frontiers | Frontiers in Education

TYPE Original Research
PUBLISHED 15 July 2022
DOI 10.3389/feduc.2022.868729



OPEN ACCESS

EDITED BY
Melissa Newberry,
Brigham Young University,
United States

REVIEWED BY
Angelica Moè,
University of Padua, Italy
Wei Shin Leong,
Ministry of Education, Singapore

*CORRESPONDENCE
Patricia Köpfer
koepfer@econ.uni-frankfurt.de

SPECIALTY SECTION
This article was submitted to Teacher Education, a section of the journal Frontiers in Education

RECEIVED 03 February 2022
ACCEPTED 27 June 2022
PUBLISHED 15 July 2022

CITATION
Köpfer P (2022) Teachers' perspectives on dealing with students' errors. *Front. Educ.* 7:868729. doi: 10.3389/feduc.2022.868729



# Teachers' perspectives on dealing with students' errors

Patricia Köpfer*

Department of Business and Economics Education, Goethe University Frankfurt, Frankfurt, Germany

With adequate support for the learner, errors can have high learning potential. This study investigates rather unsuitable action patterns of teachers in dealing with errors. Teachers rarely investigate the causes that evoke the occurrence of individual students' errors, but instead often change addressees immediately after an error occurs. Such behavior is frequent in the classroom, leaving unexploited, yet important potential to learn from errors. It has remained unexplained why teachers act the way they do in error situations. Using video-stimulated recalls, I investigate the reasons for teachers' behavior in students' error situations by confronting them with recorded episodes from their own teaching. Error situations are analyzed (within-case) and teachers' beliefs are classified in an explanatory model (cross-case) to illustrate patterns across teachers. Results show that teachers refer to an interaction of student attributes, their own attributes, and error attributes when reasoning their own behavior. I find that reference to specific attributes varies depending on the situation, and so do the described reasons that led to a particular behavior as a spontaneous or more reflective decision.

KEYWORDS

**teachers' beliefs, students' errors, accounting lessons, video-stimulated recall, error analysis**

## Introduction

Students' errors in the classroom are assumed to contain a high learning potential if handled correctly (e.g., Hattie and Timperley, 2007, p. 94ff.; Tulis et al., 2015, p. 53ff.; Metcalfe, 2017, p. 467ff.; Pan et al., 2020, p. 1105 ff.). The theoretical basis for this assumption is, for instance, the concept of negative knowledge. Negative knowledge is knowledge about how something is not and how something does not work and is required as a reflection of positive knowledge about how something is and works (Minsky, 1994, p. 515). By committing an error, misconceptions should be recognized and learning processes should be initiated (Gartmeier et al., 2008, p. 92). In order to do so, it is essential that students first recognize the error, then understand what the underlying problem was, and then correct the error (Oser, 2015, p. 72f.). Since students can often not manage these steps alone—otherwise, they would not have made the error—they need their teacher's support in form of feedback. Feedback as a component of formative assessment has been shown to have positive effects on learning from errors (Hattie and Timperley, 2007; Shute, 2008; Metcalfe, 2017). This is

because formative assessment focuses on the students' learning process by continuously evaluating students' progress to provide both students and teachers with diagnostic information. This information enables teachers to adapt their teaching and students to improve their learning (McCallum and Milner, 2021, p. 1f.; Yan et al., 2021, p. 229). In order to be able to process feedback well and to take action, students need a high level of feedback literacy, which depends on contextual factors, personal factors, and the interactions with the teacher (Chong, 2021, p. 94). Teachers also require feedback literacy to be able to provide adequate feedback and create meaningful learning opportunities (Havnes et al., 2012, p. 26). According to Wuttke and Seifried (2017, following Shulman, 1986, 1987), the necessary competency of the teacher to deal effectively with errors consists of three facets: (1) *Knowledge about domain-specific errors by students*: Teachers must be able to identify students' errors and to know about typical errors by students and their causes (Wuttke and Seifried, 2017, p. 5). (2) *Knowledge about strategies for handling errors*: Teachers need a broad variety of potential strategies to deal with errors in a constructive way (Wuttke and Seifried, 2017, p. 5). They should be able to give adequate feedback and to communicate alternative solutions (Hattie and Clarke, 2018). "Adequate" here primarily means that the feedback is adapted to the particular situation, student or error.[1] (3) *Beliefs in the potential benefit of students' errors*: Teachers must see students' errors as an opportunity to learn (Seifried and Wuttke, 2010, p. 150; Türling, 2014a, p. 107; see also the four knowledge facets used by Bray's, 2011, p. 14, for her analyses). When looking at situations in which students' errors arise publicly in a class discussion in the context of learning (Weinert, 1999, p. 106; Oser and Spychiger, 2005, p. 241), the empirical evidence points toward certain deficits of teachers when reacting to the errors, as discussed below.

First, teachers rarely perform error analysis,[2] so they do not try to examine the underlying cause of an occurring error (e.g., Collins et al., 1975, p. 72; Mindnich et al., 2010, p. 421). As early as 1975, it was assumed that this lack of error analysis occurs because the cause of the error is completely 'obvious' to the teacher (Collins et al., 1975, p.72). Secondly, a teacher frequently changes the addressee when an error occurs (Bray's, 2011, p. 30; Tulis, 2013, p. 59). Often, errors are simply corrected (e.g., Santagata, 2005, p. 503) but are not discussed in class. As a consequence, the essential steps for learning are missing: if the teacher calls on the next student when an error occurs (often repeating this process until one student gives the correct answer), there is a risk that the first step in the process of learning from errors (recognizing the error) has already not been taken. Moreover, the student should understand what the underlying difficulty was. As the teacher refrains from addressing the error, the learning potential of the error is lost (this behavior of redirecting the question to another student is therefore called the 'Bermuda Triangle of error correction', Oser and Spychiger, 2005, p. 161ff.; Tulis, 2013, p. 58). It is possible that teachers do not address errors because they think that errors should not occur in good teaching (Türling, 2014b, p. 380).

So far, there has been a lack of insight into teachers' decisions to follow the above-mentioned behavior. Since beliefs can have a strong influence on a teacher's actions in an error situation (Bray's, 2011, p. 34; Voss et al., 2013, p. 263; Matteucci et al., 2015, p. 17), the focus in this article is on the third facet of the competency to deal with errors, the teacher's beliefs.

In the domain of business and economics education, there are some studies regarding teachers' beliefs (e.g., Seifried, 2009; Kirchner, 2016; Leumann and Aprea, 2016; Berding, 2017), but only few when it comes to beliefs regarding dealing with errors in error situations. Existing studies in this domain report that teachers generally have positive attitudes toward error situations and predominantly value errors as learning opportunities rather than instructional disruptions (Mindnich et al., 2010, p. 423; Türling, 2014a, p. 188). The results emerged by questionnaire and interview, but validation with the respondents' classroom actions is pending. In other domains, teachers are often asked about their beliefs via questionnaire (e.g., Baier et al., 2019), even when it comes to handling errors (e.g., Pan et al., 2020). Results from Pan et al.'s (2020) study reveal that error avoidance is prevalent among teachers and learners. However, when errors do occur, they are dealt with constructively (Pan et al., 2020, p. 1116). Again, these are self-assessments and process observations are lacking. Studies on actual teacher action in error situations and underlying teacher reasoning are still pending. This article addresses these limitations. I examine teachers' decisions to act in error situations, in order to uncover indications for underlying beliefs about handling students' errors. For this purpose, 11 accounting lessons (in total = 916 min) given by five teachers were observed. In total, 191 errors were identified, and three situations per teacher were discussed in video-stimulated recalls. The teachers provided information on why they performed (or did not perform) error analysis and why they changed (or did not change) their addressee. The answers are classified into an explanatory model for behavior in error situations. Implications for the education and training of teachers are derived.

1 A possible classification of error types and corresponding feedback type can be found in Köpfer and Wuttke (2021).

2 The term error diagnosis is often used synonymously with error analysis. In this article, the main concern is not that the teacher recognizes and identifies an error, which is the condition considered necessary for an error analysis, but that through the analysis the *cause* of the error is revealed. Thus, error analysis can both help the teacher to identify the underlying misconceptions and enable the student to take this important step in learning from errors.

# Theoretical background

## General and domain-specific beliefs

Beliefs can be differentiated in various ways: according to constructs that represent beliefs about the teacher himself (such as the construct of self-efficacy expectations; Bandura, 1997), general beliefs (e.g., epistemological beliefs about the nature of knowledge), and domain-specific beliefs (e.g., beliefs about the teaching and learning of mathematics, Voss et al., 2013, p. 252f.). However, these distinctions are not always precise. When it comes to beliefs about handling students' errors, the most common distinction is made in relation to the relevant learning theories. Different theoretical frameworks are used (Matteucci et al., 2015), but it is common to distinguish between behaviorist/transmissive beliefs and constructivist beliefs of teachers (Staub and Stern, 2002; Kuntze et al., 2008, p. 213; Gilleece, 2012) or between entity versus incremental beliefs (also known as fixed and growth mindset, Dweck and Yeager, 2019, p. 483).

Transmissive beliefs, when incorporated into teaching principles, are seen as rather detrimental to the quality of teaching and the learning success of students (Voss et al., 2013, p. 261), while at the same time it can be shown that classes perform better when they are taught by teachers with constructivist beliefs (Staub and Stern, 2002, p. 352). Therefore, if behaviorist beliefs about students' errors are adopted, it is considered that this will have a counterproductive effect on learning, because errors are then more likely to be seen as a disruption to teaching and a flaw to be avoided. Teachers with these beliefs often ignore errors or emphasize the correct solution immediately after the error has been corrected, so that misconceptions are not allowed to sink in. Since errors are sometimes anticipated by the teacher, this teaching approach is also called *error avoidance didactics*. Thus, students are deprived of the opportunity to develop solutions themselves, to make errors and to build up the necessary negative knowledge (see Oser, 2009, p. 5; Bray's, 2011, p. 27). Teachers with moderately constructivist beliefs, on the other hand, take a more productive approach to errors, called *constructive error management*. This is expressed, for example, in the perception that error situations are meaningful learning opportunities (Kuntze et al., 2008, p. 212). This distinction in dealing with errors as learning opportunities versus obstacles is also shown in studies on fixed mindset (beliefs that intellectual abilities cannot be changed) versus growth mindset (beliefs that intellectual abilities can be developed) (Dweck and Yeager, 2019, p. 484). When students are in a growth mindset, they may see errors as information about the learning process and sustain persistence (Dweck and Yeager, 2019, p. 483). To ensure that students to experience the constructive approach to errors and develop a growth mindset themselves, it is important that teachers with a growth mindset in the classroom ensure that errors are not seen as a sign of a lack of ability and act accordingly (Yeager et al., 2022, p. 19).

