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Cognitive Ability Levels of 9th-Grade Students across Germany's Federal States: IQB Education Trends 2009–2024 and the Role of Migration Background

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Abstract

The IQB Education Trends constitute Germany's national counterpart to the PISA studies. In large-scale representative assessments conducted in 2012, 2018, and 2024, the performance of 9th- grade students in mathematics, biology, chemistry, and physics was measured, while German and English were assessed in 2009, 2015, and 2022. The present study analyses these data at the level of Germany's 16 federal states. At this highly aggregated level, performance across subjects (with the exception of English) and across all assessment cycles is extremely highly intercorrelated and can be reduced to a single global factor termed IQ-B, which may be interpreted as an almost perfect measure of general intelligence. This factor reveals a massive performance advantage of the eastern over the western federal states. After controlling for the proportion of students with a migration background, this advantage disappears entirely while a clear south-north gradient becomes evident. The region of origin of migrants emerges as a decisive variable: immigration increasingly originates from countries with substantially lower average cognitive ability. Demographic projections indicate that the share of the ethnic German population will shrink to less than one-third by the year 2100. Continuation of current trends would inevitably lead to a substantial decline in Germany's average cognitive ability level.

Keywords: Intelligence, g-factor, Cognitive ability, IQB Education Trends, Large-scale student assessment (LSSA) studies, Student achievement, Migration, Demography, Educational research, Educational policy

1 Introduction

The present study examines the cognitive performance of 9th-grade students across Germany's federal states on the basis of the IQB Education Trends conducted in 2009, 2012, 2015, 2018, 2022, and 2024, with particular attention to its association with the proportion of students with a migration background.

The IQB Education Trends represent Germany's domestic counterpart to the PISA studies. The acronym IQB stands for the Institute for Educational Quality Improvement at Humboldt University Berlin. Whereas PISA compares student performance across nations and economies, the IQB focuses on Germany as a whole and on its individual federal states. Both programmes target essentially the same age cohort — 15-year-olds in PISA and 9th-graders in IQB —, marking the end of lower secondary education. A parallel series assesses 4th-graders; the present analysis is restricted to the 9th grade because cognitive maturation is considerably more advanced at this age, providing more reliable indicators of adult cognitive capacity. PISA assesses reading, mathematics, and science as a single domain. The IQB examines linguistic competencies on the one hand and mathematical-scientific competencies on the other in separate cycles.

Linguistic competencies were measured in 2009, 2015, and 2022; mathematical and scientific competencies in 2012, 2018, and 2024. Largely identical methodology across cycles permits both a snapshot of current performance and a reliable analysis of trends over 13 and 12 years, respectively. Two

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factors dominate this period: the proportion of students with a migration background and the COVID-19 pandemic. Under the current official definition, the share of students with a migration background rose from 17.0% in 2009 to 39.9% in 2024. The marked increase in immigration since 2015 — primarily from Syria, Afghanistan and Iraq, increasingly supplemented by immigration from sub-Saharan Africa and since 2022 from Ukraine —, has fundamentally altered the composition of this group. The most recent immigrant cohorts are only partially represented in the 2022 and 2024 assessments.

The second decisive factor is the COVID-19 pandemic, which imposed severe disruptions on the cohorts tested in 2022 and 2024 but not on earlier cohorts. Global evidence, including PISA 2022, unequivocally documents substantial learning losses caused by prolonged school closures. In Germany, mean scores declined from 500 to 475 in mathematics, from 503 to 492 in science, and from 498 to 480 in reading — corresponding to effect sizes of -0.25, -0.11, and -0.18 SD, respectively (OECD 2023, p. 427). These losses cannot, of course, be attributed solely to pandemic-related restrictions.

The present study adopts a perspective absent from the official IQB reports. First, while PISA treats science as a unitary domain, the IQB distinguishes biology, chemistry, and physics. We demonstrate that, at the federal-state level, these three subjects are empirically indistinguishable and can therefore be combined into a single science factor. This is not to deny the value of subject-specific differentiation for many research questions; at the higher level of aggregation employed here, however, further consolidation is warranted. Performance in mathematics proves to be highly correlated with performance in science, justifying the construction of a joint mathematics-science factor. This factor, in turn, correlates strongly with the proportion of students with a migration background across federal states, explaining in large part the substantial performance advantage of eastern over western states.

An analogous analysis is conducted for the linguistic domain. Reading, listening, and orthography in German form a coherent factor, as do reading and listening comprehension in English. The German factor correlates very highly with the mathematics-science factor and can thus be combined into a higher-order general factor. English, however, stands apart, influenced by historically rooted regional particularities.

All findings are derived exclusively from empirical data provided by the IQB. In the Discussion section, we interpret these results from the perspective of psychometric intelligence research and demonstrate that they are precisely what this tradition would lead one to expect: the competencies measured by the IQB are, at their core, highly reliable indicators of general intelligence. The global factor IQ-B constructed in this study constitutes an almost perfect measure of general intelligence at the level of Germany's federal states. We will further note that the dominant role of general intelligence in educational attainment, occupational success, innovation, and societal prosperity is systematically disregarded in educational research and policy, even though it has been part of the firmly established scientific consensus for decades. Finally, conservative demographic projections demonstrate that continuation of current trends would inevitably produce a substantial decline in Germany's average cognitive ability level over the course of this century, with far-reaching implications for economic strength, innovative capacity, and societal stability.

2 Methods

The IQB Education Trends follow the established procedures of large-scale international and national assessments and fully meet the highest scientific standards.

2.1 Methodology employed by the IQB

The target population comprises all 9^{th}-grade students enrolled in general-education schools, including special-needs schools, with the sole exceptions of students whose primary educational need is classified as "intellectual development" and those who have received instruction in German for less than one year.

Sampling proceeds in two stages: first a stratified random selection of schools, then a random selection of classes within the selected schools. In the most recent 2024 cycle, usable data were obtained from 27,268 students in mathematics and 27,501 students in the science subjects across 1,556 participating schools. School participation rates reached 98% nationally, with a minimum of 93% at the state level.

Student participation averaged 91%, with Hamburg (80%) as a notable outlier; all other states exceeded 88%. Non-response is likely to disproportionately involve lower-performing students, yet the effect on state-level means is negligible.

In mathematics, the IQB distinguishes five core ideas (number, measurement, space and shape, functional relationships, data and chance); for the present purposes, only the global score is used. In biology, chemistry, and physics, the IQB distinguishes between subject-specific knowledge and scientific inquiry. Because the results are highly similar in all cases, the IQB report volumes focus on subject-specific knowledge. In German, the domains are reading, listening, and orthography; in English, reading comprehension and listening comprehension.

Of particular relevance to our research question is the recording of migration background. In 2024, information on migration status was missing for 11% of students overall, with markedly higher rates in certain states (e.g., Saarland 24.8%, Rhineland-Palatinate 20.6%). Missing data are very likely to disproportionately affect students with a migration background.

As is standard in large-scale assessments, raw scores were scaled to a mean of 500 and a standard deviation of 100, using 2012 as the reference year for mathematics and science and 2015 for the linguistic domains.

