a supportive error culture (Narciss and Alemdag, 2024), it remains unclear whether all students benefit equally from error culture or whether certain groups of students benefit in particular. Despite some criticism, Cronbach and Snow's (1977) concept of an aptitude–treatment interaction could also be applied to the teaching context. A teaching variable (here, error culture) may be of different relevance to different students. As mentioned above, students with migration backgrounds may differ from their peers in a number of characteristics (e.g., language problems, connection to their peers, and misunderstandings of cultural norms). Consequently, students with migration backgrounds might be more dependant on a teacher's positive error culture (Spychiger et al., 2006). Due to the lower achievement of students with migration backgrounds (see Henschel et al., 2022), language problems (see Weis et al., 2019b), a weaker connection to their classmates (and thus, the fear of being laughed at; Henschel et al., 2022), or misunderstandings of cultural norms (Spychiger et al., 2006), making mistakes could be more in the foreground for students with migration backgrounds and thus, dealing with mistakes may be more important for them. To sum up, making mistakes and dealing with mistakes could play a stronger role for students with migration backgrounds. Therefore, error culture could be key to ensuring the participation of all students and, in turn, to reducing the achievement gap.

Seiz et al. (2016) showed that teaching characteristics could reduce the achievement gap between students with and without migration backgrounds. Students with migration backgrounds benefited more from supportive teaching (Seiz et al., 2016). Thus, students' migration backgrounds emerged not only as directly related to student participation (Decristan et al., 2020; Lorenz and Gentrup, 2017), but also as important moderators influencing the role of teacher support (Seiz et al., 2016). In the present study, we extended this research by examining the interplay of migration background, error culture, and student participation. Therefore, we assumed that error culture is differentially important for students with and without migration backgrounds and investigated the moderating role for the relationship between error culture and student participation.

2.4 Investigation of the learning context

When investigating the relationship between students' migration background, error culture, and student participation, the question is whether differences exist depending on the context (here, school subjects). According to the following arguments, a subject-specific role of migration background, classroom discourse, and error culture, can result in differences between German Language Arts and Mathematics. First, migration background may have subject-specific importance. Since German is not the only language spoken by many families of students with migration backgrounds (see Weis et al., 2019b), differences between students with and without migration backgrounds might be more pronounced in a language subject. Second, classroom discourse in German Language Arts and Mathematics differs: While students perceive discussions in STEM subjects as more fact-based, classroom discourse in German Language Arts seems to be shaped by opinions (Heitmann et al., 2017). Third, errors in Mathematics seem to be more clearly defined and less dependent on the teacher (Steuer et al., 2021). However, differences between subjects regarding the importance of making and dealing with errors are also evident (Spychiger et al., 1999; Tulis, 2013). Therefore, to control for subject-specific differences, we included both subjects, German Language Arts and Mathematics.

3 The present study

Our study examined students with and without migration backgrounds by looking at their participation in classroom discourse as a proximal predictor of achievement (see Böheim et al., 2020b; Sedova et al., 2019). In particular, we investigated whether or not error culture promotes student participation in classroom discourse and

whether students with migration backgrounds may benefit more from a positive error culture. As previous studies have investigated either student characteristics (e.g., self-concept, migration background; Böheim et al., 2020a; Decristan et al., 2020) or teacher behavior (e.g., positive classroom climate; Denn et al., 2019), in the present study, we examined the interplay of the two. Seiz et al. (2016) already showed that migration background can be a relevant moderator of the relationship between supportive teaching and achievement. We built on this by shedding light on the moderating role of migration background in the relationship between error culture and student participation as an outcome variable.

Moreover, this paper contributes to existing research in two ways. First, we shed light on the role of the context. Previous studies on the relationship between migration background and student participation have focused on elementary school students (Decristan et al., 2020; Lorenz and Gentrup, 2017). In our study, we extended the picture by an explicit look at academic-track secondary schools. In addition, we investigated the role of context by looking at two different subjects (German Language Arts and Mathematics).

In particular, we investigate the following research questions (RQs):

1. Are student migration background and error culture related to student participation in classroom discourse?
2. How does a migration background moderate the relationship between error culture and student participation in classroom discourse?

The originality of the study lies in the combination of behavioral (videotaped) data on student participation in classroom discourse with the students' perceptions of error culture, such as requested for example by Wang and Eccles (2013). Analogous to Decristan et al. (2020) and Sacher (1995), we subdivide student participation in classroom discourse into student-controlled participation (students raising their hand or calling-in without hand-raising) and teacher-controlled participation (teachers calling on students). Based on this distinction, we could infer who was an active and passive contributor to the interaction. This allowed for targeted conclusions for promoting student participation in classroom discourse.

