

Chapter 2

The Necessity to Train Professional Error Competence: Empirical Findings

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Abstract Current pedagogical discourse has established that teacher competence is crucial for teaching and learning in schools. Nevertheless questions of conceptualising and measuring teacher competence have yet to be answered. In our study we analyse a facet of teacher competence essential to successful learning processes; namely teacher competence when diagnosing and responding to students' errors in a constructive manner (professional error competence; PEC). Different studies investigate how students perceive the "error culture" in their classrooms, and how teachers deal with students' errors during lessons.

Keywords Professional error competence · Pedagogical content knowledge · Error learning · Error culture · Vocational schools · Accounting education

2.1 Introduction¹

In the last few decades there has been increasing discussion on teaching quality and teachers' professional competences (e.g. Cochran-Smith and Zeichner 2005). Moreover, international comparative studies such as TEDS-M (the IEA Teacher Education and Development Study in Mathematics, see Blömeke et al. 2014) and MT21 (Mathematics Teaching in the 21st century, see Schmidt et al. 2011) reveal that German pre-service and in-service teachers lack central competence facets (e.g. content

¹The results presented in this chapter have been published before in various journals in more detail. Because the book intends to present the complete picture from the identification of training needs to key findings of a training programme, a brief overview over the studies is given here.

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knowledge, pedagogical content knowledge). These findings suggest that teacher education programs might fail to prepare student teachers for their teaching tasks. Therefore training programs with a strong focus on teaching and learning issues are currently being discussed. The basic idea is that they might foster competence acquisition at an early stage among student teachers.

A key aspect of teacher professionalism is the ability to diagnose student competencies and—based on this—to create tailored learning opportunities. This is especially true when it comes to students' errors and the use of students' errors as learning opportunities (see Chap. 1). Little is known about students' errors and which competences teachers need in order to handle them constructively, particularly in the field of economic and business education and accounting. The general idea that errors can be a learning opportunity was rarely supported in the past (e.g. Weimer 1925), but nowadays a positive view on errors is prevalent. A key aspect of fostering learning from errors is seen in an "error-friendly" learning environment (Bauer 2008; Bauer and Harteis 2012; Oser and Spychiger 2005; Wuttke and Seifried 2012; Yerushalmi and Pollinger 2006). However, a positive error climate is not enough. In addition to being error-friendly, teachers need to diagnose errors and identify their potential causes, as well as be able to use them constructively (in the sense of creating opportunities to learn) in the classroom (see Chap. 1). To foster students' learning from errors, teachers need a set of competencies (labelled as "professional error competence", PEC, see Chap. 1), namely knowledge about domain specific students' errors (domain specific CK as well as knowledge about common students' errors and potential causes for students' errors), strategies for handling errors (especially feedback strategies), and error-friendly beliefs (errors should be seen as an opportunity to learn).

Therefore, within the field of teaching-learning research, increasing effort has been directed towards identifying typical errors, the possibility of learning from errors, and the analysis of how teachers' behaviour influences students' chances of learning from errors (e.g. Baumert et al. 2010; Heinze et al. 2012).

Bearing in mind that errors are domain specific, we focus on economic and business education and in particular on accounting—knowledge in this domain is an important facet of economic competence, and the domain is seen as error-prone (see Chap. 1). Currently, little is known about students' errors and which competences teachers need to diagnose and handle them constructively in this domain.

When we started our research some years ago, we first decided to videotape lessons to find out about PEC in accounting education in commercial schools (pilot studies, see Sect. 2.2). Because this proved to be rather ineffective, we developed video vignettes representing typical error situations in accounting to measure PEC (Study 1, Sect. 2.3). The vignettes were used as prompts, and (prospective) teachers were asked to identify errors and to describe strategies how to deal with the error situation. Further research (Study 2, Sect. 2.4) was conducted with a larger sample, using a paper-pencil-test rather than video vignettes to identify (prospective) teachers' ability to find and handle students' errors.

All studies reveal that experienced teachers are much more likely to be able to diagnose students' errors and provide adequate feedback. Student teachers and

pre-service teachers perform significantly worse. Based on these findings, a training program to foster PEC of prospective teachers in accounting was developed (see Chap. 3 in this book).

