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Prof. Dr. Gabriele Kaiser
University of Hamburg (Germany) &
Nord University (Norway)

An Overview of the Current Discourse on Teachers' Professional Competence – Theoretical Perspectives and Selected Empirical Results

Introduction

Professional competencies of teachers of high importance in teachers' everyday life.

Teachers are actors in a **maelstrom** confronted with a "**blooming, buzzing confusion of sensory data**" (B. Sherin & Star, 2011, p. 69).

Need for teachers to **make sense of what they perceive**, **interpret** accordingly, and make fast **decisions (called noticing)** based on their **professional knowledge; together called competencies**.

Relevance of noticing within the competence discourse

Increasing attention in the last two decades to teachers' **professional noticing as major part of teachers' practice in classroom** and as **prerequisite for instructional quality** in the last decades.

But **no consensus regarding the understanding of noticing as part of teachers'** competencies, **inconsistent results of empirical studies**.

Structure

1. **Current Discourse** on Teachers‘ Competencies
2. The **Cognitive Approach** on Teachers‘ Competencies and the TEDS-M Study as Example
3. The **Situated Approach** on Teachers‘ Competencies and further Studies of the TEDS Research Program as Examples
4. **Integration** of Cognitive and Situated Approaches on Professional Competencies of Mathematics Teachers
5. Professional Competencies of Mathematics Teachers and their Relation to **Students‘ Achievements**
6. Further **Perspectives**

1. Current Discourse on teachers' competencies

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Current Discourse on Teachers' Competencies

Since late 1990s a growing number of empirical studies on teacher education, mainly focusing on teachers' competencies like international comparative studies on students' achievements (such as PISA); teacher knowledge as central construct.

Common core of most studies **Shulman's** description of **pedagogical content knowledge (PCK)** (1987) as

„special **amalgam** of **content** and **pedagogy** that is uniquely the province of teachers, their own special form of professional understanding".

However, no general consensus on the facets of this concept (survey by Depaepe, Verschaffel, Kelchtermans, 2013).

Two different paradigms concerning the conceptualisation of PCK:

"whether **mathematical knowledge in teaching** is located '**in the head**' of the individual teacher or is somehow a **social asset**, meaningful only in the context of its applications" (Rowland & Ruthven, 2011).

Current Discourse on Teachers' Competencies

Consequences of this cognitive and situated perspective on the definition of pedagogical content knowledge (PCK) according to Depaepe et al. (2013):

- **Cognitive perspective**: identifies a limited number of components to be part of PCK and distinguishes PCK from other categories of teachers' knowledge base;
- **Situated perspective**: describes PCK as multi-dimensional, teachers' choices simultaneously reflect mathematical and pedagogical deliberations.

Depaepe et al. (2013) point out that both perspectives are needed, because both have pitfalls and shortcomings as well as strengths.

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2. The cognitive approach on teachers‘ competencies and the TEDS-M study as example

Current Discourse on Teachers' Competencies

Theoretical starting point of studies on teachers' competencies are teaching abilities – called '**professional competencies'** (Weinert, 2001) divided into cognitive facets (teachers' professional knowledge) and affective-motivational facets (professional beliefs).

Referring to **Shulman** (1986) the **professional knowledge of teachers** are divided into several facets:

- **mathematics content knowledge (MCK)**,
- **mathematics pedagogical content knowledge (MPCK**), including curricular knowledge, and
- **general pedagogical knowledge (GPK**).

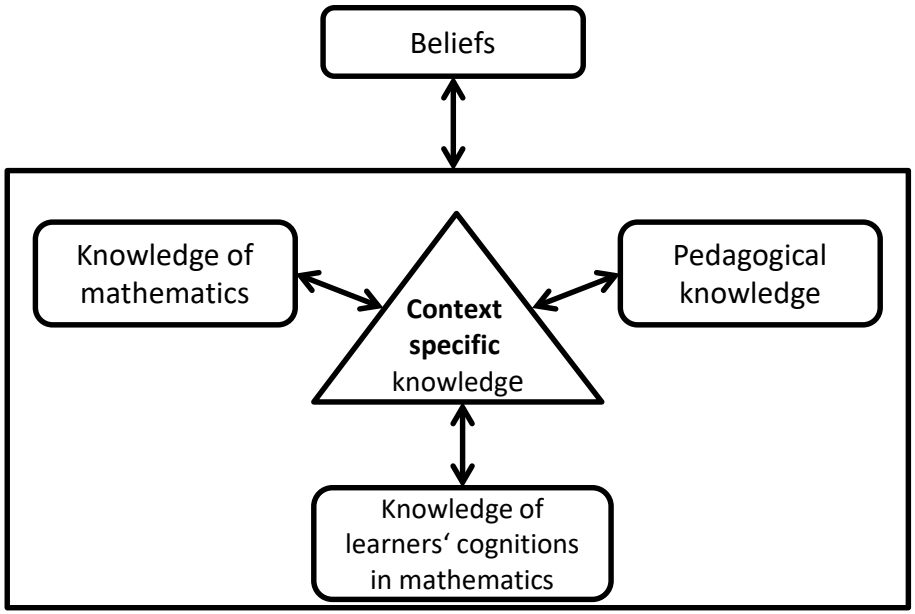
Concerning professional beliefs in particular **epistemological beliefs** about the nature of mathematics and beliefs about the teaching and learning of mathematics were included.

