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Empirische Forschung zu Unterrichtsqualität

Theoretische Grundfragen und quantitative Modellierungen

Herausgegeben von
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Themenblock V: Modellierung der Wirkungen von Unterrichtsqualität (englischsprachig)

Kommentare

Thilo Kleickmann/Mirjam Steffensky/Anna-Katharina Praetorius

Quality of Teaching in Science Education

More Than Three Basic Dimensions?

Abstract: The three basic dimensions framework for assessing quality teaching distinguishes the dimensions of cognitive activation, student support, and classroom management. Research from various disciplines suggests, however, that cognitive support is not sufficiently represented in the framework as yet. In the present study, two-level factor analyses based on student ratings of teaching quality in science education (2,659 students, grades 4 and 6) suggest four dimensions of teaching quality, with cognitive support being a separate dimension. Moreover, cognitive support predicted student achievement. The results suggest that including cognitive support as a separate dimension contributes to a more comprehensive, yet parsimonious framework of teaching quality.

Keywords: Quality of Teaching, Three Basic Dimensions Framework, Student Ratings, Science Education, Factor Analysis

1. Introduction

The basic dimensions framework a generic framework used to describe teaching quality (e. g., Klieme, Schümer & Knoll, 2001; Kunter & Voss, 2013; Praetorius, Klieme, Herbert & Pinger, 2018b) that is particularly prominent in German-speaking countries. In the basic dimensions approach, teaching quality is considered as consisting of three basic dimensions: cognitive activation, student support, and classroom management. Cognitive activation aims to involve students in higher order thinking processes and to engage them in knowledge construction and revision (e. g., through challenging tasks and exploring prior knowledge). Student support, which originated from research on classroom climate, primarily aims to foster student motivation (e. g., by supporting experiences of autonomy and social relatedness). Classroom management aims to organize the complex and dynamic teaching situation and, ultimately, to use instructional time in a productive way (e. g., through monitoring, clear rules and routines, and other strategies to prevent disruptions).

In the basic dimensions framework, cognitive activation and classroom management are considered to foster student achievement, while student support and classroom management likewise are supposed to stimulate student motivation (Klieme & Rakoczy, 2008; Kunter & Voss, 2013; Praetorius et al., 2018b). However, evidence on the predictive validity of the three basic dimensions is mixed. While some studies have shown that basic dimensions predict student learning and motivation in the hypothesized way, others did not (Praetorius et al., 2018b).

The three basic dimensions are clearly a parsimonious framework, as they reduce the complexities of high quality teaching to three core dimensions. However, is this framework sufficiently comprehensive? In this article, we argue that another feature of quality teaching – cognitive support – is not sufficiently represented in the basic dimensions framework. Cognitive support aims to reduce cognitive demands in challenging learning environments, so that students can master them (e. g., Kirschner, Sweller & Clark, 2006; Puntambekar & Hübscher, 2005). We assume that cognitive support represents a separate dimension of quality teaching. Moreover, we assume that prediction of student progress becomes more stringent – theoretically and empirically – when cognitive support is included as a separate dimension in the framework.

2. Cognitive Support as an Important Feature of Teaching Quality

Research from different disciplines highlights the role of cognitive support provided by teachers when students are involved in challenging learning environments. Social-constructivist theories emphasize the role of scaffolding student learning (Puntambekar & Hübscher, 2005; van de Pol, Volman & Beishuizen, 2010). While the notion of scaffolding originally referred to the adaptive support of students during student-teacher interactions, based on on-going diagnosis of the individual learner's progression, later versions included "blanket" scaffolding, where support is the same for all students and can relate to larger instructional units (e. g., through clarity of goals or conceptual coherence of the content presented; for an overview, see Puntambekar & Hübscher, 2005; van de Pol et al., 2010).

Similarly, theories from cognitive psychology, and cognitive load theory in particular, point to the critical role of guidance in complex learning environments. They suggest that learners' working memory capacities clearly restrict unguided learning (e. g., Kirschner et al., 2006). Therefore, teachers need to reduce the complexity of a learning environment through cognitive support by, for example, modeling, explaining, and structuring. In this tradition, the bulk of evidence demonstrates that learners, and novice learners in particular, should be provided with cognitive support while learning the concepts and procedures of a particular domain, and should not be left to discover those concepts or procedures by themselves (e. g., Alfieri, Brooks, Aldrich & Tenenbaum, 2011; Kirschner et al., 2006).

