Statistical Appendix

Methodological documentation and statistical tables accompanying “Belonging Without Equal Opportunities? Social Capital and Learning in the Polish PISA Case”. Poland, 2025 assessment. Author: Piotr Mikiewicz. Translation of the appendix dated 5 November 2026; numerical results unchanged.

Detailed analytical procedures

File and scope. The source is the supplied PISA_2025_Polska.sav file: 7,103 students, 886 variables, CNTRYID = “616”, cycle CYC = “25MS”. Schools are identified by CNTSCHID. Comparisons of three pathways use PROGN = 616002, 616003 and 616004. Primary schools and the fine arts secondary school are excluded from these comparisons. Descriptive analyses and support models use the entire Polish file after excluding missing values on the relevant variables.

Missing values and denominators. Missing-value codes declared in the file dictionary were converted to missing before analysis. Percentages refer to valid responses to each item, not all 7,103 students. N is the actual unweighted number of observations used, not the sum of weights. Questionnaire missing values were not imputed. Their exclusion may alter the composition of analytical samples.

Weighting. Point estimates use W_FSTUWT. Each statistic was recalculated using W_FSTURWT1-W_FSTURWT80. Balanced repeated replication (BRR) with Fay adjustment f = 0.5 was applied: sampling variance is the sum of squared differences between replicate and full-sample estimates divided by $80 \times (1 - 0.5)^2 = 20$. This procedure also applies to analyses involving contextual variables only.

Proficiency and IRT. Test performance is represented by PV1SCIE-PV10SCIE. Statistics were calculated separately for each plausible value (PV) and each replicate. The final estimate is the mean across the ten PV estimates. Total variance is the mean sampling variance plus 1.1 times the between-PV variance, calculated with denominator 9. The standard error is the square root of this sum. The supplied IRT-scaled results were used; test-item responses were not rescaled.

Intervals and models. Approximate 95% confidence intervals (CIs) were calculated as estimate $\pm 1.96 \times$ SE, without adjustment for multiple comparisons. Regressions use weighted least squares. Reported b coefficients are unstandardised; in performance models, units are PISA points per unit of the predictor. R^2 is a weighted goodness-of-fit measure; for performance, R^2 was averaged across ten models. An increase in R^2 does not estimate a causal effect.

Correlations. Pearson correlations were weighted. For proficiency, correlations across ten PVs were combined; intervals were calculated without Fisher transformation. A near-zero correlation indicates a weak linear association and does not rule out a nonlinear relationship.

School level. School means of ESCS and the friendship item, and students’ deviations from these means, were recalculated separately for each replicate. Correlations between school means were weighted by sums of student weights. Separate principal or school weights were not used. Contextual models are weighted regressions separating between-school and within-school components, rather than random-effects models or causal peer-effects models. The sensitivity specification excludes schools with fewer than 20 complete observations.

Software. The SAV file was read in Python using pyreadstat; calculations used NumPy. Replicate weighting and pooling across PVs were implemented in analytical scripts; standard errors from ordinary SPSS procedures were not used.

Limitations. Prior achievement and school admissions processes were not controlled. No formal mediation, structural model or separate measurement model was estimated. Ordinal responses were treated linearly in regressions; models with separate response categories remain to be estimated. Measurement equivalence across school types was not established. School means are estimates based on sampled students, not exact descriptions of entire institutions.

Variables and analytical samples

Table 1. Main variables and coding

Variable	Definition and use
FAMSUP	Provided index of perceived family support; higher values indicate more support.
TEACHSUP	Provided index of perceived teacher support in science.
BELONG	Provided index of school belonging.
ESCS	Composite index of family economic, social and cultural status.
ST004D01T	Gender: 1 = girls, 2 = boys; models compare girls with boys.
IMMIG	1 = at least one parent born in the assessment country; 2 = second-generation immigrant; 3 = first-generation immigrant. Category 1 is the reference.
REPEAT	0 = no reported grade repetition; 1 = grade repetition.
PROGN	616002 = general secondary (LO); 616003 = technical secondary; 616004 = first-stage vocational.
ST034Q01TA–Q06TA	Six items on the social experience of school; descriptive tables retain the original response direction.
ST034 items in models	Items 2, 3 and 5: 5 minus response code; items 1, 4 and 6: unchanged. Higher values always indicate a more favourable experience.
FRIEND	5 minus ST034Q02TA; higher values indicate greater reported ease of making friends.
PV1SCIE–PV10SCIE	Ten plausible values for science proficiency.

The supplied database indices were used; no item average was constructed as a replacement for an OECD index. English item descriptions translate the working labels in the Polish appendix and are not presented as verbatim official questionnaire wording. The items used descriptively do not necessarily constitute the full set used in OECD scaling. Scales are not restricted to [-1; 1].