Seminal Theoretical Approaches

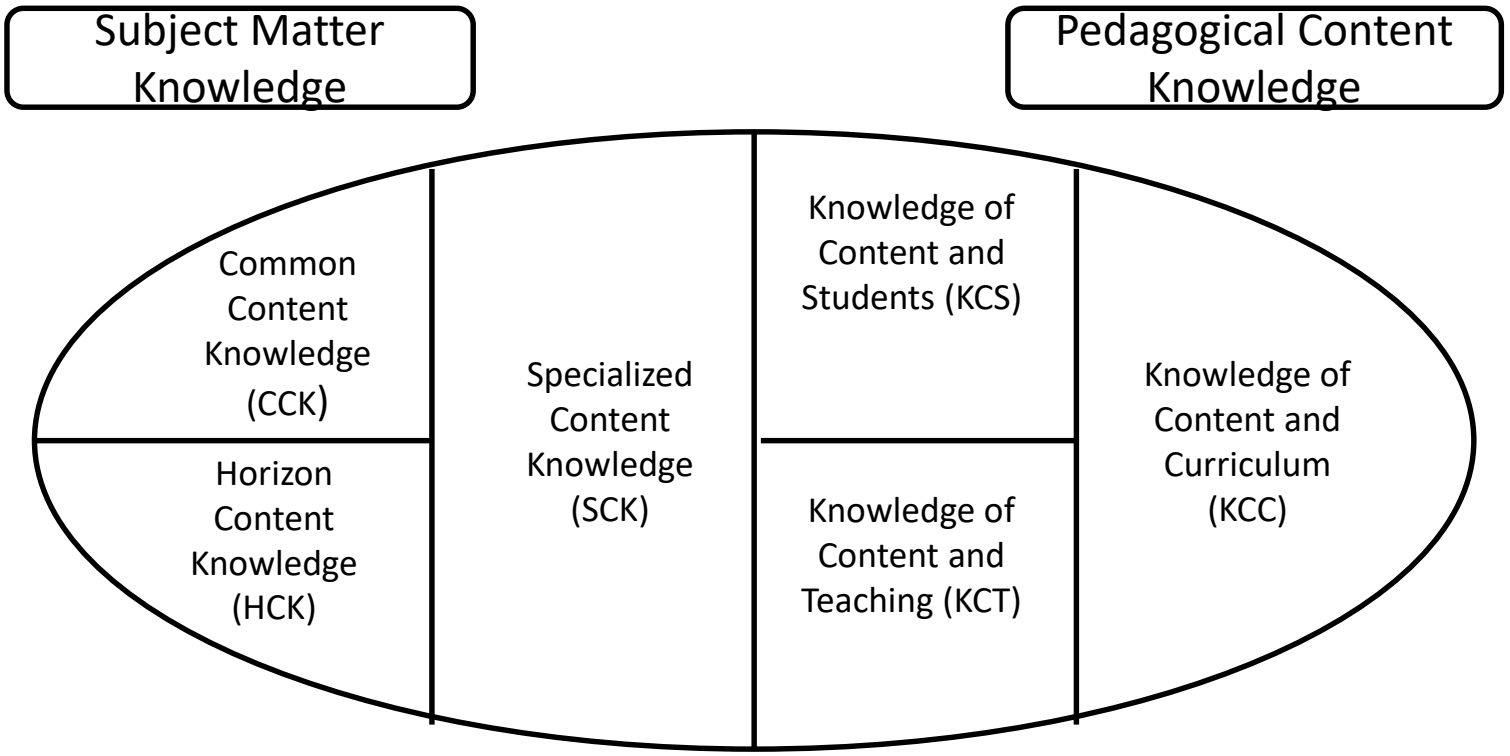
Knowledge Quartet by Rowland et al. (2011)

- Foundation: mathematical knowledge
- Knowledge-in-action:
- Transformation of mathematical knowledge into pedagogical knowledge
- Connection of mathematical topics taught
- Contingency of teaching actions

Fennema und Franke (1992)



Mathematical Knowledge for Teaching (MKT) by Loewenberg Ball, Hill, Bass et al. (2005, 2008)



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Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M) as example of a cognitively oriented study

Carried out under the auspices of the International Association for the Evaluation of Educational Achievement (IEA);

- Covering pre-service teachers from 16 countries from East and West **in their final year of teacher education**:
  - **Primary study**: pre-service teachers aiming for grade 1 through 4
  - **Secondary study**: pre-service teachers aiming for lower-secondary grades

Two studies based on nationally representative samples, follow the rigorous IEA quality control mechanisms of sampling, data collection, coding, and data analysis.

About 23,000 prospective teachers participated in the two studies, which took place from 2008-2009, results released in 2010.

Paper-and-pencil tests; variety of closed and open items or items with short-answers.

These tests were used in the study described by Dr. Saadati today.