Those theories have influenced research in various content domains – for instance, in science education. In this domain, the concept of guided inquiry underscores the role of guidance, structure, and focused goals in reducing the complexity of the inquiry process (e. g., Hardy, Jonen, Möller & Stern, 2006; Steffensky, Gold, Holodynski & Möller, 2015).

In sum, cognitive support aims to reduce complexity and cognitive demands by means of structuring content and promoting clarity, so that students can master the respective tasks and successfully gain understanding. Cognitive support includes both adjusted (also referred to as differentiated or calibrated) support during individual student-teacher interactions (e. g., by modeling, explaining, highlighting, giving analogies, and informative feedback) and blanket support, which latter is the same for groups of students or the entire class. Ultimately, blanket cognitive support includes structuring and clarity in larger instructional units (e. g., clarity of goals, coherence of the content covered in relation to student activities, reduction of task difficulty, visualizations and representations used in instructional materials; Puntambekar & Hübscher, 2007). Cognitive support can be realized in different classroom settings, such as teacher-centered or student-centered settings, or individualized teaching (Hardy et al., 2006; van de Pol et al., 2010).

The need to adapt support to learners' prerequisites (as highlighted in the first component of cognitive support) is also evinced in the concept of adaptive teaching (e. g., Hardy et al., 2011). However, cognitive support does not equal adaptive teaching. First, cognitive support also includes blanket scaffolding, and second, adaptive teaching is not relevant to cognitive support exclusively, but also to other dimensions of teaching quality, such as cognitive activation and motivational support (e. g., Kyriakides, Creemers & Panayiotou, 2018).

3. Cognitive Support and Basic Dimensions of Teaching Quality

Although the basic dimensions framework is quite commonly used in instructional research in German-speaking countries, there is no common operationalization of the three dimensions (Praetorius et al., 2018b). Accordingly, cognitive support has been considered differently across studies. Roughly four types how cognitive support has been considered can be distinguished.

In the first type (type-1 operationalization), cognitive support is not or only rudimentarily considered in the operationalization of the three basic dimensions: If considered at all, it is only rudimentarily included in student support, which is primarily focused on a supportive climate providing students with experiences of social relatedness and autonomy. Examples of this type can be found in the studies of Decristan et al. (2015), Fauth, Decristan, Rieser, Klieme and Büttner (2014), and Helm (2016).

In the second type (type-2 operationalization), studies consider cognitive support as part of student support. In such studies, student support includes both cognitive and motivational support. While cognitive support refers to the reduction of cognitive demands through structuring, as noted in the previous section, motivational support refers to support of autonomy and social relatedness. In contrast to the first type, features of cognitive support are included in the assessment of student support more comprehensively. Examples of this second type are the studies of Hochweber and Vieluf (2016), Klieme and Rakoczy (2008), Kunter and Voss (2013), and Praetorius, Lenske, and Helmke (2012).

In the third type (type-3 operationalization), specific aspects of cognitive support are included in the classroom management dimension. In particular, specific aspects of lesson clarity or structure (e. g., excursiveness [recoded]) are included as features of classroom management. The studies of Klieme et al. (2001) as well as Taut and Rakoczy (2016) are examples of this type.

The fourth type (type-4 operationalization), considers cognitive activation and cognitive support as highly interconnected aspects of one dimension of quality teaching. Cognitive structuring (Einsiedler & Hardy, 2010) and instructional support (Pianta & Hamre, 2009) are examples of such merged dimensions. Instructional support comprises key features of cognitive support (e. g., clear presentation of material, quality of feedback), but also of cognitive activation (e. g. fostering higher-level thinking, provision of engaging lessons and materials; Pianta & Hamre, 2009).

In sum, type one and three do not represent the construct of cognitive support in a comprehensive way. They include only parts of the construct, at best. Type two does consider cognitive support. However, in this type, the hypothesized way in which the three basic dimensions predict student learning and motivation is not straightforward from a theoretical point of view. In particular, it does not take into account the important role of cognitive support in student learning, because student support is supposed to foster student motivation only (Praetorius et al., 2018b). Explicitly differentiating between cognitive and motivational support would allow the setting up of differential hypotheses of student progress, with cognitive support predicting student learning and motivational support predicting student motivation. Type four points to the interconnectedness of cognitive activation and cognitive support.