Furthermore, there is evidence that dealing with errors differs across domains (Tulis, 2013, p. 60), and students' beliefs also seem to be domain-specific (Tulis, 2013, p. 64; Tulis et al., 2018, p. 13). For instance, the "Bermuda Triangle" as well as negative emotional reactions from the teacher can be observed more often in math classes (Tulis, 2013, p. 66), which is probably why students' affective-motivational adaptability in responding to errors is different in math classes than in native language classes (Tulis et al., 2018, p. 13). This is plausible, because math classes, for example, are more characterized by clearly correct/wrong answers than more open subjects such as history. As a result, in more structured domains like mathematics, other types of errors occur and errors become more salient in general. For this reason, domain-specific beliefs are also considered here. Because of the similarity of the two domains, constructs adapted to the mathematics domain are often used in the accounting domain; mathematics and accounting are both characterized by highly structured and closed learning content areas (e.g., Türling, 2014a, p. 33). For the mathematics domain, Grigutsch et al. (1998, p. 11f., based on Schoenfeld's (1989), conceptualization of epistemological beliefs about mathematics as mathematical worldviews) developed an instrument to measure whether the basic guiding beliefs about mathematics view it as either a static or a dynamic system. This, in turn, was adapted for the domain of accounting by Seifried (2009, p. 206) because of the similarity between mathematics and accounting described above. This instrument provides an indication of whether a teacher's focus in accounting classes is rather algorithmic or rather economic. In the first case, teachers see the subject more as a static system, in the second more as dynamic. Following this distinction, different errors may occur and teachers may have different ways of dealing with errors (and presumably different beliefs about how to deal with errors) depending on their view on accounting class.

## Influence of beliefs on actions

Beliefs are said to have a function of guiding and orienting action, by influencing the perception of a situation and therefore also the choice of action in this situation (Thompson, 1992, p. 130ff.; Richardson, 1996, p. 105ff.; Grigutsch et al., 1998, p. 4; Tschannen-Moran and Woolfolk Hoy, 2001, p. 783f.; Leuchter et al., 2006, p. 574; Organisation for Economic Co-operation and Development, 2009, p. 118; Kleickmann et al., 2010, p. 223ff.; Voss et al., 2013, p. 264). The relationship between beliefs and actions is seen as reciprocal, because beliefs also develop from previous actions and experiences (Richardson, 1996, p. 107ff.). The importance of beliefs is highlighted in Schoenfeld's (1998) Teaching-in-Context theory, which uses a model to explain teaching decisions. According to this model, teachers' goals,

beliefs and knowledge determine their actions in the classroom and therefore student learning outcomes. Schoenfeld (2011) adds to this model any social, intellectual or material resources of the teacher. However, due to the inconsistent definition, conceptualization, and operationalization of beliefs (e.g., Voss et al., 2013, p. 249f.), the congruence between action and beliefs has not been empirically established. Additionally, there are limited and contradictory empirical results (Aguirre and Speer, 1999, p. 327ff.; Kleickmann et al., 2010, p. 215; Voss et al., 2013, p. 255). According to Fives and Buehl (2012, p. 481), the main issue is to determine the degree of incongruence or congruence and to identify the conditions of the connection between actions and beliefs. There are indications, for example, that the congruence between beliefs and actions is more pronounced among experienced teachers than among inexperienced teachers (Kleickmann et al., 2010, p. 215). In order to accentuate a possible incongruence, Leuchter et al. (2006, p. 565f.) distinguish between beliefs that are close to action and those that are far from action, and the TALIS study also differentiates between 'abstract and concrete beliefs' (Organisation for Economic Co-operation and Development, 2009, p. 118): accordingly, beliefs close to action or concrete beliefs are more congruent with actions (Organisation for Economic Co-operation and Development, 2009, p. 118). A possible influencing variableis the emotional involvement of the teacher. The underlying emotions influence their beliefs, motivation and behavior (Moé and Katz, 2021). Only when teachers' basic psychological needs (competence, autonomy, relatedness, Ryan and Deci, 2020) are satisfied, they are more motivated to behave in an autonomy-supportive way (Aelterman et al., 2019). This gives them the opportunity to be more responsive to students and to find the right way for them to deal with errors.

Following the above-mentioned theory of Teaching-in-Context (Schoenfeld, 1998, 2011), I assume that beliefs have an impact on teachers' actions. Teachers are seen as active decision-makers, but teaching situations are (in general) complex situations. Actions or beliefs in complex situations always represent functions of various conditioning factors and, due to the multiplicity and complexity of these factors, teachers also have several action alternatives at their disposal (see the expression 'the teacher as dilemma manager' by Lampert (1985, p. 190): teachers can often only react to certain dilemmas in the classroom). In the sense of Weber (1981), however, I attribute a motive to teachers for their intentional behavior in the classroom (e.g., I assume that if they do not conduct error analysis then this is for a certain reason), and investigate the question of the motivational factors used by teachers to justify their actions. These factors can be situational and personal, and can also be the anticipated outcome of the action and its consequences (Heckhausen and Heckhausen, 2018, p.4 ff.). According to Dann and Haag (2017, p. 112), the following decision-making conditions play a role before, during and after actions and decisions in the classroom: (1) knowledge about students, (2) previous student behavior, (3) self-related cognitions and emotions of the teacher, and (4) external circumstances. Because of their action-guiding function (Aguirre and Speer, 1999, p.327 ff.; Voss et al., 2013, p. 263f.), teachers' underlying beliefs are likely to relate to these aspects.

## Access to beliefs

Beliefs have different functions; for example some beliefs support decisions (e.g., Blömeke, 2012, p. 18). They are somewhat unconscious, since decisions and their underlying beliefs are only reflected if there is a particular cause. For this reason, they are also difficult to articulate (Fives and Buehl, 2012, p. 473f.). Beliefs close to behavior are particularly difficult to access because they are immanent to action routines and are not questioned (Reusser and Pauli, 2014, p. 656). Nevertheless, in the context of teacher education and training, beliefs receive widespread research interest, because there is a question of the extent to which beliefs can be changed and purposeful beliefs can be strengthened (König, 2012, p. 10). Although the stability of beliefs is often emphasized, there is evidence that beliefs can be changed based on experience (Fives and Buehl, 2012, p. 484; Voss et al., 2013, p. 264f.). If beliefs are to be changed, they must first be made visible. Because of the above-mentioned unconscious nature of beliefs, access to them is difficult, and to gain reliable data it is crucial to choose an appropriate method of data collection. Beliefs are either partly conscious or can be made partly conscious and articulated with the help of suitable methods, for example by offering occasions for discussion (Fives and Buehl, 2012, p. 473f.). These occasions for discussion encourage a teacher to reflect on his or her actions in class and, possibly, on his or her beliefs that may have led to a particular action. In order to be able to align the (subsequent) reflection about the beliefs that guided the action as closely as possible with the action being performed, the method of thinking aloud is usually applied (e.g., interviews, Seifried, 2012, p. 137ff.), or attempts are made to evoke an exact memory by means of a stimulus (e.g., a video recording of the lesson). Attention must be paid to the fact that verbalized thought processes may not always represent memories but instead be a "*post hoc* rationalization" (Yinger, 1986, p. 267ff.; Loughran, 2002, p. 35).

# Present study

The purpose of this study is to conceptualize a theoretical model for the action-guiding beliefs about dealing with a student's error that make a teacher decide how to act (whether or not to perform error analysis or change the addressee). I use qualitative data from classroom observations and interviews as well as quantitative data from a questionnaire, in order

to reveal teachers' beliefs about dealing with students' errors. Furthermore, quantitative data were collected to have indicators for any differences in teachers' perceptions.

Due to the small amount of available knowledge about teachers' reasons for their behavior in error situations, as well as the small sample size, I refrained from testing specific hypotheses. Instead, I use an exploratory, descriptive approach. The following research questions guided the study:

1. What reasons do teachers give for their behavior in error situations (whether or not to perform error analysis or change the addressee)?
2. What beliefs about (dealing with) students' errors can be related to these reasons?

# Methodology

## Research design

This study uses a mixed methods design that includes qualitative and quantitative data. However, the focus is on the qualitative data. The qualitative data consists of classroom recordings of five teachers in initial accounting lessons using two cameras to provide an overview of the class and the teachers' actions. Based on these recordings, three error situations were identified for each class, which were presented as stimuli to the respective teacher after the recordings in semi-structured interviews (explained further below). In addition, I analyzed quantitative data regarding beliefs using a questionnaire. Consent of all responsible parties as well as involved persons was obtained.

## Participants

The participants in the study were five male teachers from five schools (two-year vocational schools for economics, which aim to enable students to receive an intermediate school-leaving certificate) in Hesse, Germany. The five teachers were between 35 and 60 years old ($M_{age}$ = 44.25, $SD$ = 11.62) and had been teaching for a little over ten years on average ($M_{experience}$ = 10.25, $SD$ = 7.93, $Min$ = 2, $Max$ = 20). Overall, 81 students (38 female, 43 male, age: $M_{age}$ = 17.03, $SD$ = 0.96) participated in the study. **Table 1** provides an overview of the participating teachers (all names are pseudonyms) and their classes. Questionnaire data are only available from four teachers, who are noted in **Table 1**.

The subjects covered were two of the most difficult subjects in accounting (Türling et al., 2012, p. 99): the transfer of entries from asset accounts to P & L accounts (statements of profit and loss), and VAT classification (pre tax and sales tax). Four of the classes were in their first year of this type of school, and one class was in its second year.

## Instruments

### Teachers' beliefs about handling students' errors

#### Beliefs about teaching and learning

Teachers' beliefs about teaching and learning are measured using two scales. In constructivist beliefs, students are seen as constructors of their own understanding (e.g., "I think that students can teach each other very well when learning accounting", 10 Items, Cronbach's α = 0.730). With transmissive beliefs, learning is seen as a one-sided transfer of knowledge (example item "In order for students to perform well in accounting, they first have to learn a lot by heart," 11 items, Cronbach's α = 0.944; adaptation of Stipek et al., 2001; Kunter et al., 2011, p. 241ff.; Robinson and Lubienski, 2011).

#### Domain-specific beliefs—accounting worldview

I surveyed domain-specific beliefs of the participating teachers using an adapted instrument. Seifried (2009, p. 206) modified an instrument developed by Grigutsch et al. (1998) for attitudes toward mathematics. Due to the structural similarity of accounting to mathematics lessons, this instrument should be suitable for use. It consists of four subscales with the aspects *process*, *application*, *formalism*, and *scheme*. Depending on the expression of the subscales, it indicates a more algorithmic or economic focus of the teacher. The scale *scheme* contains items that represent accounting as a collection of rules (example item "In accounting classes, there are precise schemes on how to solve a task," three items, Cronbach's α = 0.750) and the *formalism* scale represents accounting as an abstract formal theory (e.g., "The accounting lessons are characterized by a clear structure," four items, Cronbach's α = 0.889). If one agrees with the items of the *process* scale, the (teaching) focus is rather on ideas and thinking processes in accounting (e.g., "Students should often experience situations in accounting classes where they can develop knowledge independently," six items, Cronbach's α = 0.506) and in the case of high values in the *application* scale, on applying them to everyday life or professional life (example item "Accounting lessons are directly related to business practice," four items, Cronbach's α = 0.538; Seifried, 2009, p. 206).