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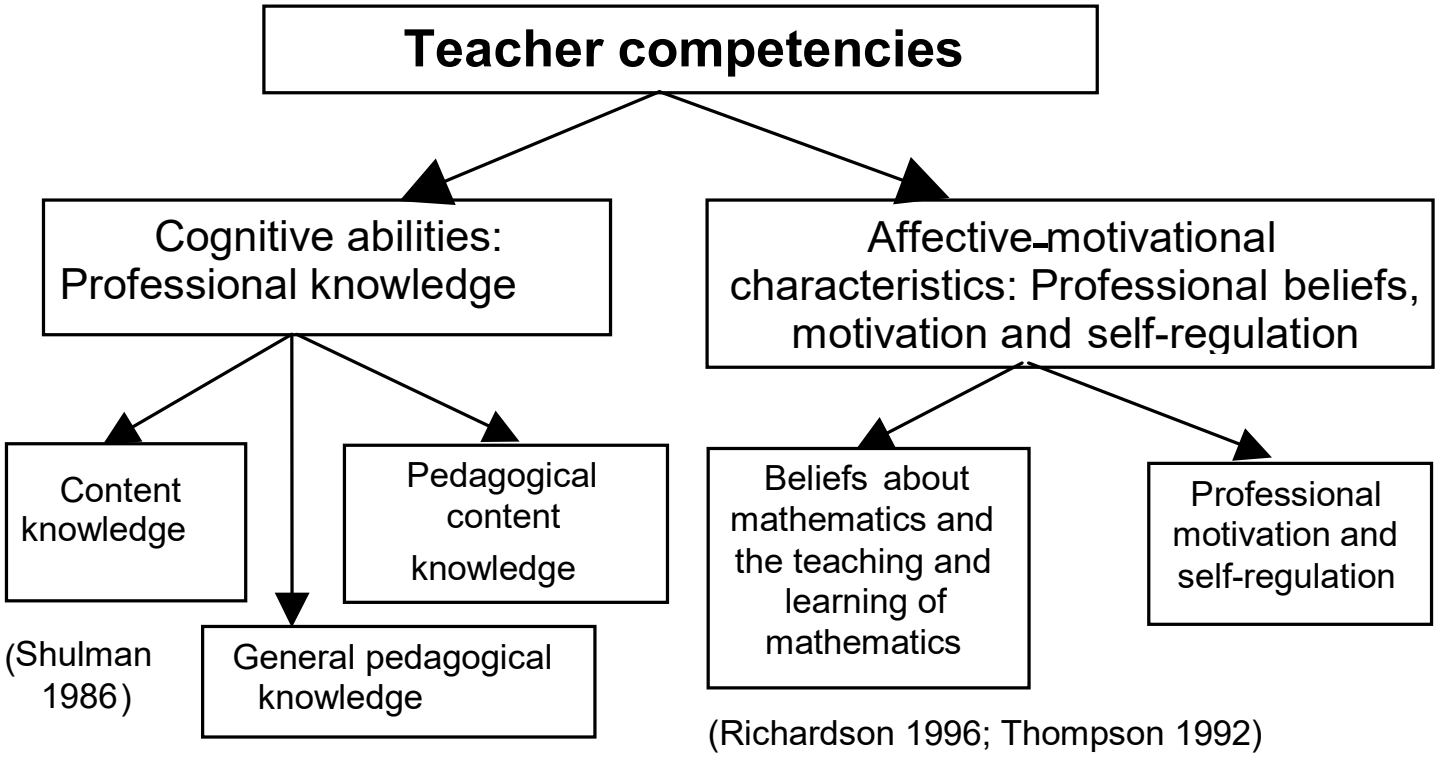
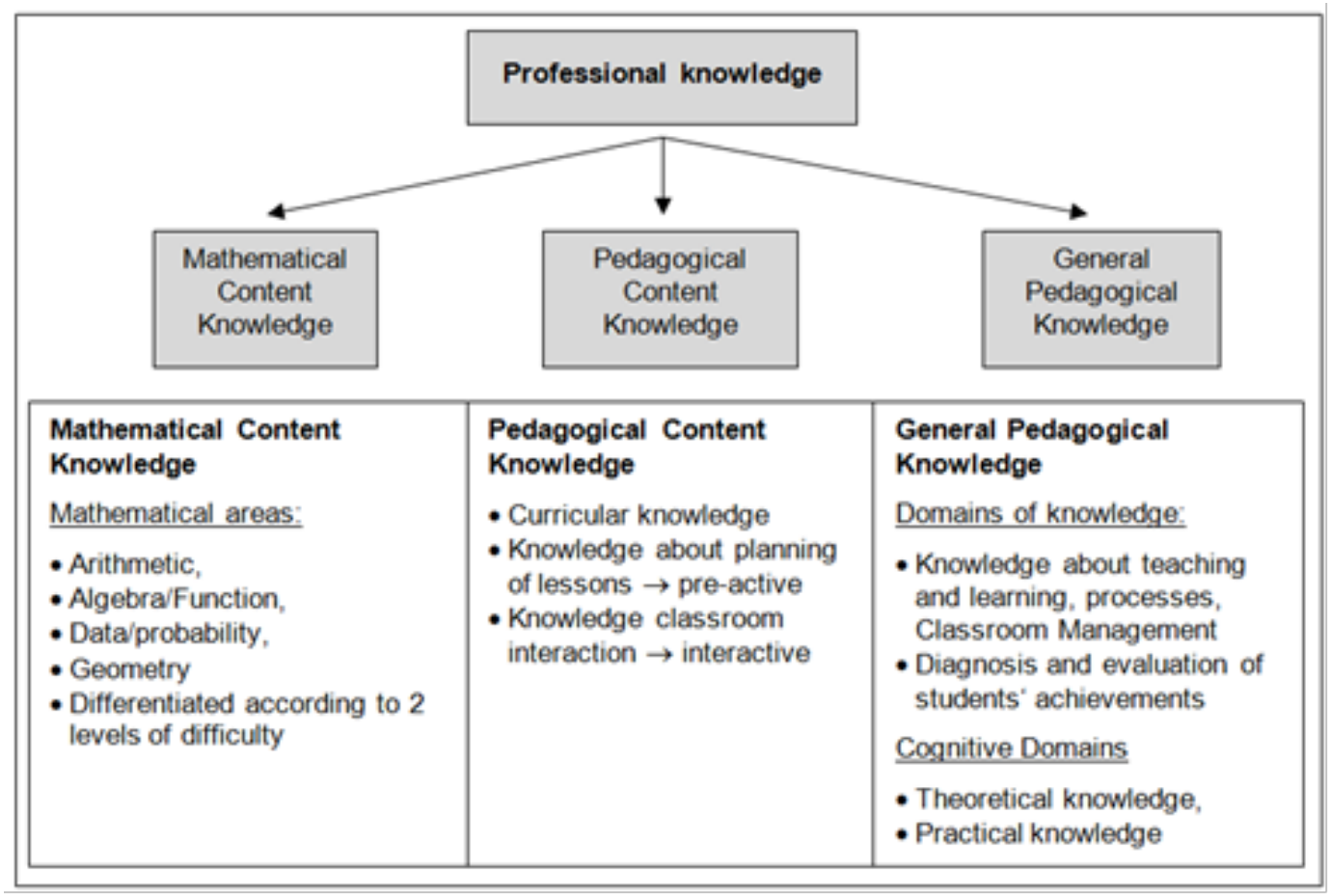
Conceptual model of teachers' professional competencies in Teacher Education and Development Study (TEDS-M)



Model of professional knowledge



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Teacher Education and Development Study: Learning to Teach Mathematics (TEDS-M) as example of a cognitively oriented study

Paper-and-pencil tests for evaluation of MCK and MPCK; variety of closed and open items or items with short-answers, 60 minutes test time.

These tests were used in the study described by Prof. Felmer and Dr. Saadati, instruments not released.

Released sample item:
Outcome: MCK / Domain: Algebra / Sub-domain: Reasoning / Secondary level

Prove the following statement: If the graphs of linear functions

$f(x) = ax + b$ and $g(x) = cx + d$

intersect at a point *P* on the *x*-axis, the graph of their sum function

$(f + g)(x)$ must also go through P.