4 Methods

4.1 Participants and procedure

The present study re-analyzed the data set from the Interaction I project (Jurik et al., 2015). Our analyses were restricted to eighth-grade students in German academic-track secondary schools.[1] The data set contains data for the subjects of German Language Arts (GLA) and Mathematics (M). A total of 501 students in 20 classes with a mean class size of 25.05 (SD = 3.52) students and their 40 teachers (65% female, on average 40.55 years old [SD = 10.51], with 11.50 years of work experience [SD = 9.34]) voluntarily participated in the study.

At the beginning and end of the 2013/14 school year, the students completed a questionnaire. In addition, one 45-minute lesson each in Mathematics and GLA was videotaped in the middle of the school year. The topics of the lessons were geometry or algebra in Mathematics and activities focusing on writing or presenting in GLA. No behavioral data were available for N = 114 (GLA) and N = 120 (M) respectively, because they refused permission or were absent. Their numbers varied widely, from one to 10 people per class (M = 5.70, SD = 2.66). These students were excluded from the analyses, leaving 381 students (59% female, M_{age} = 13.81 [SD = 0.53]) as the sample in Mathematics and 387 students (58% female, M_{age} = 13.83 [SD = 0.54]) in GLA.

4.2 Measuring student participation with video analyses

The videotaped lessons were rated by external observers to capture student and teacher controlled participation. For this purpose, two independent, previously trained coders coded the videos. They used the Interact software (Mangold, 2014) and a coding manual. In order to code the video material, each time there was a change between people speaking, a new turn was set.

As teacher–student interactions differ depending on the social form (e.g., classroom discourse vs. nonpublic work phases; Lipowsky et al., 2008), we focused on student and teacher behaviors in classroom discourse. With regard to student-controlled and teacher-controlled participation, the coders coded calling-in, self-initiated contribution, and hand-raising for student-controlled participation and calling-on for teacher-controlled participation. Here, "calling-on" means that a teacher gives a student permission to present his or her idea. This can be done non-verbally with a nod, or verbally with the student's name. A student's verbal contribution was rated as "calling-in" when a student answered a question without raising his or her hand or being called on. The category of self-initiated contributions was used when a student contributed without a teacher question or permission to talk (e. g., without being called on). Finally, the coders used the code "hand-raising" every time a student raised his or her hand. Overall, the interrater reliability of these variables was sufficient (κ = .72; interrater agreement of 85.3%).

For each student, the number of behaviors (e. g., calling in, hand-raisings, calling-on) in the videotaped lessons was added up separately for Mathematics and GLA. For the analyses carried out here, student-controlled participation was operationalized by adding up the number of hand-raising, calling-in, and self-initiated contributions. The number of events in which a student was called-on is used as teacher-controlled participation.

4.3 Questionnaire data

Error culture, migration background, and several covariates were assessed using student questionnaires.

4.3.1 Migration background

Migration background was determined at the first measurement point prior to the videotaped lesson, at the beginning of the school year.

1 In Germany (i.e., Bavaria), after the fourth grade of elementary school (at around the age of 10), children choose a secondary school. They have the choice between an academic-track secondary school and two types of non-academic-track secondary schools.

The student's country of birth as well as the mother's and father's were asked for. In line with Weis et al. (2019b), we described all students with at least one parent from abroad as children with migration backgrounds.

4.3.2 Error culture

To examine students' perceptions of the classroom teaching, the students were asked for their perception of error culture at the end of the school year. We expected the students to have a meaningful picture of the teacher and the teachers' error culture at this point. Two examples of questionnaire items are "The teacher is patient when a student makes a mistake in GLA" and "Our Mathematics teacher makes sure that nobody in our class is laughed at if they make a mistake" (adapted from Spychiger et al., 1998; Waldis et al., 2002). To ensure comparability between the subjects, the items had a parallel wording for both subjects. The answer categories were a four point Likert scale (1 = "exactly" to 4 = "not at all"). The values were recoded so that higher values also corresponded to a higher assessment of the error culture. The scale has a reliability of $\alpha = .83$ (GLA) and $\alpha = .80$ (Mathematics).