Sample sizes and comparability

Table 2. Main analytical sample sizes

Stage	N	Selection criterion
Polish student file	7 103	Entire supplied file
Family support	6 249	FAMSUP and complete controls, including REPEAT
Teacher support	6 450	TEACHSUP and complete controls, including REPEAT
Belonging models B0-B3	6 138	Complete data on all three indices and controls, including REPEAT
School type and FAMSUP	6 212	Common sample for unadjusted and adjusted models
School type and TEACHSUP	6 412	As above, for TEACHSUP
School type and BELONG	6 545	As above, for BELONG
Performance models M0-M3	6 102	Three pathways; complete indices, controls and PVs
Models for six ST034 items	5 921	Complete data on all six items and model variables
School context	6 508; 203 schools	Complete ESCS, FRIEND, controls and PVs
Restricted school-context sample	6 232; 182 schools	Schools with at least 20 complete observations
Performance models with REPEAT	6 091	Common M0-M3 sample excluding missing REPEAT

Descriptive school-type means use all available responses for each index. Models comparing school types instead use a common sample with complete controls. Their unadjusted values may therefore differ slightly from the descriptive means in the article. Tables distinguish these two bases of calculation.

Belonging models were compared on a fixed sample of 6,138 students with complete data including grade repetition; REPEAT was introduced only in B3. The shares of ESCS variation between school types and between individual schools come from different samples and should not be interpreted as one exact variance decomposition.

Appendix A. Data availability

Table 3. Availability of the main indices

Index	Valid N	Missing N	Mean (SE) and 95% CI	Minimum; maximum
FAMSUP	6 498	605	−0.039 (0.016) [−0.071; −0.007]	−2.593; 1.696
TEACHSUP	6 727	376	−0.563 (0.019) [−0.601; −0.525]	−2.712; 1.443
BELONG	6 877	226	−0.176 (0.011) [−0.199; −0.154]	−3.236; 2.757
ESCS	6 777	326	−0.072 (0.017) [−0.105; −0.039]	−5.523; 3.550

Means and SEs are weighted. Minimum and maximum are observed values after excluding missing-value codes. The national distribution need not have mean 0 or standard deviation 1.

Table 4. Availability of individual items

Code	Descriptive label	Valid N	Missing N
ST300Q01JA	Discussing how the student is doing at school	6 498	605
ST300Q10JA	Asking about the school day	6 487	616
ST300Q08JA	Interest in learning content	6 456	647
ST300Q05JA	Discussing problems at school	6 491	612
ST300Q09JA	Discussing future education	6 464	639
ST100Q05TA	Opportunity to express opinions	6 698	405
ST100Q03TA	Help with learning	6 709	394
ST100Q01TA	Interest in every student's learning	6 732	371
ST100Q04TA	Explaining until students understand	6 713	390
ST100Q02TA	Additional help when needed	6 718	385
ST034Q01TA	Feeling left out	6 841	262
ST034Q02TA	Ease of making friends	6 837	266
ST034Q03TA	Sense of belonging at school	6 817	286

Code	Descriptive label	Valid N	Missing N
ST034Q04TA	Feeling out of place	6 831	272
ST034Q05TA	Feeling liked by other students	6 827	276

Code	Descriptive label	Valid N	Missing N
ST034Q06TA	Feeling lonely	6 848	255

Appendix B. Perceived family support

Table 5. Full response distributions: family

Item	N	1	2	3	4	5
Discussing how the student is doing at school ST300Q01JA	6 498	7.8 (0.4)	6.5 (0.3)	9.2 (0.3)	23.4 (0.5)	53.0 (0.7)
Asking about the school day ST300Q10JA	6 487	9.4 (0.3)	6.6 (0.3)	9.7 (0.4)	18.2 (0.5)	56.1 (0.8)
Interest in learning content ST300Q08JA	6 456	12.0 (0.4)	10.3 (0.4)	16.9 (0.5)	24.8 (0.5)	36.0 (0.7)
Discussing problems at school ST300Q05JA	6 491	15.0 (0.5)	12.9 (0.5)	19.4 (0.5)	22.9 (0.6)	29.7 (0.6)
Discussing future education ST300Q09JA	6 464	10.9 (0.4)	15.9 (0.5)	26.2 (0.5)	21.2 (0.5)	25.8 (0.7)

Cells show valid percentages; parentheses contain SEs in percentage points. Denominators include substantive responses to each item. Percentages may not sum exactly to 100 because of rounding.

Categories: 1 = never or almost never; 2 = about once or twice a year; 3 = about once or twice a month; 4 = about once or twice a week; 5 = every day or almost every day.