Possible correct answer:
Response carefully lays out the steps of the proof in a general way, without using the given formulas of *f*(*x*) and *g*(*x*).
Example: Suppose f(x) and g(x) intersect at point (p, 0*) on the x-axis. Then f(p) =* 0*, g(p) =* 0*. Then (f + g)(p) = f(p) + g(p) =* 0 + 0 = 0*.*

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Released sample item:
Outcome: MPCK / Domain: Geometry / Sub-domain: Curriculum/Planning / Primary level

When teaching children about length measurement for the first time, Mrs. Sanchez prefers to begin by having the children measure the width of their book using paper clips, then again using pencils.

Give **TWO** reasons she could have for preferring to do this rather than simply teaching the children how to use a ruler?

Significant and acceptable reasons
Reason 1: Understanding of what measurement is
Reason 2: Need for standard units
Reason 3: Choosing most appropriate unit

Content Knowledge of Future Lower Secondary Teachers	
Country	**Mean**
Taiwan	667
Russia	594
Singapore	570
Poland*	540
Switzerland*	531
Germany	**519**
USA*	505
International	500
Malaysia	493
Thailand	479
Oman	472
Norway*	444
Philippines	442
Botswana	441
Georgia*	424
Chile*	354
IEA: Teacher Education and Development Study	© TEDS-M Germany

Results of TEDS-M secondary study – mathematical knowledge

- Taiwanese pre-service teachers outperform all other countries.
- The performance of Russian and Polish future teachers is remarkably high considering the low HDI of these countries.
- US American pre-service teachers around the international mean, whereas German pre-service teachers above.
- Unexpected low achievement of Norway given its high HDI.
- Low achievements of **Chilean** pre-service teachers.

* Reduced Coverage, Combined Participation Rate < 75% or other limitations

Pedagogical Content Knowledge Future Lower Secondary Teachers	
Country	**Mean**
Taiwan	649
Russia	566
Singapore	553
Switzerland*	549
Germany	**540**
Poland*	524
USA*	502
International	500
Thailand	476
Oman	474
Malaysia	472
Norway*	463
Philippines	450
Georgia*	443
Botswana	425
Chile*	394
IEA: Teacher Education and Development Study	© TEDS-M Germany

Results of TEDS-M secondary study – mathematics pedagogical knowledge

USA around the international mean,

Germany significantly above.

Outstanding results of Taiwanese future teachers, followed by future teachers from Russia, Singapore and Switzerland, followed by Germany.

Unexpected low achievements of Norwegian future teachers.

Improved, but still low achievements of **Chilean** pre-service teachers.

* Reduced Coverage, Combined Participation Rate < 75% or other Limitations

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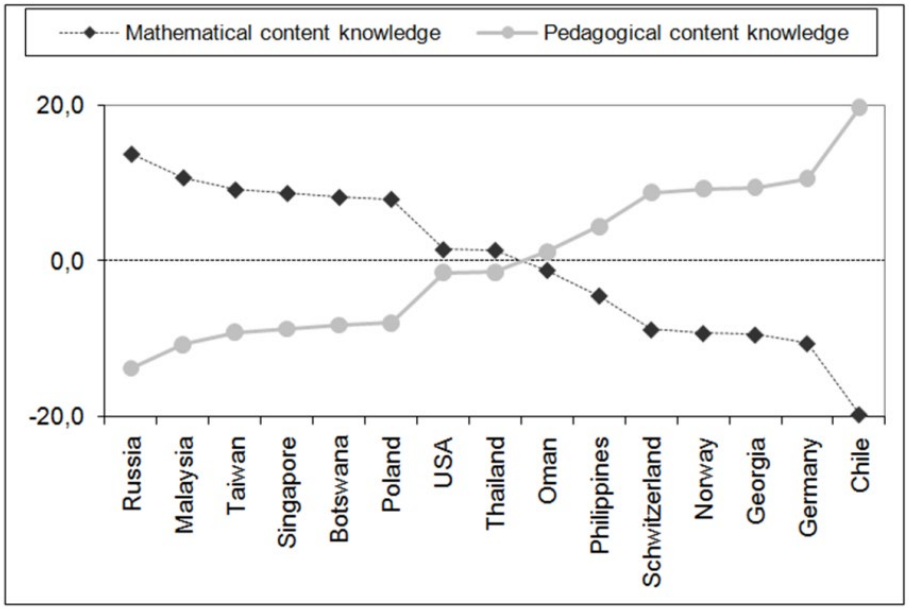
Country-specific profiles concerning the importance of mathematics content knowledge in comparison to pedagogical content knowledge

Three country-specific achievement profiles:



- **Higher achievements in mathematics** than in pedagogical content knowledge: from Asia Singapore, Taiwan and Malaysia, from East and Middle Europe Russia, Poland, from Africa Botswana
- **Higher achievements in pedagogical content knowledge than in mathematics**: Germany, Norway, Switzerland, as well as **Chile** and Georgia
- **Knowledge relatively levelled**: USA, Thailand, Oman, Philippines

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Profiles independent of absolute level of achievement

Countries with higher-achieving future teachers can be found in both distinct groups, e.g. Taiwan or Switzerland, same for lower-achieving countries.

Cultural explanations:

Strong influence of cultural traditions, which shape **profiles**:

- the cultural tradition of the **Confucian Heritage Culture** dominant in East Asian countries with high importance of content knowledge in teacher education,
- in Western countries various traditions, e.g. **content-related approaches** with high emphasis on content knowledge but within pedagogical content knowledge in Continental European **didactic traditions** (e.g. in Germany, Switzerland and Eastern Europe), **child-centered approaches** within progressive education (e.g. Scandinavian and North American countries with influences on South American countries like **Chile**).