2.2 Two Pilot Studies to Analyse How Teachers Handle Students' Errors

2.2.1 Background

It is generally assumed that it is possible to develop professional competence by learning from errors (e.g. Bauer and Harteis 2012; Wuttke and Seifried 2012). To reach this goal, an 'error-friendly' learning environment is of importance (emotional component). Besides this, it is crucial that teachers enable reflection as well as support learning processes through feedback (cognitive component). The effect of feedback following errors is drawing increasing consideration in research (e.g. Wills 2009). In two pilot studies we investigated how students perceive the "error culture" in their classrooms, and how teachers deal with learner errors occurring during lessons (Seifried and Wuttke 2010).

2.2.2 Pilot Study 1: Error Culture in Vocational Schools

A study involving 1136 students from vocational schools was conducted to investigate classroom error culture. We investigated whether we could find learning environments in vocational schools in which the fear of committing an error (emotional component) was reduced, and where learning processes were initiated after students made a mistake, thereby supporting learning from errors (cognitive component). A paper-pencil-test, based on the work of Spychiger et al. (2006) was designed with a total of 31 items that included questions about error friendliness (10 items), learning orientation (8 items), missing transparency of norms (8 items), and error anxiety (5 items). All items were answered on a 4-point scale ranging from 1 = not true at all to 4 = completely true; the internal consistencies of the subscales were moderate to high: $0.70 \leq \text{Cronbach's } \alpha \leq 0.83$. Table 2.1 shows the subscales with example items, reliability coefficients, and descriptive statistics (for details see Seifried and Wuttke 2010).

The aim of this study was to establish how students assess different facets of the error culture. Whereas the statements on learning orientation and transparency of norms focus on the teachers' competence in dealing with errors constructively, the subscales of error friendliness and error anxiety refer to the emotional experience of the students during the lessons.

The results reveal a relatively positive assessment of the error culture (Table 2.1). The subscales error friendliness and learning orientation reach values close to 3 ('partly true'), whereas learners reported little fear of making errors or complaints about a

Table 2.1 Questionnaire-subscales with sample items, reliability coefficients (Cronbach's α), and descriptive statistics

Subscales (number of items)	Sample item	Min	Max	α	M	SD
Error friendliness (10)	With our teacher, making mistakes is never bad	1.00	4.00	0.83	2.91	0.53
Learning orientation (8)	Mistakes in class help me to do it better next time	1.00	4.00	0.73	2.72	0.48
Missing transparency of norms (8)	When I make a mistake, I often do not understand why	1.00	4.00	0.76	2.10	0.52
Error anxiety (5)	I get scared when I make a mistake in class	1.00	4.00	0.70	1.87	0.56

Note $N = 1136$; 4-point scale: 1 = not true at all, 2 = rather not true, 3 = partly true, 4 = completely true

missing transparency of norms. Here the ratings are closer to 2 (meaning 'rather not true'). Taken together, the results show that the students reported a rather positive error climate. These results are in line with reference studies from general education and mathematics (e.g. Heinze et al. 2012; Oser and Spychiger 2005). Both studies employed a similar questionnaire and report comparable findings for the perception of error culture: Error anxiety rates consistently low, teacher behaviour is perceived as acceptable and while the levels in the learning oriented component are comparable, some improvement would be beneficial.

2.2.3 Pilot Study 2: Analysis of Error Situations and Teachers' Feedback

The data basis for this study consisted of a pool of videotaped lessons (10 h of accounting lessons by two different teachers) from vocational schools in Germany.² Teachers were primarily selected for their comparable (professional) biographies. The teachers were both male, about 40 years old, had completed vocational training followed by vocational teacher education and had been working as teachers for about ten years.