Appendix C. Perceived teacher support

Table 6. Full response distributions: teachers

Item	N	1	2	3	4
Opportunity to express opinions ST100Q05TA	6 698	28.3 (0.8)	28.6 (0.6)	25.9 (0.5)	17.2 (0.6)
Help with learning ST100Q03TA	6 709	22.9 (0.7)	29.5 (0.6)	30.0 (0.6)	17.6 (0.6)
Interest in every student's learning ST100Q01TA	6 732	20.2 (0.6)	31.1 (0.5)	31.4 (0.6)	17.2 (0.6)
Explaining until students understand ST100Q04TA	6 713	23.3 (0.7)	25.2 (0.5)	29.9 (0.6)	21.7 (0.6)
Additional help when needed ST100Q02TA	6 718	17.9 (0.6)	23.1 (0.6)	31.0 (0.6)	28.0 (0.7)

Cells show valid percentages; parentheses contain SEs in percentage points. Denominators include substantive responses to each item. Percentages may not sum exactly to 100 because of rounding.

Categories: 1 = every lesson; 2 = most lessons; 3 = some lessons; 4 = never or almost never. Items refer to science lessons.

Appendix D. School belonging

Table 7. Full response distributions: belonging

Item	N	1	2	3	4
Feeling left out ST034Q01TA	6 841	5.7 (0.3)	13.1 (0.5)	54.0 (0.8)	27.2 (0.6)
Ease of making friends ST034Q02TA	6 837	19.8 (0.6)	54.4 (0.7)	19.1 (0.6)	6.7 (0.4)
Sense of belonging at school ST034Q03TA	6 817	10.9 (0.5)	52.7 (0.7)	26.9 (0.6)	9.6 (0.4)
Feeling out of place ST034Q04TA	6 831	5.9 (0.3)	13.7 (0.5)	50.7 (0.7)	29.7 (0.6)
Feeling liked by other students ST034Q05TA	6 827	13.6 (0.5)	59.1 (0.6)	20.7 (0.5)	6.6 (0.3)
Feeling lonely ST034Q06TA	6 848	4.9 (0.3)	10.5 (0.4)	43.1 (0.7)	41.5 (0.7)

Cells show valid percentages; parentheses contain SEs in percentage points. Denominators include substantive responses to each item. Percentages may not sum exactly to 100 because of rounding.

Categories: 1 = strongly agree; 2 = agree; 3 = disagree; 4 = strongly disagree. Original item direction is retained: agreement does not always indicate stronger belonging.

Appendix E. Family support (FAMSUP)

Table 8. Mean FAMSUP by student characteristics

Group	N	Mean	SE	Lower CI	Upper CI
ESCS: lowest quartile	1 475	−0.244	0.032	−0.306	−0.182
ESCS: second quartile	1 592	−0.043	0.030	−0.102	0.017
ESCS: third quartile	1 638	0.049	0.030	−0.011	0.109
ESCS: highest quartile	1 650	0.096	0.024	0.048	0.143
Girls	3 372	0.026	0.024	−0.022	0.073
Boys	3 126	−0.108	0.020	−0.147	−0.070
Migration: reference category	6 144	−0.028	0.017	−0.061	0.004
Migration: second generation	21	−0.705	0.297	−1.287	−0.124
Migration: first generation	148	0.100	0.081	−0.059	0.259
No grade repetition	5 985	−0.021	0.017	−0.054	0.011
Grade repetition	478	−0.189	0.052	−0.291	−0.087

CI = 95% confidence interval. Quartiles were defined from the weighted Polish ESCS distribution before analysing each index. Cut-offs: -0.802565, -0.084024, 0.661586. Sample sizes vary across indices; missing grouping values were not assigned to any category.

Appendix E. Teacher support (TEACHSUP)

Table 9. Mean TEACHSUP by student characteristics

Group	N	Mean	SE	Lower CI	Upper CI
ESCS: lowest quartile	1 552	−0.571	0.037	−0.643	−0.498
ESCS: second quartile	1 637	−0.589	0.030	−0.647	−0.530
ESCS: third quartile	1 675	−0.614	0.031	−0.673	−0.554
ESCS: highest quartile	1 701	−0.493	0.028	−0.549	−0.438
Girls	3 445	−0.605	0.024	−0.651	−0.559
Boys	3 282	−0.519	0.025	−0.569	−0.470
Migration: reference category	6 346	−0.573	0.020	−0.612	−0.534
Migration: second generation	21	−0.828	0.221	−1.262	−0.394
Migration: first generation	161	−0.317	0.060	−0.435	−0.199
No grade repetition	6 178	−0.566	0.020	−0.605	−0.527
Grade repetition	515	−0.538	0.047	−0.630	−0.446

CI = 95% confidence interval. Quartiles were defined from the weighted Polish ESCS distribution before analysing each index. Cut-offs: -0.802565, -0.084024, 0.661586. Sample sizes vary across indices; missing grouping values were not assigned to any category.