2.2 Data sources

The present study is a secondary analysis of aggregate data freely available on the IQB website https://www.iqb.hu-berlin.de/de/. Data for the mathematical-scientific domain were extracted from Pant et al. (2013), Stanat et al. (2019), and Stanat et al. (2025); data for the linguistic domain from the corresponding reports (Köller et al., 2010; Stanat et al., 2016; Stanat et al., 2023a).

2.3 Analytical strategy

The defining characteristic of the present investigation is that the unit of analysis is not individual students or school classes, but the federal states (N = 16). This extremely high level of aggregation confers exceptional reliability on the state-level means, albeit at the cost of a very small sample size. The variables employed are the performance scores in the four subjects Mathematics, Biology, Chemistry, and Physics (each assessed in 2012, 2018, and 2024) and, for the linguistic domain, the subdomains reading, listening, and orthography in German as well as reading comprehension and listening comprehension in English (each assessed in 2009, 2015, and 2022). In addition, the proportion of students with a migration background in 2024 is included as the central external variable.

The analytical procedure follows the logic already outlined in the introduction and proceeds in clearly defined steps: aggregation of biology, chemistry, and physics into a single science factor; combination of mathematics and the science factor into a joint mathematics-science factor; aggregation of the German subdomains (reading, listening, orthography) into a German factor and of the English subdomains (reading comprehension, listening comprehension) into an English factor. A higher-order general factor (IQ-B) was constructed by averaging the mathematics-science factor and the German factor. English is deliberately excluded for reasons detailed below. At each step, the correlation of the newly formed factor with the proportion of students with a migration background is examined.

All analyses are purely correlational and conducted exclusively at the state level. It is explicitly emphasised that correlations obtained at this highly aggregated ecological level are substantially larger than those typically observed at the individual level.

3 Results

We first examine competencies in mathematics and the natural sciences, followed by linguistic competencies, and finally both domains in combination.

Table 1: Changes in the mathematics and natural sciences subjects across assessment cycles.

	Mathematics	Biology	Chemistry	Physics
2012–2018	-1	-3	-6	-3
2018–2024	-24	-24	-23	-23
2012–2024	-25	-27	-29	-26

3.1 Mathematics and natural sciences competencies

The mathematics and natural sciences domain encompasses the subjects of mathematics, biology, chemistry, and physics. Mathematics is assessed in one sample, whereas biology, chemistry, and physics are assessed in a separate sample.

Changes in national performance levels (Germany as a whole)

As an introduction, we briefly report the changes in absolute performance values for Germany as a whole. At the initial assessment in 2012, the scales were normed such that the mean was 500 and the standard deviation 100. Table 1 shows the changes in the four subjects across the three assessment cycles.

From 2012 to 2018, performance in mathematics, biology, chemistry, and physics declined by 1, 3, 6, and 3 points, respectively — differences that are practically meaningless. From 2018 to 2024, however, a sharp decline occurred, with scores falling by 24, 24, 23, and 23 points. Relative to the 2012 baseline, the cumulative losses amount to 25, 27, 29, and 26 points. It should be emphasized that the changes across the four subjects are virtually identical.

Intercorrelations within assessment cycles

Having briefly considered the absolute changes, we now turn to our central research question. We begin with the interrelations among mathematics, biology, chemistry, and physics within each of the assessment years 2012, 2018, and 2024. The corresponding product-moment correlations are presented in Table 2. The construction of the additional composite factors Natural Sciences (NS) and Mathematics–Natural Sciences (MN) is described subsequently. For orientation, the critical r-value in the present case (N = 16) at a significance level of .01 (one-tailed) is .56.

The pattern is nearly identical across all three assessment cycles. The correlations among biology, chemistry, and physics range from .96 to .99. At the highly aggregated level of the federal states, these three subjects are therefore practically indistinguishable. They were consequently combined by averaging into a single factor termed Natural Sciences (NS). As shown in the respective penultimate row of each panel, this factor serves as an almost perfect common denominator of the three subjects—the correlations reach .99 and, for chemistry in 2012, even 1.00 when rounded.

The first data column indicates that mathematics correlates very strongly with biology, chemistry, and physics at every assessment point. Consequently, the association between mathematics and the Natural Sciences factor is also extremely close. Mathematics and the Natural Sciences factor were therefore averaged to create an overall factor termed Mathematics–Natural Sciences (MN).[†] The correlations of this composite with the underlying individual subjects range from .96 to .98.Thus, for each of the three assessment years we conclude:

- *Mathematics, biology, chemistry, and physics exhibit extremely high intercorrelations, and the composite factor Mathematics–Natural Sciences (MN) serves as an almost perfect representation of their common variance.*

[†] Through this construction, mathematics carries a weight of 1/2, while biology, chemistry, and physics each carry a weight of 1/6.

Table 2: Correlations among mathematics, biology, chemistry, physics, Natural Sciences (NS), and Mathematics–Natural Sciences (MN) for 2012, 2018, and 2024.

2012	Mathematics	Biology	Chemistry	Physics	NS
Biology	.90				
Chemistry	.91	.98			
Physics	.92	.97	.99		
NS	.92	.99	1.00	.99	
MN	.98	.97	.98	.98	.98
2018	Mathematics	Biology	Chemistry	Physics	NS
Biology	.86				
Chemistry	.87	.98			
Physics	.86	.98	.97		
NS	.87	.99	.99	.99	
MN	.97	.96	.96	.96	.97
2024	Mathematics	Biology	Chemistry	Physics	NS
Biology	.88				
Chemistry	.91	.97			
Physics	.90	.96	.98		
NS	.90	.99	.99	.99	
MN	.98	.96	.97	.97	.97

Table 3: Mathematics and natural sciences competencies: correlations between assessment years 2012, 2018, 2024, and the overall composite MNC.

	2012	2018	2024
2018	.84		
2024	.80	.88	
MNC	.94	.96	.94

Temporal development of mathematics and natural sciences competencies

The foregoing findings apply within each assessment cycle. As noted at the outset, absolute performance levels changed only marginally from 2012 to 2018 but declined sharply from 2018 to 2024. We now examine the temporal development of the Mathematics–Natural Sciences factor. Table 3 presents the correlations across assessment years as well as with the overall composite MNC derived by averaging.

The values are, as expected, not as extreme as the cross-sectional correlations in Table 2, yet despite different school and student samples they reveal very high temporal stability. For the two six-year intervals 2012–2018 and 2018–2024 the stability coefficients are .84 and .88, respectively; even the twelve-year comparison yields a substantial .80. It is therefore appropriate to average the three time points into an overall factor termed Mathematics–Natural Sciences Competencies (MNC). As shown in the final row of the table, this composite — with correlations of .94, .96, and .94 to the individual assessment years — serves as an outstanding representation of performance across time. We can therefore conclude:

The overall factor Mathematics–Natural Sciences Competencies (MNC) is an excellent indicator of the federal states' performance strength in this domain.