Before analysing how teachers handle students' errors, error situations have to be identified, a process that is always normative. We argue that an error situation in class is defined either when teachers (1) explicitly reject students' statements, or (2) give another learner the floor without commenting on the first student's answer. The passing on of a question to another student contains the implicit message that the first answer was wrong (compare the "ground rules" of communication in classrooms, Edwards and Mercer 1987). An error sequence starts with either one of

²The reported observation is embedded in a more extensive study about teachers' views on teaching, their actions during lessons, and learning results of students (Seifried 2012).

these actions and is comprised of a following class discussion thematically matching and attributed to the initial error, but can include further errors in the course of discussion. The situation is completed when either the error is cleared up or the topic of the class discussion changes. This step of analysis (identifying error situations and sequences) is followed by a classification of the error situations. Here, the question is whether an error situation has learning potential.

In our view, two conditions have to be fulfilled in order for error situations (mainly in class discussion) to hold learning potential:

1. Learning from errors is fostered by teachers’ supportive behaviour. A central condition to do this is the *detection of the error(s)* learners have made, and teachers should actively use class discussions to “investigate” where the student’s error lies. Therefore, it is a matter of determining whether teachers (or other persons in the classroom) make an attempt to “locate” the root of the error (in the sense of a root cause analysis). Therefore, an analysis of whether teachers try to get to the bottom of errors during the class discussion or simply ignore them is needed.
2. If a teacher has recognized an error, then it is up to him or her to *deal with it in an “appropriate” manner* in terms of feedback quality. Therefore, a second analysis dimension concerns the quality of teachers’ feedback. Regarding the extent of elaboration during feedback, at least two forms are conceivable. Firstly, the teacher could reject students’ answers as wrong, without explaining this more thoroughly. Or, secondly, he/she could give a clear statement where the error lies and what “correct” solutions could look like (Seifried and Wuttke 2010). We therefore differentiate a low and high level of elaboration. Low elaboration means that the teacher rejects the answer by just stating that it is wrong (e.g. “no”, “wrong”, “this is not correct”, and so on). High elaboration means that teachers give an extensive feedback that helps students to do better in future. Explanations are given as to why a solution is wrong and how it could be improved (Crespo 2002).

Accordingly, we can see the first dimension as a necessary step in a process that is completed by the second dimension. Consequently, both conditions need to be fulfilled in order to assign learning potential to error situations in class discussions. We developed a coding system to analyse every error situation in reference to these two conditions. Table 2.2 shows the resulting typology of error situations which arise on the basis of the above-mentioned statements.

Table 2.2 Typology of error situations in the class discussion

Quality of error search	Quality of feedback	
	High	Low
“getting to the bottom”	Type 1 “getting to the bottom”, high elaboration	Type 2 “getting to the bottom”, low elaboration
No “getting to the bottom”	Type 3 No “getting to the bottom”, high elaboration	Type 4 No “getting to the bottom”, low elaboration

Situation type 1 can be seen as a situation with learning potential. The teacher is willing to reveal an error (“go into it”) and gives elaborate feedback to help the learner to recognise and correct the error. However, one would surely not assign any learning potential to *situation type 4*. Neither is the error identified nor does the teacher provide high-quality feedback. In such situations, learners cannot revise their pre- or mis-conceptions with regard to content and they do not learn how to do better in the future. In a *type 3 situation*, the teacher does not explicitly get to the bottom of the error but provides high-quality feedback to an incorrect comment. Here the student recognizes that something in his/her answer was not as expected, but is not told where the problem actually lies. The learner’s error provides a starting point for the teacher to repeat or vary an explanation of the learning content. To completely reject the learning potential of this situation would be rash because it is possible that experienced teachers know exactly where the learners’ (logical) flaws lie and therefore refrain from investigating the incorrect conclusion. Finally, *situation type 2* should, at the most, hold a small amount of learning potential. In the case of a wrong statement the teacher “goes into it” but he/she does not give the learner elaborate feedback. Two explanations for this are possible: either the teacher recognises the student’s error, but from his view it is not worthwhile to address the issue in detail, or the teacher does not recognise the students’ error, in spite of “going into it”, and is not prepared to tackle the facts any further.