Appendix E. School belonging (BELONG)

Table 10. Mean BELONG by student characteristics

Group	N	Mean	SE	Lower CI	Upper CI
ESCS: lowest quartile	1 593	−0.238	0.023	−0.284	−0.193
ESCS: second quartile	1 692	−0.192	0.021	−0.234	−0.151
ESCS: third quartile	1 696	−0.172	0.020	−0.212	−0.132
ESCS: highest quartile	1 722	−0.086	0.022	−0.128	−0.044
Girls	3 488	−0.316	0.014	−0.344	−0.288
Boys	3 389	−0.035	0.017	−0.069	−0.001
Migration: reference category	6 483	−0.163	0.011	−0.186	−0.141
Migration: second generation	22	−0.355	0.160	−0.668	−0.042
Migration: first generation	164	−0.398	0.057	−0.509	−0.287
No grade repetition	6 305	−0.166	0.012	−0.189	−0.143
Grade repetition	541	−0.267	0.041	−0.348	−0.186

CI = 95% confidence interval. Quartiles were defined from the weighted Polish ESCS distribution before analysing each index. Cut-offs: -0.802565, -0.084024, 0.661586. Sample sizes vary across indices; missing grouping values were not assigned to any category.

Appendix F. Regular family contact

Table 11. Regular family contact by student characteristics

Group	Doing at school	School problems	Learning content	Future education	School day
ESCS: lowest quartile	67.0	46.5	51.8	40.6	64.5
ESCS: second quartile	75.9	52.9	60.8	46.6	75.1
ESCS: third quartile	81.6	55.4	64.5	48.5	78.3
ESCS: highest quartile	82.7	56.5	66.8	51.9	80.3
Girls	79.2	54.3	62.0	47.4	76.2
Boys	73.6	50.9	59.6	46.6	72.4
Migration: reference category	77.4	52.9	61.3	46.8	75.1
Migration: second generation	31.3	30.6	35.8	34.7	50.2
Migration: first generation	75.7	58.1	62.7	56.3	71.3
No grade repetition	77.5	53.2	61.5	47.4	75.2
Grade repetition	67.3	48.4	55.4	43.6	66.3

Percentage reporting “about once or twice a week” or “every day/almost every day”. Item order: ST300Q01JA, Q05JA, Q08JA, Q09JA, Q10JA. Each cell uses valid responses for the relevant item and group as its denominator; the FAMSUP N in the preceding tables is not automatically the N for each cell.

Appendix G. Models of perceived support

Table 12. Family and teacher support by student characteristics

Predictor	FAMSUP	TEACHSUP
Intercept	−0.082 (0.018) [−0.118; −0.046]	−0.535 (0.026) [−0.585; −0.484]
Family socioeconomic status (ESCS)	0.149 (0.016) [0.118; 0.180]	0.034 (0.019) [−0.004; 0.072]
Girls (reference: boys)	0.118 (0.028) [0.062; 0.174]	−0.083 (0.030) [−0.142; −0.024]
Migration: second generation	−0.709 (0.285) [−1.268; −0.150]	−0.290 (0.234) [−0.748; 0.167]
Migration: first generation	0.217 (0.079) [0.063; 0.372]	0.268 (0.063) [0.145; 0.392]
Grade repetition	−0.035 (0.056) [−0.145; 0.075]	0.050 (0.049) [−0.045; 0.145]
N	6 249	6 450
R^2	2.02%	0.43%

Cells show b (SE), followed by [lower; upper 95% CI]. Each model uses its own complete-case sample. Support models do not involve PVs, but variance was still calculated using replicate weights.