4.3.3 Covariates

Prior research has shown that students with and without migration backgrounds differ in their achievement (e.g., Henschel et al., 2022). To explicitly examine the relationship between migration background and student participation, we added course achievement as a covariate. Course achievement was operationalized by the students' grade in the mid-term report (best grade: 1, worst grade: 6, discrete scale), as this grade was closest to the time of the videography measurement. Teachers reported the grade on the teacher questionnaire. The variable was recoded so that a higher value corresponds to better performance. In addition, we included socioeconomic status (SES) as another covariate. SES is also assumed to be related to migration background (Weis et al., 2018). HISEI indicates the highest occupational status of parents (OECD, 2017) and has the highest predictive power in Germany compared to other variables that operationalize SES (e.g., educational level of parents, home possessions; Ehmke and Siegle, 2005). The values range from 16 (e.g., office cleaner) to 90 (e.g., judge; Ganzeboom and Treiman, 1996). As previous studies have shown differences in teaching behavior between female and male (e.g., Denn et al., 2015), we include the covariate 'gender' (1 = female, 2 = male).

4.4 Data analysis

All analyses were performed using the *R*-package *mitml* (Grund et al., 2021). The analysis script is published here: https://osf.io/fx4bm/.

Since the students were in 20 classes, the nested data structure had to be taken into account. Therefore, we decided to analyze nested hierarchical linear models. Using these random-intercept models, the standard errors for the classes can be taken into account. We assume that for individual student participation, personal perception of the error culture is more important than the perception of the whole class; therefore, we controlled for the class structure but did not generate any results at the class level.

All variables were standardized to obtain standardized regression coefficients. The interclass correlations (ICCs) were calculated with the package *performance* (Lüdecke et al., 2021). To calculate R^2, we used the formula of Snijders and Bosker (2012), which is the most accurate for random-intercept models (LaHuis et al., 2014). Separate models were calculated for the two forms of participation as dependent variables as well as for both subjects. The interaction terms in the moderator analyses (RQ 2) were formed as products of the individual scale means of each student.

4.5 Missing data

To avoid estimating behavioral data, students for whom no behavioral data were available were excluded. Therefore, there are no missing values for student-controlled participation and teacher-controlled participation. To deal with missing values in the other questionnaire variables, we chose the R package mdmb (Grund et al., 2021). This package is suitable for considering interaction effects in nested hierarchical linear models. Here, the analysis model is already included in the imputation. In this way, the errors resulting from the estimation of the interaction term can be reduced. In addition to the analysis variables (e.g., error culture, course achievement, HISEI, gender), missing values were estimated with the auxiliary variables of age and further teaching variables. Twenty datasets were imputed, providing the basis for calculating the pooled results.

5 Results

5.1 Descriptive analyses

Table 1 shows the descriptive data from the questionnaire and video recordings. Overall, students assessed the error culture as rather positive, with no significant differences between the subjects. The descriptive values for student-controlled and teacher-controlled participation were a bit more difficult to interpret. For example, on average, each student showed 5.48 handraisings and calling-ins (student-controlled participation) in one GLA lesson. In addition, on average, a student was called-on (teacher-controlled participation) 2.31 times in a GLA lesson by the teacher. Overall, there was less teacher-controlled participation than student-controlled participation as well as a wide range between students in both subjects. With regard to the generalizability across subjects, we found significantly more teacher-controlled participation in GLA than in Mathematics [$t(752.38) = 2.01$, $p < .05$]. In contrast, slightly more student-controlled participation was evident in Mathematics, although the difference between the subjects in student-controlled participation was not significant [$t(736.3) = -1.91$, $p = .057$]. Looking at the ICCs, the differences between the classes were primarily visible in error culture and in the two forms of participation. This justified the inclusion of the class level in further analyses. Regarding the correlations, Table 2 shows bivariate correlations without controlling for covariates.

Approximately 34% (GLA)/35% (M) of the students reported having a migration background. While there are no descriptive differences between students with and without migration backgrounds in terms of error culture and student participation, there are clear differences between the groups regarding the socioeconomic status [HISEI; $t(149.17) = 4.21$, $p < .05$] and course achievement [$t(199.37) = 2.97$, $p < .05$]. Students with migration backgrounds show lower achievement and lower socioeconomic status. This highlights the need to include HISEI and course achievement as covariates in the analyses.

TABLE 1 Descriptive results.

