

Additional file 1

When homework counts as screen time: parental limits and adolescents' digital competence across 28 education systems in ICILS 2023

Supplementary methods, tables, and figure

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Minus signs are typographic minus signs. Differences in computer and information literacy (CIL) and computational thinking (CT) are in score points unless stated otherwise. Additional file 2 contains every system-level number in machine-readable form.

Section S1. Checks of the estimation code

We checked the estimation code in four ways and describe below how missing codes were handled.

Published national averages. Using the same weights, plausible values, and jackknife procedure as in the article, we computed the national average CIL score and its standard error for six education systems and compared them with the published values in Table 4.2 of the ICILS 2023 user guide, which reproduces the international report. All six matched at the published precision (Table S1).

Table S1. Published and reproduced national CIL averages (standard errors)

Education system	Published	Reproduced
Austria	506 (2.5)	505.6 (2.52)
Azerbaijan	319 (5.1)	318.7 (5.10)
Denmark	518 (2.7)	517.9 (2.67)
Korea, Republic of	540 (2.5)	540.4 (2.52)
Oman	379 (3.0)	379.1 (2.98)
Uruguay	447 (3.6)	447.1 (3.63)

Published values: ICILS 2023 user guide, Table 4.2. Reproduced values use all students in the national file.

Jackknife standard errors. For Austria and the first plausible value, the coefficient for the inclusive limit in Model 1 and its jackknife standard error were identical when computed with our code and with the survey package in R ($b = -19.6467$, $SE = 3.7999$ in both). The variance formula is equation 3.1 of the user guide for one plausible value and equation 3.3 for five.

Meta-analysis. Our DerSimonian-Laird results were identical to those of metafor 5.0.1 (differences below 10^{-12}). Restricted maximum likelihood estimates of the between-system variance were obtained by direct maximization of the restricted likelihood and matched metafor to within 0.0001 for every contrast. The modified Hartung-Knapp interval matched metafor's ad hoc correction exactly. Prediction intervals use the t distribution with $k - 2$ degrees of freedom.

International report. Comparing students with and without a limit among all students who answered the item, without covariates, in the 29 countries of the international report (our 28 systems and Romania), we found significant differences in 16 countries, with students without a limit scoring higher in 14 and students with a limit scoring higher in Chinese Taipei and Oman. This is the pattern reported by Rožman et al. (2025).

Data handling. Plausible values were treated as missing only when they carried the missing codes 998 or 999; eleven valid CT plausible values above 900 points were kept. Questionnaire scales and indices were set to missing for the codes 998 and 999 (and -98 for the socioeconomic index). No replicate fit failed in any model.

Section S2. Weighting for item nonresponse

The rule item was optional and was not answered by some students. In every system, students who answered it scored higher in CIL than students who did not (median of weighted system means 502 against 422 points). This is a question about the analytic sample, not about the models themselves. The analyses in the article use the analytic sample of students with valid data on the item and all covariates, weighted by the final student

weight. As a separate check, we asked whether the main estimate would change if the analytic sample were reweighted to resemble all assessed students.

Within each system, a logistic regression predicted whether a student answered the rule item from the mean of the five CIL plausible values, the socioeconomic index, gender, home language, immigrant background, computer experience, and home internet access. These predictors are observed for respondents and nonrespondents alike, except for occasional missing values, which were set to the system mean and flagged with an indicator so that every student received a predicted probability. For students in the analytic sample, the inverse of the predicted probability was normalized to a mean of 1 within the system and multiplied into the final student weight and into each of the 75 replicate weights. The response model was treated as fixed rather than re-estimated in each replicate. A second version trimmed the normalized weights at the 99th percentile.

Predicted probabilities ranged from 0.105 to 1.000. The normalized weights were close to 1 (median 95th percentile 1.12, median 99th percentile 1.29, maximum 8.74). The largest standardized difference between the analytic sample and all students on the predictors fell from a median of 0.12 before weighting to 0.06 after weighting. The pooled estimates were -25.9 points untrimmed and -25.6 points trimmed, compared with -24.7 points in the primary analysis (Table S8).

Section S3. Sensitivity to unmeasured confounding

We followed Cinelli and Hazlett (2020). Let D be the inclusive-limit indicator, Y the outcome, X the other regressors of Model 1 (intercept, no-limit indicator, and the four covariates), and Z a hypothetical omitted variable. The bias in the coefficient for D caused by omitting Z depends on two partial R-squared values: the share of the residual variance of Y explained by Z (given D and X) and the share of the residual variance of D explained by Z (given X). Because weighted least squares is ordinary least squares on transformed data, all quantities were computed in the weighted metric, for each plausible value, and then averaged across plausible values.

The robustness value is $RV = 0.5 [\sqrt{f^4 + 4 f^2} - f^2]$, where $f^2 = R^2(Y \sim D|X) / [1 - R^2(Y \sim D|X)]$. It is the partial R-squared that Z would need with both D and Y to reduce the estimate to zero. For a given partial R-squared of Z with Y, R^2y , the partial R-squared with D needed to reduce the estimate to zero is $f^2 / (R^2y + f^2)$.

For benchmarks, we used the socioeconomic index (with the other covariates held constant) and, within Model 3, educational expectations. For a hypothetical Z that is k times as strongly related to D and to Y as the benchmark covariate, we computed the implied partial R-squared values with the bounds of Cinelli and Hazlett (2020, implemented as in the sensemakr package) and the bias-adjusted estimate, moving the estimate toward zero. The bias-adjusted system estimates were pooled with the standard errors of the unadjusted model, so the reported intervals ignore uncertainty in the bias itself and are approximate. System-level values are given in Table S10.

Section S4. Variables and coding

Table S2. Variables used in the analysis

Variable	Content	Coding in the analysis	Missing codes
IS3G19A	Parental screen-time limit, school days	1 inclusive; 2 exempt (reference); 3 no	8, 9

Variable	Content	Coding in the analysis	Missing codes
		limit	
IS3G19B	Parental screen-time limit, non-school days	As IS3G19A	8, 9
PV1CIL to PV5CIL	Computer and information literacy	Plausible values	998, 999
PV1CT to PV5CT	Computational thinking	Plausible values (19 systems)	998, 999
S_LRNINTO	Learning about internet-related tasks outside school	Scale (WLE), standardized within system	998, 999
S_LRNINTS	Learning about internet-related tasks at school	Scale (WLE), standardized within system	998, 999
IISB	International index of socioeconomic background	Continuous, mean 0, SD 1	-98, 998, 999
S_SEX	Gender	0 boy; 1 girl	8, 9
S_TLANG	Test language spoken at home	0 other language; 1 test language	8, 9
S_IMMBGR	Immigrant background	0 without; 1 with	8, 9
S_EXCOMP	Computer experience	0 (<1 year) to 4 (7 years or more), linear	8, 9
S_INTNET	Home internet access	0 no; 1 yes	8, 9
S_AGE	Age	Years	98, 99
S_ISCED	Expected educational attainment	0 to 4 (ISCED levels), linear; 4 = university	8, 9
S_HISEI, S_HISCED, S_HOMLIT	Components of the socioeconomic index	Used in the flexible adjustment	98/99; 8/9
IS3G18C	ICT use outside school for schoolwork, school days	1 never to 8 three hours or more every day	98, 99
IS3G18D	ICT use outside school for other purposes, school days	As IS3G18C	98, 99
S_ACMULT	Academic-media multitasking	Scale (WLE)	998, 999
S_GENEFF	Self-efficacy, general applications	Scale (WLE)	998, 999
TOTWGTS	Final student weight	Used in all analyses	
SRWGT01 to SRWGT75	Jackknife replicate weights	Used for sampling variance	
IDSSCHOOL	School identifier	Used for the within-school model	

Variable names follow the ICILS 2023 codebook. WLE = weighted likelihood estimate. In Models 2 and 3, missing values on the added covariates were set to the system mean and flagged with an indicator.

