2.4 Relationships between Domain-Specific Knowledge, Generic Attributes, and Instructional Skills

Results from a Comparative Study with Pre- and In-Service Teachers of Mathematics and Economics

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Abstract

We introduce a theoretical framework on teachers' instructional skills to describe how they can be modeled across different domains. This framework conceptualizes teachers' instructional skills as action-related skills (during instruction) and reflective skills (before and after instruction), which are considered crucial for coping with the practical demands of everyday teaching in a specific subject. The theoretical framework assumes that both skill facets are influenced by the teacher's professional knowledge, generic attributes such as general cognitive abilities or ambiguity tolerance as well as affective and motivational factors. To investigate the relationships between teachers' instructional skills, domain-specific knowledge and generic attributes across different domains, the analytical model focuses on two subjects, mathematics and economics. Based on our study with pre- and in-service teachers of mathematics and economics (N = 564), which for the first time considers two subjects, we present results on these relationships. The findings are discussed with regard to their transferability to other domains.

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Keywords

Pre- and in-service teachers, instructional skills, mathematics, economics, generic attributes, pedagogical content knowledge, content knowledge

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1 Introduction

The daily routine of teaching requires teachers to meet a large variety of demands. The requirements in- and outside of the classroom are characterized by a high degree of situativity, contextuality, multidimensionality, simultaneity and immediacy, which make them particularly complex (Baxter and Lederman 1999; Oser et al. 2009; Borko and Shavelson 1990; Jackson 1990). Given the complexity of demands, the necessary knowledge and skills among the students of teacher education should be promoted as early as during their university studies to build up the necessary foundations for their profession at an early stage (Darling-Hammond and Lieberman 2012).

The prerequisites for teachers to meet these requirements have been intensively discussed in research. The early discourse of expertise research demonstrates that the knowledge base of a teacher consists of more than propositional knowledge. Rather, further forms of knowledge representations are necessary when describing and explaining a teacher's performance (Carter 1990; Darling-Hammond et al. 2013; Fenstermacher 1994; Schön 1983). Shulman (1986b) assumes that in addition to propositional knowledge, case and strategic knowledge are necessary to flexibly meet the demands of teaching practice. In competence research and according to the established definition of competences by Weinert (2001), the approaches to explaining teacher prerequisites are expanded to include general personal attributes, motivation and self-efficacy (e.g., Baumert and Kunter 2006). Based on a revision of the previous approaches, recent research emphasizes the importance of specific skills to explain the connection between teachers' dispositions and their real actions in instructional practice (Blömeke et al. 2015a; Kersting et al. 2012; Seidel and Stürmer 2014; Zlatkin-Troitschanskaia et al. 2019a).

Based on the various theoretical approaches and models to describe the necessary teacher prerequisites, analyses have been carried out over the years to empirically map parts of their relationships (Section 3). An empirical examination shows how challenging it is to map an overall picture in which the interdependent correlations of the individual components are considered comprehensively (Sadler 2013; Shulman 1986a). Increasingly complex theoretical models place high demands on the measurement methodology (Zlatkin-Troitschanskaia and Pant 2016). It is not surprising that there is still no uniform, empirically tested overall picture of the relationship of teachers' prerequisites in teacher research.

This also results in the still unanswered question of the domain-specificity of teachers' competences. Although the distinction of knowledge according to Shulman (1986b) in general pedagogical knowledge (GPK), content knowledge (CK), and pedagogical content knowledge (PCK) is widespread in research and has also been empirically confirmed for various subjects (Depaepe et al. 2013; Kuhn et al. 2014; Riese and Reinhold 2012), their relationship to skills that are more closely related to action has so far only been rudimentarily researched (Blömeke et al. 2016; Kersting et al. 2012). With regard to the skills themselves, there are different assumptions as to whether they can be regarded as domain-specific (e.g., "usable knowledge" in mathematics, Kersting et al. 2012) or generic ("professional vision", Seidel and Stürmer 2014; "perception, interpretation, decision-making", Blömeke et al. 2015a; Santagata and Yeh 2016). Furthermore, the question remains to what extent generic, non-subject-specific attributes of teachers (e.g., general cognitive abilities) account for correlations between subject-specific teacher skills. The patterns of influence might vary between subjects, as the nature of the subjects and their disciplinary structure differs (e.g., Gess-Newsome 1999; Shulman 1986a). The majority of studies to date still focus on just one subject respectively; studies involving several subjects have been the exception so far (for teachers from Germany, Niermann 2017). To examine the relationships across subjects, a comparative approach involving various subjects under control of generic factors is needed.

In Germany, teacher education has three stages: The first, theoretical stage takes place at university and comprises three years of bachelor studies and two years of master studies. The second stage consists of one and a half to two years of supervised practical training at schools. The third stage involves professional, fully autonomous teaching at schools. In general, teachers' instructional skills should increase during all three stages, university education, practical training, and professional practice (Berliner 1995, see also Buschang et al. 2012). However, discussion on the conditions of 'deliberate practice' suggests that simply 'doing a job' does not necessarily lead to a higher level of expertise (Ericsson 2000; Ericsson et al. 1993). Instead, the level of expertise increases particularly with opportunities

for structured learning, for example through guided self-reflection and feedback (e.g., Bronkhorst et al. 2014). Teachers encounter such opportunities especially during the first and second stage of teacher education (for empirical results, e.g., Kleickmann et al. 2013; Hill et al. 2005; Nilsson and Loughran 2012), since these two stages include both a practical aspect and university courses specifically on subject-related didactics. In the third stage (autonomous teaching), such structured learning opportunities can only be found in the form of subject-related didactic advanced vocational training, which is rather rare.