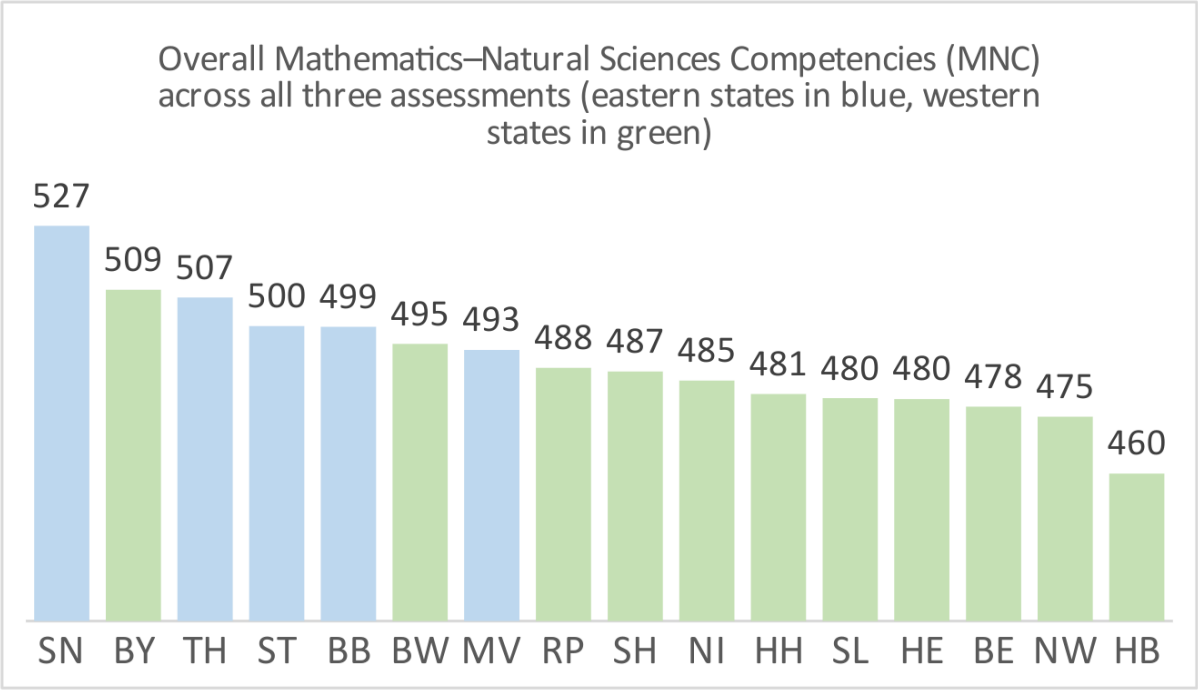

Figure 1: Overall Mathematics–Natural Sciences Competencies (MNC) across all three assessments (eastern states in blue, western states in green).

Comparison across federal states

It is now appropriate to focus on the federal states themselves. Figure 1 displays the performance level derived from the aggregate of all three assessments (MNC). To highlight the central pattern, the eastern states are shown in blue and the western states in green. The two-letter codes follow the ISO-3166-2 standard (DE-...): BW Baden-Württemberg, BY Bavaria, BE Berlin, BB Brandenburg, HB Bremen, HH Hamburg, HE Hesse, MV Mecklenburg-Western Pomerania, NI Lower Saxony, NW North Rhine-Westphalia, RP Rhineland-Palatinate, SL Saarland, SN Saxony, ST Saxony-Anhalt, SH Schleswig-Holstein, TH Thuringia.

The pattern is clearly structured. Competencies in mathematics and the natural sciences are markedly higher in the eastern federal states than in the western states. Saxony, Thuringia, Saxony-Anhalt, Brandenburg, and Mecklenburg-Western Pomerania occupy positions 1, 3, 4, 5, and 7. Only Bavaria (2nd) and Baden-Württemberg (6th) from the West rank among this group. Saxony's lead at the top is enormous, just as Bremen's lag at the bottom is striking. Before pursuing the interstate comparison further, another variable must be considered.

Mathematics and natural sciences competencies and migration background

Given the pronounced East–West disparity, it is tempting to attribute it to historical roots in decades of political division. The decisive factor, however, lies elsewhere: the proportion of students with a migration background. In several western federal states such students already constitute the majority or are on the verge of doing so; in the eastern states their share remains below twenty percent. The 2024 percentages are: Bremen 61.3, Berlin 53.4, Hamburg 52.2, Hesse 51.9, Baden-Württemberg 49.0, North Rhine-Westphalia 47.9, Rhineland-Palatinate 40.4, Saarland 40.1, Bavaria 38.0, Lower Saxony 36.8, Schleswig-Holstein 29.0, Brandenburg 17.8, Thuringia 14.8, Mecklenburg-Western Pomerania 14.4, Saxony-Anhalt 14.3, Saxony 11.8 (Stanat et al., 2025, Table 7.1, p. 271). Because of a high proportion of non-evaluable cases, the actual figures — especially for Saarland and Rhineland-Palatinate, but also for North Rhine-Westphalia, Bavaria, and Saxony — are likely somewhat higher. The IQB Education Trend, consistent with numerous other educational studies, documents that students with a migration background achieve markedly lower

Table 4: Migration status and performance level in mathematics, biology, chemistry, and physics for 2012, 2018, and 2024.

	No Migration			2. Generation			1. Generation		
Subject	2012	2018	2024	2012	2018	2024	2012	2018	2024
Mathematics	521	521	500	465	476	457	465	437	422
Biology	520	520	500	468	476	456	457	409	405
Chemistry	520	518	497	466	469	455	460	415	413
Physics	521	521	502	460	476	454	460	413	409

performance on average. Table 4 presents mean performance broken down by students without a migration background, second-generation migrants (both parents born abroad, student born in Germany), and first-generation migrants (student and both parents born abroad). Under this extremely lenient definition, grandparents' origin plays no role; thus, for example, students whose entire ancestry is Turkish are classified as "without migration background" if both parents were born in Germany. Migration status is defined here not ethnically but by place of birth of parents and student.

First, it should be noted that the values within the columns are highly similar, the only exception being that in 2018 first-generation students performed better in mathematics than in the natural-science subjects. Students without a migration background reached in 2024, in all subjects (almost exactly), the level that had been established in 2012 as the scale mean for the entire population (500). In 2012 and 2018 they had still scored 20 points above that level. Second-generation students in 2024 fell slightly less than half a standard deviation below the scale mean; in 2018 the gap had been approximately 20 points smaller. For first-generation students, the deficit in the natural-science subjects in 2012 amounted to slightly less than half a standard deviation; since 2018 it has been almost a full standard deviation. In mathematics the performance decline was somewhat smaller.

One point deserves particular emphasis: From 2012 to 2018, performance among students without a migration background remained unchanged, second-generation students improved (significantly only in physics), whereas first-generation students exhibited a sharp decline. In 2024, students without a migration background and second-generation students displayed substantially weaker performance; among first-generation students the further decline was significant only in mathematics. Our focus, however, is not on the absolute difference between students with and without a migration background; a different point is of greater interest to us.

With regard to the proportion of students with a migration background, the situation proved extremely stable over the observation period: 2024—2018: .99; 2024—2012: .97; 2018—2012: .98. Because no data are available for Hamburg in 2018, we use the 2024 migrant proportion as the reference measure. The correlation with Mathematics–Natural Sciences Competencies (MN) is -.87, -.58, and -.64 for the years 2012, 2018, and 2024, respectively. The correlation with the overall composite factor MNC is -.77. This relationship is illustrated in Figure 2. The dotted line represents the regression line; the regression equation and the proportion of shared variance are provided in the lower left.