Table S3. Sample flow and exclusions by education system

System	Students	Item not presented	Item omitted	Answered item	No SES	No gender	No language	No immigr.	Any covariate missing	Analytic n	% kept	% kept (weighted)	n CT	n learning	n non-school
Austria	3448	14	266	3168	25	76	3	77	174	2994	86.8	87.0	2994	2850	2920
Azerbaijan	3634	16	791	2827	39	0	7	181	217	2610	71.8	70.5		2079	2533
Bosnia and Herzegovina	1877	5	194	1678	6	0	0	49	55	1623	86.5	86.3		1396	1353
Chinese Taipei	5112	9	339	4764	5	0	5	37	47	4717	92.3	92.7	4717	4673	4727
Croatia	2911	24	245	2642	17	0	6	63	81	2561	88.0	87.7	2561	2413	2332
Cyprus	3182	24	350	2808	23	0	241	53	302	2506	78.8	79.3		2342	2318
Czech Republic	8169	12	472	7685	35	0	9	69	107	7578	92.8	92.4	7578	7415	7408
Denmark	3038	48	247	2743	15	52	2	54	120	2623	86.3	86.2	2623	2552	2620
Finland	4249	37	283	3929	40	0	2	34	74	3855	90.7	90.7	3855	3719	3736
France	3694	7	421	3266	49	0	7	70	117	3149	85.2	84.8	3149	2914	3077
Greece	3576	18	299	3259	6	0	6	37	47	3212	89.8	89.5		2984	2809
Hungary	3491	27	173	3291	10	0	5	32	46	3245	93.0	92.0		3212	3165
Italy	3376	4	315	3057	6	0	3	39	47	3010	89.2	88.9	3010	2922	2972
Kazakhstan	4852	7	475	4370	24	0	8	64	91	4279	88.2	88.2		3978	4078
Korea, Republic of	3723	15	167	3541	14	1	1	46	58	3483	93.6	93.5	3483	3436	3342
Kosovo	3345	6	567	2772	12	0	5	172	183	2589	77.4	76.7		2191	2140
Latvia	2705	25	194	2486	116	0	602	621	643	1843	68.1	69.0	1843	1802	1824
Luxembourg	4703	24	609	4070	95	1	6	150	237	3833	81.5	82.1	3833	3475	3696

System	Students	Item not presented	Item omitted	Answered item	No SES	No gender	No language	No immigr.	Any covariate missing	Analytic n	% kept	% kept (weighted)	n CT	n learning	n non-school
Malta	3115	21	323	2771	30	124	3	77	217	2554	82.0	80.0	2554	2329	2510
Norway (grade 9)	4436	67	399	3970	45	1	7	117	156	3814	86.0	86.4	3814	3639	3644
Oman	6437	44	696	5697	36	0	13	361	392	5305	82.4	82.1		4919	5094
Portugal	3650	5	338	3307	15	0	4	43	61	3246	88.9	88.7	3246	3168	3150
Serbia	3125	14	285	2826	5	0	2	310	314	2512	80.4	79.5	2512	2330	2260
Slovak Republic	3034	0	217	2817	14	0	2	87	101	2716	89.5	89.6	2716	2630	2566
Slovenia	3318	24	298	2996	30	0	18	73	114	2882	86.9	87.0	2882	2700	2743
Spain	11799	62	1092	10645	62	0	32	324	403	10242	86.8	86.9		9606	9537
Sweden	3401	38	264	3099	51	104	4	94	238	2861	84.1	84.1	2861	2592	2759
Uruguay	2933	13	519	2401	8	42	6	63	116	2285	77.9	78.6	2285	2054	2218
Chile *	3216	68	649	2499	27	1	12	65	98	2401	74.7	73.5		2103	2334
Netherlands *	1288	39	111	1138	37	25	1	27	85	1053	81.8	78.5	1053	1015	1055
Romania *	3270	44	459	2767	11	0	5	119	131	2636	80.6	76.1		2328	2430
United States *	2352	190	281	1881	38	0	9	61	99	1782	75.8	76.5	1782	1700	1759
Total, 28 systems	114333	610	10838	102885	833	401	1009	3397	4758	98127	85.8		62516	92320	93531

Counts of students. Covariate columns count students who answered the item but lacked that covariate; a student can lack more than one, so the columns need not add up to 'Any covariate missing'. Analytic n = answered item and no covariate missing. n CT = analytic students with CT plausible values; n learning = analytic students with both learning scales; n non-school = students with the non-school-day item and all covariates. * Not in the primary sample (see Methods); these systems enter only the sensitivity analyses with Chile added or with all 32 systems.

Table S4. Distribution of reported rule types by education system (analytic sample)

System	n	n inclusive	n exempt	n no limit	% inclusive	% exempt	% no limit	% inclusive among limits	% same rule on non-school days	% daily digital schoolwork at home
Austria (b)	2994	354	632	2008	11.6	20.2	68.2	36.6	77.4	36.6
Azerbaijan	2610	990	795	825	40.3	30.1	29.6	57.3	23.0	41.2
Bosnia and Herzegovina (c)	1623	273	485	865	17.3	30.1	52.7	36.4	61.4	43.6
Chinese Taipei	4717	999	1514	2204	21.2	33.7	45.1	38.6	69.6	28.7
Croatia (b)	2561	355	761	1445	13.4	28.9	57.7	31.6	64.8	41.8
Cyprus	2506	368	711	1427	14.8	28.2	57.0	34.4	68.4	38.6
Czech Republic (b)	7578	767	1901	4910	10.4	25.0	64.6	29.3	76.6	39.2
Denmark (a,b)	2623	111	544	1968	4.2	20.9	74.9	16.8	82.7	40.2
Finland	3855	229	777	2849	6.0	19.8	74.3	23.1	86.7	26.6
France	3149	565	960	1624	17.7	30.3	52.0	36.8	70.1	66.2
Greece	3212	704	1002	1506	21.7	31.2	47.0	41.0	52.3	37.3
Hungary	3245	356	739	2150	11.4	22.0	66.6	34.0	73.8	36.7
Italy	3010	453	806	1751	15.3	26.8	58.0	36.3	63.3	68.2
Kazakhstan (b)	4279	983	927	2369	24.5	21.8	53.6	52.9	47.7	59.8
Korea, Republic of (a)	3483	368	682	2433	10.6	19.9	69.5	34.7	85.3	36.6
Kosovo (b)	2589	1049	951	589	41.6	36.0	22.4	53.6	23.1	45.9
Latvia (b)	1843	178	334	1331	10.0	18.2	71.9	35.4	77.1	60.2
Luxembourg	3833	565	1072	2196	14.8	28.3	56.9	34.3	72.6	52.8
Malta	2554	302	756	1496	11.9	28.8	59.3	29.2	70.0	58.6
Norway (grade 9) (b)	3814	243	1078	2493	6.7	27.0	66.3	19.9	81.3	49.3

System	n	n inclusive	n exempt	n no limit	% inclusive	% exempt	% no limit	% inclusive among limits	% same rule on non-school days	% daily digital schoolwork at home
Oman	5305	2229	1683	1393	41.8	31.7	26.5	56.9	17.5	51.3
Portugal (b)	3246	398	934	1914	12.0	29.6	58.4	28.8	70.1	36.8
Serbia (b)	2512	281	632	1599	11.2	25.2	63.6	30.8	71.2	52.5
Slovak Republic	2716	425	753	1538	15.7	27.5	56.8	36.4	66.8	51.3
Slovenia (b)	2882	551	1057	1274	19.1	36.5	44.4	34.3	66.9	39.7
Spain (b)	10242	1999	4048	4195	19.1	39.5	41.5	32.6	54.8	59.6
Sweden (b)	2861	180	537	2144	6.4	18.7	74.9	25.4	84.4	43.3
Uruguay (a)	2285	430	656	1199	18.8	28.4	52.8	39.8	56.7	53.2
Median					14.8	28.3	57.4	34.5	69.8	43.5

Percentages are weighted. '% same rule on non-school days' is the share of students whose non-school-day answer matched their school-day answer. '% daily digital schoolwork at home' is the share reporting use of digital devices outside school for schoolwork every school day. Letters after system names are sampling annotations from the international report: a, participation guidelines met only after replacement schools were included; b, national defined population covers 90% to 95% of the national target population; c, coverage of 61%.