In our paper, we examine the relationships between instructional skills, domain-specific knowledge and generic attributes of teachers of mathematics and economics. In addition, we focus on the level of teachers' instructional skills at all three stages of teacher education (teacher students, trainee teachers and in-service teachers) for both subjects.

Based on the state of research, we introduce a framework on teachers' instructional skills to theoretically depict the connection between dispositions, skills and performance. The theoretical framework conceptualizes teachers' instructional skills as action-related skills (AS) and reflective skills (RS), which are considered crucial during instruction (AS) as well as before and after instruction (RS) in a specific subject. The framework assumes that both skill facets are influenced by the teacher's professional knowledge, generic attributes such as general cognitive abilities, ambiguity tolerance as well as affective and motivational factors, along with socio-biographical characteristics. Since our framework is based on previous findings from teacher research, we present selected empirical findings on the relationships between the facets of instructional skills to develop our research hypotheses.

To investigate the relationships and the levels of instructional skills across domains, our comparative study includes pre- and in-service teachers of two subjects, mathematics and economics (N = 564). Both subjects can be considered well-structured teaching domains (Short 1995). Mathematics and economics are two different but related subjects as mathematics is applied to solve certain problems in economics (CEE 2010). Studies also show that individuals' performance in mathematics tests and their performance in economics tests correlate (e.g., Ballard and Johnson 2004; Shavelson et al. 2019a). This is not surprising, as mathematics can be conceptualized as one facet of economic knowledge and skills, and therefore the two domains can be considered related disciplines (Shavelson et al. 2019b).

For the first time, this study compares two subjects and enables first evidence-based insights into the relationships between generic and domain-specific facets of teachers' instructional skills. By considering three status groups (stu-

dents, trainee teachers, experienced teachers), we can infer first conclusions about differences in the groups' respective level of instructional skills. On the basis of these findings, important insights can be gained for fostering these skills in teacher education and training programs. The results will also be discussed with regard to their transferability to other domains.

2 Theoretical Framework on Teachers' Instructional Skills

The existing modeling approaches for the description of teacher prerequisites can be divided into analytical and holistic approaches. Analytical approaches focus on single facets required for professional performance, i.e. professional competences are influenced by different interrelated cognitive and non-cognitive abilities and traits that can be measured separately and are necessary for competent behavior in professional contexts (Shulman 1986b; Schön 1983). The holistic modeling approach considers all cognitive and non-cognitive resources and their interaction, and competences are understood as a complex superordinate aptitude that enables a teacher to master specific professional demands (Corno and Snow 1986, Shavelson et al. 2019b; Zlatkin-Troitschanskaia et al. 2019b).

Analytical modeling approaches deal with several challenges such as evermore complex models which can hardly be operationalized empirically at this level of detail. As a consequence, analytical modeling approaches often focus on particular cognitive characteristics of teachers, for instance, on de-contextualized declarative knowledge (e.g., Kunter et al. 2011). Only parts of single facets of teachers' knowledge have been empirically assessed so far; this typically includes CK and PCK using traditional test methods (e.g., multiple-choice tests, text vignettes, or teacher reflections) (e.g., Holtsch et al. 2018). Yet, even these facets are only to a limited extent suitable for describing situated professional action of teachers in the instructional situation. To counterbalance the shortcomings of existing approaches, the current next generation of performance-oriented assessments based on a holistic view might be used to complement analytical approaches (Darling-Hammond et al. 2013; Jeschke et al. 2019b; Kuhn et al. 2018; Shavelson et al. 2019b; Zlatkin-Troitschanskaia et al. 2019b).

One holistic approach stems from the American tradition of performance assessment in education (Shavelson et al. 2019b), which emerged in research on "adaptive action" (Corno and Snow 1986). Since skills in real life are not neatly divided into single components, they can be analyzed through the stages that the individual goes through while handling a challenge (Shavelson et al. 2019b; Zlatkin-Troitschanskaia et al. 2019b). Current holistic approaches for compe-

tence modeling focus on competences close to professional actions, and encompass all abilities, skills and attitudes that are important for mastering professional demands (Weinert 2001). Performance assessments are based on a criterion sampling measurement approach that focuses on sampling real-life events and consolidating them into frameworks (Shavelson et al. 2019b; Zlatkin-Troitschanskaia et al. 2019b). One implication for assessment is that competence modeling must be based on a detailed analysis of real professional teaching requirements considering the complexity and contextual nature of real classroom instruction (Darling-Hammond and Baratz-Snowden, 2005; Oser et al. 2009). Blömeke et al. (2015a) differentiate several dispositions (i.e., professional knowledge, affect/motivation and generic attributes) as the basis for situation-specific skills (i.e., perception, interpretation, decision-making) and teaching performance (Zlatkin-Troitschanskaia et al. 2019a).