### Video-stimulated recalls

A stimulated recall produces retrospective commentary by the participant, triggered and supported by a visual or audio stimulus (e.g., Egi, 2008, 213). In this study, I videotaped two to three double lessons in the initial accounting class of the participating teachers. For each teacher I identified three situations in one of their own lessons in which a student publicly made an error. The teachers individually watched these three previously identified error situations and answered, within a semi-structured interview, questions about why they acted as

they did in the situation. The interviews were held for 35–86 min ($M$ = 53).

### Selection of the stimuli (error situations)

In this study, an error is a student's utterance that deviates from the norm (e.g., Weimer, 1929, p. 5). If such an incorrect or missing utterance occurs in class in public, an error situation begins. The teacher reacts to this utterance. Within an error situation, there can be several errors and different reactions by the teacher. The error situation finishes as soon as the teacher has finished dealing with the question or task that caused the error(s), or dealing with the error(s) that occurred in this situation. Because of the varying length and form of the single error situations, the number of individual errors is reported here: in the videotaped lessons of the participating teachers, 191 errors were identified. The number of errors ranges from 24 errors in Mr. Smith's class to 60 errors in Mr. Robinson's class. In terms of content, the students primarily made errors in terminology (34 out of 191 errors) and percentage calculations (54 out of 191 errors). However, the reactions across all errors are considered. The frequencies of an error analysis being performed and the addressee being changed are shown in **Table 2**.

The error situations used in the stimulated recalls were selected after the recordings of the particular teacher had been made. A pilot study showed that it would be possible to select situations spontaneously immediately after the recordings. However, an in-depth analysis of the video recordings was first carried out in order to get an overview of all the situations that occurred. The interviews therefore took place about a week after the last video recording. The criteria for selecting the error situations for the stimulated recalls were as follows: (1) general suitability as stimulus: everything is audible and the student who makes the error is clearly recognizable, (2) content fit in terms of heterogeneity of relevant feedback/behavior variants (error analysis and change of addressee), and (3) broad range of types of students' errors as well as characteristic behavior of the teaching staff.

### Semi-structured interview guide

The semi-structured interviews consisted of three phases. After general instructions and an (1) orientation phase including information about the privacy policy, obtaining consent and an explanation of the procedure, the (2) development phase followed with the video and the guiding questions. In the (3) final phase any open questions were clarified and the interviewees thanked for their willingness and time. Guiding questions should make interviewees tell the story, so that they themselves name terms that are important to them and do not get categories presented from outside. In terms of content, the questions initially referred to the videotaped error situations. The teachers gave reasons for their behavior and further information on the situation, such as whether the error occurs frequently, what the underlying problem of understanding might be, and also whether they would react in the same way in other classes or types of school.

## Data analysis

The quantitative data from the questionnaires is analyzed using descriptive statistics. The qualitative data is analyzed using both within-case analysis and cross-case analysis (Miles et al., 2014, p. 100ff.). In order to conduct a qualitative content analysis following the method of Schreier (2012), the interviews were audio-recorded and transcribed verbatim. The results of the *within-case analysis* consist of the comparison of two error situations of the video recordings (of two of the interviewed teachers). The situations selected here contrast the behaviors in error situations that are the focus of this paper. In the first situation, the teacher analyses the error and stays with the student who made the error. In the second situation, the teacher changes the addressee after a wrong answer and does not really search for the cause of the error.

The results of the *cross-case analysis* provide insights into the reasons for all five teachers' behaviors in the error situations: (1) why they did not search for the cause of the student error in the relevant situation, and (2) why they did search for the cause in other situations. Furthermore, the results show why (3) in some situations they redirected the question to another student, and (4) in other situations they did not do so and dealt with the student making the

TABLE 1 Overview of participating teachers and classes.

| Teacher | Number of students[a] | Subject of the lesson | Year |
|---|---|---|---|
| Mr. Robinson | 14–16 | VAT | 1st |
| Mr. James[b] | 11–12 | VAT | 2nd |
| Mr. Thomas[b] | 8–9 | VAT | 1st |
| Mr. Smith[b] | 21–25 | P & L accounts | 1st |
| Mr. Brown[b] | 17–19 | P & L accounts | 1st |

[a] Varies between the video recordings.
[b] Questionnaire data available.

TABLE 2 Frequencies: errors, error analysis, and change of addressee.

| | Frequencies, *n* (%) | | | | |
|---|---|---|---|---|---|
| | Mr. Robinson[a] | Mr. James[a] | Mr. Thomas[a] | Mr. Smith[a] | Mr. Brown[b] |
| Errors | 60 (100) | 36 (100) | 26 (100) | 24 (100) | 45 (100) |
| **Behavior pattern** | | | | | |
| Error analysis/no error analysis | 1 (2)/ 59 (98) | 6 (17)/ 30 (83) | 3 (12)/ 23 (88) | 1 (4)/ 23 (96) | 3 (6)/ 42 (93) |
| Change of addressee/no change of addressee | 29 (48)/ 31 (52) | 14 (39)/ 22 (61) | 0 (0)/ 26 (100) | 4 (17)/ 20 (83) | 9 (20)/ 36 (80) |
| **Combination of the two behavior patterns** | | | | | |
| No error analysis and change of addressee | 29 (48) | 13 (36) | 0 (0) | 4 (17) | 8 (18) |
| No error analysis and no change of addressee | 30 (50) | 17 (47) | 23 (88) | 19 (79) | 34 (76) |
| Error analysis and no change of addressee | 1 (2) | 5 (14) | 3 (12) | 1 (4) | 2 (4) |
| Error analysis and change of addressee | 0 (0) | 1 (3) | 0 (0) | 0 (0) | 1 (2) |

[a]Two double lessons.
[b]Three double lessons.

error instead. I describe all categories mentioned at least once among the teachers and are supported with the most significant (direct or indirect) quotations. The results lead to an explanatory model for teacher action in error situations and the underlying beliefs.

# Results

## Teachers' beliefs about handling students' errors

The questionnaire data provide information about more general beliefs regarding learning theories and domain-specific beliefs about accounting instruction with more algorithmic or economic focus. The following **Table 3** provides an overview of the descriptive results of the questionnaire. These results are only available for four of the participating teachers.

All four teachers agree with the subscale constructivist orientation of the *general beliefs* at least as much as with the subscale transmissive orientation. Mr. Brown has the highest mean value on the constructivist orientation scale with a mean of 4, followed by the other three teachers with a mean of 3. The difference between these two scales is not more than one scale point for any of them. Mr. Thomas agrees equally with both subscales ($M = 3$).

Looking at the *domain-specific beliefs*, it appears that the formalism aspect is strongest among all teachers. Mr. Brown and Mr. Thomas agree more strongly with this aspect than Mr. Smith and Mr. James do. Regarding the other aspects of the accounting worldview instrument, there are greater differences between the teachers. Mr. Smith and Mr. James see accounting less as a collection of rules than Mr. Brown and Mr. Thomas do. The opinions on the process and application aspects are opposite: Mr. Brown and Mr. Thomas agree more with the application aspect than with the process aspect; Mr. Smith and Mr. James agree more with the process aspect than with the application aspect.

In terms of content, it could be presumed that teachers with a constructivist orientation tend to have a world view about accounting class that corresponds to the application and/or process aspect. Since it is assumed that teachers with constructivist beliefs take a more productive approach to errors (Kuntze et al., 2008, p. 212), this would also be assumed for the world view aspects application and process. Teachers with a more transmissive orientation presumably tend to have higher values for the world view aspects formalism and/or scheme. Interestingly, such a relationship is not apparent from the mean scale values. Thus, no conclusion can be drawn about beliefs about the inherent benefit of students' errors.

## Teachers' behavior in error situations (within-case analysis)

In order to show examples of the error situations and the behavior of the teachers discussed here, two contrasting situations of two teachers are described in more detail and compared with each other. The *first situation* takes place in Mr. Thomas' class on a Wednesday in the fifth teaching hour, about ten minutes after the start of class. This is the introductory lesson in the VAT classification topic. Nine students are present, and Mr. Thomas has brought receipts from various purchases in supermarkets and chemists that are analyzed within the classroom discussion. Based on these receipts, the students have the task of preparing accounting records with the corresponding accounts. The discussion of the second receipt begins as follows (Words in bold are the errors or the students making errors):

> *Mr. Brown:* Vehicle fleet to liabilities—affecting net income or not?

TABLE 3 Results of beliefs about students' errors.

| | Mr. Brown | Mr. Thomas | Mr. Smith | Mr. James |
|---|---|---|---|---|
| Transmissive orientation | 3 | 3 | 2 | 2 |
| Constructivist orientation | 4 | 3 | 3 | 3 |
| World view "process" | 2 | 2 | 3 | 3 |
| World view "application" | 3 | 3 | 2 | 2 |
| World view "formalism" | 4 | 4 | 3 | 3 |
| World view "scheme" | 4 | 3 | 2 | 2 |

Mean scale value, four-point Likert scale ranging from 1 (*disagree*) to 4 (*agree*).

***Anne:*** **Yes.**
*Mr. Brown:*] Vehicle fleet to liabilities: asset account, liability account. Is there anything here with profit and loss accounts? [He nods to Samuel.]
***Samuel:*** **This is a loss.**
*Mr. Brown:* Where is a loss?
*Samuel:* We are buying something.
*Mr. Brown:* Vehicle fleet: balance sheet account, liabilities: balance sheet account. Where's the profit or loss account here? [He calls George.]
***George:*** **Fleet of vehicles: loss. And liabilities: profit.**

*Mr. Brown:* Oh, this is getting exciting. So now, let us see: vehicle fleet—balance sheet. Is vehicle fleet an asset account or a profit and loss account? Asset accounts are on the balance sheet. Ah, let us do it like this: If—write it down! That's a great sentence, watch this, it's good.—If an accounting record contains only balance sheet accounts, is the business case affecting or not affecting the net income? People, look here: if only this or that [points to balance sheet accounts on the blackboard] is addressed, does this have anything to do with equity capital or with profit/loss? No! So, if only balance sheet item accounts are addressed, then? [He points to Ben.]