Table S5. System-level estimates for the main contrasts [95% confidence intervals]

System	CIL, inclusive vs exempt, Model 0	CIL, inclusive vs exempt, Model 1	CIL, inclusive vs exempt, SD units	CT, inclusive vs exempt	CIL, no limit vs exempt	CT, no limit vs exempt	CIL, inclusive vs exempt, within school	Within-system SD of CIL
Austria (b)	-18.5 [-27.8, -9.3]	-16.9 [-25.5, -8.3]	-0.24 [-0.36, -0.11]	-26.3 [-39.4, -13.2]	1.9 [-4.7, 8.5]	-7.6 [-17.2, 2.0]	-11.2 [-20.0, -2.4]	71.8
Azerbaijan	-24.8 [-37.9, -11.6]	-21.0 [-32.9, -9.1]	-0.22 [-0.34, -0.10]	–	3.3 [-10.0, 16.6]	–	-12.3 [-21.9, -2.6]	96.9
Bosnia and Herzegovina (c)	-47.1 [-65.4, -28.8]	-40.6 [-57.2, -23.9]	-0.40 [-0.57, -0.24]	–	-4.1 [-15.5, 7.4]	–	-37.3 [-53.4, -21.2]	100.3
Chinese Taipei	-11.9 [-19.4, -4.4]	-15.0 [-22.5, -7.6]	-0.18 [-0.27, -0.09]	-18.7 [-29.5, -7.9]	-9.2 [-14.5, -4.0]	-13.0 [-21.6, -4.5]	-10.3 [-17.5, -3.1]	83.6
Croatia (b)	-36.5 [-50.8, -22.3]	-33.4 [-47.0, -19.9]	-0.36 [-0.51, -0.21]	-39.8 [-56.9, -22.8]	-2.8 [-12.8, 7.3]	-8.8 [-21.6, 4.0]	-29.7 [-43.2, -16.1]	92.6
Cyprus	-35.4 [-48.2, -22.6]	-26.8 [-38.5, -15.2]	-0.28 [-0.40, -0.16]	–	4.0 [-6.0, 14.0]	–	-22.3 [-34.2, -10.3]	96.1
Czech Republic (b)	-21.8 [-29.9, -13.7]	-19.8 [-26.5, -13.1]	-0.30 [-0.40, -0.20]	-21.3 [-30.8, -11.8]	-0.7 [-4.5, 3.2]	-5.8 [-10.8, -0.8]	-17.6 [-23.8, -11.4]	65.8
Denmark (a,b)	-44.8 [-63.2, -26.4]	-33.3 [-50.7, -16.0]	-0.48 [-0.72, -0.23]	-39.8 [-64.5, -15.2]	-6.1 [-14.8, 2.5]	-8.7 [-19.9, 2.5]	-30.3 [-48.3, -12.3]	69.9
Finland	-49.7 [-65.9, -33.6]	-40.5 [-54.8, -26.3]	-0.52 [-0.71, -0.34]	-54.8 [-75.7, -33.8]	-10.4 [-17.4, -3.3]	-18.8 [-29.8, -7.7]	-30.3 [-42.4, -18.2]	77.6
France	-14.3 [-21.5, -7.0]	-11.7 [-18.7, -4.7]	-0.17 [-0.27, -0.07]	-18.6 [-28.0, -9.2]	-1.1 [-6.9, 4.7]	-2.3 [-11.3, 6.7]	-10.0 [-16.5, -3.6]	69.9
Greece	-31.3 [-41.5, -21.0]	-24.8 [-33.9, -15.7]	-0.29 [-0.39, -0.18]	–	-2.8 [-9.8, 4.2]	–	-17.5 [-26.9, -8.2]	86.9
Hungary	-29.7 [-43.1, -16.4]	-21.9 [-32.4, -11.4]	-0.28 [-0.41, -0.14]	–	3.8 [-3.9, 11.5]	–	-17.9 [-27.8, -8.1]	79.3
Italy	-20.2 [-30.3, -10.1]	-19.1 [-28.4, -9.9]	-0.27 [-0.39, -0.14]	-21.8 [-32.7, -10.9]	0.9 [-5.3, 7.2]	-3.1 [-12.0, 5.8]	-14.5 [-23.5, -5.4]	71.5
Kazakhstan (b)	-26.6 [-34.5, -18.7]	-24.5 [-32.2, -16.7]	-0.28 [-0.36, -0.19]	–	26.2 [18.3, 34.0]	–	-11.7 [-18.6, -4.8]	88.3
Korea, Republic of (a)	-36.1 [-46.9, -25.2]	-31.0 [-41.8, -20.3]	-0.37 [-0.49, -0.24]	-44.1 [-60.0, -28.1]	-10.6 [-16.8, -4.4]	-25.9 [-37.1, -14.8]	-28.0 [-38.1, -17.8]	84.6
Kosovo (b)	-18.3 [-28.1, -8.5]	-15.2 [-24.2, -6.2]	-0.16 [-0.25, -0.06]	–	4.4 [-7.2, 15.9]	–	-10.3 [-19.3, -1.2]	98.0
Latvia (b)	-27.6 [-45.6, -9.7]	-28.3 [-44.4, -12.1]	-0.38 [-0.59, -0.16]	-46.6 [-67.4, -25.8]	1.1 [-9.2, 11.3]	-6.8 [-18.1, 4.4]	-31.8 [-47.0, -16.6]	74.9
Luxembourg	-38.4 [-49.1, -27.8]	-32.0 [-42.1, -21.9]	-0.38 [-0.50, -0.26]	-35.5 [-47.6, -23.4]	3.6 [-2.4, 9.6]	-1.5 [-9.1, 6.1]	-30.0 [-39.3, -20.7]	83.5
Malta	-43.4 [-58.0, -28.8]	-37.7 [-51.6, -23.8]	-0.40 [-0.54, -0.25]	-38.7 [-57.4, -20.1]	0.3 [-9.1, 9.6]	-7.8 [-19.0, 3.5]	-34.2 [-47.2, -21.3]	95.1
Norway (grade 9) (b)	-57.9 [-73.8, -42.0]	-48.1 [-63.1, -33.0]	-0.63 [-0.82, -0.43]	-56.8 [-79.1, -34.5]	-7.7 [-14.3, -1.1]	-8.7 [-19.4, 1.9]	-47.6 [-61.2, -34.0]	76.4
Oman	-10.9 [-19.2, -2.6]	-9.1 [-16.1, -2.1]	-0.09 [-0.16, -0.02]	–	-11.2 [-18.4, -4.0]	–	-6.4 [-12.9, 0.1]	98.7