4. The Present Study

In the present study, we used student ratings to assess teaching quality in upper elementary and lower secondary science education. Recent studies have demonstrated that elementary school children can already differentiate between cognitive activation, supportive climate (with a focus on motivational support), and classroom management in science lessons (Decristan et al., 2015; Fauth et al., 2014). In the present study, we included items explicitly designed to assess cognitive support, to test our assumption of four basic dimensions, with cognitive support being a separate dimension of teaching quality.

First, we investigated the factor structure of student ratings of teaching quality, aiming thereby to test whether a four-factor model including the dimensions of cognitive activation, cognitive support, motivational support, and classroom management fits the data better than alternative, more parsimonious models that include cognitive support in a common factor with motivational support (as suggested in the aforementioned type-2 operationalization), classroom management (type-3 operationalization), or cognitive activation (type-4 operationalization).

Second, we investigated the predictive validity of the hypothesized four dimensions of high quality teaching for students' conceptual understanding of the water cycle as well as for students' interest. We hypothesized that cognitive activation, cognitive support, and classroom management predict student understanding, while motivational support and classroom management predict student interest.

5. Method

5.1 Participants and Design

Our analyses were based on data from a study on science education in German fourth- and sixth-grade classes (Kauertz et al., 2011). The sample used to test the factor structure consisted of 60 fourth-grade classrooms with 1,326 students (age: $M = 10.3$ years, $SD = 0.6$ years; 53% male) and 54 sixth-grade classrooms with 1,333 students (age: $M = 12.2$ years, $SD = .7$ years; 54% male). While grade 4 is comprehensive schooling in Germany, the sixth-grade subsample included 28 classes from non-academic track schools (Hauptschule) and 26 classes from academic track schools (Gymnasium). All classes were located in North Rhine-Westphalia in the west of Germany.

For research question 1 (factor structure), we used the full data set of 2,659 students in 114 classrooms. For research question 2 (predictive validity), we used the subsample of 60 classrooms with 1,326 fourth-graders, as valid information on student achievement and interest were available for this subsample.

Students rated teaching quality at the end of the teaching unit on the topic of the water cycle. All participating 114 teachers taught this topic in their science classes. States of matter, condensation, evaporation, and conditions affecting these processes were the key physics concepts addressed in this unit. The topic of the water cycle, and the respective physics concepts, are valid for the science curricula of grades 4 and 6 in North Rhine-Westphalia.

Students' understanding of the water cycle and related physics concepts was assessed using repeated measures directly before and after the teaching unit. Students' interest in the teaching unit was also assessed directly after the teaching unit. As a covariate, students' interest in physics topics was assessed before the teaching unit.

5.2 Measures

Students rated teaching quality along a set of 20 items assigned to four scales: cognitive activation (five items), cognitive support (five items), motivational support (five items), and classroom management (five items; see Table A1 in the Appendix for item wording). Cognitive activation included provoking cognitive conflict, testing of hypotheses, justification of beliefs, and application of newly constructed knowledge in everyday situations. Two items, in contrast to the commonly used generic items in previous studies (e.g. Fauth et al., 2014), specifically addressed cognitive activation in the context of science inquiry. Cognitive support comprised clarity of goals and procedures, highlighting of important aspects, adequate reduction of complexity, and the absence of incomprehensible terms.

Motivational support included teacher sensitivity to student problems, positive feedback, and autonomy support. As three items addressed teacher sensitivity, further aspects of motivational support, such as support of student autonomy, were addressed to a small degree only. Classroom management was operationalized by the absence of disruptions and no wasting of time. Consequently, this measure did not assess teacher actions to prevent disruptions (for a similar operationalization see Fauth et al., 2014; for an operationalization focusing on teacher actions see Kunter, Baumert & Köller, 2007). All items were rated on a four-point scale ranging from "strongly disagree" (1) to "strongly agree" (4). Hence, the scale mean was 2.5.

In respect of students rating the quality of teaching, variance within classes can be distinguished from variance between classes. In the present study, we were interested in the shared perceptions of students reflected in between-class variance. Intra-class correlations indicated substantial variance between classes *(ICC1, see Tab. 1)* and the reliability of the class-level measures *(ICC2):* For cognitive activation, cognitive support, motivational support, and classroom management *ICC2* were .80, .80, .87, and .84 respectively. Cronbach's alphas were .71, .61, .83, and .83 respectively.

Student understanding of the water cycle was assessed by a test consisting of 26 multiple-choice items covering physics concepts such as states of matter, condensation, evaporation, and conditions affecting related processes. The distractors included the typical alternative conceptions of students, derived from literature on student conceptions (e.g., Amin, Smith & Wiser, 2017). Students' pre- and posttest scores (WLE scores) were scaled concurrently using the Rasch model. EAP/PV-reliability was .74 at pretest and .82 at posttest. The values for *ICC2* were .78 and .85 for pre- and posttest respectively.