Based on these conceptual considerations and focussing on the holistic modeling approach, we developed our theoretical framework on teachers' instructional skills (Figure 1; Lindmeier 2011; Zlatkin-Troitschanskaia et al. 2019a). We assume that teachers' situation-specific skills (described as perception, interpretation and decision-making by Blömeke et al. 2015a), can differ depending on two essential facets of teaching practice, which exist in all subjects: action-related skills (AS) for in-classroom teaching practice, and reflective skills (RS) for pre- and post-classroom demands (Lindmeier 2011; Zlatkin-Troitschanskaia et al. 2019a):

- AS are considered a domain-specific cognitive resource that enables teachers to handle specific subject-related situations during instruction in the classroom, for example, when reacting immediately to students in a fast and adaptive fashion (e.g., a teacher should be able to recognize students' difficulties and to react flexibly in a didactically appropriate manner).
- RS are considered a domain-specific cognitive resource that enables teachers to prepare and evaluate specific situations in pre- and post-instructional phases (e.g., a teacher should already consider how to effectively prevent misconceptions among students while planning the lesson).

In accordance with our assumptions, we divide the dispositions into professional knowledge, various generic attributes as well as affective and motivational factors. The professional knowledge base as well as the affective and motivational factors can be further viewed as both domain-specific constructs (e.g., CK, PCK, motivation to teach a certain subject) and as cross-domain constructs (e.g., general

motivation to teach).[1] Among the generic attributes, we focused on the following dispositions, which can be expected to have a significant relationship with situation-specific skills (for the current state of research, see Section 3): ambiguity tolerance, Big Five personality traits, general cognitive abilities, and teacher-specific self-efficacy. In the following, we present selected empirical findings on the relationships between the various components. The findings serve as a basis for the derivation of our research hypotheses.

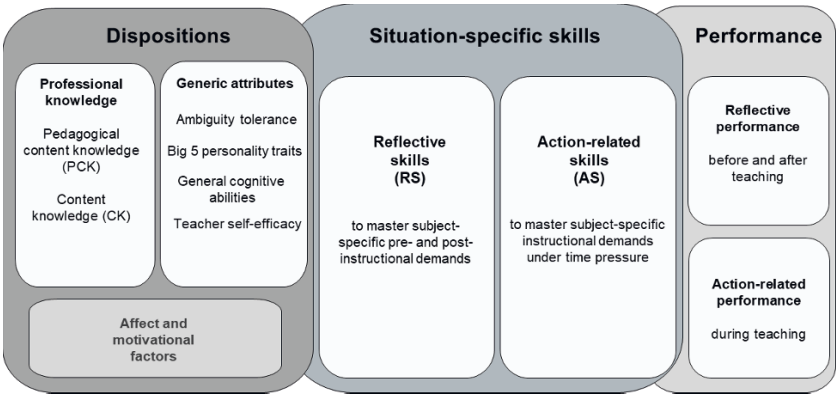

Figure 1 Theoretical framework on teachers' instructional skills (according to Lindmeier 2011; Zlatkin-Troitschanskaia et al. 2019a, p. 154)

3 State of Research

3.1 Professional Knowledge and Situation-Specific Instructional Skills

Research on teachers' knowledge and skills is gaining importance across disciplines and internationally (e.g., Richmond et al. 2019; Gitomer and Bell 2016). As early research shows, the subject-specific knowledge of teachers predicts both instructional quality and student learning (Shulman 1986a; e.g., for the mathe-

1 Based on the state of research, in our theoretical framework we also differentiate motivational aspects as an important component of teachers' dispositions (Figure 1). Due to the limited test time, however, we were only able to focus on selected aspects in our study, which means these facets were only assessed with a few questions in the socio-demographic part, and we will therefore not go into them in more detail in this article.

matical knowledge of mathematics teachers, Hill et al. 2005; Lindmeier et al. under review). Recent studies have indicated that knowledge alone is not sufficient to explain teachers' performance and to describe the situational prerequisites of teachers to cope with typical teaching demands (Kersting et al. 2012; Santagata and Sandholtz 2018). Studies in the domain of mathematics confirmed that teachers' instructional skills are empirically separable from knowledge (Blömeke et al. 2014; Knievel et al. 2015; Hepberger et al. 2019) and even more predictive for instructional quality and student learning than teacher knowledge (Kersting et al. 2010; Kersting et al. 2012). Blömeke et al. (2014) also showed that mathematics teachers' CK, acquired during teacher education, was a crucial predictor for performance characteristics such as their perception of classroom situations or how quickly they recognize student difficulties. As König et al. (2014) demonstrate in their study, *general* pedagogical knowledge and skills can be empirically distinguished as well.

3.2 Generic Attributes and Situation-Specific Instructional Skills

Studies are concerned with identifying generic teachers' attributes that favor or inhibit professional teaching skills (Bromme and Haag 2008; Keller-Schneider 2009; Lin et al. 2005; Lohmann et al. 1966). In the following, we focus on teachers' ambiguity tolerance, the Big Five inventory, general cognitive abilities and teachers' self-efficacy.

Ambiguity tolerance. One focal point of many studies is the role of ambiguity tolerance as a personal trait that determines differences in dealing with uncertainty (e.g., Sorrentino et al. 1984). Ambiguity-tolerant persons tolerate uncertain situations and even have a real need for them, as they interpret such situations as challenges (König 2003). Many of the demanding situations of everyday teaching practice can be characterized as particularly uncertain and complex, for instance, student learning processes or the challenge of engaging with a new class (Dalbert and Radant 2010). Due to this openness of teaching routine, teachers generally (inter)act in uncertain situations. The low predictability of teaching is seen by ambiguity-tolerant individuals as an opportunity to give students space for independent constructions of the subject matter: The more pronounced a teacher's tolerance for ambiguity is, the more open he or she in turn designs his or her teaching practice (König and Dalbert 2007). A study with teachers at vocational schools confirmed that a more positive perception of one's own performance as well as more frequent use of cooperative learning methods are common characteristics of

ambiguity-tolerant teachers, and the general ability to adequately fulfil pedagogical requirements increases with higher ambiguity tolerance (König 2003). Mayr (2011) also identified ambiguity tolerance as a "special" personal characteristic that is positively related to pedagogical skills.