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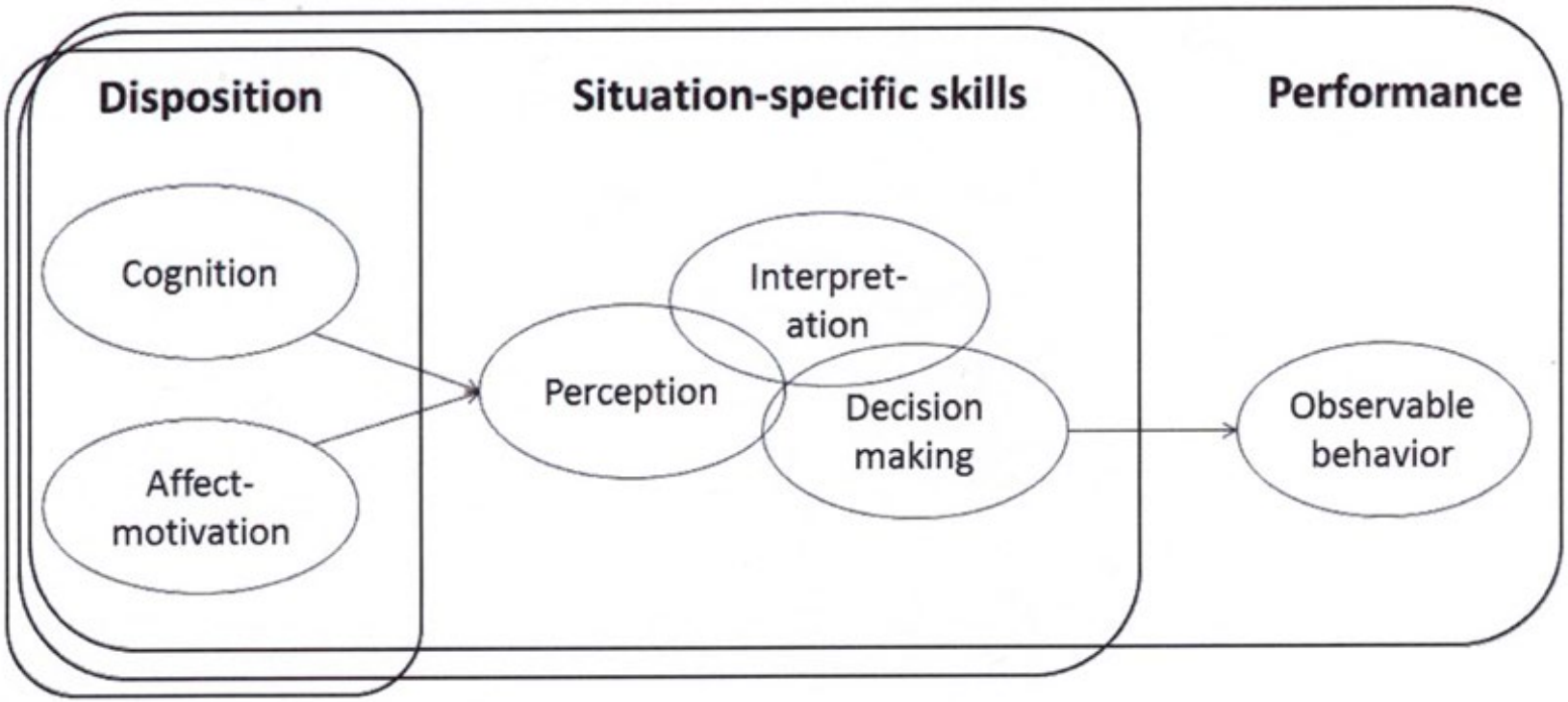
3. The situated approach on teachers‘ competencies and further studies of the TEDS Research Program as examples

Further development

Main question:

- How can **professional competence** be analysed in a **more performance-oriented way** including a situated perspective and situation-specific skills?

Further development of the discourse on teachers' competence - Theoretical basis „Competence as continuum model" by Blömeke, Gustafsson, Shavelson (2015)



Further development of the discourse on teachers' competence

Integration of additional **practice-oriented, situated facets** linked to the concept of **noticing,** which takes up a strong action-oriented or instrumental point of view apart from the knowledge-based facets of teacher competence, namely MCK, MPCK and GPK, taken from the cognitively oriented study TEDS-M.

Three situated facets of **noticing** (Carter et al., 1988; Van Es & Sherin, 2002; Sherin, Jacobs & Philipp 2011):

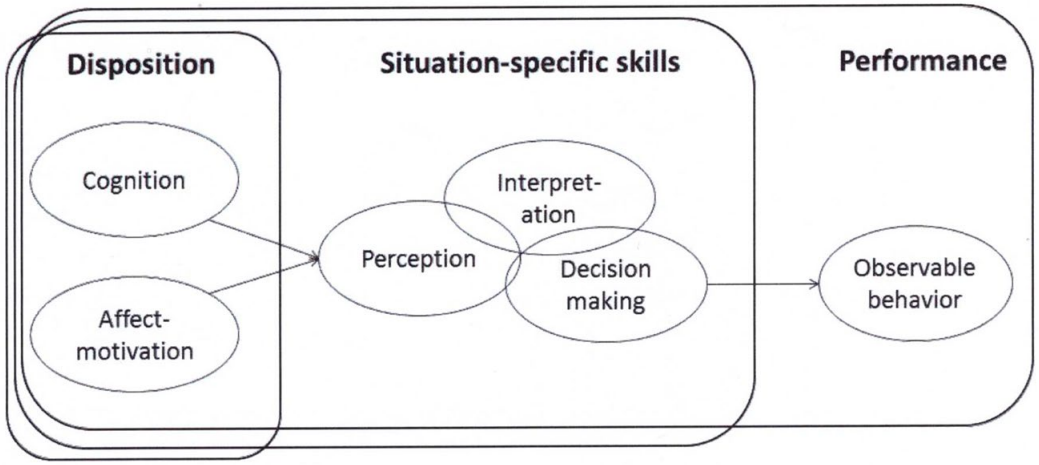
- **Perceiving** particular **events** in an instructional setting or "attending to particular events"
- **Interpreting** the perceived activities in the classroom or "making sense of events in an instructional setting"
- **Decision-making**, either as anticipating a response to students' activities or as proposing alternative instructional strategies (Erickson, 2011; Neuweg, 2011)

Teacher noticing - Own theoretical framework

Departure point of own framework:

- teachers' noticing as **situated** or **situation-specific** skills complementing the knowledge-based construct of teachers' competence;
- teachers' situation-specific skills as necessary **transformation or mediation** of the cognitive dimensions of competence (e.g., knowledge) into classroom performance (Blömeke and Kaiser, 2017).