The shared variance between migrant proportion and Mathematics–Natural Sciences competencies amounts to 59.9 percent — an exceptionally strong finding that is hardly surprising from a psychometric perspective. More noteworthy is the following: Because of their far lower proportion of students with a migration background and consistently high performance, the five eastern states initially appear as a distinct superior cluster. When examined relative to the regression line, however, the picture changes dramatically, as shown in Table 5. The table presents, alongside the 2024 migrant proportion and overall MNC performance, the fitted values derived from the regression equation –0.7426x + 516.94 as well as the residual (difference between observed and expected value).

Saxony performs 19 points above expectation based on its proportion of students with a migration background. Thuringia is 1 point above, whereas Brandenburg, Saxony-Anhalt, and Mecklenburg-Western Pomerania register -4, -7, and -13, respectively. The unweighted mean residual for the eastern states is

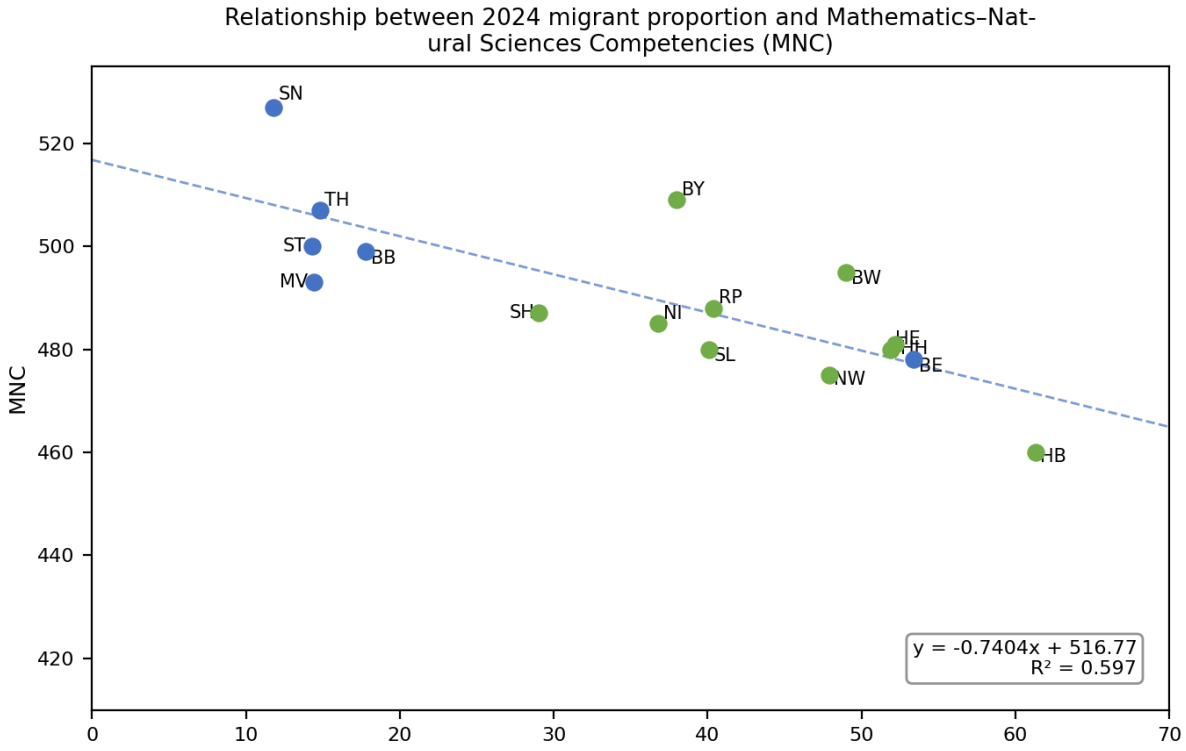

Figure 2: Relationship between 2024 migrant proportion and Mathematics–Natural Sciences Competencies (MNC).

-0.82. For the western federal states the unweighted mean is +0.38. Thus, the performance advantage of the eastern states is an artifact of their lower proportions of students with a migration background. Instead of an East–West gradient, this perspective reveals a different pattern: a South–North gradient, with Bavaria (21), Saxony (19), Baden-Württemberg (14), Rhineland-Palatinate (1), Hesse (1), and Thuringia (1) in the positive range. The correlation with the latitude of each state's geographic centroid is .65 ($p < .01$).

Here we have compared overall performance in Mathematics–Natural Sciences Competencies with migration background in 2024. Table 6 presents the correlations between performance levels in the individual subdomains and the proportion of students with a migration background within the years 2012, 2018, and 2024.[‡]

Two findings stand out: First, the association between migrant proportion and performance was extraordinarily strong in 2012; second, the association is consistently negative and somewhat weaker in mathematics than in the natural-science subjects. Residual analyses alternately favour eastern or western states depending on year and domain, yet differences between East and West are generally minimal and lack statistical or practical significance. In conclusion:

- *Once the proportion of students with a migration background is taken into account, the performance advantage of the eastern federal states in mathematics and the natural sciences disappears entirely. What emerges instead is a South–North gradient rather than an East–West divide.*

[‡] In 2012 and 2018, usable information on migration background was unavailable for 19.5 percent and 11.5 percent of students, respectively. In 2012 the non-response rate exceeded 45 percent in Berlin, Saarland, and Bremen; in Hamburg in 2018 no migration-background data were reported because the non-response rate exceeded 70 percent.

Table 5: Regression of Mathematics–Natural Sciences Competencies on 2024 migrant proportion: observed values (MNC), expected values, and residuals.

	Migr2024	MNC	Fitted	Residual
Baden-Württemberg	49.0	495	481	14
Bavaria	38.0	509	489	21
Berlin	53.4	478	477	1
Brandenburg	17.8	499	504	-4
Bremen	61.3	460	471	-12
Hamburg	52.2	481	478	3
Hesse	51.9	480	478	1
Mecklenburg-W. P.	14.4	493	506	-13
Lower Saxony	36.8	485	490	-5
North Rhine-Westphalia	47.9	475	481	-6
Rhineland-Palatinate	40.4	488	487	1
Saarland	40.1	480	487	-7
Saxony	11.8	527	508	19
Saxony-Anhalt	14.3	500	506	-7
Schleswig-Holstein	29.0	487	495	-8
Thuringia	14.8	507	506	1

Table 6: Correlation between proportion of students with a migration background and performance in the mathematics and natural sciences domain for 2012, 2018, and 2024.

	2012	2018	2024
Mathematics	$-.78$	$-.44$	$-.49$
Biology	$-.91$	$-.72$	$-.79$
Chemistry	$-.90$	$-.65$	$-.75$
Physics	$-.88$	$-.70$	$-.73$
NS	$-.90$	$-.70$	$-.76$
MNC	$-.87$	$-.58$	$-.64$

Note. NS = Natural Sciences; MNC = Mathematics–Natural Sciences Competencies.