System	CIL, inclusive vs exempt, Model 0	CIL, inclusive vs exempt, Model 1	CIL, inclusive vs exempt, SD units	CT, inclusive vs exempt	CIL, no limit vs exempt	CT, no limit vs exempt	CIL, inclusive vs exempt, within school	Within-system SD of CIL
Portugal (b)	-27.1 [-39.0, -15.2]	-23.1 [-34.3, -11.8]	-0.30 [-0.45, -0.16]	-26.2 [-37.6, -14.9]	11.0 [5.2, 16.8]	6.0 [-2.5, 14.5]	-19.3 [-30.7, -8.0]	76.2
Serbia (b)	-37.0 [-50.7, -23.3]	-33.3 [-45.7, -21.0]	-0.40 [-0.55, -0.25]	-38.7 [-55.8, -21.5]	-1.5 [-8.9, 5.8]	-6.5 [-19.0, 6.0]	-28.5 [-39.2, -17.8]	83.6
Slovak Republic	-40.6 [-51.9, -29.4]	-25.4 [-35.5, -15.3]	-0.33 [-0.47, -0.20]	-37.1 [-51.7, -22.5]	-1.0 [-7.5, 5.5]	-5.3 [-14.0, 3.3]	-17.3 [-26.1, -8.5]	76.1
Slovenia (b)	-20.4 [-29.5, -11.4]	-20.5 [-29.2, -11.7]	-0.27 [-0.38, -0.15]	-22.5 [-35.5, -9.6]	-5.9 [-13.6, 1.9]	-11.8 [-22.5, -1.2]	-16.5 [-24.9, -8.1]	76.3
Spain (b)	-18.6 [-25.7, -11.5]	-18.4 [-24.6, -12.1]	-0.24 [-0.32, -0.16]	–	-2.9 [-8.1, 2.3]	–	-17.4 [-22.9, -12.0]	76.4
Sweden (b)	-38.3 [-55.9, -20.7]	-26.9 [-44.0, -9.8]	-0.35 [-0.56, -0.13]	-48.4 [-74.9, -21.8]	5.2 [-3.2, 13.5]	-3.2 [-17.3, 10.9]	-24.8 [-40.3, -9.3]	77.8
Uruguay (a)	-45.7 [-57.4, -33.9]	-36.3 [-47.3, -25.2]	-0.39 [-0.50, -0.27]	-42.0 [-56.9, -27.2]	-0.2 [-8.9, 8.6]	-4.0 [-14.6, 6.5]	-30.9 [-41.9, -19.8]	93.8

Score points unless marked as SD units. Model 1 adjusts for socioeconomic background, gender, home language, and immigrant background; the within-school model also removes school means. Standard errors combine jackknife sampling variance and imputation variance. A dash means the CT assessment was not administered. Standard errors for every model are given in Additional file 2.

Table S6. Pooled results under alternative synthesis methods

Contrast	k	DerSimonian-Laird [95% CI]	tau2 (DL)	I2 (%)	Q (df), p	REML [95% CI]	tau2 (REML)	Modified Hartung-Knapp 95% CI	95% prediction interval
CIL, inclusive vs exempt, Model 0	28	-29.8 [-34.3, -25.4]	106.0	78.1	123.4 (27), < .001	-29.9 [-34.5, -25.4]	112.8	[-34.6, -25.1]	[-51.5, -8.2]
CIL, inclusive vs exempt, Model 1	28	-24.7 [-28.1, -21.4]	50.6	66.9	81.5 (27), < .001	-24.8 [-28.2, -21.4]	54.0	[-28.3, -21.1]	[-39.8, -9.7]
CIL, inclusive vs exempt, SD units	28	-0.30 [-0.34, -0.26]	0.0079	68.2	85.0 (27), < .001	-0.30 [-0.34, -0.26]	0.0074	[-0.34, -0.26]	[-0.49, -0.11]
CT, inclusive vs exempt	19	-32.9 [-38.1, -27.7]	72.2	58.5	43.3 (18), < .001	-33.0 [-38.3, -27.7]	76.7	[-38.6, -27.3]	[-51.7, -14.1]
CT, inclusive vs exempt, SD units	19	-0.31 [-0.35, -0.26]	0.0034	41.4	30.7 (18), .031	-0.31 [-0.35, -0.26]	0.0035	[-0.35, -0.26]	[-0.44, -0.18]
CIL, no limit vs exempt	28	-0.6 [-3.4, 2.1]	40.4	76.1	112.7 (27), < .001	-0.6 [-3.5, 2.2]	43.1	[-3.6, 2.3]	[-14.0, 12.8]
CT, no limit vs exempt	19	-7.1 [-10.1, -4.1]	18.3	44.1	32.2 (18), .021	-7.1 [-10.1, -4.1]	19.7	[-10.3, -3.9]	[-16.7, 2.5]
CIL, inclusive vs no limit	28	-25.2 [-29.9, -20.5]	132.0	85.3	183.2 (27), < .001	-25.1 [-29.5, -20.7]	111.8	[-30.1, -20.3]	[-49.3, -1.1]
Learning outside school (SD units)	28	-0.08 [-0.10, -0.06]	0.0000	0.0	20.6 (27), .803	-0.08 [-0.10, -0.06]	0.0000	[-0.10, -0.05]	[-0.10, -0.05]
Learning at school (SD units)	28	-0.02 [-0.05, 0.02]	0.0040	52.5	56.9 (27), < .001	-0.02 [-0.05, 0.02]	0.0041	[-0.05, 0.02]	[-0.15, 0.12]
Outside minus at school (SD units)	28	-0.05 [-0.08, -0.03]	0.0002	3.5	28.0 (27), .413	-0.06 [-0.09, -0.03]	0.0013	[-0.08, -0.03]	[-0.09, -0.02]
CIL, any limit vs no limit (binary)	28	-8.2 [-11.3, -5.0]	60.0	85.2	182.4 (27), < .001	-8.2 [-11.4, -4.9]	63.3	[-11.5, -4.8]	[-24.4, 8.1]
CIL, any limit vs no limit, unadjusted	28	-6.2 [-10.1, -2.3]	95.4	89.0	246.1 (27), < .001	-6.2 [-10.3, -2.2]	103.3	[-10.4, -2.0]	[-26.7, 14.3]

DL = DerSimonian-Laird; REML = restricted maximum likelihood. The modified Hartung-Knapp interval uses the t distribution with k - 1 degrees of freedom and a variance correction factor of at least 1 (Roever et al., 2015). The prediction interval is based on the DL estimates and the t distribution with k - 2 degrees of freedom.

Table S7a. Equivalence of no limit and exempt limits in CIL at three margins

Margin (points)	95% CI of pooled estimate inside	95% PI inside	All leave-one-out CIs inside	Systems with 95% CI inside
±5	yes	no	yes	1 of 28
±10	yes	no	yes	11 of 28
±15	yes	yes	yes	20 of 28

Pooled difference −0.6 [−3.4, 2.1]; 95% prediction interval [−14.0, 12.8]. Equivalence refers to the pooled average only.

Table S7b. Leave-one-out pooled estimates (CIL)

System left out	Inclusive vs exempt [95% CI]	No limit vs exempt [95% CI]
Austria	−25.1 [−28.6, −21.6]	−0.7 [−3.6, 2.1]
Azerbaijan	−24.9 [−28.3, −21.4]	−0.7 [−3.5, 2.1]
Bosnia and Herzegovina	−24.3 [−27.6, −21.0]	−0.5 [−3.4, 2.3]
Chinese Taipei	−25.2 [−28.6, −21.8]	−0.3 [−3.0, 2.5]
Croatia	−24.4 [−27.8, −21.1]	−0.6 [−3.4, 2.3]
Cyprus	−24.7 [−28.1, −21.2]	−0.8 [−3.6, 2.1]
Czech Republic	−25.0 [−28.6, −21.5]	−0.6 [−3.6, 2.4]
Denmark	−24.5 [−27.9, −21.2]	−0.4 [−3.3, 2.4]
Finland	−24.2 [−27.5, −20.9]	−0.3 [−3.0, 2.5]
France	−25.3 [−28.6, −22.0]	−0.6 [−3.5, 2.3]
Greece	−24.8 [−28.2, −21.3]	−0.5 [−3.4, 2.3]
Hungary	−24.9 [−28.3, −21.4]	−0.8 [−3.6, 2.1]
Italy	−25.0 [−28.5, −21.5]	−0.7 [−3.6, 2.2]
Kazakhstan	−24.8 [−28.3, −21.3]	−1.7 [−3.9, 0.5]
Korea, Republic of	−24.5 [−27.9, −21.1]	−0.2 [−3.0, 2.5]
Kosovo	−25.1 [−28.6, −21.7]	−0.8 [−3.6, 2.1]
Latvia	−24.7 [−28.1, −21.3]	−0.7 [−3.5, 2.2]
Luxembourg	−24.4 [−27.8, −21.0]	−0.8 [−3.7, 2.1]
Malta	−24.3 [−27.6, −21.0]	−0.7 [−3.5, 2.2]
Norway (grade 9)	−23.9 [−27.1, −20.8]	−0.3 [−3.2, 2.5]
Oman	−25.3 [−28.5, −22.1]	−0.2 [−3.0, 2.5]
Portugal	−24.8 [−28.3, −21.4]	−1.1 [−3.8, 1.5]
Serbia	−24.4 [−27.8, −21.0]	−0.6 [−3.5, 2.3]

System left out	Inclusive vs exempt [95% CI]	No limit vs exempt [95% CI]
Slovak Republic	-24.7 [-28.2, -21.3]	-0.6 [-3.5, 2.3]
Slovenia	-25.0 [-28.4, -21.5]	-0.4 [-3.3, 2.4]
Spain	-25.1 [-28.6, -21.6]	-0.5 [-3.4, 2.4]
Sweden	-24.7 [-28.1, -21.3]	-0.8 [-3.7, 2.0]
Uruguay	-24.2 [-27.6, -20.9]	-0.6 [-3.5, 2.2]

Each row gives the DerSimonian-Laird pooled estimate for the remaining 27 systems.