In total, 76 error sequences were identified and assigned to one of the four types of error situations. The results show that the conditions described as necessary for recognising the reasons for an error—the “getting to the bottom”—are rarely fulfilled in the analysed error sequences. Thereby, not even the first decisive step that should be the basis for learning from errors is present during class discussions. Moreover, the feedback reported here can hardly be described as elaborate. Error situation type 1 (high learning potential) is rarely observed (7 observations). Should such sequences actually turn out to be effective for learning, not enough class time is given to them. High-quality feedback without error analysis (type 3) also rarely occurs (4 observations). It is, however, different with error sequences of the second type. We frequently observed that teachers get to the bottom of the error, but then only give the learner very small clues, if any, about a better solution (20 observations). Finally, Type 4 error sequences occur most frequently (45 observations). However, an unfavourable response to errors provides the learner with virtually no clues as to the error they made or how it could be remedied.

To sum up: The pilot studies show that there is a positive error climate in vocational schools—there is no problem with the emotional component. However, the cognitive component is in a rather bad state, as teachers usually do not go to the bottom of the errors and do not give helpful feedback.

2.3 A Cross-Sectional Vignette Study on Professional Error Competence of Prospective VET Teachers

2.3.1 Background

This study provides evidence on PEC using a sample size of $n = 287$ (prospective) teachers (i.e. student teachers, respectively bachelor's and master's students, pre-service teachers, and in-service teachers) in the domain of accounting (Türling et al. 2012; Wuttke and Seifried 2013).

In numerous studies that assess competences, self-reports are used. However, current discussions and research trends are characterised by a preference for behavioural data collected in performance situations, even if this means a higher test diagnostic effort than self-reports. A major disadvantage of using self-reports is that they are biased by over- or underestimation found in self-assessment (e.g. Leutner et al. 2008, p. 185f.). A mixed-methods approach with both performance data and self-reports to consider various areas of competence seems effective and was used in our study. To analyse the knowledge of (prospective) teachers about students' errors on the basis of performance data, video vignettes (i.e. short video sequences representing typical error situations in accounting lessons) were used as stimuli for situational decisions on action and combined with semi-structured interviews (for the advantages of video vignettes see Seguin and Ambrosio 2002; Veal 2002).

In order to validly measure competences, typical—not random—students' errors in accounting have to be embedded into the video vignettes. As a first step, we conducted interviews with experts (teachers and teacher educators in accounting) about typical students' errors in accounting. We subsequently interviewed students about their typical errors and we analysed classroom assignments in accounting. The combined results were used to write a detailed script for the video vignettes. The screenplay included dialogues (e.g. teacher-student-interaction, student-student-interaction, students making errors), teaching materials (e.g. the teacher's writing on the chalkboard), instructions for camera positions, instructions for the actors (including their movements), and a description of what the room should look like (Wuttke and Seifried, in press). The video vignettes were then shown to (prospective) teachers as prompts to test whether they are able to identify students' errors and to handle them adequately.

To analyse the verbal data from the vignette interviews, a two-step approach was used. First we coded the number of identified errors and whether the interviewees were able to correct the errors. This was used as an indicator for content knowledge (knowledge about domain specific students' errors). In a second step, we analysed the test persons' strategies for handling errors. Based on existing empirical evidence (e.g. Brophy 1999), the following criteria were used (see Wuttke and Seifried, in press):

- *Structuring the problem space.* This means that the teacher/the test person uses explanations or visualizations to structure the learning content, stresses relationships between constructs, explains technical terms, shows how to do the journal entries, or uses t-accounts to support the understanding of the students. An example is if a teacher uses a t-account to visualize the account transactions.
- *Cognitive activation of the learners.* In this case, a teacher initiates a cognitive conflict (e.g. does it makes sense that the purchase price for a good is higher than the sales price), by asking questions in a Socratic manner, stimulating learning and reflection processes by giving hints on crucial aspects of a learning subject.
- *Adaptivity of the explanations/instruction strategies.* This category is about the activation of students' prior knowledge and taking students' experiences into account when teachers give an explanation. The teacher shows analogies, differences and connections between learning subjects. A teacher might use students' experience with a privately used cash book to illustrate the basic principles of financial accounting.
- *Consolidation.* Consolidation means doing exercises to make sure that students fully absorb and truly learn from errors. It is important that teachers are able to vary exercises away from routine tasks and towards offering problem solving tasks to their students. This category includes all activities of the teacher that ensure that errors are detected and fixed.