3.2 Linguistic competencies

We now turn to the linguistic domain, which in German encompasses the subdomains of reading, listening, and orthography, and in English comprises reading comprehension and listening comprehension. A small percentage of students participated only in the German assessment.

Changes in national performance levels (Germany as a whole)

Here, too, we first consider absolute performance levels for Germany

German and English present entirely different patterns. In German, the change from 2009 to 2015 amounted to –6 points in reading, –8 in listening, and +2 in orthography. Although the declines in reading and listening are statistically significant due to the very large sample, they are of minor practical importance. From 2015 to 2022, however, a steep drop occurred (–25, –44, and –31 points). Over the full 13-year span the cumulative changes are –31 points in reading, –52 in listening, and –29 in orthography. In English, by contrast, performance improved in both subdomains and in each period, with gains ranging from 19 to 24 points. Cumulatively, reading comprehension rose by 41 points and listening comprehension by 47 points.

Table 7: Changes in German and English, 2009, 2015, 2022.

	German			English	
	Reading	Listening	Orthography	Reading	Listening
2009–2015	–6	–8	2	19	24
2015–2022	–25	–44	–31	22	23
2009–2022	–31	–52	–29	41	47

Table 8: Correlations among subdomains and the overall factors German and English within the years 2009, 2015, and 2022

2009	G-Reading	G-Listening	G-Orthogr.	E-Reading	E-Listening	German
G-Listening	.84					
G-Orthogr.	.82	.83				
E-Reading	.68	.80	.83			
E-Listening	.18	.48	.47	.80		
German	.93	.95	.95	.83	.42	
English	.40	.64	.64	.93	.97	.61
2015	G-Reading	G-Listening	G-Orthogr.	E-Reading	E-Listening	German
G-Listening	.91					
G-Orthogr.	.79	.79				
E-Reading	.72	.76	.71			
E-Listening	.04	.28	.18	.63		
German	.96	.95	.91	.77	.17	
English	.35	.53	.44	.86	.93	.46
2022	G-Reading	G-Listening	G-Orthogr.	E-Reading	E-Listening	German
G-Listening	.95					
G-Orthogr.	.90	.92				
E-Reading	.38	.51	.56			
E-Listening	.05	.25	.28	.83		
German	.98	.98	.96	.49	.20	
English	.20	.39	.43	.95	.96	.34

Intercorrelations within assessment cycles

Table 8 displays the correlations among the performance profiles of the federal states within the three assessment years. The subdomains are aggregated into the composite factors German and English, respectively.

As in the mathematics and natural sciences domain, the linguistic domain yields a clear pattern, albeit with one notable particularity to which we will return shortly.

First, we consider German, where the picture is highly consistent. Correlations among reading, listening, and orthography range from .82 to .84 in 2009, .79 to .91 in 2015, and .90 to .95 in 2022. At all time points the association between reading and listening is the strongest. The composite factor German, formed by averaging, represents the common variance of the three subdomains very well, with correlations ranging from .91 to .98; the highest values occur in 2022 (.98 for both reading and listening, .96 for orthography).

In English, the correlation between reading comprehension and listening comprehension is .80, .63, and .83 across the three cycles. Here, too, the averaged factor English is an excellent representation, with values of .93 and .97 in 2009, .86 and .93 in 2015, and .95 and .96 in 2022. As an interim conclusion:

Table 9: Linguistic competencies: correlations among assessment years 2009, 2015, 2022, and the overall composites German and English.

	German			English			
	2009	2015	2022	2009	2015	2022	
2015	.65			.77			2015
2022	.75	.88		.77	.80		2022
German	.86	.92	.96	.93	.91	.93	English

- Both in German and in English the subdomains can be combined into a single overall factor.

The correlation between the German and English composite factors is still relatively high at .61 in 2009, declines to .46 in 2015, and reaches only .34 in 2022. In the cross-subject comparison, a sharp separation between English reading comprehension and English listening comprehension is evident. English reading comprehension correlates with German reading, listening, and orthography at .68, .80, and .83 in 2009; .72, .76, and .71 in 2015; and .38, .51, and .56 in 2022. The corresponding values for English listening comprehension are markedly lower: .18, .48, .47; .04, .28, .18; and .05, .25, .28. Relative to the aggregated German factor, English reading comprehension yields .83, .77, and .49, whereas English listening comprehension yields only .42, .17, and .20. Regarding the cross-subject relationship we conclude:

- The association between German and English has weakened over time.
- The overlap between the two subject factors is driven primarily by English reading comprehension; the low correlation of English listening comprehension with German attenuates the overall relationship between the two factors.

Temporal development of linguistic competencies

Table 9 presents the German and English factors across the three assessment years together with the corresponding overall composites.

The performance profiles of the federal states are quite stable in both subjects (correlations ranging from .65 to .88), and the averaged composites accordingly represent the common variance very well (.86 to .96). It is worth noting only that the values for German in 2009 are somewhat weaker.

Both in German and in English the overall composite factor is an excellent indicator of the federal states' performance level.

Comparison across federal states

Figure 3 displays the performance of the federal states on the overall German composite factor. Western states are again shown in green and eastern states in blue.

In German, too, the eastern federal states perform better on average than the western states, but the difference of 6.6 points is not statistically significant. Figure 4 presents the comparison for the overall English composite factor. For reasons discussed later, Saarland is marked in yellow.

In English we observe an entirely new pattern. Here the western federal states substantially outperform the eastern states — despite Saarland ranking last and Bremen, as in the other domains, performing very poorly. The western advantage of 14.9 points is not only statistically significant ($p < .01$; Welch t-test) but also large in effect size (Cohen's $d = 1.37$). We therefore conclude:

On the overall German composite there is no significant East–West difference; on the overall English composite the western federal states perform markedly better on average than the eastern states.