Student interest in the teaching unit was measured using a scale of six items (sample item: I always looked forward to the lessons on the water cycle). Cronbach's alpha and *ICC2* were .82 and .81 respectively. We used a slightly modified version of the scale to obtain a covariate of students' prior interest. In this scale, the items did not refer to the topic of the water cycle, as this had not been taught yet, but more generally to physics topics in elementary science education. The Cronbach's alpha and *ICC2* of that scale were .80 and .81 respectively.

The wording of all items for teaching quality, student understanding, and student interest was simple, and all items were read out loud by a trained data collector in order to minimize language and reading problems.

In the analyses on the prediction of student outcomes, we included measures of cognitive ability using the CFT 20-R (Cronbach's alpha =.72; Weiß, 2006), a German version of the Culture Fair Intelligence Tests, and socio-economic status was operationalized by the sum of the International Socio-Economic Index assigned to father and mother (Ganzeboom, de Graaf & Treiman, 1992) as covariates.

5.3 Data Analyses

We used two-level confirmatory factor analyses (CFA) to test our assumptions on the factor structure of student ratings of teaching quality. In particular, we used a doubly-latent model (see Figure 1) according to the framework suggested by Marsh et al. (2009).

Our model comparisons were based on several goodness-of-fit indices (Hu & Bentler, 1998), such as the Akaike Information Criterion (AIC). For all models, we specified cross-level invariant factor loadings. In order to control for school type differences, we included two dummy variables as between-level covariates in the CFA models.[1]

In order to investigate the prediction of student outcomes, we used two-level regression analyses. In these analyses, we used the manifest-latent approach (Marsh et al., 2009), with latent aggregation of within-level constructs to between-level constructs, to model student ratings of teaching quality. We introduced students' general cognitive abilities (CFT), socio-economic status (SES), and gender as manifest covariates on the within-class level. Student understanding and interest (pre- and posttest scores) were also included, using the manifest-latent approach. On the between level, posttest student understanding respectively interest were regressed on teaching quality, pretest understanding respectively interest. We conducted separate models for student understanding and interest, as well as for the dimensions of teaching quality. We used full information maximum likelihood (FIML) estimation with robust standard errors implemented in M*plus* (Muthén & Muthén, 1998–2012) to deal with missing data.

6. Results

6.1 Descriptive Results

Table 1 shows descriptive results of the study variables on the between level. The means for cognitive activation, cognitive support, and motivational support were high (M = 3.16, 3.12, and 3.20) and those for classroom management medium (M = 2.61). The correlation between cognitive activation and motivational support was particularly high (r = .82), while the other correlations were low to medium. The proportion of variance between classes was descriptively higher for motivational support and classroom management (*ICC1* = .24 and .22 respectively) compared to cognitive activation and cognitive support (*ICC1* = .15 and .16).

The mean values for the achievement test indicate that the items were rather difficult for elementary school children (M = 6.61 at pretest and 9.64 at posttest; theoretical maximum = 22). However, the test differentiated sufficiently between classes (*ICC1* = .15 and .22 for pre- and posttest).

1 Following the recommendation of a reviewer, we did not include further covariates in the CFA models.

	2	3	4	5	6	7	8	9	10	11	M	SD	ICC1
1. Cognitive activation (1–4)	.38	.82	.19	−.01	−.03	.38	.68	−.11	−.13	.03	3.16	0.28	0.15
2. Cognitive support (1–4)		.50	.41	.34	.49	.46	.58	.02	.34	.45	3.12	0.28	0.16
3. Motivational support (1–4)			.18	.18	.04	.36	.72	.02	−.04	.08	3.20	0.40	0.24
4. Classroom management (1–4)				.15	.35	.20	.25	.09	.19	.38	2.61	0.39	0.22
5. Achievement, T1 (0–24)					.60	.28	.11	−.05	.41	.35	6.61	1.30	0.14
6. Achievement, T2 (0–24)						.24	.11	−.12	.35	.45	9.64	1.89	0.20
7. Interest, T1 (1–4)							.70	.04	.24	.12	3.26	0.28	0.16
8. Interest, T2 (1–4)								.07	.12	.04	3.14	0.39	0.16
9. Gender (male = 1, female = 0)									−.04	−.01	0.53	0.09	0.00
10. SES (mother and father; 32–180)										.23	69.06	13.25	0.07
11. Cognitive ability (0–30)											14.93	1.17	0.06

Note. Statistics are based on the original metric of the variables (scale range in brackets). The intra-class correlation (ICC1) indicates the proportion of variance between classes.