In addition, a paper-pencil-test was used to investigate knowledge about students' errors from another point of view. It was designed as a fictional class test including students' errors. The participants had to identify and correct these errors within a given time. To obtain information on how the participants perceive their own knowledge about students' errors, we used a standardized questionnaire. In this way, the participants' knowledge about domain specific errors, their strategies for handling errors and their error beliefs were measured. For the complete design and measurement process, see Fig. 2.1.

2.3.2 Results

The following findings are of particular interest:

1. *Knowledge about domain specific students' errors:* The ability to identify and correct errors (performance measures based on the video vignette test and the paper-pencil test) of both student and pre-service teachers is rather low. Apparently, knowledge relevant for successful teaching is missing. In contrast, in-service teachers score rather high in these tests, consequently generating significant differences between the test groups with a high effect size (explained variance: 27%). Analysis of self-perception reveals that student and pre-service

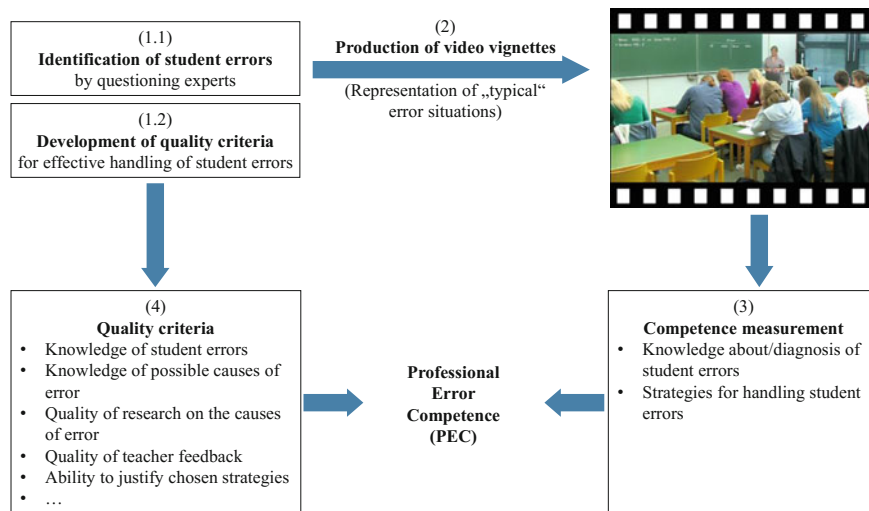


Fig. 2.1 Assessment of competences with video vignettes

teachers tend to overestimate their own competence, whereas in-service teachers perceive themselves in a more realistic way.

2. *Strategies for handling errors:* To analyse how the respondents handle errors and give feedback, quality measures from teaching-learning research were used (structuring, cognitive activation, adaptability, and consolidation). Again significant differences in favour of in-service teachers could be found, generating high effect sizes. This is particularly true for aspects strongly related to pedagogical content knowledge. For example, with regard to the category “cognitive activation” in-service teachers achieve both a higher rate of using subcategories like creating a cognitive conflict or leading their students to generate ideas or questions, as well as a higher level of elaborated reasoning on why to use those strategies in an error situation (explained variance: 32%). Overall, the in-service teachers clearly outperform the other groups. Concerning their self-perception, the findings are quite similar to those described above for the knowledge facet.
3. *Beliefs about the chances of learning from errors:* The (prospective) teachers’ beliefs can be described as “error-friendly”, i.e. inherent benefits of students’ errors prevail instead of perceiving them as obstacles. No significant group differences were found.

To summarise, the results indicate that student teachers as well as pre-service teachers have deficits in PEC. This is true for the ability to identify errors as well as the ability to handle students’ errors adequately and foster students’ learning from errors. Since in-service teachers perform much better, we assume that PEC can be developed in learning processes. So far, however, opportunities to learn and acquire competence at both the university and practical training level seem to be rather inefficient with regard to PEC. This is particularly problematic for teachers in

practical training because they already have to teach on their own authority. If—in the beginning—they are not able to identify students' errors and handle them adequately (i.e. give supporting feedback), it is possible that some student cohorts might not learn from errors.

