Supplementary materials for

Lindermayer, C., Kosiol, T., Ufer, S. (2026): How much motivation is in student ratings of mathematics instructional quality? Disentangling the role of individual characteristics, class averages, and class heterogeneity

CONTENTS

A1 Sample items from instructional quality scales

The following table lists all items included in the final scales for classroom management (8 items), cognitive activation (13 items), and student support (9 items), based on established scales from Kunter et al. (2017). Students rated on a 4-point Likert scale (0 = *strongly disagree* to 3 = *strongly agree*) how well the statements applied to their last five mathematics lessons.

Scale	Subscale (# items)	Item
1. Classroom management	a. Attention to student distractions (4)	"In class, our teacher made sure that we were paying attention."
		"In class, our teacher always knew exactly what was going on."
		"In class, our teacher always checked our homework very carefully."
		"In class, our teacher immediately noticed when students started doing something else."
	b. Disturbances (1)	"Nonsense was continuously being done during class." (reversed)
	c. Wasting time (3)	"Our teacher often started the lesson unpunctually." (reversed)
		"At the beginning of class, it took a very long time for students to settle down and start working." (reversed)
		"A lot of time was wasted during class." (reversed)
2. Cognitive activation	a. Independence and obligation to provide reasoning (8)	"Our teacher often asks us to explain our work steps in detail."
		"Our teacher encouraged us to compare and evaluate different approaches to solving tasks."

		"In class, our teacher sometimes let us pursue our own ideas—even if they were misleading—until we figured it out ourselves."
		"In class, the teacher sometimes accepted mistakes and allowed us to continue until we discovered on our own that something was wrong."
		"Our teacher assigned tasks that required us to show multiple solution paths."
		"Our teacher often demanded that we justify our work steps thoroughly."
		"In class, I was able to solve tasks in the way I personally considered best."
		"In class, I could use my own strategies to solve difficult tasks."
	b. Discursive treatment of different student solutions (5)	"In class, we often discussed the different ways of working on the tasks."
		"In class, several students often presented their solutions for a task."
		"Our teacher often asked if anyone had approached the task differently."
		"In class, we more often discussed answers that we had previously worked out in groups."
		"In class, the teacher often refrained from immediately saying whether an answer was right or wrong."
3. Student support	a. Teachers' diagnostic competence (5)	"Our teacher noticed immediately if someone didn't understand something correctly."
		"Our teacher knew exactly what each of us was capable of."
		"Our teacher immediately knew which tasks we had difficulties with."
		"Our teacher instantly recognized when someone did not understand something."
		"Our teacher quickly noticed if a student was falling behind in class."
	b. Adaptive relief for difficult tasks (4)	"Our teacher gave good examples in class to make the tasks understandable."
		"Our teacher assigned tasks that all students could tackle to the best of their ability."
		"Our teacher clarified the subject matter so well that I could transfer what I learned to new tasks."

	Our teacher explained especially difficult parts very slowly and carefully.

A2 Sample items from the mathematics motivational instruments

The following table provides all items that were included in the final scales for assessing mathematics-related motivational variables—intrinsic motivation (4 items), interest (3 items), and self-concept (4 items)—based on established scales from Wild et al. (2001). Students responded on a 4-point Likert scale (0 = *not true at all* to 3 = *exactly true*).

Scale	**Item**
1. Intrinsic motivation	"I put effort into my math lessons because I want to understand the content."
	"I put effort into my math lessons because it is important to me to grasp the mathematical concepts."
	"I put effort into my math lessons because I want to find out whether my answer is correct or not."
	"I put effort into my math lessons because engaging with mathematical topics and problems is important to me – regardless of school or other people."
2. Interest in Mathematics	"I put effort into my math lessons because I enjoy math class."
	"Math is one of my favorite subjects."
	"I usually look forward to the next math lesson."
3. Mathematics Self-Concept	"I am good at mathematics."
	"Mathematics is easy for me."
	"When the math teacher asks a question, I usually know the correct answer."
	"I find it easy to keep up in math class."
	"I am good at solving math problems."