Tab. 1: Descriptive statistics for study variables on the between level: Zero order correlations, means, standard deviations, and intra-class correlations

6.2 Research Question 1: Factor Structure

Research question 1 addressed the factor structure of student ratings of teaching quality in the units on the water cycle. To test our hypotheses, we compared the fit of five CFA models (Tab. 2): Model 1 featured four factors (cognitive activation, cognitive support, motivational support, and classroom management) on each level. This was the model we expected to show the best model fit. Model 2 featured three factors and represented the second type of basic dimensions framework, as outlined above. In this model, cognitive and motivational support formed one common factor ("support-factor"). Model 3 also featured three factors, and represented the third type of basic dimensions framework. In this model, cognitive support and classroom management formed one common factor. In Model 4, another three-factor model, cognitive activation and cognitive support formed one common factor, as suggested in the type-4 operationalization. Due to the high zero-order correlation between cognitive activation and motivational support on the between level, we additionally tested another three-factor model variant: In this model, cognitive activation and motivational support formed one common factor

Model	Features	AIC	BIC	RMSEA	CFI	TLI	SRMR within	SRMR between
1	4 factors	**122434**	**123045**	**0.03**	**0.91**	**0.90**	**0.05**	**0.11**
2	3 factors (CS and MS merged)	123140	123699	0.04	0.86	0.85	0.06	0.14
3	3 factors (CS and CM merged)	123599	124157	0.05	0.82	0.81	0.08	0.19
4	3 factors (CA and CS merged)	123172	123731	0.04	0.85	0.84	0.06	0.12
5	3 factors (CA and MS merged)	123102	123660	0.04	0.86	0.85	**0.05**	0.12
6	1 factor	127464	127952	0.08	0.53	0.51	0.11	0.21

Note. CA = cognitive activation, CS = cognitive support, MS = motivational support. Values indicating the best model fit are in bold type.

Tab. 2: Results of the two-level confirmatory factor analyses: model-fit indices

(Model 5). Model 6, finally, included only one global factor for teaching quality. Table 1 shows the model fit indices for the six models. All fit indices consistently supported Model 1.

Standardized factor loadings on the between level in the best fitting model (model 1) ranged from $\lambda = .69$ to .92 for cognitive activation, from $\lambda = .66$ to .94 for cognitive support, from $\lambda = .81$ to 1.00 for motivational support, and from $\lambda = .86$ to .98 for classroom management. Figure 1 shows that factor correlations on the between level were medium-sized to high.

The latent correlations between the four factors on the between level indicated that cognitive activation and motivational support were particularly highly correlated (r = .84) while the other correlations were of medium size (r = .39 to .54).

6.3 Research Question 2: Prediction of Student Understanding and Interest

Our second research question addressed the predictive validity of the four factors of teaching quality. Table 3 shows the results for the prediction of students' conceptual understanding of the water cycle. Models 1–4 included only one dimension of teaching quality, whereas model 5 incorporated all four dimensions simultaneously. The results from models 1–4 showed that cognitive support and classroom management predicted student understanding, while cognitive activation and motivational support did not. In model 5, only cognitive support was significantly related to student understanding. The predictors in model 5 explained 54 % of between-level variance in students' posttest understanding.

Table 4 shows the respective results for prediction of student interest. In the models 1–4, cognitive activation, cognitive support, and motivational support predicted stu-