Big Five personality traits. The most influential model on the construct of personality traits is the Big Five personality model, which differentiates between five traits to describe differences in behavior, thoughts, motivations, and emotions: openness, conscientiousness, extraversion, agreeableness, and neuroticism (John et al. 2008). Studies on personality traits have so far lacked a consistent picture of teacher personality (Eulenberger 2015). The use of the Big Five inventory (Benet-Martínez and John 1998) has led to heterogeneous findings of the relationship between a teacher's personality and teaching behavior (Bastian et al. 2017; Cutchin 1998; Job 2004; Rockoff et al. 2011). Klassen and Tze (2014) reviewed a meta-analysis (43 studies; n = 9,216 teachers) in which all Big Five personality traits, except for agreeableness, were shown to significantly correlate with teacher effectiveness. In contrast, Corcoran and O'Flaherty (2018), who used performance rankings resulting from classroom observations of 400 pre-service teachers to asses teaching performance, found no significant relationship between Big Five personality traits and teaching performance, whereas previous teaching performance in combination with academic achievement scores emerged as significant predictors of teaching performance. Aydin et al. (2013) reported not only significant positive effects on teaching competences for conscientiousness, extraversion, and agreeableness, but also significant negative effects for neuroticism for 206 pre-service teachers. Mayr (2016) revealed extraversion and openness as being particularly relevant to teachers.

General cognitive abilities. Empirical research has revealed that a person's general cognitive abilities are decisive for academic and professional success and facilitate the acquisition of professional knowledge and skills (Kuncel et al. 2004; Colquitt et al. 2000). General cognitive skills are also decisive for the professional success of teachers, in particular when beginning a career (Kennedy et al. 2008). Some studies report positive correlations between students' performance (Aloe and Becker 2009; Zumwalt and Craig 2005) and teachers' diagnostic skills (Kaiser et al. 2012). In two studies with different settings, Kaiser et al. (2012) investigated the relationship between prospective teachers' cognitive abilities and their accuracy of judgement in the grading of student performance. The Advanced Progressive Matrices Test (APM) by Raven (1962) was used to measure the teachers' cognitive abilities. In both studies, expectations were confirmed, and cognitive abilities correlated positively with accuracy in student performance evaluation (Kaiser et al. 2012). Furthermore, Mathesius et al. (2019) showed that the three sub-facets of

the IST-2000-R intelligence test (verbal, numerical and figural intelligence) and the sum of the three sub-facets correlate significantly positively with the scientific reasoning of teacher education students in biology.

Teacher' self-efficacy. Self-efficacy is described as a subjective certainty of being able to cope with unknown or difficult situations (Schwarzer and Jerusalem 2002). The self-efficacy of teachers is considered an individual conviction in terms of the extent to which the teacher is able to promote and support the students' learning and behavior, even under difficult conditions (Tschannen-Moran and Hoy 2001). A high expectation of self-efficacy is essentially regarded as positive, since it correlates with a more productive confrontation with challenges, more time for planning lessons, higher motivation, higher stamina, higher use of student feedback for further development of lessons, higher flexibility, more demanding goals, and a high level of achievement (Schwarzer and Warner 2014). Klassen et al. (2011) as well as Tschannen-Moran et al. (1998) provided extensive reviews of teacher efficacy research, showing consistently that teachers' self-efficacy correlates positively with their teaching behavior (Klassen and Tze 2014; see also Ghaith and Yaghi 1997; Guskey 1988; Koşar 2015; Holzberger et al. 2013; Morris-Rothschild and Brassard 2006; Ross 1998; Wolters and Daugherty 2007; Woolfolk et al. 1990). Holzberger et al. (2014) showed a significant correlation between teachers' self-efficacy and three dimensions of instructional behavior (cognitive activation, teacher–student relationship, and classroom management).

3.3 Teachers' Knowledge and Skills in Mathematics and Economics

Most teacher education degrees and programs are mainly designed for a specific subject respectively (e.g., programs for mathematics teachers), although they usually also comprise fundamental general pedagogical topics (e.g., Kunina-Habenicht et al. 2019). Accordingly, most studies of teacher knowledge and skills are limited to one subject, and studies involving several subjects have been the exception so far (for German teachers, Niermann 2017; Praetorius et al. 2015). This is astonishing, as in some educational systems, including Germany, secondary school teachers receive equal training in two subjects, for example, mathematics and physics or mathematics and economics.

Blömeke and colleagues (2016) attempted to empirically separate teacher skills of one domain (mathematics) from general pedagogical skills that are not related to a domain but are operationalized in a similar way (for the context of classroom management). Their results indicated that, in a sample of practicing mathemat-

ics teachers, skills for applying mathematical knowledge are more closely related to skills for applying pedagogical knowledge than to mathematics CK and PCK, giving first evidence that teachers' skills for applying CK and PCK may not be specific to the domain of mathematics. Like most currently available studies, this too focused on teacher skills in only one domain, neglecting to compare teachers' intra-individual ability to apply knowledge in more than one domain even though teachers usually teach two different subjects.