- **Reference to the approach modeling competence as a continuum** by Blömeke, Gustafsson, & Shavelson (2015)



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Teacher noticing - Own theoretical framework

Conceptualization in general discourse

Attending to particular events in an instructional setting

Making sense of events in an instructional setting

Activity-oriented facet
- **Decision-making** (Kaiser et al., 2015)
- **Deciding how to respond** (Jacobs et al., 2011)
- **Shaping** (van Es & Sherin, 2021)

Enactment (Thomas et al., 2020)

(Dindyal et al., 2021; Jacobs et al., 2010; Sherin et al., 2011a; Thomas et al., 2020, van Es & Sherin, 2021; Weyers, König, Scheiner, et al., 2023)

Own conceptualization in TEDS Research Program

(a) **perceiving** particular events in an instructional setting

(b) **interpreting** the perceived activities in the instructional setting

(c) **decision-making**, either as anticipating responses to students' activities or as proposing alternative instructional strategies (Kaiser et al., 2015, p. 374)

Comparison of Own Theoretical Framework on Teachers Noticing with other approaches

- **Similarity** of PID-model to earlier approaches (such as Jacobs et al., 2010), but **going beyond** those approaches, which are mainly focusing on teachers' professional **noticing of students' mathematical thinking**.

- Overall: PID model comprises a **broad understanding of teachers' noticing**, including many aspects important for **quality-oriented mathematics teaching**, such as design of mathematics teaching, potential for cognitive activation of students, and classroom management (Kaiser et al., 2015, 2017).

- Usage of this model within the **TEDS Research Program** (TEDS-Follow-up, TEDS-Instruct/Validate, TEDS-East-West, TEDS-Chile, TEDS-IME)

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4. Integration of Cognitive and Situated Approaches on Professional Competencies of Mathematics Teachers

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Design of Studies in TEDS Research Program and Used Instruments

Online questionnaire (Items on beliefs, professional satisfaction, school experiences etc.)	**Video-vignette test 1** (questions to the video) M_PID P_PID	**Video-vignette test 2** (questions to the video M_PID P_PID	**Video-vignette test 3** (questions to the video) M_PID P_PID	**Digitalized paper-and-pencil-test 1** (reduced achievement test from TEDS-M) MCK MPCK	**Digitalized paper-and-pencil-test 2** (reduced achievement test from TEDS-M) GPK

Newly developed Instruments – TEDS-FU Video

Development of **three video-vignettes** developed in TEDS-Follow up for primary and **secondary** mathematics teachers; focus on secondary teachers :

- video-vignettes cover a **range of mathematical topics** usually taught in grades 8-10 (functions, volumes and surfaces), lasting 3.5 to 4 minutes
- **scripted plots** with different teachers and different students from different types of German schools
- providing **overview** about the **lesson**, but focus on different phases of teaching, e.g. introduction of a mathematical task followed by work on task, followed by discussion of results …
- provision of **background material** such as information about the class and prior teaching, task used and its solution

After watching each of the three videos, teachers had to answer **closed** and **constructed-response items** relating to scenes observed.

Instruments and Data Collection

Distinction between Perception, Interpretation, and Decision-making under:

- **pedagogical perspective (P_PID),** e.g. lesson structure, adaptivity, motivation, classroom management, assessment
- **mathematics pedagogical perspective (M_PID),** e.g. different explanations of mathematical concepts, analysis of mental processes, identification of task types, mathematical ideas

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Example of a shortened and released video vignette

Context information: In the video a sequence taken from a mathematics classroom in a German comprehensive school is shown. Concerning their mathematical abilities the class is heterogeneous.

Mathematical task:

The task dealt with is the following:

On a farm there are geese and cows. Altogether there are 105 animals, and there are four times as much geese than cows on the farm.

How many geese and how many cows are on the farm?

Mathematics pedagogical background: Well-known misconception of variables, first published by Rosnick & Clement (1980), variable understood as entity and not as quantity of the entity or no distinction between entity and variable.

Variety of items using Likert scales and open items, for example.:

Likert scales on perceiving and interpreting (M_PID): Assessment of student's answers from a mathematical point of view

Open items on decision-making (P_PID): Prevention of classroom disturbances

Open items on perceiving (M_PID): Rephrasing of a student's argument

Open items interpreting (M_PID): Description of the student's misconception of variables

Data evaluation

Development of extensive **coding manuals** with correct, semi-correct and wrong answers out of the material using verbatim answers by test persons.

Example item:

Kira's answer 4g = k is not correct if k refers to cows and g refers to geese. Kira's answer is possibly based on a misconception of variables. Please describe this misconception.

Example of a **correct answer**:

"She translated the wording 'four times more geese' literally into the mathematical language rather than multiplying the number of cows. So she uses the variable as a mere substitute in the spoken language."

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Transfer of theoretical framework and instruments to China and Chile

Transfer of the theoretical framework and instruments to China (study with Dr. Yang) and Chile (study by Dr. Saadati and Prof. Felmer).

Translation and double-check of the extensive **coding manual**.

Intensive training of coders in China and Chile with **double-coding**, satisfactory values of Cohen's kappa (0.84 in China and 0.89 in Chile).
Check of **internal consistency of the scales**, satisfactory results.