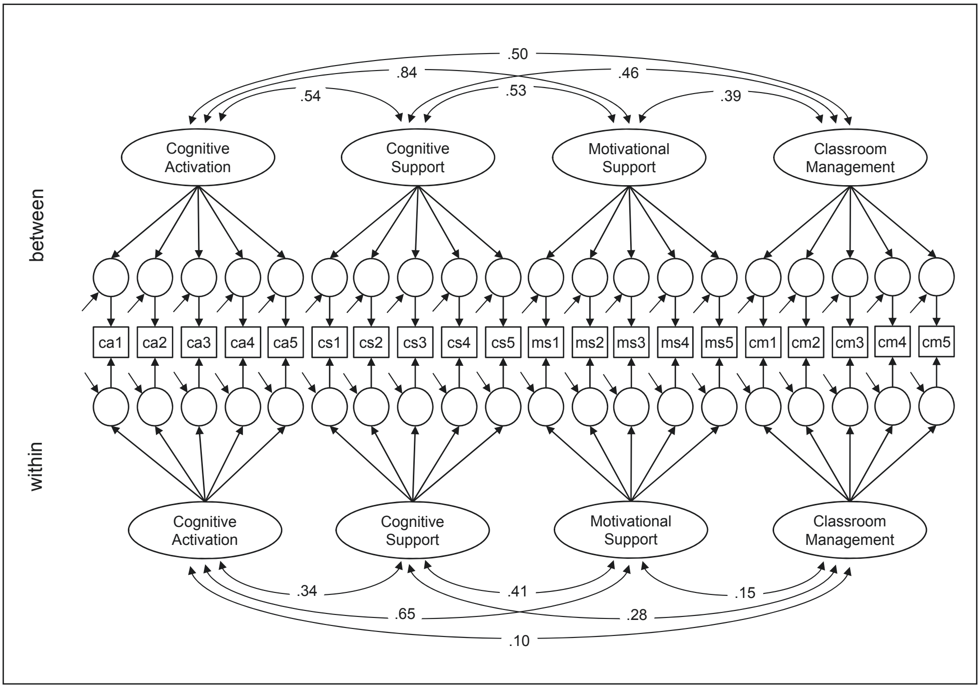

Fig. 1: Two-level confirmatory factor analysis model featuring each of four factors on the within and the between levels. Factor loadings are constrained to be equal across levels. On the between level, two dummy variables coding the type of school were included as covariates.

dent interest, but classroom management did not. In model 5, none of the dimensions of teaching quality was significantly related to student interest. The predictors in model 5 explained 86 % of between-level variance in students' posttest interest.

	M0		M1		M2		M3		M4		M5	
	B	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**	**B**	**SE**
Within												
Understanding, pretest	**.54**	.03	**.54**	.03	**.53**	.03	**.54**	.03	**.54**	.03	**.53**	.03
Cognitive ability	**.13**	.03	**.13**	.03	**.11**	.03	**.12**	.03	**.12**	.03	**.11**	.03
SES	**.07**	.03	**.07**	.03	**.06**	.03	**.07**	.03	**.07**	.03	**.06**	.03
Gender (male)	−.02	.03	−.02	.03	.00	.02	−.02	.02	−.02	.03	.00	.02
Cognitive activation			.01	.03							.01	.03
Cognitive support					**.10**	.03					**.13**	.03
Motivational support							−.02	.04			−.07	.04
Classroom management									.02	.02	.00	.02
R^2	*.37*		*.37*		*.38*		*.37*		*.37*		*.38*	
Between												
Understanding, pretest	**.53**	.10	**.53**	.10	**.44**	.12	**.55**	.10	**.52**	.11	**.43**	.16
Cognitive activation			−.04	.14							.04	.38
Cognitive support					**.35**	.15					**.59**	.18
Motivational support							−.07	.13			−.48	.36
Classroom management									**.30**	.15	.13	.16
R^2	*.29*		*.29*		*.40*		*.29*		*.38*		*.54*	

Note. Significant coefficients ($p < .05$) in bold.

Tab. 3: Results of two-level regression analyses predicting students' conceptual understanding of the water cycle and related physics concepts

	M0		M1		M2		M3		M4		M5	
	B	SE	B	SE	B	SE	B	SE	B	SE	B	SE
Within												
Interest, pretest	**.39**	.03	**.31**	.03	**.33**	.03	**.31**	.03	**.38**	.03	**.26**	.03
Cognitive ability	.01	.02	.01	.02	−.04	.03	.02	.02	.00	.02	−.01	.02
SES	−.02	.03	.00	.03	−.04	.03	−.02	.03	−.02	.03	−.04	.03
Gender (male)	**−.07**	.03	−.04	.03	−.03	.03	−.04	.03	**−.07**	.03	−.02	.03
Cognitive activation			**.32**	.03							**.14**	.03
Cognitive support					**.29**	.03					**.20**	.03
Motivational support							**.40**	.03			**.26**	.03
Classroom management									**.09**	.03	.02	.03
R^2	*.16*		*.26*		*.23*		*.31*		*.17*		*.36*	
Between												
Interest, pretest	**.77**	.07	**.54**	.10	**.57**	.10	**.56**	.10	**.75**	.08	**.50**	.10
Cognitive activation			**.51**	.11							.17	.29
Cognitive support					**.37**	.11					.14	.13
Motivational support							**.55**	.11			.34	.31
Classroom management									.08	.11	−.02	.10
R^2	*.60*		*.81*		*.70*		*.85*		*.60*		*.86*	

Note. Significant coefficients ($p < .05$) in bold.