Appendix H. Belonging models

Table 13. Sequential BELONG models

Predictor	B0 Student characteristics	B1 + Family support	B2 + Teacher support	B3 + Grade repetition
Intercept	−0.023 (0.018) [−0.058; 0.012]	−0.011 (0.018) [−0.046; 0.024]	0.058 (0.019) [0.021; 0.095]	0.059 (0.020) [0.021; 0.097]
Family socioeconomic status (ESCS)	0.064 (0.012) [0.040; 0.088]	0.042 (0.013) [0.017; 0.067]	0.042 (0.012) [0.019; 0.065]	0.041 (0.012) [0.018; 0.065]
Girls (reference: boys)	−0.279 (0.022) [−0.323; −0.236]	−0.296 (0.021) [−0.337; −0.255]	−0.283 (0.021) [−0.324; −0.243]	−0.283 (0.021) [−0.324; −0.243]
Migration: second generation	−0.269 (0.147) [−0.558; 0.020]	−0.163 (0.150) [−0.456; 0.131]	−0.139 (0.147) [−0.427; 0.148]	−0.136 (0.148) [−0.425; 0.154]
Migration: first generation	−0.152 (0.058) [−0.265; −0.038]	−0.181 (0.058) [−0.295; −0.066]	−0.210 (0.057) [−0.322; −0.098]	−0.209 (0.057) [−0.322; −0.097]
Family support (FAMSUP)	—	0.144 (0.010) [0.123; 0.164]	0.118 (0.010) [0.098; 0.138]	0.118 (0.010) [0.098; 0.138]
Teacher support (TEACHSUP)	—	—	0.132 (0.012) [0.108; 0.155]	0.132 (0.012) [0.108; 0.155]
Grade repetition	—	—	—	−0.014 (0.046) [−0.103; 0.076]
N	6 138	6 138	6 138	6 138
R^2	3.83%	7.52%	10.40%	10.41%

Cells show b (SE) and 95% CI. The common sample has complete data including REPEAT even where that variable is not included in a model. A dash indicates a predictor not included in the specification.

Table 14. BELONG explained by support alone

Predictor	b	SE	Lower CI	Upper CI
Intercept	−0.095	0.014	−0.124	−0.067
Family support (FAMSUP)	0.113	0.011	0.092	0.134
Teacher support (TEACHSUP)	0.137	0.012	0.114	0.160

N = 6,138; R^2 = 6.72%. Same sample as models B0-B3.

Appendix I. School type and student experiences

Table 15. Mean indices by school type

School type	Family support	Teacher support	Belonging
General secondary school (LO)	0.063 (0.022) [0.021; 0.106] N = 3 339	−0.526 (0.026) [−0.576; −0.476] N = 3 405	−0.209 (0.017) [−0.242; −0.176] N = 3 434
Technical secondary school	−0.089 (0.021) [−0.130; −0.048] N = 2 463	−0.644 (0.038) [−0.718; −0.570] N = 2 550	−0.138 (0.022) [−0.181; −0.095] N = 2 614
First-stage vocational school	−0.273 (0.071) [−0.411; −0.134] N = 641	−0.475 (0.071) [−0.614; −0.336] N = 710	−0.167 (0.045) [−0.256; −0.079] N = 765

All available responses for each index within each pathway. Cells show mean (SE), 95% CI and unweighted N. These are the descriptive means used in the blog article.

Table 16. Differences from general secondary schools, before and after adjustment

Index and comparison	N	Unadjusted difference	Adjusted difference
FAMSUP Technical secondary school (reference: LO)	6 212	−0.139 (0.027) [−0.192; −0.086]	−0.054 (0.028) [−0.109; 0.002]
FAMSUP First-stage vocational school (reference: LO)	6 212	−0.310 (0.074) [−0.455; −0.166]	−0.165 (0.081) [−0.324; −0.005]
TEACHSUP Technical secondary school (reference: LO)	6 412	−0.126 (0.048) [−0.220; −0.032]	−0.145 (0.052) [−0.248; −0.042]
TEACHSUP First-stage vocational school (reference: LO)	6 412	0.023 (0.076) [−0.126; 0.173]	0.024 (0.078) [−0.129; 0.176]
BELONG Technical secondary school (reference: LO)	6 545	0.081 (0.029) [0.023; 0.138]	0.062 (0.031) [0.001; 0.124]
BELONG First-stage vocational school (reference: LO)	6 545	0.056 (0.049) [−0.041; 0.152]	0.086 (0.049) [−0.010; 0.181]

For each index, unadjusted and adjusted comparisons use the same complete-case sample. Controls: ESCS, gender and migration background. Cells show b (SE) and 95% CI. These are not differences calculated directly from the preceding table without excluding missing control variables.

Full models comparing school types

Table 17. Regressions of indices on school type and controls

Predictor	FAMSUP	TEACHSUP	BELONG
Intercept	−0.034 (0.024) [−0.081; 0.014]	−0.466 (0.034) [−0.533; −0.399]	−0.055 (0.021) [−0.097; −0.013]
Technical secondary school (reference: LO)	−0.054 (0.028) [−0.109; 0.002]	−0.145 (0.052) [−0.248; −0.042]	0.062 (0.031) [0.001; 0.124]
First-stage vocational school (reference: LO)	−0.165 (0.081) [−0.324; −0.005]	0.024 (0.078) [−0.129; 0.176]	0.086 (0.049) [−0.010; 0.181]
Family socioeconomic status (ESCS)	0.128 (0.016) [0.096; 0.159]	0.023 (0.019) [−0.013; 0.060]	0.087 (0.013) [0.062; 0.113]
Girls (reference: boys)	0.100 (0.028) [0.044; 0.155]	−0.109 (0.031) [−0.170; −0.047]	−0.273 (0.023) [−0.317; −0.228]
Migration: second generation	−0.606 (0.295) [−1.183; −0.029]	−0.268 (0.228) [−0.714; 0.179]	−0.197 (0.150) [−0.490; 0.097]
Migration: first generation	0.216 (0.081) [0.057; 0.375]	0.323 (0.066) [0.194; 0.452]	−0.152 (0.059) [−0.269; −0.035]
N	6 212	6 412	6 545
R^2	2.13%	0.90%	4.19%