Table S8. Weighting for item nonresponse: diagnostics by education system

System	Item response (%)	Item response, weighted (%)	CIL, respondents	CIL, nonrespondents	Min. propensity	Weight, 95th pct.	Weight, max.	Max. SMD before	Max. SMD after	Reweight estimate	Reweight, trimmed
Austria	91.9	91.7	511	448	0.225	1.11	4.13	0.096	0.041	-19.7 [-29.6, -9.7]	-18.0 [-27.0, -9.1]
Azerbaijan	77.8	76.4	332	275	0.210	1.18	3.89	0.210	0.128	-22.5 [-34.5, -10.5]	-21.8 [-33.8, -9.8]
Bosnia and Herzegovina	89.4	89.4	446	388	0.566	1.11	1.60	0.102	0.052	-42.0 [-58.6, -25.3]	-41.8 [-58.6, -25.1]
Chinese Taipei	93.2	93.5	521	438	0.334	1.13	2.80	0.074	0.016	-15.6 [-23.5, -7.8]	-15.6 [-23.4, -7.8]
Croatia	90.8	90.6	495	404	0.279	1.11	3.32	0.118	0.066	-35.5 [-49.7, -21.3]	-35.0 [-49.0, -20.9]
Cyprus	88.2	88.3	468	404	0.291	1.08	3.10	0.127	0.076	-26.3 [-38.8, -13.9]	-26.8 [-38.8, -14.7]
Czech Republic	94.1	93.7	529	472	0.387	1.09	2.44	0.065	0.020	-21.6 [-29.1, -14.2]	-20.8 [-27.8, -13.7]
Denmark	90.3	90.1	524	465	0.471	1.10	1.97	0.122	0.080	-34.7 [-53.0, -16.5]	-34.7 [-52.9, -16.5]
Finland	92.5	92.5	515	409	0.268	1.12	3.52	0.119	0.064	-44.0 [-59.4, -28.7]	-43.5 [-58.5, -28.5]
France	88.4	88.0	505	442	0.209	1.18	4.28	0.133	0.041	-14.3 [-22.5, -6.1]	-13.2 [-21.0, -5.4]
Greece	91.1	90.8	466	401	0.105	1.10	8.74	0.083	0.029	-28.4 [-39.4, -17.4]	-25.4 [-35.0, -15.8]
Hungary	94.3	93.5	509	445	0.482	1.07	1.98	0.061	0.030	-22.8 [-33.7, -11.9]	-22.8 [-33.7, -11.8]
Italy	90.6	90.4	494	457	0.587	1.08	1.55	0.071	0.034	-19.3 [-28.6, -10.0]	-19.4 [-28.6, -10.1]
Kazakhstan	90.1	89.8	412	364	0.374	1.13	2.42	0.079	0.020	-25.1 [-32.9, -17.2]	-24.9 [-32.7, -17.1]
Korea, Republic of	95.1	95.1	544	466	0.231	1.06	4.16	0.058	0.031	-30.7 [-41.5, -19.9]	-31.2 [-42.0, -20.3]

System	Item response (%)	Item response, weighted (%)	CIL, respondents	CIL, nonrespondents	Min. propensity	Weight, 95th pct.	Weight, max.	Max. SMD before	Max. SMD after	Reweight estimate	Reweight, trimmed
Kosovo	82.9	82.6	364	314	0.163	1.15	5.17	0.146	0.067	-16.5 [-25.9, -7.1]	-16.1 [-25.4, -6.9]
Latvia	91.9	92.0	513	461	0.367	1.08	2.54	0.074	0.035	-31.1 [-48.0, -14.3]	-29.6 [-46.2, -13.1]
Luxembourg	86.5	87.1	502	441	0.230	1.15	3.83	0.124	0.052	-32.9 [-43.2, -22.7]	-32.5 [-42.6, -22.4]
Malta	89.0	87.5	487	391	0.261	1.12	3.50	0.153	0.090	-40.3 [-56.8, -23.9]	-38.8 [-53.7, -24.0]
Norway (grade 9)	89.5	89.8	511	425	0.109	1.12	8.41	0.147	0.082	-52.8 [-70.1, -35.4]	-50.0 [-65.4, -34.6]
Oman	88.5	88.3	385	337	0.129	1.05	6.99	0.123	0.091	-9.5 [-16.7, -2.4]	-9.0 [-15.9, -2.0]
Portugal	90.6	90.4	516	455	0.278	1.12	3.29	0.090	0.034	-25.2 [-36.8, -13.6]	-24.4 [-36.0, -12.8]
Serbia	90.4	89.9	451	375	0.281	1.10	3.32	0.189	0.140	-33.6 [-46.5, -20.7]	-33.6 [-46.3, -20.9]
Slovak Republic	92.8	92.6	503	439	0.254	1.10	3.67	0.111	0.066	-25.2 [-35.8, -14.6]	-25.7 [-36.0, -15.4]
Slovenia	90.3	90.4	491	416	0.426	1.14	2.16	0.124	0.065	-21.7 [-31.0, -12.5]	-21.3 [-30.4, -12.2]
Spain	90.2	90.2	502	434	0.207	1.12	4.43	0.121	0.066	-18.8 [-25.5, -12.2]	-18.7 [-25.3, -12.1]
Sweden	91.1	91.1	512	420	0.183	1.12	5.16	0.141	0.086	-27.3 [-45.2, -9.4]	-28.0 [-45.8, -10.2]
Uruguay	81.9	82.6	459	392	0.250	1.20	3.32	0.157	0.056	-37.5 [-48.7, -26.2]	-37.7 [-49.0, -26.5]

CIL means are weighted means over the five plausible values. Weights are the normalized inverse-propensity factors (mean 1 in the analytic sample). SMD = largest absolute standardized mean difference between the analytic sample and all students across the response-model predictors. Estimates are inclusive minus exempt, Model 1, score points.