	Min (GLA/M)	Max (GLA/M)	M (GLA/M)	SD (GLA/M)	ICC (GLA/M)	Missings (GLA/M)
1. Error culture	1/1	4/4	3.13/3.16	.75/.70	29.4%/15.5%	20/19
2. Migration background	0/0	1/1	–	–	9.7%/10.8%	23/24
3. HISEI	19.78/23.57	88.96/88.96	68.18/68.13	15.57/15.51	2.0%/2.5%	55/55
4. Course achievement	1/0	5/5	3.00/2.68	.86/1.19	5.5%/5.9%	73/42
5. Gender	1/1	2/2	–	–	20.7%/22.3%	4/3
6. Student-controlled participation	0/0	36/43	5.48/6.36	5.75/6.94	14.7%/13.4%	0/0
7. Teacher-controlled participation	0/0	12/14	2.31/2.03	2.04/1.76	7.6%/19.9%	0/0

The value before the slash indicates the result in German Language Arts (GLA; $N = 387$); the value after the slash shows the result in Mathematics (M; $N = 381$). Student-controlled participation means handraising and calling-in, teacher-controlled participation refers to calling-on.

TABLE 2 Correlations (GLA/M) between the analysis variables.

	1.	2.	3.	4.	5.	6.	7.
1. Error culture	–						
2. Migration background	.05/−.01	–					
3. HISEI	−.15/−.04	−.19*/−.18*	–				
4. Course achievement	.16*/.11	−.16/−.15	.21*/.17	–			
5. Gender	−.20*/−.05	.00/.02	.03/.06	−.13/.03	–		
6. Student-controlled participation (SCP)	.17*/.02	.03/.06	.06/.07	.02/.17*	−.10/.03	–	
7. Teacher-controlled participation (TCP)	.15/.05	−.05/−.02	.04/.09	.15/.16*	−.05/.00	.74*/.77*	–

*$p < .05$. The value before the slash indicates the result in German Language Arts (GLA); the value after the slash shows the result in Mathematics (M). For all correlations with migration background or gender, the method according to Spearman was used, otherwise according to Pearson. Coding of migration background: 0 = no migration background, 1 = migration background; Coding of gender: 1 = female, 2 = male.

TABLE 3 Results from nested hierarchical linear models on the relationship between error culture and migration background with student participation (RQ 1).

Dependent variable	German Language Arts				Mathematics			
	Student-controlled participation (SCP)		Teacher-controlled participation (TCP)		Student-controlled participation (SCP)		Teacher-controlled participation (TCP)	
	β (*SE*)	*p*	β (*SE*)	*p*	β (*SE*)	*p*	β (*SE*)	*p*
Intercept	.02 (.10)	.854	.02 (.07)	.833	.01 (.10)	.924	.02 (.12)	.872
Error culture	**.15 (.06)**	**<.05**	.11 (.06)	.070	.05 (.05)	.319	.08 (.05)	.125
Migration background	.09 (.05)	.089	−.01 (.05)	.837	.08 (.05)	.150	.01 (.05)	.841
Covariates								
Course achievement	.02 (.06)	.737	.12 (.07)	.086	**.14 (.06)**	**<.05**	**.13 (.05)**	**<.05**
HISEI	.10 (.05)	.050	.03 (.06)	.551	.06 (.06)	.269	.07 (.06)	.231
Gender	−.00 (.05)	.962	.01 (.05)	.800	.08 (.05)	.139	.05 (.05)	.299
R^2	.02		.03		.02		.01	

Significant correlations are printed in bold. Coding of migration background: 0 = no migration background, 1 = migration background; Coding of gender: 1 = female, 2 = male.

5.2 Relationship between error culture and migration background with student participation in classroom discourse (RQ 1)

To answer the first research question, we examined the roles of error culture and migration background in predicting student participation in classroom discourse. Table 3 presents the results of these models (including covariates) separately for student- and teacher-controlled participation, and on the left for GLA and on the right for Mathematics. Looking at GLA, there was a significant relationship between error culture and the frequency of student-controlled participation ($\beta = 0.15$, $p < .05$). The relationship between error culture and the frequency of teacher-controlled participation did not reach significance ($\beta = 0.11$, $p = .070$). Students' migration background ($\beta_{SCP} = 0.09$, $p = .089$; $\beta_{TCP} = -0.01$, $p = .837$) did not make a significant contribution to predicting both forms of participation. Looking at Mathematics, there was no significant relationship between error culture and either form of participation

TABLE 4 Results from nested hierarchical linear moderator analyses: migration background as a moderator of the relationship between error culture and student participation (RQ 2).