*Ben:* It's not affecting net income.
*Mr. Brown:* And with this statement we can do task 3. Vehicle fleet to liabilities - affecting or not affecting net income? [He points to Ella.]
*Ella: (no answer)*
*Mr. Brown:* Is vehicle fleet a balance sheet account?
*Ella:* Yes.
*Mr. Brown:* Is a liability a balance sheet account?
***Ella:*** **No.**
*Mr. Brown:* Is a liability one of the balance sheet items on the liabilities side [shown on the blackboard]?
*Ella:* Oh, yes.
*Mr. Brown:* So is it affecting the net income or not? [He calls Samuel.]
*Samuel:* Not affecting net income.
*Mr. Brown:* Because there are two balance sheet accounts in it.

The *second situation* was observed in Mr. Brown's class on a Thursday at the end of the fifth lesson. This is the third double lesson since the introduction of the topic on 'Transition from asset accounts to profit and loss accounts' and there are 17 students present. The class plenary discusses the results of a previous practice phase in which the students had to assess whether a business case was affecting the net income or not. Two business cases in this exercise have already been discussed; the third is 'Purchase of a new truck on target', and forms the basis of the following class discussion. After the student Anne presents the correct accounting record, the discussion concerns the actual question of effects on the net income:

*Mr. Brown:* Vehicle fleet to liabilities—affecting net income or not?
***Anne:*** **Yes.**
*Mr. Brown:* Vehicle fleet to liabilities: asset account, liability account. Is there anything here with profit and loss accounts? [He nods to Samuel.]
***Samuel:*** **This is a loss.**
*Mr. Brown:* Where is a loss?
*Samuel:* We are buying something.
*Mr. Brown:* Vehicle fleet: balance sheet account, liabilities: balance sheet account. Where's the profit or loss account here? [He calls George.]
***George:*** **Fleet of vehicles: loss. And liabilities: profit.**
*Mr. Brown:* Oh, this is getting exciting. So now, let us see: vehicle fleet—balance sheet. Is vehicle fleet an asset account or a profit and loss account? Asset accounts are on the balance sheet. Ah, let us do it like this: If—write it down! That's a great sentence, watch this, it's good.—If an accounting record contains only balance sheet accounts, is the business case affecting or not affecting the net income? People, look here: if only this or that [points to balance sheet accounts on the blackboard] is addressed, does this have anything to do with equity capital or with profit/loss? No! So, if only balance sheet item accounts are addressed, then? [He points to Ben.]
*Ben:* It's not affecting net income.
*Mr. Brown:* And with this statement we can do task 3. Vehicle fleet to liabilities - affecting or not affecting net income? [He points to Ella.]

*Ella: (no answer)*
*Mr. Brown:* Is vehicle fleet a balance sheet account?
*Ella:* Yes.
*Mr. Brown:* Is a liability a balance sheet account?
***Ella:* No.**
*Mr. Brown:* Is a liability one of the balance sheet items on the liabilities side [shown on the blackboard]?
*Ella:* Oh, yes.
*Mr. Brown:* So is it affecting the net income or not? [He calls Samuel.]
*Samuel:* Not affecting net income.
*Mr. Brown:* Because there are two balance sheet accounts in it.

The two situations have in common that they are initial lessons, in a fifth period in the middle of the week, in two of the most difficult topics in accounting. In both situations, the first task, in plenary, is to prepare the correct accounting record for a business case. In the second situation, the task goes one step further, and the business case is to be examined for its effect on the net income. At first, only the topic of the lesson and the number of students differ. While Mr. Thomas only has nine students in the class, Mr. Brown has 17. In the first situation, one student makes an error. In the second situation, the first error is followed by others, made by different students. This seems to be due to the teachers' behavior, as teachers deal very differently with occurring errors.

Mr. Thomas interacts with Noah in the whole situation, although the student Audrey, after Noah's wrong answer, makes it clear that she has another, perhaps the right, answer. There is no change of addressee. Furthermore, Mr. Thomas starts an error analysis after the wrong answer, because he asks Noah how he concluded that 'receivables' could be one of the affected accounts. This makes it clear what is wrong with the answer. Noah has the correct answer at hand after this question from the teacher. Mr. Thomas does not immediately respond to this correct answer, but once again points out to Noah that it is important from whose perspective a receipt is viewed and the accounting record is set up. In the second situation (with Mr. Brown), six students are involved in answering the question. Anne, Samuel, George and Ella each makes an error, but the errors are of different kinds. While Anne makes a wrong decision about the effect on the net income, Samuel and George seem to have fundamentally misunderstood what profit and loss accounts are. Ella seems not to be aware that liabilities are a liability account. Apart from the frequent change of addressees, there is only one attempt at error analysis. Mr. Brown asks Samuel why, in the business case, he thinks a loss would occur. Based on his answer and the subsequent (incorrect) answer from George, Mr. Brown seems to have come across a misunderstanding and provides an explanation by means of a mnemotechnic verse. Since the mnemonic refers to the current account type, Mr. Brown then queries the account type for the account concerned. At the end of the situation, (only) Samuel gives the correct answer to the task. In contrast to the exemplary situation in Mr. Thomas' lesson, it is not clear here whether each individual student really knows what he or she did wrong and why. There is a lack of obvious error determination and analysis. The teacher does not deal with Anne's answer any longer, and it is not clear whether Anne has the same misunderstanding or understands correctly after the class discussion. Asked about the reasons for his behavior, Mr. Brown refers only to Anne: she is a good student and did not think properly at that moment. Besides, he says that the students still have some conceptual difficulties with this topic because it is new. He states that he did not intend to change the addressee and that the reason why he did not carry out an error analysis is that he knew the cause of the error and did not want to expose the student.

## Reasons for teachers' behavior in error situations (cross-case analysis)

### Error analysis

#### Reasons for absence of error analysis

I asked the teachers in the stimulated recalls why they did not perform an error analysis.

*Frequency/Reason of the Error:* One reason given by all five teachers in almost all the situations is that they themselves know the cause of the error and therefore do not need to ask the student, because the error often occurs. Besides the answer "Yes, I know where the error is" (given by Mr. James and by Mr. Brown), they also give precise descriptions of what the student has obviously done wrong in the situation. For example, not only is it recognized that the wrong accounting record probably resulted from the student setting it up from the wrong perspective—she took the perspective of the buyer instead of the seller—as reported by Mr. Thomas, but it is also recognized where the wrong amount comes from in the case of a miscalculation. Mr. Thomas explains, "He means the gross invoice amount, which he has correctly: 476. However, that was not asked for at this point." Mr. Robinson describes a situation in which he knows from the amount mentioned that the student was off by one decimal place in the calculation.

*Prior Knowledge of the Student:* Another argument for the lack of error analysis, which is mentioned, is the level of achievement or prior knowledge of the student who made the error. If a student who has so far answered similar tasks correctly commits the error, the error is justified by the fact that the student lacked practice; it is assumed that the right thing was meant, but the wrong thing was said. Mr. James says:

> But it was Emma. And I think, I went after that, that Emma is actually a very smart student and that it was simply a careless error on her part. And I am also

> convinced that she actually knows better. That's why I didn't go directly into it again.

*Personality/Resources of the Student & Error Type:* Other attributes of the students are also used to decide whether to find the underlying cause of the error. The teachers refer to the fact that they are teaching at a type of school in which the students often come from different cultures and have not yet had much experience of success in their school careers. Furthermore, if the answer given is a long way from the correct answer, Mr. Brown points out:

> His focus is getting tighter and tighter. There are 19 [classmates] around him, who see that he doesn't know. And sometimes I also do it when I have the feeling that I can somehow 'feed' something and that gives me the result that I want. If there is a small piece missing. But when I see that this is far from the right answer, then another questioning and drilling and a dialogue only with the error making student in this school form is equal to exposing. They feel embarrassed. And the point is that they have the feeling that they cannot save face. They begin to feel ashamed.

*Emotions/Resources of the Teacher:* Teachers see their behavior as being based mainly on the attributes of the students, but also on their own person or on an interplay of their constitution and the type of school. Mr. James regards the absence of error analysis as negligence, and Mr. Brown is aware that he does not follow up on errors because of a lack of patience and sometimes even out of selfishness:

> But it could also be that I simply had no patience or—now I'm being selfish—simply liked the idea I had so much that I wanted to get rid of it. Yes, a lot is of course related to the way I act as a teacher in such a teaching setting. For example, if I suck at it or whatever, it carries over to the class. If I'm receptive or in a good mood, then everything is much more relaxed, somehow looser. And now in this situation, I think I really had a good thought and wanted to do it that way.

*Unconsciously taken Decision:* Both Mr. Robinson and Mr. Brown give answers to this question which refer to the situation-dependency of their actions or to the fact that they had no concrete reasons for their decision to act. Mr. Brown puts it this way:

> So, this is a random product. I might as well have asked again. This is one thing, it is decided in a fraction of a second and I chose something else in that moment. Whatever the reason. I can't reconstruct it now. In another situation, an hour later or whatever, I might have asked.

### Reasons for carrying out error analysis

However, there are also 14 situations (see **Table 2** above) in which the teachers do analyze the cause of the error. In these situations, after a student has given an incorrect answer, the teacher asks why this answer was given and lets the student explain how they arrived at their answer. In these situations, the interviewed teachers only refer to their knowledge about the students.

*Prior Knowledge of the Student:* Mr. James demonstrates this behavior more often than his colleagues in this sample. On the one hand, he uses error analysis for students who perform less well, to see if the student has understood where the error lies. On the other hand, even in situations where he does not conduct error analysis, Mr. James sees a need for this action. In a situation where a high achieving student makes an error and Mr. James simply tells her the correct answer, Mr. James notes in the stimulated recall that error analysis would have been important at this point because other students may not have been able to understand where the error lies: "Here my actions were related to Emma. However, of course it would have been possible to clarify this again: Why is there a wrong thought now? Because the student sitting next to her is having difficulties in understanding." Similarly, the argument that the student has never made a particular error is given in the reasoning *against* (see above) as well as the reasoning *for* an error analysis to be performed. Mr. James explains, "Olivia never made that error. Suddenly she makes that error. And then I ask, 'Yes, why?' And then we try to put it back on track."

*Personality of the Student:* By analogy to the reasoning above (section "Reasons for Absence of Error Analysis") that a student might find an error analysis to be a shameful re-drilling, Mr. Smith explains that he only investigates the cause of the error with those students who, by their nature, can tolerate it and are not unsettled by it.

## Change of addressee

### Reasons for change of addressee

*Personality of the Students:* One reason for a change of addressee, which the teachers mention several times, is that after an error has occurred other students should be given the chance to give the correct solution. For example, Mr. Robinson wants to give the students the opportunity to receive a sense of achievement by providing the right solution.

*Knowledge of the Student:* On the other hand, changing the addressee gives the teacher information about whether other students have understood. Mr. James sums it up, "But also that I generally see, did the others also misunderstand it? So for me, this is also a feedback somehow, when another student comes up with the right explanation."