3.4 Development of Teachers´ Instructional Skills in Mathematics and Economics

According to teaching expertise research, practical teaching experience is related to a higher development of instructional skills (Baer et al. 2007; Beck et al. 2008). For economics, in particular, Kuhn (2014) shows the expected increase of PCK along the subgroups of bachelor students, master students, trainee teachers, and in-service teachers. The differences in PCK levels are significant, with the exception of the difference between trainee teachers and in-service teachers (for development of E-CK and E-PCK, Seifried and Wuttke 2015). For mathematics, Schönfeld and Kilpatrick (2008) show that M-PCK is increasing upon professional entry due to practical experience, and that the repertoire of teaching strategies is expanding, but M-CK is only being expanded in parts (Llinares and Krainer 2006). The quasi longitudinal comparisons by Kleickmann et al. (2013) show corresponding differences in M-CK and M-PCK between prospective teachers at the end of their training and experienced teachers. Since experienced teachers have an average of 21 years' work experience, it is not possible to make any statements about the changes that may occur during professional practice.

4 Research Framework

4.1 Hypotheses

On the basis of the current state of research and with a focus on the relationships between teachers' instructional skills, domain-specific knowledge and generic attributes as well as on the levels of teachers' instructional skills, we address the following hypotheses in our study for two subjects, economics and mathematics:

- H1: The four constructs (CK, PCK, AS, RS) from the theoretical framework (Figure 1) are related, but empirically separable in each subject.
- H2: Generic attributes (general cognitive abilities, self-efficacy, ambiguity tolerance, neuroticism) show less influence on AS and RS than domain-specific knowledge (CK and PCK) and the patterns of relation are comparable across the two subjects.
- H3: With an increasing degree of domain-specific expertise, a teacher's CK, PCK, AS, and RS become more pronounced.

4.2 Design and Sample

We conducted a comparative, quasi-experimental study with pre- and in-service teachers of two domains, mathematics and economics, including participants who teach both. The combination of the two domains is particularly attractive for teachers at upper-secondary schools with a vocational focus ("Berufsschule"). To achieve quasi-experimental variation and to examine interdependencies between the two domains, the overall sample ($N = 564$) comprises three status groups which differ in their degree of expertise and also in their training in mathematics or economics as well as in both subjects (Table 1). The recruitment of our sample took place at universities, teacher training ("Referendariat") colleges, and schools from 52 cities in 10 German federal states. The prerequisite for teacher trainees to participate was that they had to be in the second half of their training program so that they can be considered advanced trainees. Participation was voluntary, and a monetary incentive was offered as compensation. The participants also received automated feedback on their results using a feedback tool. Participants' ages ranged from 18 to 64 years ($M = 30.1$, $SD = 8.41$), and gender distribution was 46.2 % female and 53.8 % male participants (Table 1).

Table 1 Description of sample

Expertise/ Domain	Mathematics	Both	Economics	Overall
Students	55	54	180	289
Trainee teachers	90	18	49	157
Experienced teachers	24	27	67	118
Overall	169	99	296	564

4.3 Instruments

AS and RS in mathematics and economics were measured using video-based performance assessments (Jeschke et al. 2019b; Kuhn et al. 2018). The performance assessment for mathematics AS (AS-M) comprises 9 items in which participants have to react directly to the students seen in the videos and help them to solve specific mathematical problems. Similarly, the 7 items used to assess AS in economics (AS-E) focus on the teaching of central curricular content in economics. Participants had to respond verbally and under time pressure. Responses were recorded via microphone. Within the 9 items for mathematics RS (RS-M) and the 7 items for economics RS (RS-E) the participants had to reflect on classroom situations seen in the video and provide possible reasons for students' difficulties or alternative actions. Participants provided written responses. A scoring scheme that was developed for each item describes specific criteria for adequate teacher responses based on a theoretical framework and findings from the pre-test studies (Jeschke et al. 2019b; Kuhn et al. 2018; Zlatkin-Troitschanskaia et al. 2019a).

To adequately assess the knowledge components CK and PCK, we used previously tested and validated instruments with closed and open-ended paper-pencil items for mathematics CK (CK-M, 11 items, Dreher et al. 2018) and PCK (PCK-M, 13 items, Loch et al. 2015) as well as for economics CK (CK-E, 14 items, Zlatkin-Troitschanskaia et al. 2014) and PCK (PCK-E, 11 items, Kuhn et al. 2016).

To assess generic attributes, we used the scale of perceived self-efficacy of teachers (Schmitz and Schwarzer 2000) and the scale of figural intelligence for general cognitive abilities (Liepmann et al. 2007); personality traits were assessed using a Big Five inventory (Benet-Martínez and John 1998; Gerlitz and Schupp 2005) as well as an inventory for measuring ambiguity tolerance developed by Reis (1996).

The open-ended (constructed) responses were transcribed and coded by two trained independent raters with interrater agreements of Cohen's $\varkappa$ between acceptable and very good, based on at least 20 % of the open responses (randomly selected) for each item (for mathematics: AS-M: $\varkappa$ = .77–.90 (M = .84); RS-M: $\varkappa$ = .80–1.00, (M = .92); CK-M and PCK-M: $\varkappa$ = .70–1.00 (M = .89), for economics: AS-E: $\varkappa$ = .60–.89 (M = .76); RS-E: $\varkappa$ = .5–.78 (M = .66); PCK-E: $\varkappa$ = .60–.89 (M = .78)).