Dependent variable	German Language Arts				Mathematics			
	Student-controlled participation (SCP)		Teacher-controlled participation (TCP)		Student-controlled participation (SCP)		Teacher-controlled participation (TCP)	
	β (*SE*)	*p*	β (*SE*)	*p*	β (*SE*)	*p*	β (*SE*)	*p*
Intercept	.02 (.10)	.856	.01 (.06)	.895	.01 (.10)	.913	.02 (.11)	.867
Error culture	**.15 (.06)**	**<.05**	.09 (.06)	.120	.04 (.05)	.419	.07 (.05)	.166
Migration background	.07 (.05)	.157	.01 (.05)	.860	.09 (.05)	.079	.04 (.05)	.442
Error culture × Migration background	.02 (.05)	.640	.05 (.05)	.306	.07 (.05)	.169	.05 (.05)	.252
Covariate								
Course achievement	.20 (.06)	.812	**.19 (.09)**	**< .05**	**.15 (.05)**	**<.05**	**.15 (.05)**	**<.05**
HISEI	**.11 (.05)**	**<.05**	.03 (.06)	.671	.07 (.06)	.223	.07 (.06)	.251
Gender	−.00 (.05)	.937	.01 (.05)	.876	.08 (.05)	.149	.05 (.05)	.301
R^2	.02		.06		.02		.02	

Significant correlations are printed in bold. Coding of migration background: 0 = no migration background, 1 = migration background; Coding of gender: 1 = female, 2 = male.

(β_{SCP} = 0.05, p = .319; β_{TCP} = 0.08, p = .125). As in GLA, migration background did not play a role here either (β_{SCP} = 0.08, p = 0.150; β_{TCP} = 0.01, p = .841). The covariate course achievement was only significant in Mathematics (β_{SCP} = 0.14, p < .05; β_{TCP} = 0.13, p = < 0.05), but not in GLA (β_{SCP} = .02, p = .737; β_{TCP} = 0.12, p = .086).

5.3 Moderating role of migration background (RQ 2)

In addition, we examined whether students with and without migration backgrounds benefited differently from error culture regarding the frequency of their participation (RQ 2) (Table 4). The interaction term between error culture and migration background did not make a significant contribution in GLA (β_{SCP} = 0.02, p = .640; β_{TCP} = 0.05, p = .306) or Mathematics (β_{SCP} = 0.07, p = .169; β_{TCP} = 0.05, p = .252). On a descriptive level, Figures 1A,C show that for GLA, a positive error culture for students with and without migration backgrounds went hand in hand with increased participation.

In line with our expectations, this increase was greater for students with migration backgrounds. This descriptive trend also appears for Mathematics (Figures 1B,D). While students without migration backgrounds seemed to benefit little or not at all from a more positive error culture, a better error culture led to more participation among students with migration backgrounds.

6 Discussion

The aim of this study was to examine the relationship between migration background, error culture, and student participation in classroom discourse. Our study revealed subject-specific differences in the relationships that point to the (lack of) generalizability of findings from one subject. According to our results, students' perception of error culture was related to their participation in classroom discourse in German Language Arts, but not in Mathematics. In contrast, migration background did not play a significant role for students' participation in either subject. Contrary to our theoretical assumptions, we did not find significantly different relationships between error culture and student participation, depending on whether students had or did not have migration backgrounds. Nevertheless, the results indicate nonsignificant trends that seem to highlight the important role of error culture for students with migration backgrounds.

6.1 Student participation seems to be independent from migration background in eighth-grade students

Since students with and without migration backgrounds differ in terms of their achievement (see, e.g., Andon et al., 2014) and student participation has been shown to predict student achievement (e.g., Böheim et al., 2020b; Sedova et al., 2019), we assumed that there would be differences in student participation depending on the students' migration status. However, in the present dataset, we found no significant relevance of migration background for student participation in classroom discourse (regardless of the subject). Prior research also showed inconsistent findings. While Decristan et al. (2020) and Lorenz and Gentrup (2017) found differences in student participation between students with and without migration backgrounds in their video analyses, the results of Jansen et al. (2022) and Decristan et al. (2023) were in line with our results and did not indicate differences. The reason for these different results may be the students' ages. While the analyses of Decristan et al. (2020) and Lorenz and Gentrup (2017) were restricted to younger students in elementary schools, we investigated exclusively and Jansen et al. (2022) and Decristan et al. (2023) mostly older students from academic-track secondary schools. While all children in Germany attend elementary schools, academic-track secondary schools are intended for students with the highest achievements (Reinhold et al., 2019; Schiepe-Tiska et al., 2019; Weis et al., 2019a). Also, there seem to be social disparities in the choice of a secondary school (i.e., non-academic-track or academic-track; Maaz et al., 2008). If students with migration backgrounds attend academic-track secondary schools, they may have adapted well to their classmates without migration backgrounds in classroom discourse;