*Explanation in Students' Language:* At the same time, in Mr. Robinson's lessons, students who know the correct solution must also explain their line of thought in arriving at that answer. He states that this could then be an acceptable line of thought

for the student who made the error, and that explanations from classmates are often better understood by many students than explanations from the teacher.

*Emotions/Resources of the Teacher:* Mr. James sees the change of addressee as giving himself relief, since he does not have to react to an error himself, but a fellow student takes over this task: "There are several reasons for this. Number one: Relief of course. When you have taught for eight hours—as I did today—then you have to make space somewhere."

*Unconsciously taken Decision:* Just as with the justification for the absence of an error analysis, Mr. James explains that his decision to change the addressee in a particular situation was not made consciously. He is of the opinion that a conscious decision rarely occurs in this profession anyway:

> Well, you have to say quite clearly that we as teachers do not always act consciously. That is clear. Most things happen unconsciously. With 25 hours a week, you can't think through or plan every detail. Maybe some people can. I haven't met any.

### Reasons for dealing with the student making the error

If there is no change of addressee in an error situation, but the teacher continues to deal with the student who has made the error, then the student will be asked further questions, for example, to get closer to the correct answer. Alternatively, the student is told that the answer is wrong and is allowed to make another oral contribution.

*Subject/Difficulty of the Error:* Mr. Brown uses this method for dealing with a student who makes an error particularly when the topic is new or interfaces with another topic that may be more difficult. Mr. Smith wants to give students who might actually know better a chance to rethink their answer:

> In that case, I think Lucas had already understood that in principle, but now he just mixed it up. That he has already realized it, but that he still has problems with debit and credit. Then he is encouraged to think again and when he looks at it, he often makes the right decision. Therefore, he gets the chance to improve before someone else says so.

*Knowledge of the Student:* For Mr. James, the reason for this approach is that the student who made the error must come to know what the correct answer is. Even after a change of addressee, he feels that it is important to go back to the student and make sure that he has understood how to do it correctly.

*Unconsciously taken Decision:* Mr. Thomas does not give a direct reason why, in an error situation, he dealt with the student who made the error, and explains that this action took place spontaneously: "I didn't know that a wrong answer was coming. I did not think of a method to lead the student to the right answer. That was, I would say, *ad hoc*."

## Explanatory model for teachers' behavior in error situations

Overall, the teachers' responses can be summarized as follows. When asked about the reasons for certain behavior in error situations, the teachers expressed reasons that relate to beliefs about the (prior) knowledge, personality, and resources of the students; their own emotions and resources; and the attributes of the error (subject, type (frequency/difficulty), and underlying reason). The relationships between the behavior in error situations and the beliefs can be combined into an explanatory model as follows (**Figure 1**).

By their very nature, interaction processes in everyday teaching cannot be planned, and any causal attribution is initially irrelevant. Nevertheless, the explanatory model derived here can be used to describe connections between beliefs and behavior in error situations.

Depending on the behavior shown, different beliefs come into play in the reasoning. Results show that each behavior is justified with attributes of the students. In the case of reasoning for the performance of an error analysis, only the attributes of the students come into play. As soon as situations with rather non-adaptive behavior patterns (not conducting error analysis or changing the addressee instead), teachers mention reasons about themselves. The teachers interviewed refer to negative as well as positive aspects: they want to provide some relief for themselves or to establish their own ideas. With attributes of the occurring error, the teachers justify two of their behavior patterns. This applies when they do not perform an error analysis or when they do not change their addressee and instead deal with the error-making student (in a class plenary; that does not mean that the cause of the error is also investigated).

The question is pursued to which of the beliefs described in section "General and Domain-Specific Beliefs" the statements of the teachers can be assigned. Whether the teachers rather apply an error avoidance didactics, i.e., see errors as obstacles to learning, or understand errors as learning opportunities and practice a constructive error management (Gewiese et al., 2011, p.2).

In general, the behavior of the interviewed teachers may not be described as error avoiding, since obviously many errors are allowed—or at least occur. With regard to errors, none of the teachers expressed themselves in any way that could lead to the conclusion that they see errors as an obstacle to learning. Rather, it seems that they see errors as a given and have no particularly negative or positive beliefs about them. However, the way they deal with the errors that occur and the beliefs they reveal about how to deal with student errors are not always particularly constructive.

The fact that all behaviors are reasoned with beliefs about student attributes is conform to theories and empirical findings

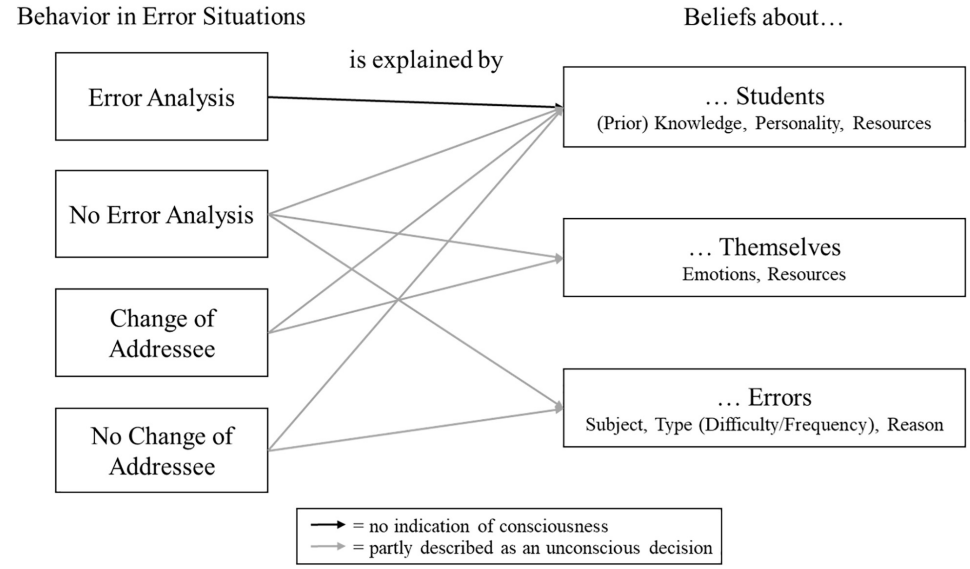


FIGURE 1
Explanatory model for behavior in error situations demonstrated in this study ($n$ = 5).

on learning from errors and the appropriate feedback. Feedback, especially in error situations, should be oriented to the student (e.g., Shute, 2008, p. 154ff.). The same is true for reasoning with error attributes such as the underlying subject or the difficulty of the error. These are not only aspects that are considered in many error taxonomies, but also according to which the appropriate adequate feedback should be derived (Köpfer and Wuttke, 2021, p. 472ff.). However, teachers consistently seem to underestimate the learning potential from errors. Thus, they could provide error analysis to encourage those students to think whose errors may not become public.

The consideration of not wanting to expose a student is understandable and justified because when negative emotions prevalent, a student is unable to learn from errors (see Oser et al., 1999, p. 27f.). However, in this case, other actions should be taken, e.g., calling on other students who made similar errors but have no problem being the focus of attention, or addressing the error later again, in order to not let the learning potential of the error unexploited. Otherwise, this is almost tantamount to error-avoidance didactics—by avoiding continuing working with the error, the possibly negative attitude towards errors among the students can be reinforced. Positive attitudes toward errors of all participants and thus positive error climate in the classroom is an important conditional factor for learning from errors (Oser and Spychiger, 2005, p.65; Oser, 2009, p. 5).

The intention, for example, to change the addressee after an error has occurred in order to give another student the chance to find the correct answer and thus have a positive learning experience, is certainly benevolent. However, in doing so, the learning potential of the error is neglected by not addressing it. It may not be apparent to any of the students what exactly the error was and how it can be avoided in the future (Tulis, 2013, p. 58). Changing the addressee until the correct answer is given can lead to guessing and is not in line with available empirical evidence on learning from errors. Studies indicate that in learning situations, the correct answer can be remembered even better after committing an error and correcting it than without having committed an error (Kornell et al., 2009, p. 995f.; Kornell et al., 2015, p. 291).

Overall, the teachers interviewed seem to be more likely not to see students' errors as an obstacle, but they seem to lack information about theories and empirical findings, as well as the appropriate pedagogical content knowledge for dealing with errors.

## Discussion

In the present study, I explored teachers' perception on their behavior in error situations in accounting classes. General and domain-specific beliefs were surveyed using a questionnaire and classroom videos and interview data of the participating teachers were analyzed. The focus is on teachers' behavior in error situations, (not) performing an error analysis, and (not) changing the addressee after the occurrence of a student error. I asked the teachers about the reasons for their actions and connected this to underlying beliefs. Since from previous studies, there were no concrete explanations for the frequently observed non-adaptive behavior in error situations.

Overall, it can be concluded that teachers reason their behavior in error situations with beliefs about attributes of the students, the teachers themselves, and the errors. However, the reference to specific attributes varies depending on the situation. In all the behavior alternatives, utterances about the students' variables predominate, as in the study by Hofer (1986, p. 76ff.). Thus, the attributes of the students are important to the teachers in all error situations. This is an indication that the teachers orient their actions primarily toward the students. That they do not differ in this respect is also shown by the descriptive results of the quantitative data (see below).

When asked why they *did not* conduct an error analysis, the teachers stated that they knew how the error occurred and knew the misunderstanding that lies behind the error and that the error analysis was therefore unnecessary. This supports the assumption made by Collins et al. (1975, p. 72), that teachers do not perform error analysis because the errors that occur are 'obvious' to them. The argument that an analysis could nevertheless be useful in order to give the students the opportunity to reflect for themselves and thus, at best, avoid the error in the future, is expressed much less frequently. There is no indication that more experienced teachers might mention this first reason more often (Türling, 2014a, p. 82). All but one of the participating teachers had been teaching their classes for at least three quarters of a year; one teacher had less experience with this very class, but he had the longest experience in teaching.

A reasonable explanation would also have been that teachers tended not to conduct an error analysis on 'easier' errors and instead tended to redirect the question, but this was not mentioned. When the teachers used the attributes of the error to justify their behavior, they referred to whether the topic was new (that is, according to them, more difficult), or whether the error was a typical error known to them together with its cause. Furthermore, the teachers stated that their behavior depends on how different the error is from the correct answer.

When it comes to a *change of addressee*, the teachers mentioned aspects that are partly in line with theoretical and empirical findings about learning from errors. For example, they expressed justifications, which indicate that there is a lack of awareness of the so-called 'Bermuda Triangle of the error correction', which can result when changing addressees (Oser and Spychiger, 2005, p. 161ff.; Tulis, 2013, p. 58). Thus, the examined teachers showed no awareness that it is important to stay with the student who made the error and to ensure that he or she recognizes the error, understands their underlying misconception, and knows how to do better in future.