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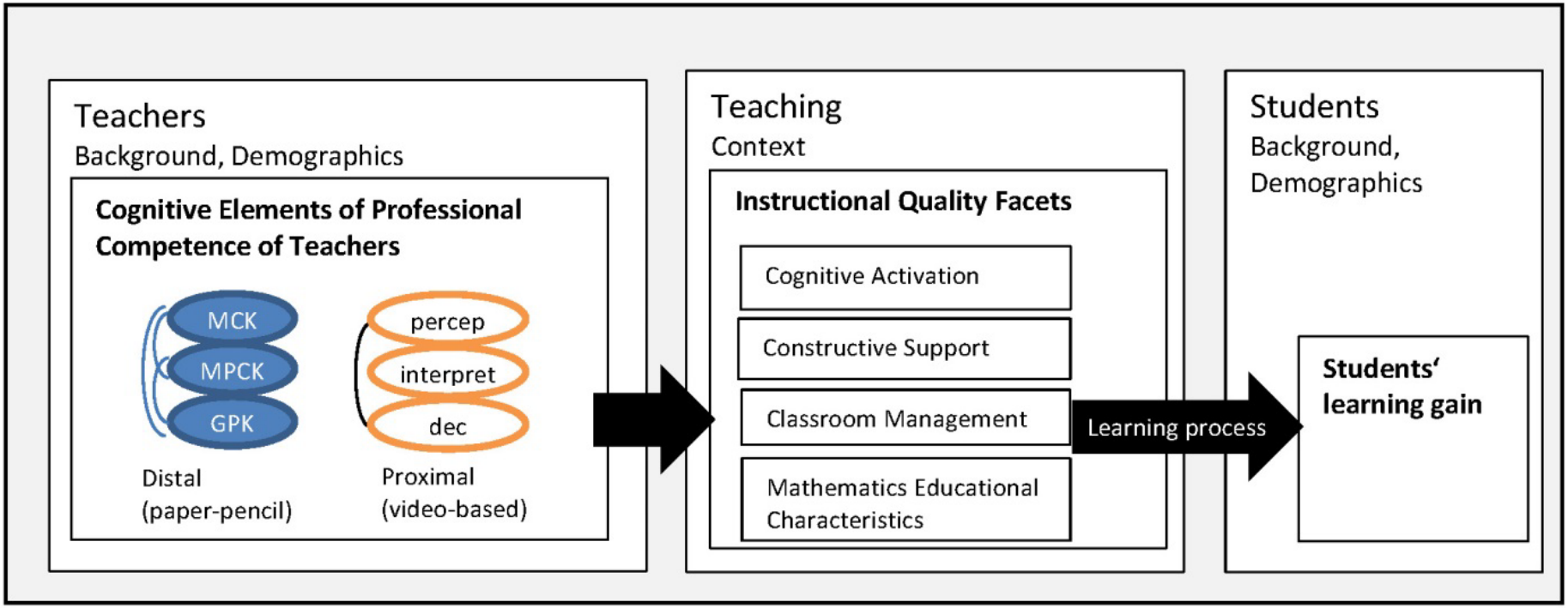
5. Professional Competencies of Mathematics Teachers and their Relation to Students' Achievements

TEDS Research Program

Acronym	Project name (English translation)
MT21	Mathematics Teaching in the 21st Century (P-TEDS)
TEDS-M 2008	Teacher Education and Development Study – Learning to Teach Mathematics
TEDS-Telekom	Efficiency of innovative projects in mathematics teacher education
TEDS-LT	Teacher Education and Development Study – Learning to Teach
TEDS-FU	Teacher Education and Development Study – Learning to Teach Mathematics, Follow Up
TEDS-I	Teacher Education and Development Study – TEDS-Instruct
TEDS-V	Teacher Education and Development Study – TEDS-Validate
TEDS-V-T	Teacher Education and Development Study – TEDS-Validate-Transfer
TEDS-East-West	Teacher Education and Development Study – East West
TEDS-IME	Teacher Education and Development Study – Inclusive Mathematics Education

Impact Model in TEDS Research Program (Kaiser et al., 2017)



Newly developed Instruments – focusing on Instructional Quality

Development of a h*ybrid measurement instrument for instructional quality in mathematics lessons in the frame of the studies TEDS-Instruct and TEDS-Validate*:

- Adapting the instrument from the Pythagoras study with three basic dimensions by (Rakoczy & Pauli, 2006);
- New development of items for mathematics didactic quality or adaptation from subject-specific observation instruments.

Distinction of **two dimensions**:

Subject-specific Dimension

- Mathematical correctness
- Subject-specific depth
- Subject-specific explanations
- Competence orientation

Instruction-specific Dimension

- Variety of representations
- Intelligent practising
- Relevance of the conten
- Examples

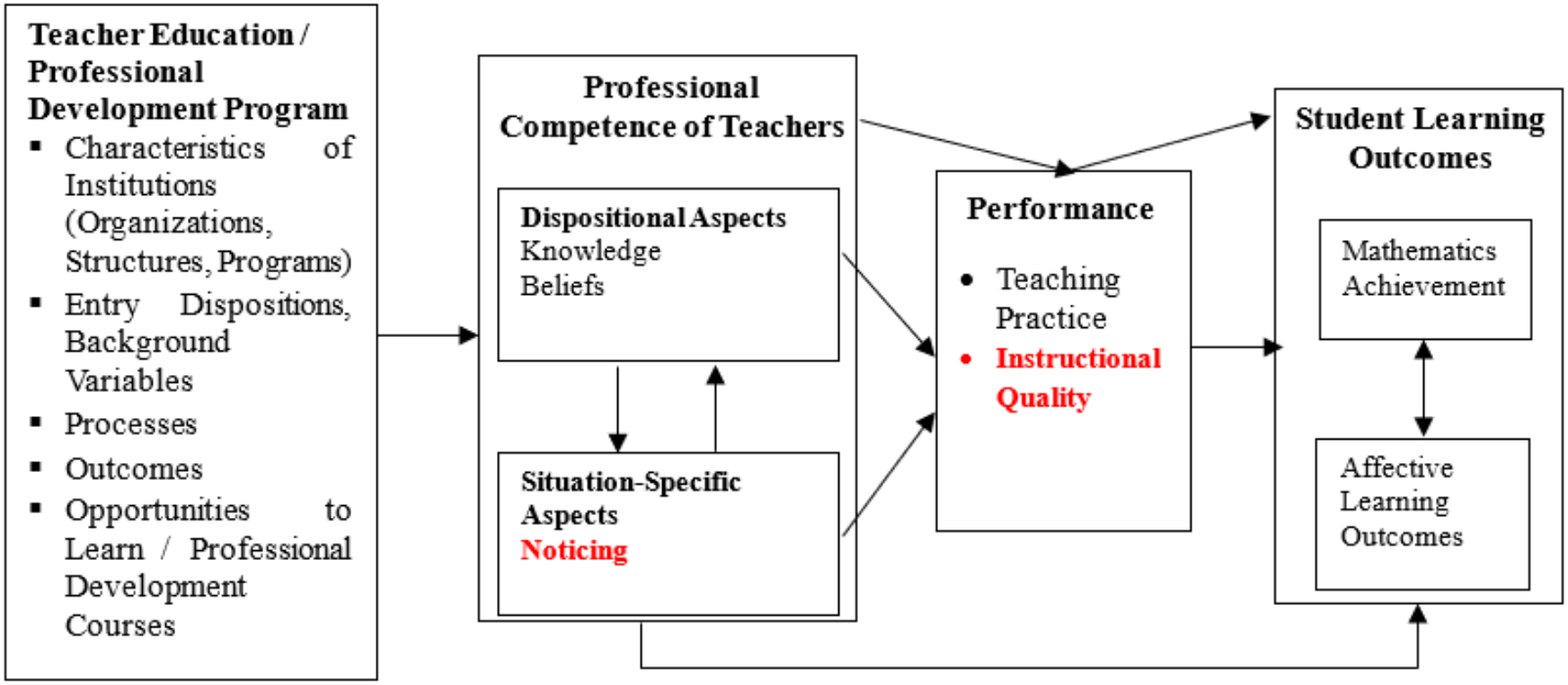
Newly developed Instruments – Focusing of the Construct Instructional Quality