Cells show b (SE) and 95% CI. Reference school type: general secondary school (LO). Differences in coefficient magnitude and precision across models are not a formal test of differences in association strength.

Appendix J. Social composition and proficiency

Table 18. Science performance by school type

School type	N	Mean	SE	Lower CI	Upper CI
General secondary school (LO)	3 472	538.4	3.8	530.9	546.0
Technical secondary school	2 709	480.1	4.1	472.1	488.1
First-stage vocational school	855	395.8	6.4	383.2	408.4

Weighted means pooled across ten PVs. All available test results within each school type; this sample is larger than the 6,102 students in models M0-M3.

Table 19. Pathway shares and family socioeconomic status

School type	Pathway N	Weighted share	N ESCS	ESCS (SE) and 95% CI
General secondary school (LO)	3 472	48.26%	3 400	0.248 (0.027) [0.195; 0.302]
Technical secondary school	2 709	37.93%	2 568	−0.260 (0.025) [−0.309; −0.212]
First-stage vocational school	855	13.81%	749	−0.703 (0.038) [−0.778; −0.628]

Shares refer to students in the three compared pathways, not the entire national school system. Differences in school-type means account for approximately 15.34% of weighted ESCS variance in this sample.

Appendix K. Science performance models

Table 20. Sequential models of science performance

Predictor	M0	M1	M2	M3
Intercept	515.40 (2.70) [510.11; 520.69]	553.13 (4.10) [545.09; 561.18]	554.23 (4.09) [546.22; 562.24]	554.24 (4.09) [546.21; 562.26]
Family socioeconomic status (ESCS)	35.56 (1.89) [31.85; 39.27]	17.67 (1.96) [13.84; 21.51]	17.97 (1.98) [14.10; 21.85]	18.18 (1.99) [14.28; 22.09]
Girls (reference: boys)	−9.71 (2.96) [−15.50; −3.91]	−23.54 (2.75) [−28.94; −18.14]	−23.01 (2.77) [−28.44; −17.58]	−23.87 (2.84) [−29.44; −18.30]
Migration: second generation	−69.29 (26.00) [−120.24; −18.34]	−53.67 (21.96) [−96.71; −10.64]	−54.49 (21.91) [−97.43; −11.54]	−54.74 (21.82) [−97.50; −11.98]
Migration: first generation	−32.63 (8.42) [−49.13; −16.13]	−31.10 (8.17) [−47.11; −15.09]	−31.28 (8.15) [−47.27; −15.30]	−31.94 (8.17) [−47.95; −15.93]
Technical secondary school (reference: LO)	—	−49.26 (5.57) [−60.18; −38.35]	−49.00 (5.54) [−59.86; −38.13]	−48.72 (5.55) [−59.60; −37.85]
First-stage vocational school (reference: LO)	—	−123.10 (7.65) [−138.09; −108.12]	−123.53 (7.76) [−138.74; −108.33]	−123.19 (7.82) [−138.52; −107.86]
Family support (FAMSUP)	—	—	−2.62 (1.26) [−5.08; −0.15]	−2.21 (1.23) [−4.61; 0.20]
Teacher support (TEACHSUP)	—	—	2.57 (1.19) [0.23; 4.91]	3.01 (1.25) [0.56; 5.46]
School belonging (BELONG)	—	—	—	−3.31 (1.64) [−6.53; −0.09]
N	6 102	6 102	6 102	6 102
R^2	12.150%	26.917%	27.062%	27.134%

Cells show b (SE) and 95% CI. M0: ESCS, gender and migration; M1: additionally school type; M2: additionally FAMSUP and TEACHSUP; M3: additionally BELONG. All models use the same 6,102 students. A dash indicates a predictor not included.

The increase in R^2 from M1 to M3 is 0.217 percentage points. This is not a mediation test. Small coefficients close to nominal significance thresholds should be interpreted in light of the exploratory analysis and the number of associations examined.