Consistently with the findings of Bray's (2011, p. 30) study, the teachers studied were concerned about negatively affecting the students' self-esteem with a public discussion of the error. That is one reason why they avoided discussing the errors. However, a better approach would be to help students to see errors and feedback as positive. For example, a high level of feedback literacy would be beneficial. Students with a higher level of feedback literacy feel less offended by critical feedback (Carless and Boud, 2018, p. 1318) and the same can be assumed for dealing with making errors.

As a reason for their behavior in error situations, the teachers mainly mentioned aspects related to their experience with the students and the students' prior knowledge (as described by Dann and Haag, 2017, p. 112). The teachers seemed to have a good knowledge of their students' cognitions and emotions. They described the students' learning behavior and the extent to which they have already experienced success, or lack of success, in their school careers. All of the participating teachers used in their arguments their perceptions of each student's previous behavior and prior knowledge, as well as other attributes of the students, such as their sense of shame and cultural conditioning. There was nothing said about time or space resources, and they never mentioned any lack of time in class. Which is surprising, because working conditions can impact teachers' formative assessment implementation (Ahmedi, 2019, p. 172). External circumstances such as time constraints can be implicitly assumed here, at most, when the teachers justified their actions by the limitations of their own resources. That was done when two of the participating teachers stated that their behavior was due to negligence or selfishness and that they wanted to give themselves some relief through their behavior in the situation. This corresponds to the assumption that teachers need to have their basic needs satisfied first to be able to demonstrate a more motivating teaching style and, in that case, to provide support in dealing with errors (Moé and Katz, 2021).

Teachers who show adequate patterns of action in error situations are more likely to have strong constructivist beliefs (and low transmissive beliefs, Kuntze et al., 2008, p. 212) as well as dynamic worldviews (rather than static worldviews) toward the domain of accounting. However, the teachers do not show any remarkable differences here. Each teacher has at least the same mean scale value for constructivist orientation as for transmissive orientation. The difference between these two scales is not more than one scale point for any of them. Which is not unusual, because constructivist and transmissive beliefs are not mutually exclusive (Organisation for Economic Co-operation and Development, 2009, p. 120). The teachers in the two contrasted situations also differ only marginally in these scales of the instruments surveyed. Mr. Brown did not perform an error analysis, but he changes several times his addressee. He has a scale mean one Likert point higher on the *scheme* aspect of the accounting world view. However, he even has a scale mean that is one Likert point higher for constructivist orientation. For the world view aspects *process* and *application*, however, Mr. Brown and Mr. Thomas have the same scores. It is notable that Mr. Thomas does not change the addressee once in the observed lesson, but in comparison with the other teachers, he can hardly give any reasons for his behavior. None of the theoretically considered connections between the beliefs

concerning learning theories and domain-specific beliefs with teacher action could be found in this study. However, the instruments used do not provide any concrete statements about what the beliefs about dealing with errors actually consist of. They merely provide indications as to whether the subject is possibly more structured and closed (as compared to open), and whether errors are thus possibly perceived more negatively (Tulis et al., 2018, p. 13ff.).

It is particularly interesting that there is only one case in which no action is described as unconscious (neither is it described as explicitly conscious), and in that case an error analysis is performed. In all the other behavior patterns it is mentioned at least once that the teacher does not know why he acted exactly as he did in that case, and that he would probably act completely differently the next time. Thus, it can be seen that beliefs about actions in error situations are also partially automated and unquestioned, making them difficult to articulate (Fives and Buehl, 2012, p. 474; Reusser and Pauli, 2014, p. 646). Error analysis, however, is a specific pattern of action in an error situation that is omitted more often than not. When the teachers perform error analysis, it is done with a very specific intention, which can also be expressed afterward.

## Limitations

Even though this study provides insights into the rationales for action and underlying beliefs, it is important to note that it has several limitations. First, it is limited in scope. It focuses on the perceptions of five male teachers from five different schools, and the results therefore cannot be generalized to other teachers. The numbers were the results of a rather time-intensive study design (916 min of video recordings, 191 error situations) that did not allow for a larger sample size. The teachers participated in the study voluntarily. Hence, it is possible that the participating teachers differ in their perceptions from teachers who would not have participated voluntarily. The next limitation is the fact that the quantitative data (questionnaire) is only available from four participants. Therefore, any characteristics or differences can only be described between four of the five participating teachers. Furthermore, only two instruments were used. Further studies could include additional standardized instruments, e.g., on self-efficacy and the underlying mindset of teachers.

Critically, in the stimulated recall interviews conducted here, the extent to which the teachers' utterances are retrospective justifications (e.g., Loughran, 2002, p. 35; Neuweg, 2015, p. 52), or whether they actually had this intuition when acting in class, cannot be decided with certainty. Expectancy effects could occur here, triggered, for example, by the request or pressure to remember (Borg, 2018, p. 81ff.) or even the video stimulus itself (Yinger, 1986, p. 270).

## Educational implications

The data suggest that there is room for improvement in teachers' handling of students' errors, as the behavioral patterns observed indicate, according to previous research in the area of learning from errors, that learning potential is often lost in error situations. The insights into teachers' perceptions can help with adapting teacher education and training in the future with regard to this topic in the different phases—university education, pre-service and teaching practice. First, it would be important to improve teachers' competency in perceiving their own teaching actions. If teachers were (more) aware of their actions and the beliefs that lay behind them, and if they were able to exchange and develop these, this would have consequences for the quality of teaching and the learning processes of the students (Voss et al., 2013, p. 263; Matteucci et al., 2015, p. 14; Schweer et al., 2017, p. 138). In training on how to deal with errors, teachers could learn about scientific theories and findings on learning from errors, and could discover their own beliefs on this topic. It could be shown that the method of stimulated recall is a suitable method to make beliefs visible. Using video clubs is not innovative (e.g., Sherin and van Es, 2008; Blomberg et al., 2014), but it is still seldom carried out in actual education and training. The relevance of reflection on teaching action is emphasized. The same applies to the education of future teachers: the topic could possibly be integrated as a fixed education component. The perspectives of prospective teachers need to be uncovered and contrasted with scientific perspectives, but it is also important to show the relevance of reflection and to develop the ability to reflect. In these seminars, the focus should first be on the fact that an error analysis can be quite useful, even if the teacher knows the cause of the error. It is important that students can understand their underlying misconceptions.

It should also be pursued how an error analysis and dealing with the error making student could be conducted while also considering the teacher's own needs. Since it is striking that especially in situations with rather non-adaptive behavior, teachers justify this with their own emotions and resources. Adaptive action strategies in error situations should be automatically retrievable and become part of teachers' action routines. Thus, the learning potential of errors would be less dependent on the teacher's emotions and resources. In cooperation with (prospective) teachers, it should be elaborated which errors should and can be reacted to in which way. Starting point for this could be, for instance, the work of Köpfer and Wuttke (2021).

What has been left out of this research is the students' perspective. In order to evaluate the effectiveness of teachers' action in error situations, it would be necessary to capture students' opinions about making errors and receiving feedback. This is because there is evidence that feedback information is

received differently by students and teachers (Havnes et al., 2012, p. 23) and if not appreciated by students, feedback may have little impact (Chong, 2021, p. 92). Not only teachers need feedback literacy to provide qualitative (appropriate) feedback, but students need feedback literacy to see errors and feedback as important components of the learning process, so that they can perceive and process the feedback (Hattie and Clarke, 2018; McCallum and Milner, 2021, p. 2). From an ecological perspective, feedback literacy emerges through an interplay of various internal and contextual components (Chong, 2021, p. 97). As far as feedback in error situations is concerned, this research showed what teachers base their actions on, what beliefs they have and what contextual factors play a role. It became apparent that teachers decide on their actions through interaction with the context and the learners. A review of how this is perceived by the students is still pending. Future research should examine this in order to resolve any discrepancies between the context (teacher action, topic, etc.) and the individual (e.g., students' beliefs) (Chong, 2021, p. 100). Carless and Boud (2018, p. 1322) suggest meta-dialogues as a possible teaching intervention for resolving the discrepancies between teachers' and students' perspectives.

In this article, beliefs are only differentiated from each other in terms of *content*. It would also be of interest to classify the beliefs mentioned by the teachers into, for example, a taxonomy of "thought units" (as suggested by Marland, 1986, p. 213), with a distinction being made according to cognitive processing depth (see the brief discussion of this in Anderson, 2019, p. 3). The distinction between abstract and concrete beliefs (Organisation for Economic Co-operation and Development, 2009, p. 118), especially with regard to the description of actions as rather unconscious or spontaneous, could also be made by classifying the beliefs in such a taxonomy. Future research should investigate whether the relationships between the beliefs and patterns of action shown here can also be demonstrated across school types and subjects. Teachers could be asked in different subjects what their attitude toward errors is. A comparison between structured subjects as well as between structured and more open subjects would be interesting in order to identify similarities and differences (as in Tulis et al., 2018). There are also subject differences in feedback practices (Havnes et al., 2012, p. 26). The beliefs identified here could be made available to a larger sample for validation using questionnaires, as in the study by Matteucci et al. (2015).

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors upon reasonable request.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

## Funding

This submission was supported by the Open Access Publication Fund of the Goethe University of Frankfurt.

## Conflict of interest

The author declares 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

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

Aelterman, N., Vansteenkiste, M., Haerens, L., Soenens, B., Fontaine, J. R., and Reeve, J. (2019). Toward an integrative and fine-grained insight in motivating and demotivating teaching styles: the merits of a circumplex approach. *J. Educ. Psychol.* 111:497e521. doi: 10.1037/edu0000293

Aguirre, J., and Speer, N. M. (1999). Examining the relationship between beliefs and goals in teacher practice. *J. Math. Behav.* 18, 327–356. doi: 10.1016/S0732-3123(99)00034-6

Ahmedi, V. (2019). Teachers' attitudes and practices towards formative assessment in primary schools. *J. Soc. Stud. Educ. Res.* 10, 161–175.

Anderson, J. (2019). In search of reflection-in-action: an exploratory study of the interactive reflection of four experienced teachers. *Teaching Teacher Educ.* 86, 1–17. doi: 10.1016/j.tate.2019.102879

Baier, F., Decker, A.-T., Kleickmann, T., Klusmann, U., Kunter, M., and Voss, T. (2019). What makes a good teacher? The relative importance of mathematics

teachers' cognitive ability, personality, knowledge, beliefs, and motivation for instructional quality. *Br. J. Educ. Psychol.* 89, 767–786. doi: 10.1111/bjep.12256

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. New York, NY: Freeman.