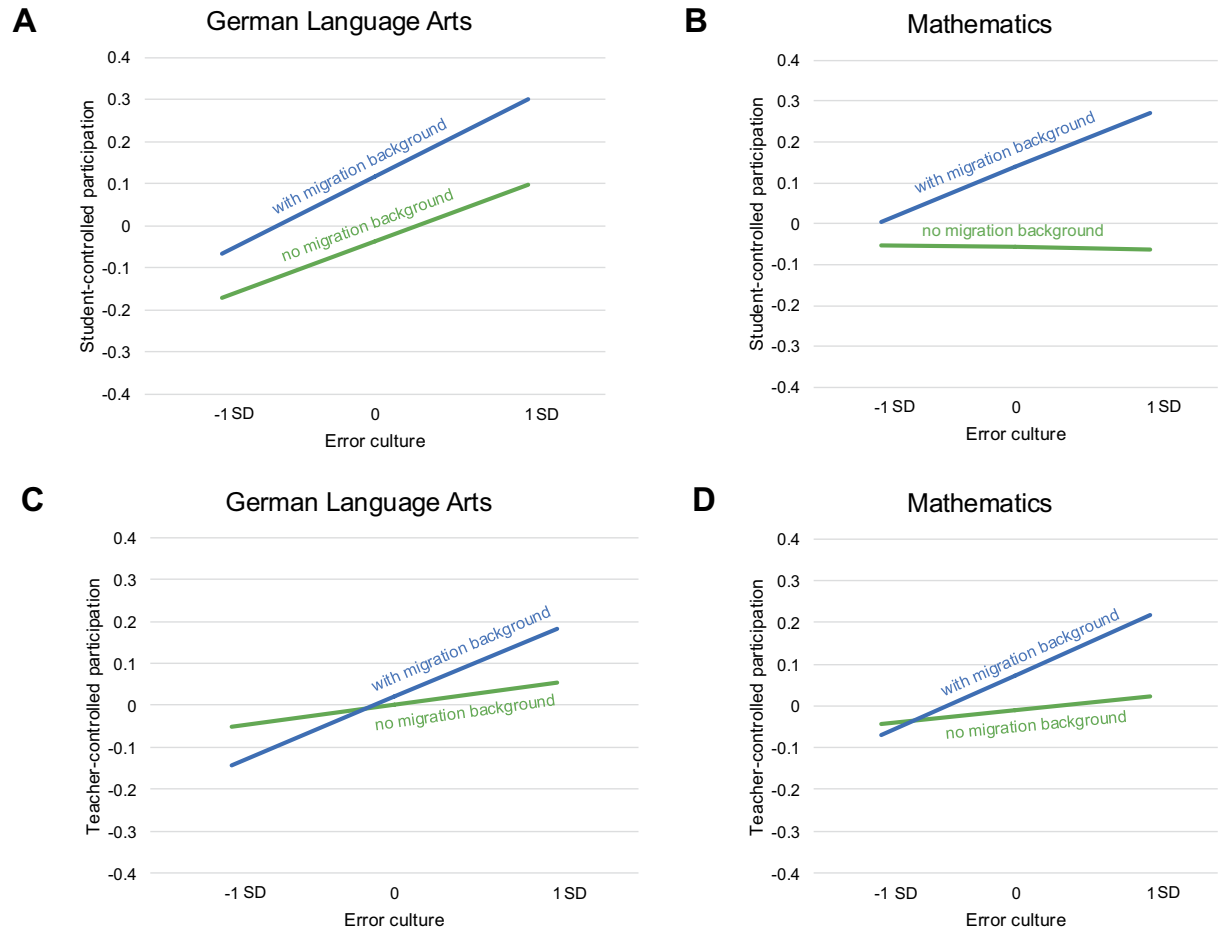

FIGURE 1
Visualization of the standardized regression coefficients of the moderator analyses with migration background as moderator for student-controlled participation **(A and B)** and teacher-controlled participation **(C and D)** in GLA and Mathematics.

thus, differences in student participation may not be apparent. This indicates that the role of migration background depends on a variety of context factors (see Heine and Stemmler, 2021). Future research should test whether these results also hold for other (non-academic-track secondary) school types.