Table S9. Learning of internet-related tasks outside and at school, by education system (within-system SD units)

System	n	Outside, inclusive vs exempt	At school, inclusive vs exempt	Outside minus at school	Outside, no limit vs exempt	At school, no limit vs exempt	r (outside, at school)
Austria	2850	-0.09 [-0.21, 0.03]	0.00 [-0.14, 0.14]	-0.09 [-0.26, 0.08]	0.05 [-0.05, 0.15]	-0.09 [-0.20, 0.02]	0.16
Azerbaijan	2079	-0.06 [-0.16, 0.05]	0.08 [-0.04, 0.20]	-0.14 [-0.30, 0.02]	0.10 [-0.04, 0.23]	0.07 [-0.06, 0.19]	0.24
Bosnia and Herzegovina	1396	-0.14 [-0.31, 0.03]	0.05 [-0.14, 0.25]	-0.19 [-0.41, 0.02]	0.13 [-0.01, 0.27]	-0.04 [-0.17, 0.08]	0.23
Chinese Taipei	4673	-0.05 [-0.15, 0.06]	-0.10 [-0.20, 0.00]	0.05 [-0.01, 0.11]	0.06 [-0.03, 0.14]	0.03 [-0.06, 0.11]	0.69
Croatia	2413	-0.01 [-0.18, 0.16]	0.07 [-0.06, 0.21]	-0.08 [-0.27, 0.10]	0.09 [0.01, 0.18]	-0.03 [-0.12, 0.07]	0.29
Cyprus	2342	-0.10 [-0.22, 0.02]	-0.01 [-0.14, 0.13]	-0.09 [-0.21, 0.03]	0.07 [-0.03, 0.16]	-0.02 [-0.13, 0.09]	0.40
Czech Republic	7415	-0.10 [-0.21, 0.00]	-0.12 [-0.21, -0.03]	0.02 [-0.11, 0.15]	0.11 [0.04, 0.18]	-0.06 [-0.12, 0.00]	0.27
Denmark	2552	-0.03 [-0.27, 0.21]	-0.05 [-0.26, 0.16]	0.02 [-0.29, 0.34]	-0.02 [-0.12, 0.08]	-0.12 [-0.22, -0.02]	0.11
Finland	3719	-0.08 [-0.27, 0.11]	0.06 [-0.11, 0.23]	-0.14 [-0.36, 0.09]	0.05 [-0.02, 0.13]	-0.10 [-0.19, -0.02]	0.23
France	2914	-0.09 [-0.19, 0.02]	0.00 [-0.12, 0.11]	-0.08 [-0.24, 0.07]	0.01 [-0.07, 0.10]	-0.10 [-0.20, -0.01]	0.12
Greece	2984	-0.08 [-0.17, 0.00]	-0.05 [-0.15, 0.06]	-0.04 [-0.15, 0.07]	0.04 [-0.02, 0.10]	-0.11 [-0.20, -0.03]	0.39
Hungary	3212	-0.11 [-0.27, 0.05]	-0.12 [-0.23, -0.01]	0.01 [-0.16, 0.17]	0.10 [0.00, 0.19]	-0.11 [-0.19, -0.04]	0.12
Italy	2922	-0.05 [-0.16, 0.06]	-0.02 [-0.14, 0.11]	-0.03 [-0.18, 0.12]	0.06 [-0.04, 0.15]	-0.12 [-0.22, -0.02]	0.12
Kazakhstan	3978	-0.04 [-0.15, 0.06]	0.08 [-0.02, 0.18]	-0.12 [-0.22, -0.02]	0.19 [0.10, 0.28]	0.11 [0.02, 0.19]	0.53
Korea, Republic of	3436	0.00 [-0.12, 0.13]	0.13 [-0.01, 0.27]	-0.12 [-0.24, 0.00]	0.03 [-0.04, 0.10]	-0.02 [-0.10, 0.07]	0.47
Kosovo	2191	-0.08 [-0.17, 0.01]	0.08 [-0.01, 0.17]	-0.16 [-0.28, -0.04]	0.12 [-0.01, 0.24]	-0.01 [-0.13, 0.11]	0.19
Latvia	1802	-0.15 [-0.35, 0.05]	-0.11 [-0.30, 0.08]	-0.04 [-0.18, 0.10]	0.13 [0.00, 0.26]	0.06 [-0.08, 0.20]	0.59
Luxembourg	3475	-0.21 [-0.32, -0.10]	-0.18 [-0.28, -0.07]	-0.03 [-0.16, 0.09]	-0.03 [-0.11, 0.05]	-0.07 [-0.15, 0.00]	0.31
Malta	2329	-0.14 [-0.29, 0.01]	-0.09 [-0.23, 0.05]	-0.05 [-0.22, 0.11]	0.13 [0.02, 0.23]	-0.11 [-0.20, -0.02]	0.33
Norway (grade 9)	3639	-0.16 [-0.31, -0.01]	-0.11 [-0.26, 0.04]	-0.05 [-0.23, 0.12]	-0.02 [-0.10, 0.06]	-0.09 [-0.17, -0.01]	0.46
Oman	4919	-0.02 [-0.10, 0.05]	0.02 [-0.05, 0.09]	-0.04 [-0.13, 0.05]	0.05 [-0.05, 0.16]	-0.02 [-0.09, 0.06]	0.25
Portugal	3168	0.01 [-0.11, 0.14]	0.10 [-0.02, 0.22]	-0.09 [-0.25, 0.07]	0.06 [-0.01, 0.14]	-0.11 [-0.20, -0.03]	0.08

System	n	Outside, inclusive vs exempt	At school, inclusive vs exempt	Outside minus at school	Outside, no limit vs exempt	At school, no limit vs exempt	r (outside, at school)
Serbia	2330	-0.16 [-0.30, -0.03]	-0.17 [-0.30, -0.04]	0.01 [-0.15, 0.16]	0.11 [0.01, 0.21]	-0.14 [-0.25, -0.04]	0.23
Slovak Republic	2630	0.00 [-0.12, 0.13]	0.04 [-0.07, 0.15]	-0.04 [-0.17, 0.10]	0.12 [0.04, 0.19]	0.02 [-0.07, 0.12]	0.28
Slovenia	2700	-0.12 [-0.23, -0.02]	0.06 [-0.05, 0.17]	-0.18 [-0.34, -0.02]	0.07 [-0.01, 0.15]	-0.05 [-0.14, 0.04]	-0.03
Spain	9606	-0.07 [-0.18, 0.03]	0.00 [-0.10, 0.10]	-0.07 [-0.18, 0.03]	0.07 [0.00, 0.15]	-0.05 [-0.13, 0.02]	0.23
Sweden	2592	-0.13 [-0.31, 0.06]	-0.17 [-0.36, 0.02]	0.04 [-0.20, 0.28]	-0.11 [-0.21, -0.02]	-0.14 [-0.27, -0.02]	0.39
Uruguay	2054	-0.13 [-0.28, 0.02]	-0.01 [-0.14, 0.12]	-0.12 [-0.28, 0.05]	0.06 [-0.06, 0.17]	-0.02 [-0.13, 0.10]	0.34

Each scale was standardized within the system (weighted mean 0, SD 1) among students with both scales. Model 1 covariates. The difference column was computed in the full and replicate samples, so its standard error accounts for the correlation between the scales. The two scales were calibrated separately; the comparison is between standardized associations, not levels of learning.

Table S10. Sensitivity to unmeasured confounding, by education system (CIL, inclusive vs exempt)