Berding, F. (2017). Development and validation of the IMEB-M, a German questionnaire for assessing topic-specific epistemic beliefs. *J. Vocat. Educ. Training* 69, 517–539. doi: 10.1080/13636820.2017.1344870

Blomberg, G., Glogger, I., Renkl, A., Seidel, T., and Sherin, M. G. (2014). Understanding video as a tool for teacher education: investigating instructional strategies to promote reflection. *Instruct. Sci.* 42, 443–463. doi: 10.1007/s11251-013-9281-6

Blömeke, S. (2012). "Does greater teacher knowledge lead to student orientation? The relationship between teacher knowledge and teacher beliefs," in *Teachers' Pedagogical Beliefs. Definition and Operationalisation, Connections to Knowledge and Performance, Development and Change*, ed. J. König (Münster: Waxmann), 15–35.

Borg, S. (2018). "Teachers' beliefs and classroom practices," in *The Routledge Handbook of Language Awareness*, eds P. Garrett and J. M. Cots (New York, NY: Routledge), 75–91. doi: 10.4324/9781315676494-5

Bray, W. S. (2011). A collective case study of the influence of teachers' beliefs and knowledge on error-handling practices during class discussion of mathematics. *J. Res. Math. Educ.* 42, 2–38. doi: 10.5951/jresematheduc.42.1.0002

Carless, D., and Boud, D. (2018). The development of student feedback literacy: enabling uptake of feedback. *Assessm. Evaluat. Higher Educ.* 43, 1315–1325. doi: 10.1080/02602938.2018.1463354

Chong, S. W. (2021). Reconsidering student feedback literacy from an ecological perspective. *Assess. Evaluat. Higher Educ.* 46, 92–104. doi: 10.1080/02602938.2020.1730765

Collins, A., Warnock, E. H., and Passafiume, J. J. (1975). "Analysis and Synthesis of Tutorial Dialogues," in *Psychology of Learning and Motivation*, Vol. 9, ed. G. H. Bower (Cambridge, MA: Academic Press), 49–87. doi: 10.1016/s0079-7421(08)60268-6

Dann, H.-D., and Haag, L. (2017). "Lehrerkognitionen und Handlungsentscheidungen [Teacher cognitions and decisions to act]," in *Lehrer-Schüler-Interaktion: Inhaltsfelder, Forschungsperspektiven und Methodische Zugänge*, Vol. 24, ed. M. K. W. Schweer (Wiesbaden: Springer VS), 89–120. doi: 10.1007/978-3-658-15083-9_4

Dweck, C. S., and Yeager, D. S. (2019). Mindsets: a view from two eras. *Perspect. Psychol. Sci.* 14, 481–496. doi: 10.1177/1745691618804166

Egi, T. (2008). Investigating stimulated recall as a cognitive measure: reactivity and verbal reports in SLA research methodology. *Lang. Awareness* 17, 212–228. doi: 10.1080/09658410802146859

Fives, H., and Buehl, M. M. (2012). "Spring cleaning for the "messy" construct of teachers' beliefs: what are they? Which have been examined? What can they tell us?," in *APA Educational Psychology Handbook: Individual Differences and Cultural and Contextual Factors*, 3rd Edn, Vol. 2, eds K. R. Harris, S. Graham, T. Urdan, S. Graham, J. M. Royer, and M. Zeidner (Washington, DC: American Psychological Association), 471–499. doi: 10.1037/13274-019

Gartmeier, M., Bauer, J., Gruber, H., and Heid, H. (2008). Negative knowledge: understanding professional learning and expertise. *Vocat. Learn.* 1, 87–103. doi: 10.1007/s12186-008-9006-1

Gewiese, A., Wuttke, E., Kästner, R., Seifried, J., and Türling, J. M. (2011). "Professionelle Fehlerkompetenz von Lehrkräften – Wissen über Schülerfehler und deren Ursachen. [Teachers' professional error competence - knowledge of students' errors and their causes," in *Lehr-Lernforschung und Professionalisierung. Perspektiven der Berufsbildungsforschung*, eds U. Faßhauer, J. Aff, B. Fürstenau, and E. Wuttke (Farmington Hills: Verlag Barbara Budrich), 161–172.

Gilleece, L. (2012). "Teachers' pedagogical beliefs: findings from the first OECD teaching and learning international survey," in *Teachers' Pedagogical Beliefs. Definition and Operationalisation, Connections to Knowledge and Performance, Development and Change*, ed. J. König (Münster: Waxmann), 109–129.

Grigutsch, S., Raatz, U., and Törner, G. (1998). Einstellungen gegenüber mathematik bei mathematiklehrern [Mathematics teachers' attitudes towards mathematics]. *J. Mathematik Didaktik* 19, 3–45. doi: 10.1007/BF03338859

Hattie, J., and Clarke, S. (2018). *Visible Learning: Feedback*. London: Routledge. doi: 10.4324/9780429485480

Hattie, J., and Timperley, H. (2007). The power of feedback. *Rev. Educ. Res.* 77, 81–112. doi: 10.3102/003465430298487

Havnes, A., Smith, K., Dysthe, O., and Ludvigsen, K. (2012). Formative assessment and feedback: making learning visible. *Stud. Educ. Eval.* 38, 21–27. doi: 10.1016/j.stueduc.2012.04.001

Heckhausen, J., and Heckhausen, H. (2018). *Motivation und Hande [Motivation and Action]*, 5th Edn. Berlin: Springer, doi: 10.1007/978-3-662-53927-9

Hofer, M. (1986). *Sozialpsychologie erzieherischen Handelns: Wie das Denken und Verhalten von Lehrern organisiert ist [Social Psychology of Educational Action: How Teachers' Thinking and Behavior are Organized]*. Göttingen: Hogrefe.

Kirchner, V. (2016). *Wirtschaftsunterricht aus Sicht von Lehrpersonen. Eine Qualitative Studie zu Fachdidaktischen Teachers' Beliefs in der Ökonomischen Bildung [Teaching Economics from Teachers' Perspectives. A Qualitative Study on Subject Didactical Teachers' Beliefs in Economic Education]*. Wiesbaden: Springer. doi: 10.1007/978-3-658-10832-8

Kleickmann, T., Möller, K., and Vehmeyer, J. (2010). Zusammenhänge zwischen Lehrervorstellungen und kognitivem Strukturieren im Unterricht am Beispiel von Scaffolding-Maßnahmen [Relations between teacher conceptions and features of scaffolding]. *Unterrichtswissenschaft* 38, 210–228.

König, J. (2012). "Teachers' pedagogical beliefs. Current and future research," in *Teachers' Pedagogical Beliefs. Definition and Operationalisation, Connections to Knowledge and Performance, Development and Change*, ed. J. König (Münster: Waxmann), 7–11.

Köpfer, P., and Wuttke, E. (2021). Entwicklung und Anwendung einer Klassifizierungshierarchie von Fehlertypen und Feedbackarten. *Zeitschrift Berufs Wirtschaftspädagogik* 117, 461–499. doi: 10.25162/zbw-2021-0020

Kornell, N., Hays, M. J., and Bjork, R. A. (2009). Unsuccessful retrieval attempts enhance subsequent learning. *J. Exp. Psychol.* 35, 989–998. doi: 10.1037/a0015729

Kornell, N., Klein, P. J., and Rawson, K. A. (2015). Retrieval attempts enhance learning, but retrieval success (versus failure) does not matter. *J. Exp. Psychol.* 41, 283–294. doi: 10.1037/a0037850

Kunter, M., Baumert, J., Blum, W., Klusmann, U., Krauss, S., and Neubrand, M. (eds) (2011). *Professionelle Kompetenz von Lehrkräften. Ergebnisse des Forschungsprogramms COACTIV [Professional Competence of Teachers. Results of the COACTIV Research Programme]*. Münster: Waxmann.

Kuntze, S., Heinze, A., and Reiss, K. (2008). Vorstellungen von mathematiklehrkräften zum umgang mit fehlern im unterrichtsgespräch [Mathematics teachers' beliefs about error-handling during class discussion]. *J. Mathematik Didaktik* 29, 199–222. doi: 10.1007/BF03339062

Lampert, M. (1985). How do teachers manage to teach? Perspectives on problems in practice. *Harvard Educ. Rev.* 55, 178–194. doi: 10.17763/haer.55.2.56142234616x4352

Leuchter, M., Lipowsky, F., Pauli, C., and Reusser, K. (2006). Unterrichtsbezogene überzeugungen und handlungsleitende kognitionen von lehrpersonen [Lesson-related general beliefs and situational beliefs in teaching staff]. *Zeitschrift Erziehungswissenschaft* 9, 562–579. doi: 10.1007/s11618-006-0168-z

Leumann, S., and Aprea, C. (2016). Financial literacy aus sicht von lehrpersonen an beruflichen schulen in der schweiz. eine mixed-methods-studie zu deren domänenspezifischen vorstellungen [Financial literacy from the perspective of teachers at vocational schools in switzerland. A mixed-methods study of their domain-specific perceptions]. *Zeitschrift Ökonomische Bildung* 4, 36–64.

Loughran, J. J. (2002). Effective reflective practice: in search of meaning in learning about teaching. *J. Teacher Educ.* 53, 33–43. doi: 10.1177/0022487102053001004

Marland, P. W. (1986). Models of teachers' interactive thinking. *Element. School J.* 87, 209–226. doi: 10.1086/461490

Matteucci, M. C., Corazza, M., and Santagata, R. (2015). Learning from errors, or not. An analysis of teachers' beliefs about errors and error-handling strategies trough questionnaire and video. *Prog. Educ.* 37, 33–54.

McCallum, S., and Milner, M. M. (2021). The effectiveness of formative assessment: student views and staff reflections. *Assess. Evaluat. Higher Educ.* 46, 1–16. doi: 10.1080/02602938.2020.1754761

Metcalfe, J. (2017). Learning from Errors. *Annu. Rev. Psychol.* 68, 465–489. doi: 10.1146/annurev-psych-010416-044022

Miles, M. B., Huberman, A. M., and Saldaña, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook*, 3nd Edn. Thousand Oaks, CA: Sage.

Mindnich, A., Seifried, J., and Wuttke, E. (2010). "Fehlerkultur und Umgang mit Schülerfehlern im kaufmännischen Unterricht [Error culture and dealing with students' errors in commercial education]," in *Erziehungswissenschaftliche Forschung. Nachhaltige Bildung. Beiträge zur 5. DGfE-Sektionstagung „Empirische Bildungsforschung/EEPF-KBBB im Frühjahr 2009*, eds B. Schwarz, P. Nenniger, and R. S. Jäger (Landau: VEP), 418–424.

Minsky, M. (1994). Negative expertise. *Int. J. Expert Syst.* 7, 13–19.