6.2 Error culture partially predicts student participation

Since prior research has shown that teacher support is an important antecedent of classroom participation (Böheim et al., 2020b; Denn et al., 2019; Fredricks et al., 2004; Reyes et al., 2012), we assumed that the specific facet of error culture was relevant to student participation in classroom discourse. However, this assumption was only partially confirmed. While there was a significant relationship between error culture and student participation in GLA, the relationship was not evident in Mathematics. These differences are in line with existing studies on subject differences. As Mathematics is perceived as a more static, defined subject with less freedom (Grossman and Stodolsky, 1995; Stodolsky and Grossman, 2000) and discussions in languages are more open (Heitmann et al., 2017), there are also differences in the error culture. In Mathematics, errors are more clearly defined and obvious, whereas in GLA they are more likely to be noticed only by the teacher (Steuer et al., 2021). In terms of dealing with errors, Mathematics teachers are more likely to react negatively to errors and are more likely to delegate error correction to classmates (Tulis, 2013).

Based on these differences, it is logical that error culture plays a greater role in GLA: In these open discussions, students are unsure whether their answer is correct and will only participate if they do not have to expect a negative reaction from their teacher or peers. The fact that the covariate course achievement only plays a significant role in Mathematics also supports this hypothesis. In Mathematics, students tend to know beforehand whether their answer is correct and only answer if it is. Since high achievers know the correct answer more often, they participate more often, whereas in GLA low achievers also try once.

Most importantly, the differential, subject-specific findings of the present study extend prior research by emphasizing the relevance of the context (here, subject). As such, our study also contributes to the discussion on the generalizability of a supportive teaching atmosphere (Praetorius and Gräsel, 2021), in particular with regard to the domain-specificity of error culture (Spychiger et al., 1999; Tulis, 2013), as well as with regard to the role that error culture plays in student participation.

6.3 The relationship between error culture and student participation seems to be independent of students' migration background

Based on four arguments (language problems, connection to peers, cultural norms, and teacher expectations), we assumed that error culture is particularly important for students with migration backgrounds. Contrary to our theoretical assumptions, our results indicate that, on average, the importance of error culture for student participation is not statistically different between students with and without migration backgrounds. This is in line with the results of a review that generally indicated difficulties in finding aptitude-treatment interactions (Tetzlaff et al., 2021). On the contrary, at least with regard to achievement there is little evidence to suggest that a positive teaching atmosphere is particularly important for students with migration backgrounds (Seiz et al., 2016). However, Seiz et al. (2016) also included non-academic–track secondary schools in their analyses. As mentioned above, in non-academic-track secondary schools, differences between students with and without migration backgrounds may be more pronounced, and thus a possible interaction effect might be more visible. Although not reflected in the regression analyses, the graphs may suggest a possible interaction. Therefore, we encourage future researchers to shed more light on differences within the group of students with migration backgrounds.

6.4 Limitations

Our research took advantage of the mixed-methods approach of the dataset (behavioral data for student participation and questionnaire data for students' perceptions of error culture) and the comparison of two different contexts (here, subjects). Nevertheless, with this secondary data analysis, we were bound by some methodological as well as conceptual restrictions. In particular, we discuss the time point of data collection, the school sample, the heterogeneity within the group of students with migration backgrounds, and the role of student participation as a dependent variable.

First, the data for this study were collected in 2013/14. Schools and teaching have changed in recent years, both in terms of the composition of students (e.g., slightly more students with migration backgrounds today; Federal Statistical Office of Germany, 2014; Federal Statistical Office of Germany, 2023) and teaching methods. Nevertheless, the processes examined in this paper are transferable to the present. First, the proportion of students with migration backgrounds per class already varied greatly in our sample, so classes with high proportions of students with migration backgrounds were already included in the sample. Second, the assessment of error culture and the participation of the students also differed among the students. Therefore, a large number of individually different processes were already considered for the analyses. In the spirit of much-requested multiple use of data, we therefore reanalyzed this dataset to fully exploit its potential.

Second, another limitation resulted from the school sample. We extended previous research on elementary schools by explicitly looking at academic-track secondary schools. Due to this focus, the results cannot be extended to other types of schools. Moreover, the fact that all students in the present study were relatively homogeneous regarding their achievement may mean that students with migration backgrounds adapted well to their classmates who did not have migration backgrounds. Therefore, possible differences between students with and without migration backgrounds are less likely to be found in academic-track secondary schools compared to a school from before the separation (e.g., elementary schools).