System	R ² Y~D X (%)	RV (%)	R ² D~SES (%)	R ² Y~SES (%)	R ² D needed if R ² Y = 20% (%)	R ² D needed if R ² Y = 40% (%)	Estimate	Adjusted, k = 1	Adjusted, k = 2	Adjusted, k = 3	RV, Model 3 (%)	R ² D~expect. (%)	R ² Y~expect. (%)
Austria	0.48	6.7	0.12	11.0	2.4	1.2	-16.9	-14.0	-11.1	-8.1	5.5	0.13	5.7
Azerbaijan	0.92	9.1	0.16	8.3	4.4	2.3	-21.0	-18.4	-15.7	-13.0	8.9	0.03	3.7
Bosnia and Herzegovina	2.01	13.3	0.51	10.1	9.3	4.9	-40.6	-33.7	-26.9	-20.0	12.8	0.18	8.7
Chinese Taipei	0.47	6.7	0.19	8.6	2.3	1.2	-15.0	-12.1	-9.1	-6.1	6.7	0.00	3.0
Croatia	1.29	10.8	0.08	4.6	6.1	3.2	-33.4	-31.6	-29.8	-27.9	10.4	0.02	1.0
Cyprus	0.89	9.0	0.80	13.3	4.3	2.2	-26.8	-16.7	-6.5	3.8	7.9	0.25	7.5
Czech Republic	0.77	8.4	0.02	11.9	3.7	1.9	-19.8	-18.7	-17.7	-16.6	7.3	0.21	5.9
Denmark	0.92	9.2	0.37	8.1	4.4	2.3	-33.3	-27.0	-20.7	-14.3	8.4	0.21	3.8
Finland	1.42	11.3	0.16	8.0	6.7	3.5	-40.5	-36.6	-32.6	-28.6	11.5	0.00	4.6
France	0.37	5.9	0.03	12.1	1.8	0.9	-11.7	-10.4	-9.1	-7.7	4.5	0.42	5.8
Greece	1.19	10.4	0.42	8.4	5.7	2.9	-24.8	-20.4	-15.9	-11.3	9.7	0.15	10.1
Hungary	0.75	8.3	0.36	23.0	3.6	1.8	-21.9	-13.5	-5.1	3.3	8.9	0.01	8.2
Italy	0.80	8.5	0.00	7.9	3.9	2.0	-19.1	-18.9	-18.6	-18.3	8.2	0.07	3.5
Kazakhstan	1.00	9.6	0.14	6.4	4.8	2.5	-24.5	-22.1	-19.7	-17.3	9.3	0.01	3.5
Korea, Republic of	1.00	9.5	0.10	4.6	4.8	2.5	-31.0	-28.9	-26.8	-24.7	8.7	0.26	3.7
Kosovo	0.53	7.0	0.12	11.0	2.6	1.3	-15.2	-12.6	-10.0	-7.4	7.6	0.02	5.9
Latvia	1.04	9.7	0.00	6.4	5.0	2.6	-28.3	-27.8	-27.3	-26.9	10.2	0.05	4.8
Luxembourg	1.81	12.7	0.26	17.7	8.4	4.4	-32.0	-26.4	-20.7	-15.0	12.0	0.24	4.4
Malta	1.53	11.7	0.23	10.5	7.2	3.7	-37.7	-32.7	-27.8	-22.8	10.5	0.42	5.4
Norway (grade 9)	2.34	14.3	0.68	6.7	10.7	5.6	-48.1	-41.1	-34.1	-27.0	13.3	0.54	5.1

System	R2 Y~D X (%)	RV (%)	R2 D~SES (%)	R2 Y~SES (%)	R2 D needed if R2 Y = 20% (%)	R2 D needed if R2 Y = 40% (%)	Estimate	Adjusted, k = 1	Adjusted, k = 2	Adjusted, k = 3	RV, Model 3 (%)	R2 D~expect. (%)	R2 Y~expect. (%)
Oman	0.18	4.1	0.04	5.3	0.9	0.4	-9.1	-8.0	-7.0	-5.9	4.1	0.01	5.1
Portugal	0.93	9.2	0.19	12.3	4.5	2.3	-23.1	-19.1	-15.2	-11.2	7.9	0.30	5.6
Serbia	1.40	11.2	0.14	10.6	6.6	3.4	-33.3	-29.7	-26.1	-22.4	9.6	0.58	7.7
Slovak Republic	1.44	11.4	1.19	15.0	6.8	3.5	-25.4	-15.5	-5.5	4.7	9.9	0.32	5.4
Slovenia	1.01	9.6	0.00	6.1	4.9	2.5	-20.5	-20.1	-19.7	-19.4	7.7	0.75	6.6
Spain	0.84	8.8	0.00	9.2	4.1	2.1	-18.4	-18.2	-18.0	-17.9	7.5	0.31	4.9
Sweden	0.65	7.8	0.49	10.7	3.2	1.6	-26.9	-18.8	-10.6	-2.4	7.8	0.01	6.5
Uruguay	1.95	13.1	0.97	12.6	9.0	4.7	-36.3	-26.5	-16.6	-6.6	12.0	0.01	4.7
Median	1.0	9.4		9.6	4.6	2.4					8.8		5.2

D = inclusive-limit indicator; Y = CIL; X = other regressors of Model 1. R2 values are partial R-squared values in percent, computed in the weighted metric for each plausible value and averaged. RV = robustness value (share of residual variance of both D and Y that an omitted variable must explain to reduce the estimate to zero). SES = international socioeconomic index, as a benchmark covariate given the other covariates. 'Adjusted, k' = bias-adjusted estimate for an omitted variable k times as strong as SES in its partial R2 with D and with Y. The last three columns use educational expectations as the benchmark within Model 3. The median of R2 D~SES is 0.2%.

Table S11. Meta-regressions of system-level estimates (exploratory)

Outcome and moderator	k	Slope [95% CI]	p	R2 (%)
CIL gap (SD units) on % inclusive	28	0.0073 [0.0045, 0.0100]	< .001	78
CT gap (SD units) on % inclusive	19	0.0129 [0.0049, 0.0209]	.003	69
Within-school CIL gap (points) on % inclusive	28	0.577 [0.277, 0.877]	< .001	52
CIL gap (SD units) on % daily digital schoolwork at home	28	0.0009 [−0.0032, 0.0049]	.667	0
CIL gap (SD units) on system mean CIL	28	−0.00089 [−0.00164, −0.00014]	.021	25
CIL gap (points) on % inclusive	28	0.499 [0.193, 0.804]	.002	40
CIL gap (points) on % daily digital schoolwork at home	28	0.079 [−0.255, 0.413]	.629	0
CIL gap (points) on system mean CIL	28	−0.042 [−0.113, 0.028]	.229	2
Binary coefficient (points) on % inclusive among limits	28	−0.273 [−0.621, 0.074]	.118	6
No limit vs exempt (points) on % no limit	28	0.007 [−0.220, 0.234]	.950	0
CIL gap (SD) on % inclusive, adjusting for system mean CIL	28	0.0150 [0.0105, 0.0194]	< .001	100
CIL gap (SD) on % inclusive, adjusting for % daily digital schoolwork	28	0.0073 [0.0044, 0.0102]	< .001	75
CIL gap (SD) on % inclusive, without the four systems above 24%	24	0.0128 [0.0054, 0.0201]	.002	62
CIL gap (SD) on % inclusive, without the four Nordic systems	24	0.0062 [0.0036, 0.0088]	< .001	
CIL gap (SD) on % inclusive, without both groups of four	20	0.0085 [0.0001, 0.0170]	.048	

Random-effects meta-regression with restricted maximum likelihood and the Knapp-Hartung adjustment (metafor). For the models with two moderators, the slope for the percentage of inclusive limits is shown. Slopes for percentages are per percentage point. The four systems above 24% are Azerbaijan, Kazakhstan, Kosovo, and Oman; the four Nordic systems are Denmark, Finland, Norway, and Sweden. These analyses were not planned before the data were examined.

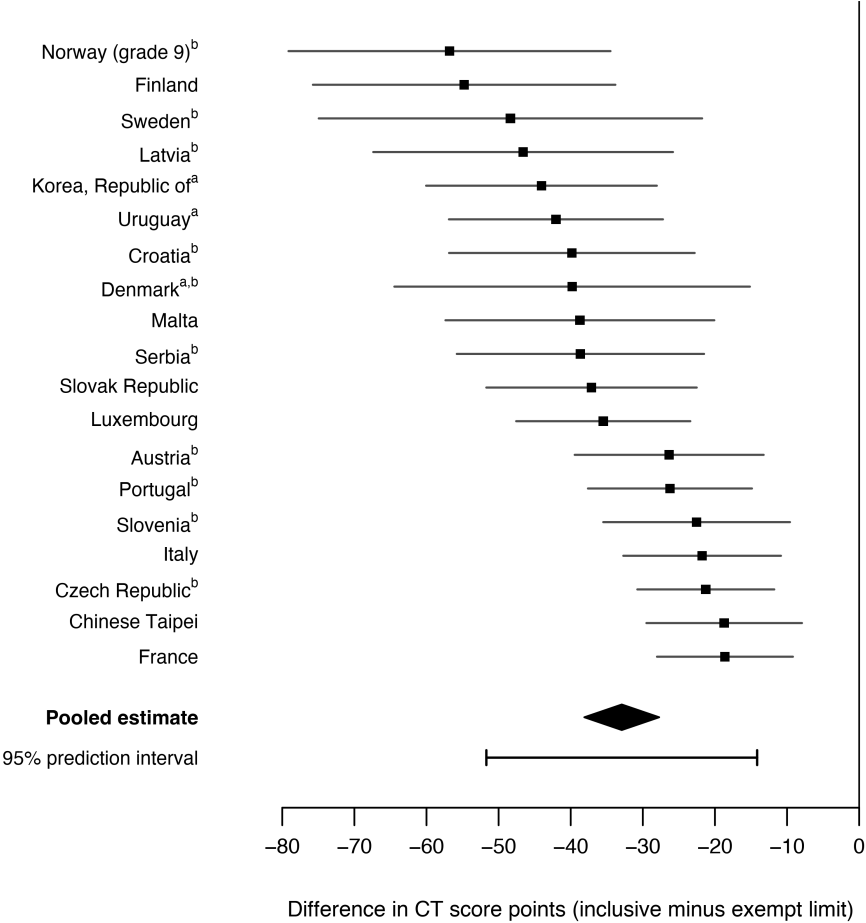
Table S12. Limit versus no-limit comparison and its relation to the three rule types (CIL)