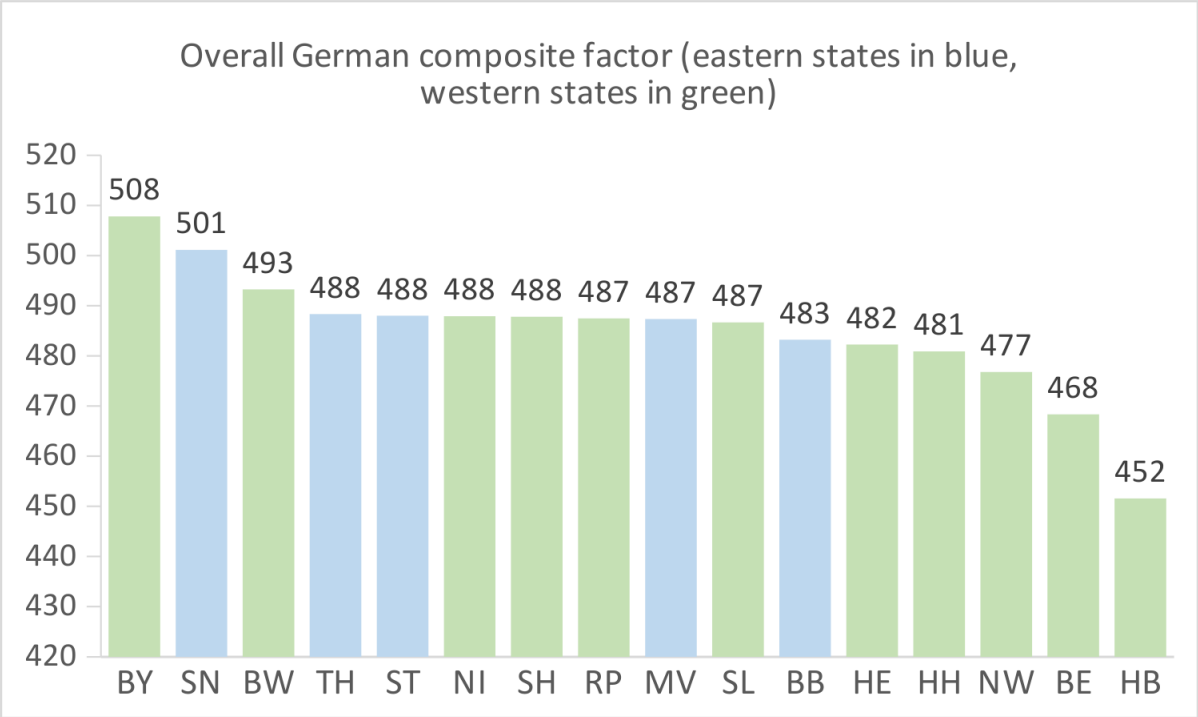

Figure 3: Overall German composite factor (eastern states in blue, western states in green).

Table 10: Migration background and performance in German: absolute scores and changes between consecutive assessment points.

	Reading				Listening				Orthography			
Migrant	2009	2015	2015	2022	2009	2015	2015	2022	2009	2015	2015	2022
No	531	524	518	506	533	528	522	492	520	520	515	494
2. Gen.	471	469	467	452	466	461	459	426	481	486	484	463
1. Gen.	453	432	426	380	454	415	412	349	452	443	436	348
No	–7	–7	–12	–12	–6	–6	–31	–31	0	0	–20	–20
2. Gen.	–1	–1	–14	–14	–6	–6	–33	–33	6	6	–21	–21
1. Gen.	–22	–22	–46	–46	–38	–38	–62	–62	–9	–9	–53	–53

Note. The upper half presents absolute scores; the lower half presents changes between consecutive assessments.

Linguistic competencies and migration background

We now examine linguistic competencies in relation to migration background. A minor complication arises because students with special educational needs were not included in 2009, and a renorming to means of 496 (reading) and 500 (listening and orthography) occurred in 2015. Consequently, the year 2015 appears twice in Table 10: The upper half presents absolute scores, the lower half the changes between consecutive assessments.

Given the abundance of figures, it is advisable to examine first the changes presented in the lower half of the table. The first, third, and fifth columns indicate the changes from 2009 to 2015. For students without a migration background the values are –7, –6, and 0, and for second-generation students –1, –6, and +6. For both groups these changes are negligible. First-generation students, by contrast, exhibit substantial losses in reading and listening (–22 and –38) and a negative value also in orthography (–9). From 2015 to 2022, all groups record notable to very large declines. For students without a migration background and second-generation students the losses are nearly identical: -12, -31, -20 and -14, -33, -21, respectively. For

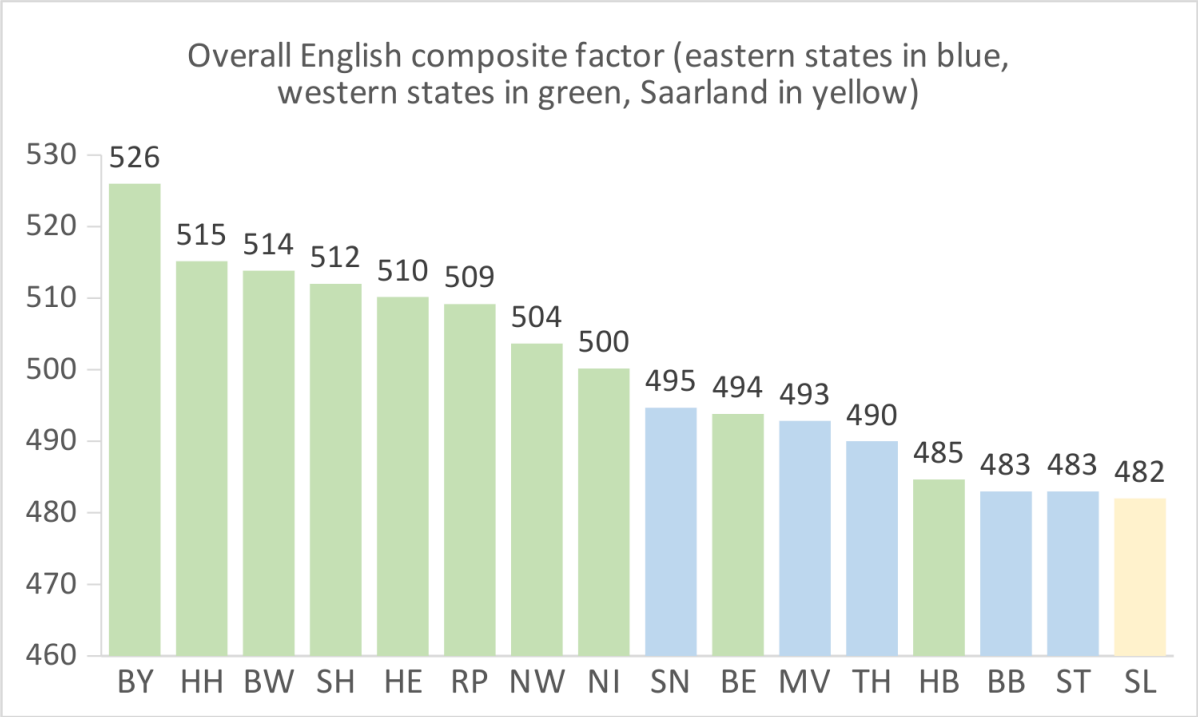

Figure 4: Overall English composite factor (eastern states in blue, western states in green, Saarland in yellow).

Table 11: Migration background and performance in English: absolute scores and changes between consecutive assessment points.

	Reading Comprehension				Listening Comprehension			
Migrant	2009	2015	2015	2022	2009	2015	2015	2022
No	497	514	508	536	492	512	507	535
2. Gen.	464	490	488	519	458	491	489	529
1. Gen.	452	484	479	487	443	482	477	491
No	17	17	27	27	20	20	28	28
2. Gen.	26	26	32	32	32	32	35	35
1. Gen.	32	32	8	8	39	39	14	14

first-generation students the declines are particularly severe: -46, -62, -53.

From the absolute scores in the upper half of the table it follows that second-generation students lag 51 to 60 points behind students without a migration background in reading, 63 to 68 points in listening, and 31 to 39 points in orthography — on average approximately half a standard deviation. For first-generation students the gap relative to students without migration background ranges from 78 to 126 points in reading, 99 to 143 points in listening, and 68 to 146 points in orthography. The smallest gap is invariably found in 2009 and the largest in 2022. In 2009 the deficit amounted to approximately three-quarters of a standard deviation, in 2015 roughly one full standard deviation, and in 2022 nearly one and a half standard deviations. Table 11 presents the corresponding values for English.