A3 Sample items from the self-developed instrument for mathematics achievement (T1)

The following table provides sample items from our self-developed instrument for assessing mathematics achievement of 8th-grade students at the beginning of the school year (T1). The final test included 12-13 items (depending on the school track), comprising both items common to all tracks and track-specific items, all aligned with curricula standards and the competence level model by Blum et al. (2006). Seven pilot classes were used to select items based on item fit. Experts from the educational authority reviewed all items for difficulty, terminology, and expected completion time. Students' responses were coded dichotomously by trained raters; about 20% were double-coded. Inter-rater reliability was excellent (Cohen's Kappa > 0.9 for all items).

<table>
<tr><th>School track(s)</th><th>Sample item</th></tr>
<tr><td>Low attaining</td><td>1. At a school party, Lena buys five bottles of lemonade for herself and her friends. She pays 6,50 € for the five bottles.

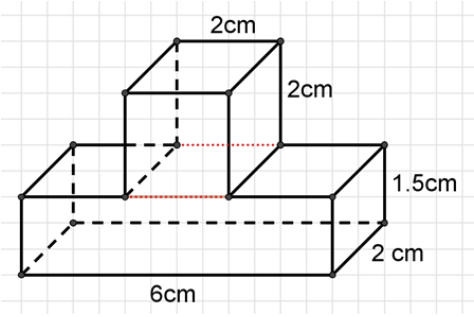
How much does one bottle cost?

Write down your calculation and enter the result below.</td></tr>
<tr><td>Low, medium, high attaining</td><td>2. Use the following table to answer the following question.
<table><tr><th>Number of sheets</th><th>Thickness of the stack of sheets</th></tr><tr><td>100</td><td>12 mm</td></tr><tr><td>250</td><td>30 mm</td></tr><tr><td>1000</td><td>120 mm</td></tr><tr><td>4000</td><td>480 mm</td></tr><tr><td>7500</td><td>900 mm</td></tr></table>How thick is a stack of 6500 sheets of paper?

Write down your calculation and enter the result below.</td></tr>
<tr><td>Low, medium, high attaining</td><td>3. Calculate the missing value:

15 € is ____ % of 75 €.

Write down your calculation.</td></tr>
<tr><td>Low, medium, high attaining</td><td>4. Calculate the volume of the body shown. Write down your calculation and enter the result below in the correct unit.

 
</td></tr>
</table>

A4 Descriptive statistics

The following table provides descriptive statistics for all measures.

Measure	No. items	M	SD	Reliability	Min	Max	Skewness	Kurtosis	N
1. Classroom management (T1)	8	0.00	1.00	0.63	-6.34	6.10	0.30	4.84	1,654
2. Classroom management (T2)	8	0.00	1.00		-5.53	5.30	-0.02	4.14	1,654
3. Cognitive activation (T1)	13	0.00	1.00	0.77	-7.22	5.59	-0.77	5.96	1,654
4. Cognitive activation (T2)	13	0.00	1.00		-6.35	6.53	0.03	7.56	1,654
5. Student support (T1)	9	0.00	1.00	0.77	-3.66	3.02	-0.14	1.52	1,654
6. Student support (T2)	9	0.00	1.00		-3.54	2.90	0.02	1.18	1,654
7. Mathematics achievement (T1)	12-13 [1]	0.00	1.00	0.67	-3.15	4.67	-0.19	0.43	1,654
8. Intrinsic Motivation (T1)	4	0.00	1.00	0.64	-3.32	5.79	-0.06	0.93	1,654
9. Interest (T1)	3	0.00	1.00	0.76	-2.12	2.20	0.31	-0.58	1,654
10. Self-concept (T1)	5	0.00	1.00	0.81	-2.58	2.06	-0.01	-0.22	1,654
11. Socio-economic status (SES)	1	0.00	1.00	-	-1.99	1.29	-0.33	-0.74	1,654