Live-rating by trained raters with background in teacher education.

Rating on a four-point response scale (1 = "strongly disagree" to 4 = "strongly agree"). Description of the items using indicators that describe possible aspects of teaching quality.

Extensive **rating manual, publicly available** (Schlesinger et al., 2018)

Impact chain of teachers' competencies (Kaiser & König, 2019) **and influences** (Yang & Kaiser, 2022)



Design of TEDS-Instruct and TEDS-Validate

Implementation of the studies with **in-service teachers in Federal States of Hamburg** (n=119) and **Thuringia, Saxony, Hesse** (n=99): 2015-2019

37 teachers with lesson observations in Hamburg, 45 in Thuringia, Saxony, Hesse. Lesson observations twice 90 minutes in Hamburg, in other federal states often only 45 minutes, rating with two raters.

In addition:

- Assessment of knowledge-based competence facets using digitalized knowledge tests: mathematical knowledge (**MCK**), mathematical didactic knowledge (**MPCK**), pedagogical knowledge (**GPK**) with shortened tests from TEDS-M
- Assessment of teacher noticing using video-vignettes: noticing from a mathematics didactics and pedagogical perspective **(M_PID and P_PID**), classroom management expertise (**CME**)
- **Speed-test and beliefs** with Likert scales

Focusing on the Whole Impact Chain - Opening up the black box (Blömeke et al., 2022)

Analyses based on data from TEDS-Instruct and TEDS-Validate and comprised 154 classes with 3,496 students.

Central assumption: **no direct effects of teachers' MCK or MPCK on students' learning progress in mathematics**, indicating that a '**black-box' model** (Baumert et al., 2010) omitting potentially mediating processes would be unable to explain student progress. Rather than analyzing the direct effects of teacher knowledge on students' learning progress, an **impact chain with multiple mediation processes** was developed while controlling for school type and student background aiming to open the black box by considering indirect effects based on mediation processes.

Results:

- Large differences between the different classes; school type was strongly related to students' learning progress in mathematics, indicating a strong selectivity of the German lower secondary school system.
- Student background correlated strongly with school type but had no separate predictive effect on learning progress.
- **No significant direct effect of teachers' MCK or MPCK** was observed on students' learning progress, confirming the black-box problem.

Focusing on the Whole Impact Chain - Opening up the black box (Blömeke et al., 2022)

Further results:

- MCK had a strong predictive effect on MPCK, which, in turn, had a strong effect on the situation-specific or noticing skills;
- Teachers' situation-specific skills (PID) had a significant but weak predictive effect on students' mathematical learning progress and fully mediated the effects of MPCK on student progress.

Overall, only the combination of teachers' MPCK and PID skills fully mediated its effect on learning progress; mediation through MPCK or PID skills only was insignificant.

Further approach: Inclusion of **instructional quality** as another **mediator** of the effects of teacher competencies on students' learning progress in mathematics (restricted to the data from TEDS-I due to incomplete data in TEDS-V).

Results: Teachers' MCK significantly and with a large effect size predicted their MPCK; in turn, MPCK significantly and with a large effect size predicted teachers' PID skills.

Finally, teachers' PID skills significantly and with a large effect size predicted instructional quality.

Focusing on the Whole Impact Chain - Opening up the black box (Blömeke et al., 2022)

Confirmation of the model competence as a continuum by Blömeke et al. (2015) and the impact model of TEDS-I and TEDS-V: Assumption that these mediating processes, including situation-specific skills, would be more proximal to classroom practice and students' learning gains than teachers' knowledge.

Overall:

- teachers' situation-specific skills (PID skills) are crucial for implementing instructional quality;
- the findings confirm that teachers' knowledge can be regarded as precondition for teachers' PID skills and, therefore, for students' learning progress.

To sum up, the analyses can be seen as ***opening up*** *the black box and* as a milestone in empirical research on teachers' competencies and their effects on students' learning.

C**onfirmation** of the necessity to consider a **situated perspective on teachers' competence,** including more proximal measurement instruments while still keeping the more distal knowledge instruments.

Finally, the findings emphasize that **teacher competencies** must be conceptualized and empirically modeled as a **multidimensional construct**, and its effects should be evaluated via **complex effect chains**.

6. Further Perspectives

Further perspectives

Results point out **that complex studies focusing the whole impact chain are needed** for the evaluation of the impact chain, single studies are not adequate.

Transfer of the instruments used in the various studies of the TEDS Research Program **only in parts transferable to East Asian or South American** context. Necessity to conceptualize **instructional quality differently** with less emphasis on classroom management in China and differentiated emphasis in Chile, differentiated focus on subject- and instruction quality dimensions.

Overall, call for more international comparative studies as they can open the window for the better understanding of its own culture, but necessity to develop **culturally sensitive frameworks and instruments**.

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