In the upper half of the table, it is immediately apparent that the differences are far smaller than in German. There the range extends from 533 to 348 points; here it spans only 536 to 443. Moreover, the trend is precisely reversed. Whereas performance in German declined— particularly sharply from 2015 to 2022—, both reading comprehension and listening comprehension in English improved steadily in all groups. Among students without a migration background and second-generation students, the gains in the

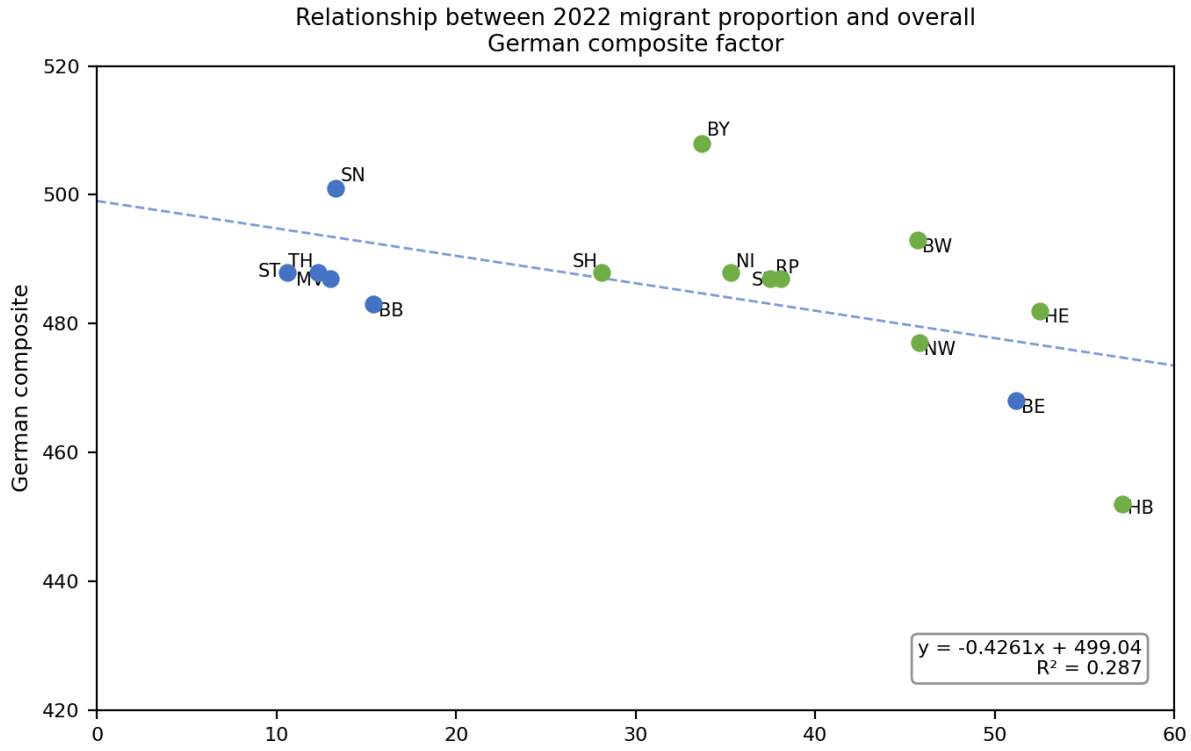

Figure 5: Relationship between 2022 migrant proportion and overall German composite factor.

second period were somewhat larger than in the first, and second-generation students recorded gains 5 to 12 points greater than those of students without a migration background. As a result, the gap between these two groups steadily narrowed.

Particularly noteworthy are the first-generation students. With gains of 32 and 39 points, they recorded the largest increases from 2009 to 2015; from 2015 to 2022, however, they registered the smallest gains, with only 8 and 14 points. Consequently, in 2022 the gap in reading comprehension to students without a migration background was 4 points wider than before, whereas in listening comprehension it was 5 points narrower. At this juncture we emphasize a key point:

In both German and English, the performance changes from 2015 to 2022 were far more unfavorable for first-generation students—relative to students without a migration background and second-generation students—than were the changes from 2009 to 2015.

We now turn to the association between the 2022[§] proportion of students with a migration background and overall performance in German, which is depicted in Figure 5. Because no data are available for Hamburg, $N = 15$ here.

The pattern closely resembles that observed for mathematics and natural sciences competencies, but the shared variance is markedly lower at 29.2 percent. Figure 6 illustrates the association with overall English performance.

In English the relationship reverses: States with a higher proportion of students with a migration background achieve better performance, though the correlation is only .32. Of particular interest again is the East—West comparison based on residuals. The underlying data are provided in Table 12.

The unweighted mean residual is 6 points higher for western states in German and 7 points higher in English, but neither comparison reaches significance in a one-tailed Welch t-test ($p = .12$ and $p = .10$, respectively). Instead, in German the latitude of each state's geographic centroid explains 48.7 percent of the residual variance ($r = -.70$, $p < .01$). In English the corresponding correlation is -.33 and nonsignificant; inclusion of Hamburg (which ranks second-highest in English) would further reduce it. Thus:

[§] The correlation with migration background in 2012 and 2018 is .96 in each case.