Moé, A., and Katz, I. (2021). Emotion regulation and need satisfaction shape a motivating teaching style. *Teachers Teach.* 27, 370–387. doi: 10.1080/13540602.2020.1777960

Neuweg, G. H. (2015). *Das Schweigen der Könner: Gesammelte Schriften zum impliziten Wissen [The silence of skilled persons: Collected writings on tacit knowledge]*. Münster: Waxmann.

Organisation for Economic Co-operation and Development (2009). *Creating Effective Teaching and Learning Environments: First Results from Talis*. Paris: OECD.

Oser, F. (2009). Aus Fehlern lernen: wie negatives Wissen hilft, es besser zu machen [Learning from mistakes: how negative knowledge helps to do better]. *Profi_L Magazin für das Lehren und Lernen* 9, 4–6.

Oser, F. (2015). ""Und eine neue welt…" funktionen des negativen wissens. oder: wenn fehler früchte tragen ['and a new world.' functions of negative knowledge. or: if errors bearing fruit]," in *Fehler: Ihre Funktionen im Kontext Individueller und Gesellschaftlicher Entwicklung*, eds M. Gartmeier, H. Gruber, T. Hascher, and H. Heid (Münster: Waxmann), 71–89.

Oser, F., and Spychiger, M. (2005). *Lernen ist schmerzhaft: Zur Theorie des negativen Wissens und zur Praxis der Fehlerkultur [Learning is Painful: About the Theory of Negative Knowledge]*. Weinheim: Beltz.

Oser, F., Hascher, T., and Spychiger, M. (1999). "Lernen aus fehlern: zur psychologie des „negativen" wissens. [Learning from mistakes: on the psychology of "negative" knowledge.]," in *Fehlerwelten: Vom Fehlermachen und Lernen aus Fehlern: Beiträge und Nachträge zu einem Interdisziplinären Symposium aus Anlaß des 60. Geburtstags von Fritz Oser*, ed. W. Althof (Opladen: Leske + Budrich), 11–41. doi: 10.1007/978-3-663-07878-4_1

Pan, S. C., Sana, F., Samani, J., Cooke, J., and Kim, J. A. (2020). Learning from errors: students' and instructors' practices, attitudes, and beliefs. *Memory* 28, 1105–1122. doi: 10.1080/09658211.2020.1815790

Reusser, K., and Pauli, C. (2014). "Berufsbezogene Überzeugungen von Lehrerinnen und Lehrern [Teachers' job-related beliefs]," in *Handbuch der Forschung zum Lehrerberuf*, 2nd Edn, eds E. Terhart, H. Bennewitz, and M. Rothland (Münster: Waxmann), 643–661.

Richardson, V. (1996). "The role of attitudes and beliefs in learning to teach," in *Handbook of Research on Teacher Education*, 2nd Edn, ed. J. Sikula (New York, NY: Macmillan), 102–119.

Robinson, J. P., and Lubienski, S. T. (2011). The development of gender achievement gaps in mathematics and reading during elementary and middle school. *Am. Educ. Res. J.* 48, 268–302. doi: 10.3102/0002831210372249

Ryan, R. M., and Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: definitions, theory, practices, and future directions. *Contemp. Educ. Psychol.* 61:101860. doi: 10.1016/j.cedpsych.2020.101860

Santagata, R. (2005). Practices and beliefs in mistake-handling activities: a video study of Italian and US mathematics lessons. *Teaching Teacher Educ.* 21, 491–508. doi: 10.1016/j.tate.2005.03.004

Schoenfeld, A. (1998). Toward a theory of teaching-in-context. *Iss. Educ.* 4, 1–94. doi: 10.1016/S1080-9724(99)80076-7

Schoenfeld, A. H. (1989). Explorations of students' mathematical beliefs and behavior. *J. Res. Math. Educ.* 20, 338–355. doi: 10.2307/749440

Schoenfeld, A. H. (2011). Toward professional development for teachers grounded in a theory of decision making. *ZDM* 43, 457–469. doi: 10.1007/s11858-011-0307-8

Schreier, M. (2012). *Qualitative Content Analysis in Practice*. Thousand Oaks, CA: Sage.

Schweer, M. K. W., Thies, B., and Lachner, R. P. (2017). "Soziale wahrnehmungsprozesse und unterrichtliches handeln: eine dynamisch-transaktionale perspektive [Social perceptual processes and instructional action: a dynamic-transactional perspective]," in *Lehrer-Schüler-Interaktion: Inhaltsfelder, Forschungsperspektiven und Methodische Zugänge*, 2nd Edn, Vol. 24, ed. M. K. W. Schweer (Wiesbaden: Springer VS), 121–244. doi: 10.1007/978-3-658-15083-9_5

Seifried, J. (2009). "Unterricht aus der Sicht von Handelslehrern [Teaching from the perspective of trade teachers]," in *Konzepte des Lehrens und Lernens*, Vol. 16, eds K. Breuer, G. Tulodziecki, and K. Beck (Bern: Lang).

Seifried, J. (2012). "The role of teachers' pedagogical beliefs: an analysis from the perspective of vocational education and training," in *Teachers' Pedagogical Beliefs. Definition and Operationalisation, Connections to Knowledge and Performance, Development and Change*, ed. J. König (Münster: Waxmann), 131–147.

Seifried, J., and Wuttke, E. (2010). Student errors: how teachers diagnose them and how they respond to them. *Empiric. Res. Vocat. Educ. Training* 2, 147–162. doi: 10.1007/BF03546493

Sherin, M. G., and van Es, E. A. (2008). Effects of video club participation on teachers' professional vision. *J. Teacher Educ.* 60, 20–37. doi: 10.1177/0022487108328155

Shulman, L. (1987). Knowledge and teaching: foundations of the new reform. *Harvard Educ. Rev.* 57, 1–23. doi: 10.17763/haer.57.1.j463w79r56455411

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educ. Res.* 15, 4–14. doi: 10.3102/0013189X015002004

Shute, V. J. (2008). Focus on formative feedback. *Rev. Educ. Res.* 78, 153–189. doi: 10.3102/0034654307313795

Staub, F. C., and Stern, E. (2002). The nature of teachers' pedagogical content beliefs matters for students' achievement gains: quasi-experimental evidence from elementary mathematics. *J. Educ. Psychol.* 94, 344–355. doi: 10.1037/0022-0663.94.2.344

Stipek, D. J., Givvin, K. B., Salmon, J. M., and MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching Teacher Educ.* 17, 213–226. doi: 10.1016/S0742-051X(00)00052-4

Thompson, A. G. (1992). "Teachers' beliefs and conceptions: a synthesis of the research," in *Handbook of Research on Mathematics Teaching and Learning: A Project of the National Council of Teachers of Mathematics*, ed. D. A. Grouws (London: Macmillan), 127–146.

Tschannen-Moran, M., and Woolfolk Hoy, A. (2001). Teacher efficacy: capturing an elusive construct. *Teaching Teacher Educ.* 17, 783–805. doi: 10.1016/S0742-051X(01)00036-1

Tulis, M. (2013). Error management behavior in classrooms: teachers' responses to student mistakes. *Teaching Teacher Educ.* 33, 56–68. doi: 10.1016/j.tate.2013.02.003

Tulis, M., Steuer, G., and Dresel, M. (2015). "Learning from errors: process and contextual conditions. Towards a model of individual processes within contexts," in *Fehler. Ihre Funktionen im Kontext Individueller und Gesellschaftlicher Entwicklung*, eds M. Gartmeier, H. Gruber, T. Hascher, and H. Heid (Göttingen: Waxmann), 53–70.

Tulis, M., Steuer, G., and Dresel, M. (2018). Positive beliefs about errors as an important element of adaptive individual dealing with errors during academic learning. *Educ. Psychol.* 38, 139–158. doi: 10.1080/01443410.2017.1384536

Türling, J. M. (2014a). *Die professionelle Fehlerkompetenz von (angehenden) Lehrkräften: Eine empirische Untersuchung im Rechnungswesenunterricht [The Professional Error Competence of (Prospective) Teachers: An Empirical Examination in Accounting Education]*. Wiesbaden: Springer VS. doi: 10.1007/978-3-658-04931-7_5

Türling, J. M. (2014b). Lehrerhandeln in fehlersituationen - wie (angehende) lehrkräfte mit schülerfehlern umgehen [Teacher action in error situations - How (prospective) teachers deal with student errors]. *Unterrichtswissenschaft* 42, 366–384.

Türling, J. M., Seifried, J., and Wuttke, E. (2012). "Teachers' knowledge about domain specific student errors," in *Learning from Errors at School and at Work*, Vol. 1, eds E. Wuttke and J. Seifried (Opladen: Budrich), 95–110. doi: 10.2307/j.ctvbkk37w.9

Voss, T., Kleickmann, T., Kunter, M., and Hachfeld, A. (2013). "Mathematics teachers' beliefs," in *Mathematics Teacher Education: Vol. 8. Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers: Results from the COACTIV Project*, eds M. Kunter, J. Baumert, W. Blum, U. Klusmann, S. Krauss, and M. Neubrand (Berlin: Springer), 249–272. doi: 10.1007/978-1-4614-5149-5_12

Weber, M. (1981). Some categories of interpretive sociology. *Sociol. Quart.* 22, 151–180. doi: 10.1111/j.1533-8525.1981.tb00654.x

Weimer, H. (1929). *Psychologie der Fehler [Psychology of Errors]*, 2nd Edn, Vol. 1. Bad Heilbrunn: Julius Klinkhardt.

Weinert, F. E. (1999). "Aus Fehlern lernen und Fehler vermeiden lernen [Learn from mistakes and avoid mistakes]," in *Fehlerwelten: Vom Fehlermachen und Lernen aus Fehlern: Beiträge und Nachträge zu einem interdisziplinären Symposium aus Anlaß des 60. Geburtstags von Fritz Oser*, ed. W. Althof (Opladen: Leske + Budrich), 101–109. doi: 10.1007/978-3-663-07878-4_5

Wuttke, E., and Seifried, J. (2017). *Professional Error Competence of Preservice Teachers*. Basel: Springer International Publishing. doi: 10.1007/978-3-319-52649-2

Yan, Z., Li, Z., Panadero, E., Yang, M., Yang, L., and Lao, H. (2021). A systematic review on factors influencing teachers' intentions and implementations regarding formative assessment. *Assess. Educ.* 28, 228–260. doi: 10.1080/0969594X.2021.1884042

Yeager, D. S., Carroll, J. M., Buontempo, J., Cimpian, A., Woody, S., Crosnoe, R., et al. (2022). Teacher mindsets help explain where a growth-mindset intervention does and doesn't work. *Psychol. Sci.* 33, 18–32. doi: 10.1177/09567976211028984

Yinger, R. J. (1986). Examining thought in action: a theoretical and methodological critique of research on interactive teaching. *Teaching Teacher Educ.* 2, 263–282. doi: 10.1016/S0742-051X(86)80007-5