Third, our sample did not allow us to look at the group of students with migration backgrounds in a differentiated way. Previous studies show that students with migration backgrounds differ depending on their country of origin (Bozick et al., 2016; Froehlich and Schulte, 2019; Schofield, 2006) and the length of stay in Germany (e.g., whether the students themselves or their parents migrated; Müller and Stanat, 2006; Segeritz et al., 2010). On this basis, it can be assumed that differences between students with and without migration backgrounds may be more pronounced when considering students from a culture that is different from the German culture (Hofstede, 2011; Hofstede et al., 2010) or students who have recently moved to Germany. However, such a contrast was not possible in our study due to the small sample size. Future studies should therefore take a differentiated look at this group of students.

Finally, our study considered student participation as a dependent variable and examined possible predictors (e.g., migration background and error culture). As in previous video studies (e.g., Pielmeier et al., 2018), we can only explain a small part of the variance in student participation. This highlights the fact that "classrooms are messy, unpredictable contexts" (Parsons et al., 2018, p. 206) and that many questions remain unanswered. Given the inconsistent findings of the present study, future research should further explore the mediating mechanisms between error culture (or teacher support in general) and achievement. Roorda et al. (2017) showed that student participation mediated the relationship between the teacher–student relationship and achievement. In order to draw further conclusions about the importance of error culture in narrowing the achievement gap, more research on possible mediating mechanisms is needed.

6.5 Implications for theory and practice and avenues for future research

First, students with migration backgrounds did not participate in classroom discourse significantly differently than their peers without migration backgrounds. Although this is surprising given the often-found differences in achievement, it is also reassuring: Teachers do not seem to treat students with migration backgrounds differently from students without migration backgrounds, and students with migration backgrounds do not seem to behave differently. Therefore, the ideal of equal participation seems to be achieved and students with migration backgrounds seem to be fully integrated in the classroom, which can also be seen as a success of integration measures. Nevertheless, the question of where differences in achievement come from if they are not due to classroom discourse, remains open. This brings the learning environment outside the classroom (e.g., parental support; Holzberger et al., 2023) to the fore. For example, special support and a quiet place to study while doing homework could be promising approaches for students with migration backgrounds. Therefore, future research should investigate whether aspects of the home learning environment can explain the achievement gap between students with and without migration backgrounds.

Second, students who perceive error culture more positively also participate more often in classroom discourse, at least in GLA. This finding now has two consequences for the practice: First, it seems important to sensitize teachers to error culture. Their behavior sets an

example for the students: Students notice how teachers deal with mistakes. Teachers should therefore pay attention to small daily events to signal to students that mistakes are a normal part of the learning process. Second, teachers should be trained to deal with mistakes. Appropriate responses to common student mistakes should therefore be part of teacher education. In addition, the subject-specific differences in the role of error culture for student participation underline the role of context. Therefore, future research should investigate the relationship between error culture and student participation in other subjects (e.g., Science) to further explore whether the role of error culture is more similar to GLA or Mathematics.

7 Conclusion

Our study contributes substantially to the current research by (a) explicitly looking at the role of migration background on student participation in academic-track secondary schools, (b) investigating the interplay of teaching behavior (i.e., error culture) and student characteristics (i.e., migration background) on student participation, and (c) contrasting occurring processes in two specific subjects, namely German Language Arts and Mathematics. Previous studies have found that students with and without migration backgrounds differ in their performance (e.g., Weis et al., 2018). Focusing on student participation, our results indicate that students with and without migration backgrounds in academic-track secondary schools do not seem to differ systematically in their participation in classroom discourse. Thus, student participation does not seem to be the crucial mediating process in explaining the often-revealed achievement gap.

Moreover, our findings indicate that a positive error culture may play a role in participation in classroom discourse; however, this finding may not be generalizable across subjects (with positive findings for German Language Arts, but not for Mathematics). In addition, although it may be reasonable to assume that a positive error culture is particularly necessary for students with migration backgrounds, our findings do not reveal differential relationships. Thus, in order to adequately support students with migration backgrounds, further aspects of teaching behavior need to be investigated. Who participates in classroom discourse is thus a multilayered process dominated by individual, classroom-specific, and subject-specific characteristics. Providing appropriate support for students with migration backgrounds is not simply a case of more of the same, but rather of targeted support that takes a close look at the challenges they face.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The data set is not publicly accessible, as this does not include the participants' declaration of consent. Requests to access these datasets should be directed to simon.munk@tum.de.

Ethics statement

The studies involving humans were approved by Bayerisches Staatsministerium für Unterricht und Kultus. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

SM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. DH: Conceptualization, Supervision, Writing – review & editing. RB: Conceptualization, Writing – review & editing, Investigation. TS: Funding acquisition, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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