The internal consistency of all test instruments used was acceptable to good (*Cronbach's* α = .60–.84, see Table 2). The relatively lower reliabilities of the domain-specific constructs can still be considered marginally sufficient in view of the scale lengths and the conceptual heterogeneity of the constructs (e.g., Blömeke et al. 2015b; Hill et al. 2004).

Table 2 Description of the test instruments

Instruments	Number of items	Assessment format	Response format	Cronbach's α (*N*)	Authors
CK-M	11	Paper-pencil	MC[a]/CR[b]	.62 (247)	Dreher et al. 2018
PCK-M	13	Paper-pencil	MC/CR	.60 (393)	Loch et al. 2015
AS-M	9	Video-based	CR/orally	.60 (244)	Jeschke et al. 2019b
RS-M	9	Video-based	CR	.61 (387)	Lindmeier 2011
CK-E	14	Paper-pencil	MC	.60 (393)	Zlatkin-Troitschanskaia et al. 2014
PCK-E	11	Paper-pencil	MC/CR	.61 (387)	Kuhn 2014; Kuhn et al. 2016
AS-E	7	Video-based	CR/orally	.64 (390)	Kuhn et al. 2018
RS-E	7	Video-based	CR	.61 (384)	Kuhn et al. 2018
Teacher Self-efficacy	10	Question-naire	Rating scale	.66 (513)	Schmitz and Schwarzer 2000
Figural intelligence	20	Paper-pencil	MC	.78 (563)	Liepmann et al. 2007
Ambiguity tolerance	16	Question-naire	Rating scale	.77 (527)	Reis 1996
BFI-25	25	Question-naire	Rating scale		Benet-Martínez and John 1998; Gerlitz and Schupp 2005
Extraversion				.84 (539)	
Agreeable-ness				.66 (518)	
Conscien-tiousness				.77 (542)	
Neuroticism				.73 (541)	
Openness				.82 (539)	

Notes. [a]Multiple-Choice; [b]Constructed Response

5 Results

H1: The four constructs (CK, PCK, AS, RS) are related, but empirically separable in each domain.

To examine H1, a correlation analysis using SPSS 23 is conducted. The non-standardized sum scores from the tests are used to depict the domain-specific constructs CK, PCK, AS and RS in mathematics and economics. In Tables 3 and 4, the bivariate Pearson correlations between the respective constructs are illustrated.[2]

Table 3 Pearson correlations between knowledge and skills constructs in the domain of mathematics

	CK-M	PCK-M	AS-M
PCK-M	.39***	–	–
AS-M	.37***	.32***	–
RS-M	.45***	.42***	.49***

Notes. ***$p < .001$

Table 4 Pearson correlations between knowledge and skills constructs in the domain of economics

	CK-E	PCK-E	AS-E
PCK-E	.33***	–	–
AS-E	.30***	.29***	–
RS-E	.21***	.37***	.33***

Notes. ***$p < .001$

The manifest correlations mostly refer to moderate correlations, therefore, the assumption of empirical separability of the constructs in pair-wise correlations (H1) can be regarded as confirmed. High correlations, which point to a greater proximity of the two constructs, can be seen in the domain of mathematics between CK-M and RS-M and between RS-M and AS-M.

The bivariate correlations between the respective constructs are consistently higher in mathematics ($.32 < r < .49$) than in economics ($.21 < r < .37$). This result confirms previous findings on the relationship between CK and PCK, where the

2 We refer to additional analysis using multivariate linear regression models to examine the relationships controlling common variance between CK and PCK (Jeschke et al. 2019a).

correlations are stronger in the domain of mathematics than in other domains, including economics (Section 2). The explanations discussed include the more "substance/content"-focused orientation of mathematics education and a more specialized expertise, which requires a greater synergy between the constructs in the domain of mathematics.

Differences between the two domains can also be seen in the relationships between CK and AS, as well as between CK and RS. While the correlation between CK and AS is weaker (.37) than the correlation between CK and RS (.45) for the domain of mathematics, the opposite is evident for the domain of economics, where the correlation between CK and AS of $r = .30$ is stronger than the correlation between CK and RS (.21) in this sample.

H2: Generic attributes (general cognitive abilities, self-efficacy, ambiguity tolerance, neuroticism) show less influence on the AS and RS than domain-specific knowledge (CK and PCK) and the patterns of relation are comparable across the two subjects.[3]

As expected, in both subjects, correlations between domain-specific knowledge and AS are higher compared to the weak or non-existent correlations between generic attributes and AS (Table 5). For both subjects, significant weak correlations were found between AS and general cognitive abilities as well as AS and neuroticism (expected negative correlation), while no significant correlations were found between AS and self-efficacy. For AS in economics, in contrast to mathematics, an additional significant, although rather weak, correlation with ambiguity tolerance was identified.

Table 5 Pearson correlations between generic attributes and AS in mathematics and economics

	AS-M	AS-E
Cognitive abilities	.16*	.12*
Teacher self-efficacy	-.03	.03
Ambiguity tolerance	.06	.17**
Neuroticism	-.16*	-.15**

Notes. *$p < .05$; **$p < .01$

Due to the stronger domain-specific correlation, we used a multiple linear regression model, which initially only included CK and PCK as predictors of AS. In a

3 In the following, only the results for AS are described, due to limited space.

second step, we also included the generic attributes as additional predictors to analyze whether they have a further influence on AS (Tables 6 and 7).