Tab 4: Results of two-level regression analyses predicting students' interest in the teaching unit on the water cycle

7. Discussion

Research from different disciplines suggested that cognitive support plays a crucial role in high quality teaching. As previous conceptions of the basic dimensions framework represented cognitive support insufficiently, or included it in other dimensions (see operationalization types 2, 3, and 4 as outlined above), we tested a modification of the original framework in the present study. In particular, we suggested a four-dimensional framework, with cognitive support forming a factor separate from cognitive activation, motivational support, and classroom management. We tested this framework in relation to its factor structure and the prediction of student outcomes in a teaching unit on the topic of the water cycle in the domain of science education.

Our factor-analytic results supported the notion that cognitive activation, cognitive support, motivational support, and classroom management form four separate, yet correlated dimensions of student perceived teaching quality in science education (for similar conceptions of teaching quality, see Korneck, Krüger & Szogs, 2017; Lipowsky, 2015). Alternative models featuring only three factors yielded poorer model fit. These models included models representing the second, third, and fourth type of the basic dimensions framework noted in the introduction. In particular, a model with only one factor representing general teaching quality, showed insufficient model fit with regard to common threshold values. The medium to high factor correlations might (also) reflect functional dependencies among the dimensions (e. g., classroom management as a prerequisite for effective classroom teaching).

The results on the predictive validity of the four dimensions of teaching quality were only partly in line with our hypotheses. The two-level regression models including the dimensions of teaching quality separately as predictors, showed that cognitive support and classroom management predicted student understanding as hypothesized, but cognitive activation did not. Considering the four dimensions of teaching quality simultaneously, only cognitive support was significantly related to student understanding. This finding underscores the importance of cognitive support as rated by students, for student learning. Concerning student interest, the models including the dimensions of teaching quality separately showed that cognitive activation, cognitive support, and motivational support were predictive, but classroom management was not. Considering the four dimensions of teaching quality simultaneously, none of the dimensions of teaching quality was significantly related to student interest. This finding suggests that cognitive activation, cognitive support, and motivational support share common variance with student interest and lack incremental predictive validity.

The result that student perceived cognitive activation did not predict student learning as well as the very high correlation between cognitive activation and motivational support has also been found in other studies (e. g., Fauth et al., 2014). This pattern may challenge the assumption that student ratings – or at least young children's ratings – are suitable for measuring cognitive activation: Students might not be sufficiently capable of separating cognitive activation from their own abilities. Cognitive interviews (e. g., Lenske, 2016) might be one way of determining to what extent this is the case.

Aside from the non-expected results concerning cognitive activation and classroom management, cognitive and motivational support yielded the hypothesized pattern of results: while cognitive support predicted student achievement (and interest), motivational support predicted student interest only. Thus, the separate assessment and modeling of the two dimensions might be promising for future research based on student ratings.

While previous studies using student ratings to assess teaching quality did not find significant effects of student support on student achievement gains (e. g., Fauth et al., 2014; Pinger, Rakoczy, Besser & Klieme, 2017), cognitive support was significantly related to student understanding in the present study, and indeed, was the strongest predictor of student understanding among the four dimensions of teaching quality. These results underscore the relevance of cognitive support as rated by students.

In essence, cognitive support serves to reduce cognitive demands in challenging, cognitively activating learning environments so that students can master them. Future research might address the specific roles of adaptive support during student-teacher interactions, and also blanket scaffolding, where support is the same for all students and can refer to larger instructional units (Puntambekar & Hübscher, 2005). Moreover, the presumably different mediating mechanisms through which cognitive and motivational support, as well as classroom management, affect student outcomes would be a highly relevant field for future research (Praetorius et al., 2018b).

8. Limitations

The present study complements recent findings on student perceived teaching quality in science education (Decristan et al., 2015; Fauth et al., 2014). As in these previous studies, we assessed teaching quality and student outcomes in the context of a specific teaching unit (here, on the water cycle). Long-term effects therefore were not in the scope of the present research. The design allowed, however, a close alignment of outcome measures and teaching unit.