Note. *T1:* first measurement time, *T2:* second measurement time, *M*: mean, *SD*: standard deviation, *Reliability*: WLE reliability (for classroom management, cognitive activation, and student support, reliability was calculated across both time points and is therefore reported jointly for T1 and T2), *Min*: minimum, *Max*: maximum, *N*: number of students, [1] depending on the booklet of the different school tracks. All instructional quality variables (classroom management, cognitive activation, student support) are based on student-reported perceptions referring to the last five mathematics lessons. All motivational variables (intrinsic motivation, interest, self-concept) are mathematics-related.

A5 Pearson within-class correlations and between-class correlations

The following table shows correlations among all variables at the within-class level (upper triangle, N = 1,654 students) and between-class level (lower triangle, N = 73 classes).

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Classroom management (T1)	-	0.50	0.46	0.50	0.55	0.51	0.49	0.37	0.32	0.39	0.13
2. Classroom management (T2)	0.81	-	0.48	0.56	0.51	0.57	0.52	0.37	0.34	0.41	0.19
3. Cognitive activation (T1)	0.66	0.75	-	0.51	0.66	0.52	0.48	0.39	0.36	0.40	0.15
4. Cognitive activation (T2)	0.56	0.74	0.74	-	0.54	0.63	0.55	0.39	0.36	0.44	0.20
5. Student support (T1)	0.67	0.72	0.81	0.69	-	0.56	0.52	0.38	0.42	0.47	0.15
6. Student support (T2)	0.67	0.78	0.71	0.76	0.78	-	0.57	0.39	0.38	0.48	0.21
7. Mathematics achievement	0.66	0.74	0.65	0.63	0.49	0.65	-	0.35	0.39	0.51	0.28
8. Intrinsic motivation	0.56	0.50	0.52	0.47	0.60	0.65	0.41	-	0.54	0.44	0.09
9. Interest	0.33	0.32	0.47	0.46	0.53	0.57	0.32	0.48	-	0.68	0.07
10. Self-concept	0.37	0.36	0.50	0.50	0.49	0.57	0.48	0.51	0.74	-	0.15
11. Socio-economic status (SES)	0.46	0.52	0.47	0.40	0.19	0.34	0.78	0.16	0.10	0.24	-

Note. *T1*: first measurement point, *T2:* second measurement point.
All instructional quality variables (classroom management, cognitive activation, student support) are based on student-reported perceptions referring to the last five mathematics lessons.
All motivational variables (intrinsic motivation, interest, self-concept) are mathematics-related.
All within-class correlations were significant at $p < .01$.
All between-class correlations were significant at $p < .05$, except for SES with student support (T1), intrinsic motivation, and interest (highlighted in grey).

Blum, W., Drüke-Noe, C., Hartung, R., & Köller, O. (2006). Bildungsstandards Mathematik: konkret [Mathematics educational standards: concrete]. *Sekundarstufe I: Aufgabenbeispiele, Unterrichtsanregungen, Fortbildungsideen. Berlin: Cornelsen Scriptor*.

Kunter, M., Baumert, J., Leutner, D., Terhart, E., Seidel, T., Dicke. T., Holzberger, D., Kunina-Habenicht, O., Linninger, C., Lohse-Bossenz, H., Schulze-Stocker, F., & Stürmer, K. (2017). *Dokumentation der Erhebungsinstrumente der Projektphasen des BilWiss-Forschungsprogramms von 2009 bis 2016 [Documentation of the survey instruments of the project phases of the BilWiss research program from 2009 to 2016]*. Goethe-Universität.

Wild, E., Gerber, J., Exeler, J., & Remy, K. (2001). Dokumentation der Skalen-und Item-Auswahl für den Kinderfragebogen zur Lernmotivation und zum emotionalen Erleben [Documentation of the scales and items of the questionnaire on motivation and emotional experience]. *Universität Bielefeld*.