System	Any limit vs no limit, unadjusted	Any limit vs no limit, adjusted	% inclusive among limits	Implied: share x gap minus no-limit diff.	Binary estimate	Report replication (all respondents)
Austria	-4.5 [-10.5, 1.4]	-8.2 [-14.3, -2.0]	36.6	-8.10	-8.17	-4.9 [-10.9, 1.1]
Azerbaijan	-21.9 [-34.6, -9.2]	-15.2 [-27.1, -3.4]	57.3	-15.34	-15.24	-19.8 [-32.1, -7.5]
Bosnia and Herzegovina	-12.5 [-23.2, -1.8]	-10.6 [-20.3, -1.0]	36.4	-10.72	-10.64	-15.7 [-27.0, -4.4]
Chinese Taipei	13.3 [7.9, 18.7]	3.6 [-1.2, 8.3]	38.6	3.43	3.55	12.8 [7.3, 18.3]
Croatia	-8.0 [-18.7, 2.8]	-7.8 [-17.6, 2.1]	31.6	-7.80	-7.77	-8.0 [-18.6, 2.7]
Cyprus	-11.0 [-20.8, -1.1]	-13.2 [-21.8, -4.7]	34.4	-13.20	-13.25	-13.5 [-22.5, -4.5]
Czech Republic	-2.0 [-5.4, 1.4]	-5.2 [-8.6, -1.7]	29.3	-5.12	-5.16	-2.4 [-5.8, 1.0]
Denmark	1.1 [-7.5, 9.7]	0.5 [-7.5, 8.6]	16.8	0.54	0.54	-2.5 [-11.3, 6.4]
Finland	2.8 [-5.1, 10.7]	1.0 [-5.7, 7.8]	23.1	0.99	1.04	1.2 [-7.1, 9.5]
France	4.8 [-0.5, 10.1]	-3.2 [-8.1, 1.7]	36.8	-3.20	-3.23	3.2 [-2.0, 8.4]
Greece	-5.2 [-11.7, 1.3]	-7.4 [-14.0, -0.8]	41.0	-7.38	-7.44	-5.9 [-12.2, 0.4]
Hungary	-6.9 [-14.8, 1.0]	-11.3 [-18.3, -4.3]	34.0	-11.22	-11.32	-7.9 [-15.9, 0.1]
Italy	-6.0 [-11.4, -0.6]	-7.9 [-13.1, -2.6]	36.3	-7.86	-7.87	-8.0 [-13.5, -2.5]
Kazakhstan	-41.3 [-48.6, -34.0]	-39.1 [-45.9, -32.3]	52.9	-39.11	-39.12	-41.3 [-48.7, -33.9]
Korea, Republic of	1.8 [-4.1, 7.7]	-0.1 [-6.0, 5.8]	34.7	-0.15	-0.08	1.6 [-4.1, 7.3]
Kosovo	-13.7 [-25.8, -1.6]	-12.5 [-24.1, -1.0]	53.6	-12.52	-12.52	-14.0 [-26.0, -2.1]
Latvia	-13.0 [-22.8, -3.2]	-11.1 [-20.4, -1.7]	35.4	-11.07	-11.08	-16.3 [-24.8, -7.8]
Luxembourg	-8.5 [-14.1, -2.9]	-14.7 [-19.5, -9.8]	34.3	-14.61	-14.68	-9.9 [-15.2, -4.6]
Malta	-9.3 [-18.4, -0.3]	-11.4 [-20.4, -2.3]	29.2	-11.30	-11.36	-15.1 [-23.1, -7.1]
Norway (grade 9)	-0.2 [-6.9, 6.6]	-2.0 [-8.6, 4.6]	19.9	-1.88	-1.98	-2.4 [-9.0, 4.2]
Oman	10.3 [2.9, 17.7]	6.1 [-0.7, 12.8]	56.9	6.06	6.05	10.4 [3.1, 17.7]
Portugal	-19.6 [-25.5, -13.6]	-17.6 [-23.1, -12.1]	28.8	-17.63	-17.60	-20.1 [-26.0, -14.1]

System	Any limit vs no limit, unadjusted	Any limit vs no limit, adjusted	% inclusive among limits	Implied: share x gap minus no-limit diff.	Binary estimate	Report replication (all respondents)
Serbia	-6.5 [-14.2, 1.1]	-8.8 [-16.0, -1.6]	30.8	-8.77	-8.82	-10.6 [-18.1, -3.1]
Slovak Republic	-4.0 [-10.8, 2.8]	-8.4 [-14.0, -2.7]	36.4	-8.23	-8.38	-5.3 [-12.4, 1.8]
Slovenia	3.5 [-3.1, 10.0]	-1.2 [-7.8, 5.4]	34.3	-1.14	-1.19	2.3 [-4.2, 8.8]
Spain	1.1 [-3.8, 6.0]	-3.1 [-7.7, 1.6]	32.6	-3.08	-3.05	1.3 [-3.6, 6.2]
Sweden	-13.5 [-22.0, -5.0]	-11.9 [-19.6, -4.1]	25.4	-12.00	-11.87	-15.2 [-23.4, -7.0]
Uruguay	-15.6 [-24.1, -7.1]	-14.3 [-22.1, -6.6]	39.8	-14.29	-14.32	-16.6 [-25.7, -7.5]
Romania (report sample only)						-19.1 [-28.9, -9.2]

Binary estimates compare students with any limit to students with no limit (reference), so negative values mean lower scores for students with a limit. 'Implied' = (share of inclusive limits among all limits) x (inclusive minus exempt, Model 1) minus (no limit minus exempt, Model 1); it matches the adjusted binary estimate closely (correlation 0.99997, mean absolute difference 0.06 points). The last column repeats the comparison of the international report: all students who answered the item, no covariates, 29 countries.

Figure S1. Difference in computational thinking between students with schoolwork-inclusive and schoolwork-exempt limits, by education system



Squares are adjusted differences (Model 1) in score points with 95% confidence intervals. The diamond is the random-effects pooled estimate (-32.9, 95% CI [-38.1, -27.7]), and the bar is the 95% prediction interval ([-51.7, -14.1]). Superscripts as in Table S4.

Reference cited in this file

Cinelli, C., & Hazlett, C. (2020). Making sense of sensitivity: Extending omitted variable bias. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, 82(1), 39-67. <https://doi.org/10.1111/rssb.12348>

Roever, C., Knapp, G., & Friede, T. (2015). Hartung-Knapp-Sidik-Jonkman approach and its modification for random-effects meta-analysis with few studies. *BMC Medical Research Methodology*, 15, Article 99. <https://doi.org/10.1186/s12874-015-0091-1>

Rožman, M., Holtmann, M., & Meinck, S. (2025). Students' engagement with information and communications technologies. In J. Fraillon (Ed.), *An international perspective on digital literacy: Results from ICILS 2023* (pp. 139-180). Springer. https://doi.org/10.1007/978-3-031-87722-3_7