Appendix L. Components of belonging

Table 21. Item-performance correlations and adjusted models

Experience	Correlation r (SE) and 95% CI	Adjusted b (SE) and 95% CI
Feeling less left out	0.048 (0.016) [0.015; 0.080]	1.61 (1.70) [−1.72; 4.95]
Ease of making friends	−0.152 (0.015) [−0.182; −0.121]	−18.34 (1.61) [−21.49; −15.19]
Sense of belonging at school	0.058 (0.016) [0.026; 0.090]	1.18 (1.54) [−1.84; 4.20]
Feeling less out of place	0.037 (0.016) [0.005; 0.069]	1.52 (1.63) [−1.67; 4.71]
Feeling liked by other students	−0.015 (0.016) [−0.045; 0.017]	−2.87 (1.57) [−5.94; 0.21]
Feeling less lonely	0.026 (0.016) [−0.005; 0.058]	0.45 (1.46) [−2.42; 3.31]
School belonging (BELONG)	−0.001 (0.017) [−0.034; 0.033]	—

Common sample: 5,921 students. Each item was entered into a separate regression with ESCS, gender, migration, school type, FAMSUP and TEACHSUP. All items are oriented so that higher values indicate a more favourable experience. b represents a one-category response difference, assuming equal intervals. The BELONG row reports a correlation only.

Table 22. Direct sense of belonging and mean science performance

Response to ST034Q03TA	N	Mean	SE	Lower CI	Upper CI
Strongly agree	726	480.3	5.6	469.4	491.2
Agree	3 615	510.0	2.7	504.8	515.2
Disagree	1 838	493.4	3.3	486.9	499.9
Strongly disagree	638	479.1	4.2	470.9	487.2

Descriptive means for the entire Polish file, without restriction to the three pathways or adjustment for other student characteristics. These are not categorical-model estimates or tests of differences between response categories.

Appendix M. Between-school comparisons

Table 23. Correlations of school means and sensitivity sample

Association	203 schools	182 schools
School-mean ESCS and science performance	0.834 (0.016) [0.803; 0.866]	0.831 (0.017) [0.797; 0.864]
School-mean ESCS and friendship item	−0.148 (0.088) [−0.320; 0.024]	−0.143 (0.073) [−0.287; 0.001]
School-mean friendship item and science performance	−0.330 (0.068) [−0.463; −0.196]	−0.310 (0.064) [−0.434; −0.185]

Cells show r (SE) and 95% CI. Main sample: N = 6,508; sample restricted to schools with at least 20 observations: N = 6,232. Schools are weighted by sums of student weights. “Friendship” refers to the mean of the single FRIEND item, not overall relationship quality.

Between-school differences account for 28.03% of weighted ESCS variance in the main sample and 25.95% in the restricted sample. This is neither the percentage of student performance explained by schools nor evidence of a causal effect of social composition.

Models separating levels of analysis

Table 24. Science performance, individual and school ESCS, and the friendship item

Predictor	Student characteristics	+ School means	+ School type
Intercept	575.30 (5.84) [563.85; 586.75]	740.27 (38.61) [664.60; 815.94]	722.39 (38.63) [646.68; 798.10]
Family socioeconomic status (ESCS)	36.93 (1.92) [33.17; 40.70]	—	—
Ease of making friends	−21.73 (1.72) [−25.10; −18.37]	—	—
Student ESCS deviation from school mean	—	6.10 (1.29) [3.56; 8.63]	6.05 (1.29) [3.52; 8.59]
School-mean ESCS	—	110.90 (4.56) [101.97; 119.83]	93.25 (6.65) [80.22; 106.27]
Friendship item: student deviation from school mean	—	−14.82 (1.30) [−17.37; −12.28]	−14.87 (1.30) [−17.42; −12.32]
Friendship item: school mean	—	−75.62 (13.34) [−101.77; −49.47]	−67.01 (13.58) [−93.64; −40.39]
Girls (reference: boys)	−12.02 (2.86) [−17.63; −6.41]	−23.35 (2.57) [−28.39; −18.32]	−24.42 (2.52) [−29.35; −19.48]
Migration: second generation	−61.81 (23.41) [−107.69; −15.94]	−51.81 (21.24) [−93.44; −10.19]	−48.35 (19.94) [−87.44; −9.27]
Migration: first generation	−32.83 (7.39) [−47.33; −18.34]	−33.05 (6.55) [−45.89; −20.21]	−33.49 (6.70) [−46.63; −20.35]
Technical secondary school (reference: LO)	—	—	−6.03 (6.26) [−18.30; 6.24]
First-stage vocational school (reference: LO)	—	—	−42.10 (11.87) [−65.37; −18.83]
R^2	15.24%	36.37%	37.55%

N = 6,508; schools = 203. Cells show b (SE) and 95% CI. The first model does not separate levels; the second includes school means and deviations from them; the third adds school type. A dash indicates a predictor not included. Models omit FAMSUP and TEACHSUP; their sample differs from M0-M3.