2.4 Measuring Professional Error Competence by a Knowledge Test

2.4.1 Background

In this study we approached a large sample of students, mainly in Germany and in Austria (Bouley et al. 2015; Fritsch et al. 2015). The focus was not only on PEC but on a broader conceptualization of Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) of prospective teachers. The PCK test items covered three competence facets which are particularly relevant for the quality of accounting lessons: (1) knowledge of students' conceptions and typical students' errors (12 items with a clear link to PEC), (2) knowledge of tasks as instructional tools (12 items), and (3) knowledge of multiple representations and explanations (12 items). The items also covered different content areas. The content areas were defined with the help of expert interviews and aimed at measuring a broad understanding of accounting. Content areas included purpose, relevance and legal basis of accounting, system of double-entry bookkeeping, and procurement and sales (including the system of value added tax).

2.4.2 Sample

The total sample consisted of 1,158 teacher students in a bachelor's or master's program of economic and business education at 24 German universities and an additional 243 teacher students from Austrian universities. For the quality of the instrument, see Fritsch et al. (2015). Prospective teachers in Germany and Austria differed with regard to their opportunities to learn (OTL) before starting university education. In Austria, about 70% of prospective teachers had completed a commercial high school, compared to about 40% in Germany. Regarding university education, prospective teachers differed especially with regard to their attended courses in accounting didactics. At the master's level, 68% of prospective teachers in Austria had completed such a course—compared to only 12% of prospective teachers in Germany.

2.4.3 Results

For analysing the data, Item-Response-Theory was used. On average, prospective teachers studying at Austrian universities outperformed their counterparts at German universities. The effects for both—CK and PCK—were significant. This is in line with expectations: Austrian students usually have more learning opportunities in CK as well as in PCK in the field of accounting.

To analyse the influence of OTL on CK and PCK, multiple regression models were estimated. The assumption that OTL outside of, as well as during, university education have an impact on prospective teachers' CK was supported by the data—this was especially true for Germany. With regard to OTL, in both countries, CK was significantly predicted by *commercial apprenticeship* and *a major in accounting*. However, Germany and Austria differed concerning the influence of OTL in didactics. In contrast to Germany, in Austria, CK was significantly influenced by the variable *courses in business didactics*, whereas in Germany, the attendance of *courses in accounting didactics* was important for the acquisition of CK. Furthermore, it seems that in Austria, OTL during university had a slightly larger influence on the development of CK than OTL outside of university education. On the contrary, in the German regression model, a *commercial apprenticeship* had the highest effect ($\beta = 0.46$; $p < 0.001$). In the case of Germany, at least 43% of the variance in CK could be explained by the predictor variables, compared to 17% for Austria.

To summarise: the results generally indicate student teachers' deficits in CK and PCK, and therefore in PEC as well. Opportunities to learn can make a difference. For the acquisition of CK, it seems that OTL during (especially a major in accounting) and outside of university play a role in both countries, however, learning opportunities during university education barely have an impact on prospective teachers' PCK. The acquisition of competence at both the university and practical training level seems to be inefficient. This evidence provides clues that a competence based teacher education is still lacking at university level.

2.5 Conclusions and Implications for the Development of a Training Program to Foster Learning from Errors

As stated above, previous studies reveal deficits of both teacher students and pre-service teachers: their knowledge of domain specific student errors and their strategies for handling errors constructively are both at a fairly low level. The question remains when and how these competences should be acquired in the course of a teacher-training program with limited time. Subsequently, the question emerges of which competences are central—if there has to be choice (e.g. due to

time limits in training programs). What are appropriate ways to develop not only teachers', but also learners' competence? Specific trainings to promote prospective teachers' professional error competence are called for. However, before implementing trainings on a larger scale, their effectiveness has to be established. This is the focus of our training study.

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Professional Error Competence of Preservice Teachers
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