The operationalizations of the three basic dimensions have been heterogeneous in previous studies (Praetorius et al., 2018b). In the present study, available items and operationalizations were restricted, due to our re-analysis of student ratings of teaching quality. Our measure of cognitive support did not cover feedback, for instance, and our measure of classroom management was limited to items on disruptions, and did not consider teacher actions to prevent disruptions (such as monitoring). Our motivational support measure mainly addressed teacher sensitivity and assessed autonomy support, for instance, only marginally. Finally, our measure of cognitive activation included two items addressing cognitive activation in the context of science inquiry. These do not consistently follow a generic approach to teaching quality. Another issue seems to be item formulations that did not exclusively refer to the class (i. e., the level of our analysis) but to individual students (Marsh et al., 2012). Finally, the sample size did not allow us to test factor structure and measurement invariance between grades 4 and 6.

Future research then should test the generalizability of our results across content domains and age groups in short- and long-term designs, and with more comprehensive measures of cognitive activation, cognitive support, motivational support, and classroom management, including other perspectives (teachers and external observers in particular).

9. Conclusion

The three basic dimensions framework is a parsimonious, generic model for teaching quality that is prominent in German-speaking countries in particular. It has provided an important step in establishing common ground for the description of quality teaching. A next step might now be to test potentially relevant modifications of the framework in order to achieve greater comprehensiveness.

The present study suggests such a modification of the basic dimensions approach. On the basis of student ratings of teaching quality in science education, it provides preliminary evidence on the factorial and predictive validity of a four-factor model differentiating cognitive activation, cognitive support, motivational support, and classroom management.

Future research may test this framework in varying settings, as well as including further increments (see, for instance, Praetorius & Charalambous, 2018a) by means of factor analyses and tests of predictive validity. Such research could enable exploration of the theoretical and empirical value added of more comprehensive over more parsimonious frameworks of teaching quality.

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Item	**λ_w**	**λ_b**
Cognitive activation		
Our teacher demonstrates with an experiment that our explanations are not correct yet.	.57	.89
We often observe things that astonish us.	.64	.92
We can test our assumptions with experiments.	.65	.93
Our teacher asks us to give reasons for our assumptions.	.41	.69
Our teacher asks us to use what we have learned to explain observations from everyday life.	.44	.74
Cognitive support		
In the classroom, often too many questions are treated at the same time. (reverse coded)	.58	.89
In the classroom, I often do not know what we are talking about. (reverse coded)	.63	.94
I know exactly what to do when I am working.	.44	.66
Our teacher often uses foreign words we do not understand. (reverse coded)	.40	.70
Our teacher rarely helps us during classroom talk to find a solution. (reverse coded)	.32	.74
Motivational support		
Our teacher has always time if I want to talk with her/him about something particular.	.77	.97
Our teacher pays attention to my problems.	.81	1.00
If I do not like something, I can talk to our teacher.	.73	.99
If we try hard, we get complimented.	.59	.87
During instruction, we are supported to work autonomously.	.51	.81
Classroom management		
Students are fooling around in the lessons. (reverse coded)	.65	.90
The teacher has to be loud quite often. (reverse coded)	.68	.86
After asking us to be quiet, our teacher has to wait a long time until everybody is actually quiet. (reverse coded)	.66	.91
During instruction, it is often turbulent and loud. (reverse coded)	.76	.98
At the beginning of a lesson, it takes a long time until the students are quiet. (reverse coded)	.61	.87

Tab. A1: Items used to assess teaching quality and standardized factor loadings on the within (λw) and between (λb) level

Zusammenfassung: Das Modell der drei Basisdimensionen von Unterrichtsqualität unterscheidet die Dimensionen kognitive Aktivierung, konstruktive Unterstützung und Klassenführung. Forschung aus unterschiedlichen Disziplinen legt nahe, dass kognitive Unterstützung in dem Modell nicht hinreichend berücksichtigt ist. Faktorenanalysen auf der Basis von Schülereinschätzungen zum naturwissenschaftlichen Unterricht (2,659 Schüler*innen, Klasse 4 und 6) weisen in der vorliegenden Studie auf ein vierdimensionales Modell mit kognitiver Unterstützung als separater Dimension hin. Kognitive Unterstützung sagte zudem den Lernerfolg der Schüler*innen voraus. Die Ergebnisse unterstreichen, dass die Ergänzung um diese Dimension zu einem vollständigeren, aber dennoch sparsamen Modell von Unterrichtsqualität beiträgt.

Schlagworte: Unterrichtsqualität, drei Basisdimensionen, Schülerratings, naturwissenschaftlicher Unterricht, Faktorenanalyse

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