Appendix N. Sensitivity to school sample size

Table 25. Models excluding schools with fewer than 20 observations

Predictor	Student characteristics	+ School means	+ School type
Intercept	578.63 (5.77) [567.32; 589.93]	747.86 (44.05) [661.51; 834.21]	719.44 (44.02) [633.16; 805.72]
Family socioeconomic status (ESCS)	35.05 (2.09) [30.95; 39.14]	—	—
Ease of making friends	−21.31 (1.61) [−24.47; −18.15]	—	—
Student ESCS deviation from school mean	—	6.16 (1.29) [3.64; 8.68]	6.15 (1.29) [3.63; 8.67]
School-mean ESCS	—	112.00 (5.10) [102.01; 121.99]	96.48 (7.68) [81.42; 111.54]
Friendship item: student deviation from school mean	—	−15.21 (1.27) [−17.70; −12.72]	−15.23 (1.28) [−17.73; −12.73]
Friendship item: school mean	—	−77.69 (15.31) [−107.69; −47.68]	−65.89 (15.50) [−96.27; −35.51]
Girls (reference: boys)	−14.74 (3.10) [−20.81; −8.68]	−24.24 (2.69) [−29.51; −18.96]	−24.60 (2.66) [−29.81; −19.39]
Migration: second generation	−50.77 (23.78) [−97.39; −4.16]	−46.48 (23.02) [−91.60; −1.36]	−45.68 (21.99) [−88.78; −2.58]
Migration: first generation	−31.17 (7.26) [−45.39; −16.94]	−34.97 (6.94) [−48.57; −21.37]	−34.76 (7.03) [−48.55; −20.98]
Technical secondary school (reference: LO)	—	—	−4.36 (7.10) [−18.29; 9.56]
First-stage vocational school (reference: LO)	—	—	−40.86 (14.13) [−68.55; −13.17]
R^2	14.08%	34.55%	35.61%

N = 6,232; schools = 182. Cells show b (SE) and 95% CI. The first model does not separate levels; the second includes school means and deviations from them; the third adds school type. A dash indicates a predictor not included. Models omit FAMSUP and TEACHSUP; their sample differs from M0-M3.

Appendix O. Alternative performance models

Table 26. Selected coefficients in sensitivity analyses

Specification	N	Predictor	b (SE) and 95% CI
Without school type	6 102	Family support (FAMSUP)	−0.57 (1.43) [−3.37; 2.23]
Without school type	6 102	Teacher support (TEACHSUP)	3.67 (1.49) [0.74; 6.60]
Without school type	6 102	School belonging (BELONG)	−5.52 (2.03) [−9.49; −1.54]
With grade repetition	6 091	Family support (FAMSUP)	−2.06 (1.22) [−4.45; 0.34]
With grade repetition	6 091	Teacher support (TEACHSUP)	3.07 (1.25) [0.62; 5.51]
With grade repetition	6 091	School belonging (BELONG)	−3.36 (1.66) [−6.61; −0.10]
With grade repetition	6 091	Grade repetition	−11.36 (4.50) [−20.19; −2.54]
General secondary schools only	3 235	Family support (FAMSUP)	−4.85 (1.81) [−8.39; −1.30]
General secondary schools only	3 235	Teacher support (TEACHSUP)	4.56 (1.73) [1.18; 7.95]
General secondary schools only	3 235	School belonging (BELONG)	0.93 (2.25) [−3.47; 5.34]
Technical schools only	2 313	Family support (FAMSUP)	−1.73 (1.73) [−5.13; 1.66]
Technical schools only	2 313	Teacher support (TEACHSUP)	2.98 (1.85) [−0.64; 6.60]
Technical schools only	2 313	School belonging (BELONG)	−6.61 (2.51) [−11.52; −1.70]
Vocational schools only	554	Family support (FAMSUP)	3.95 (2.62) [−1.19; 9.09]
Vocational schools only	554	Teacher support (TEACHSUP)	−5.02 (3.00) [−10.91; 0.87]
Vocational schools only	554	School belonging (BELONG)	−5.57 (5.72) [−16.77; 5.63]

Without school type: ESCS, gender, migration and three indices. With REPEAT: full model M3 plus grade repetition. Within-school-type models: ESCS, gender and three indices; migration is omitted. These are therefore not strict tests of interactions between school type and relational indices. The table reports relational and REPEAT coefficients from these specifications, not all control coefficients.

Source of all tables: author’s calculations using the supplied Polish PISA 2025 file. Tables document the specifications fitted; their completeness does not replace a confirmatory analysis plan. Differences in sample sizes and control sets must be considered when comparing results.