As expected, for both subjects, domain-specific knowledge (PCK, CK) has a highly significant influence on the dependent variable AS, which remains even after the inclusion of generic attributes ($p < .01$). The addition of generic attributes increases the explanatory power of the models, however, in both domains only one significant relationship between the generic attributes and AS was found. In this respect, the patterns between both subjects can be interpreted similarly. For mathematics, there is a significant negative effect on AS for neuroticism ($\beta = .15$, $p < .05$), whilst for economics there is a significant positive effect of general cognitive skills on AS ($\beta = .10$, $p < .05$).

Table 6 Multiple linear regressions on the score in AS-M

	Model 1			Model 2		
Variable	Coefficient B	SE (B)	*Beta (β)*	Coefficient B	SE (B)	*Beta (β)*
Constant	3.01***	0.71		7.97**	2.87	
PCK	0.21**	0.07	.20**	0.19**	0.07	.19**
CK	0.26***	0.06	.29***	0.25***	0.06	.29***
Self-efficacy				-1.08	0.749	-.09
Ambiguity tolerance				-0.02	0.42	-.00
General cognitive abilities				0.05	0.06	.06
Neuroticism				-0.49*	0.22	-.15*
R^2	.17***			.20***		
Corrected R^2	.17***			.18***		

Notes. $N = 226$ (model 1)/211 (model 2); *$p < .05$, **$p < .01$, ***$p < .001$

Table 7 Multiple linear regressions on the score in AS-E

	Model 1			Model 2		
Variable	Coefficient B	SE (B)	*Beta (β)*	Coefficient B	SE (B)	*Beta (β)*
Constant	2.51***	0.43		1.23	1.68	
PCK	0.19***	0.05	.21***	0.19***	0.05	.21***
CK	0.26***	0.05	.24***	0.26***	0.06	.24***
Self-efficacy				-0.03	0.44	-.00
Ambiguity tolerance				0.36	0.25	.08
General cognitive abilities				0.07*	0.04	.10*
Neuroticism				-0.21	0.12	-.09
R^2	.14***			.18***		
Corrected R^2	.13***			.17***		

Notes. $N = 377$ (model 1)/358 (model 2); $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$

H3: With an increasing degree of domain-specific expertise, a teacher's CK, PCK, AS, and RS become more pronounced.

For a comparative analysis of teachers' domain-specific knowledge and skills levels, CK, PCK, AS and RS in the three status groups (students, trainee teachers, and experienced teachers) were considered separately. The basic assumption was that the test results of those constructs increase with a higher level of training and increased professional expertise. To investigate this assumption, the mean score values of the different status groups were compared (Figures 2 and 3). The general effects of group affiliation were described through ANOVA and post-hoc analyses.

The explained variance in knowledge and skill levels through group affiliation was fairly high in economics, especially for the constructs PCK-E (partial $\eta^2 = .207$) and RS-E (partial $\eta^2 = .161$), and with moderate effects for the two other constructs (CK-E: partial $\eta^2 = .021$; AS-E: partial $\eta^2 = .055$). In mathematics, a moderate effect was found for AS-M (partial $\eta^2 = .026$), no effects were identified for the three other constructs (CK-M: partial $\eta^2 = .004$, PCK-M: partial $\eta^2 = .004$, RS-M: partial $\eta^2 = .002$).

The results of the post-hoc tests (Games-Howell adjusted) confirm that a person's PCK-E and RS-E are significantly higher with increasing expertise, and indicated significant differences in mean scores between students and trainee teachers (PCK-E: 1.63**; RS-E: 1.35***), students and experienced teachers (PCK-E: 3.34**; RS-E: 2.63***), and trainee teachers and experienced teachers (PCK-E: 1.72**; RS-E: 1.28**). For AS-E, significant differences were found between stu-

dents and trainee teachers (.98*), and students and experienced teachers (1.47***). For CK-E and AS-M, significant differences were identified between students and experienced teachers only (CK-E: .94*; AS-M: 1.60*).

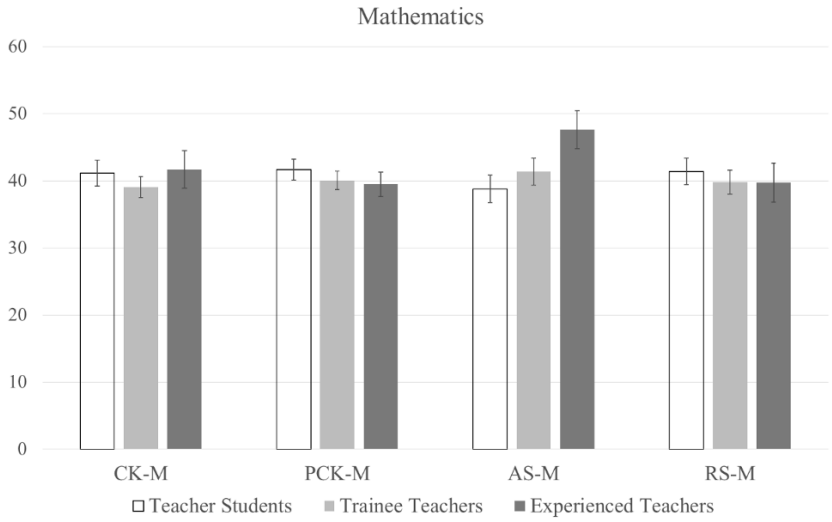

Figure 2 Relative mean scores (CK-M, PCK-M, AS-M, RS-M) by groups in mathematics Error bars represent standard error.

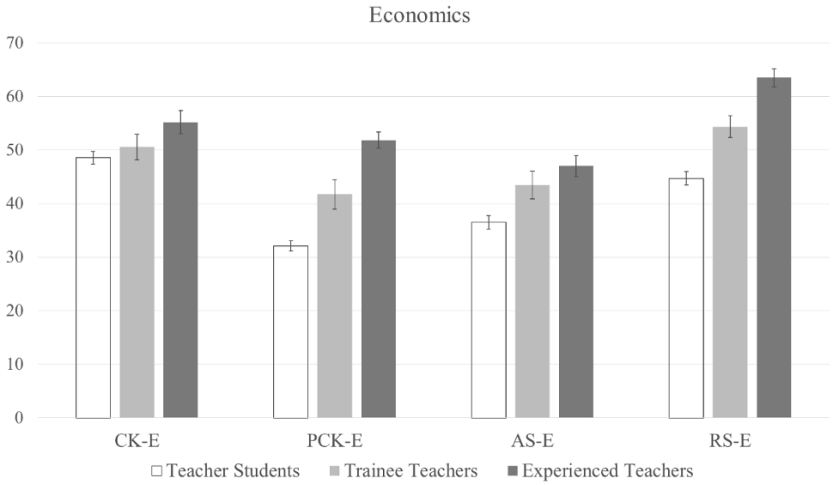

Figure 3 Relative mean scores (CK-E, PCK-E, AS-E, RS-E) by groups in economics Error bars represent standard error.

6 Discussion and Conclusion

This comparative study investigates how relationships between different facets of instructional skills behave in the domains of mathematics and economics. The results show largely moderate (to strong) correlations between the four constructs (CK, PCK, AS, RS), so that the separability in pairwise correlations (H1) can be confirmed for both domains. In particular, there is a tendency for bivariate correlations to be consistently stronger in mathematics than in economics. The correlations indicate that AS and RS align differently with the conceptual understanding of the subject (for economics, e.g., Mankiw 2012) in mathematics and economics. For economics, spontaneous responses to students' statements in the form of appropriate impulses and explanations (AS) essentially depend on whether the student's mistake was correctly identified by the (prospective) teacher (Zlatkin-Troitschanskaia et al. 2019a), which might be mirrored in these findings. Dealing with students' mistakes reflectively (RS), for instance, when planning future lessons, requires subject-specific understanding as well, but additionally also requires more specific didactical instructions and their application. This may also explain the comparatively strong correlation between PCK-E and RS-E for the domain of economics. For mathematics, the result that subject-specific knowledge

(CK, PCK) tendentially correlates more strongly with RS than with AS supports the assumption that mathematics teachers are able to apply their knowledge more effectively when dealing with reflective tasks such as lesson planning and evaluation (RS) than with instructional tasks under time pressure (AS).

While we identified weak correlations between generic attributes and AS in both domains, it becomes evident that the correlation between domain-specific knowledge (CK, PCK) and AS is not only much stronger, but also partially explains the relationships to generic attributes. In both domains, generic attributes (general cognitive abilities, self-efficacy, ambiguity tolerance, neuroticism) show weaker correlations to AS than the two domain-specific knowledge constructs CK and PCK. Overall, H2 can be regarded as confirmed.

As we assumed in H3, knowledge and skills develop during teacher training, resulting in a higher level of expertise. This hypothesis cannot be confirmed for both domains in our study. Only in economics did participants with a higher level of expertise also achieve higher test scores, thus indicating that the four constructs (CK, PCK, AS, RS) are becoming increasingly more pronounced with the test subjects' level of expertise. In contrast, in mathematics, only an increase in the level of AS could be determined in the given sample.

Since H3 was only tested by cross-sectional (not longitudinal) comparison and not experimental, these findings do not allow any statements about possible causal relationships between the examined constructs. In addition, the instruments still require improvement in terms of reliability, a lack of which may hamper the detection of expertise effects. Despite these limitations, these results provide an important basis for further studies on possible explanatory factors.

With regard to our subsample of pre- and in-service teachers trained in both subjects, mathematics and economics (n = 99), we found preliminary evidence suggesting that some of the knowledge and skills used in mathematics are related to the knowledge and skills necessary for teaching economics (Jeschke et al. 2019a, b). This result is in line with previous findings (Ballard and Johnson 2004; Shavelson et al. 2019a, b) and supports the assumption that mathematics-specific aspects could contribute to knowledge and skills for teaching economics. Therefore, teacher knowledge and skills particularly in mathematics may foster the acquisition of teacher knowledge and skills in economics (in all three stages of teacher education).

In this study, not all relationships between all central constructs of our theoretical framework (Figure 1) could be empirically tested. Nonetheless, our findings significantly contribute to a more elaborate understanding of the relationships between domain-specific knowledge, generic attributes and instructional skills. In our domain-comparative study, we gain first empirical insights into relationship

patterns in two different domains. These findings can be considered first indications regarding the domain-specificity of teachers' instructional skills. The assessments developed and validated in our study can be used in future empirical research and expanded to further constructs and subjects.

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