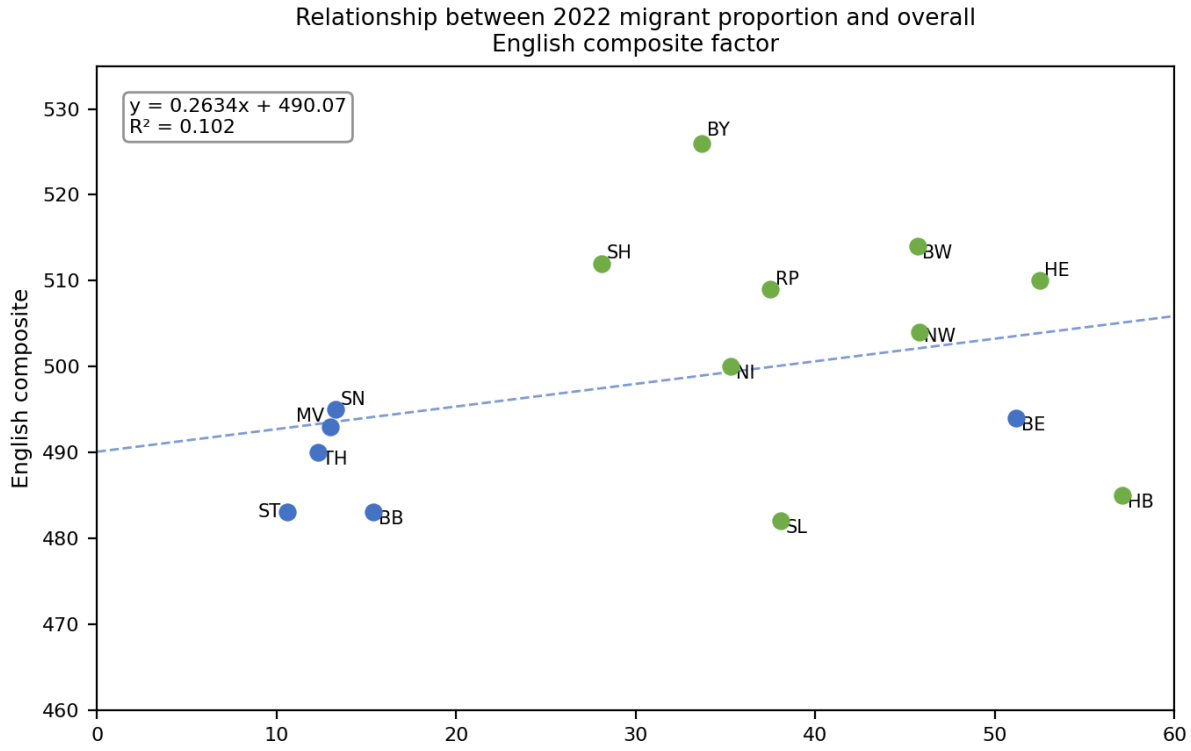

Figure 6: Relationship between 2022 migrant proportion and overall English composite factor

- *After controlling for the proportion of students with a migration background, no East–West difference remains in either German or English. In German, a South–North gradient emerges instead.*

Finally, we examine correlations between performance and the proportion of students with a migration background, broken down by assessment year, subdomain, and overall composite. Table 13 presents German on the left and English on the right.[¶]

German and English again yield fundamentally different patterns. In German the sign is consistently negative: States with a larger proportion of students with a migration background exhibit lower performance. The association was very weak in 2009 (-.20) but reached -.73 in 2015 and -.64 in 2022. Across subdomains the order is reading -.72, listening -.56, orthography -.39; for the overall German composite the value is -.58.

In English the association with migrant proportion is much weaker and essentially mirrors the German pattern in reverse. The correlation is positive and moderate in 2009 (.48), virtually disappears in 2015 (.09), and remains very weak in 2022 (.22). Whereas migration background correlates strongly with German reading, it shows no association whatsoever with English reading comprehension (-.03). English listening comprehension, by contrast, yields a moderate positive correlation of .52. Because of these highly divergent subdomain correlations, the overall English composite correlates only weakly with migrant proportion (.31).

3.3 Educational attainment of ninth-grade students in the IQB Education Trend, 2009–2024

Thus far we have examined mathematics and natural sciences competencies and linguistic competencies separately, both because they are conceptually distinct domains and because they were assessed in different survey waves. We now consider them jointly.

[¶] In 2012 and 2018, usable information on migration background was missing for 19.5 percent and 11.5 percent of students, respectively. In 2012 the non-response rate exceeded 45 percent in Berlin, Saarland, and Bremen; in Hamburg in 2018 no migration-background data were reported because the non-response rate exceeded 70 percent.

Table 12: Regression of German and English competencies on migration background: observed values, expected values, and residuals.

		German			English		
	Migr2022	M	Fitted	Resid.	M	Fitted	Resid.
Baden-Württemberg	45.7	493	480	14	514	502	12
Bavaria	33.7	508	485	23	526	499	27
Berlin	51.2	468	477	-9	494	503	-10
Brandenburg	15.4	483	493	-9	483	494	-11
Bremen	57.1	452	475	-23	485	505	-20
Hamburg	—	481			515		
Hesse	52.5	482	477	6	510	504	6
Mecklenburg-W. P.	13.0	487	494	-6	493	493	-1
Lower Saxony	35.3	488	484	4	500	499	1
North Rhine-Westphalia	45.8	477	480	-3	504	502	2
Rhineland-Palatinate	37.5	487	483	4	509	500	9
Saarland	38.1	487	483	4	482	500	-18
Saxony	13.3	501	494	8	495	494	1
Saxony-Anhalt	10.6	488	495	-7	483	493	-10
Schleswig-Holstein	28.1	488	487	1	512	497	15
Thuringia	12.3	488	494	-6	490	493	-3

Table 13: Proportion of students with a migration background and performance in German and English: assessment years, subdomains, and overall composites.

German		English	
Category	r	r	Category
2009	-.20	.48	2009
2015	-.73	.09	2015
2022	-.64	.22	2022
Reading	-.72	-.03	Reading
Listening	-.56	.52	Listening
Orthography	-.39		
German	-.58	.31	English

Note. r = correlation with migration background.

Construction of an overall scale of educational attainment

In the mathematics and natural sciences domain, we combined mathematics, biology, chemistry, and physics into the overall composite factor Mathematics–Natural Sciences Competencies (MNC), with mathematics weighted equally to the three natural-science subjects taken together. In the linguistic domain, the factor German was formed by averaging reading, listening, and orthography, and the factor English by averaging reading comprehension and listening comprehension.

The subject English is excluded from the subsequent analyses for three reasons. First, the correlation between German and English is only modest (.41), and the correlation between Mathematics–Natural Sciences and English is essentially zero (.07). Second, whereas performance in Mathematics–Natural Sciences and German has deteriorated over time, performance in English has improved markedly. Third, international large-scale assessments such as PISA typically include only mathematics, natural sciences, and the mother tongue; foreign-language competencies are either omitted entirely or treated marginally.

The correlation between the Mathematics–Natural Sciences Competencies composite (MNC) and the

Table 14: Correlations of the subdomains with the overall factor IQ-B

Correlation with overall factor IQ-B					
Mathematics	.98	German Reading	.97	English Reading	.52
Biology	.92	German Listening	.85	Engl. Listening	-.08
Chemistry	.93	German Orthogr.	.80		
Physics	.95				

German factor is .83 — virtually identical to the correlation between German reading and German orthography (.84). It should be borne in mind that the former association pertains to conceptually distinct domains assessed with different samples at different points in time, whereas the latter pertains to subdomains within the same subject assessed with the same samples at the same points in time.

Given this close relationship, it would be straightforward to combine MNC and German by simple averaging into an overall factor. Following the PISA approach, however, we instead construct the overall composite by averaging mathematics, natural sciences, and German. Because the correlation between the two variants is .995, the distinction is immaterial. We designate the overall factor representing ninth-grade educational attainment across the years 2009 to 2024 as IQ-B. Table 14 presents the correlations of the individual subdomains with this overall factor; for information, the values for English reading and listening comprehension—which are not included in IQ-B—are also provided. The overall factor IQ-B is most strongly determined by mathematics (.98) and reading (.97), followed by physics (.95), chemistry (.93), biology (.92), listening (.85), and orthography (.80).

Comparison across federal states

We conclude by examining the federal states at the level of overall performance IQ-B from 2009 to 2024. The profile of absolute performance levels is displayed in Figure 7. As was statistically inevitable, we observe the familiar pattern: Saxony occupies first place, Bremen last, and the eastern federal states — with ranks 1, 3, 4, 6, and 7 — outperform the western states by a wide margin; only Bavaria and Baden-Württemberg are able to place among them.

Figure 8 places this picture in perspective by taking into account the 2024 proportion of students with a migration background.

Once again we observe the familiar pattern: The shared variance between migrant proportion and educational performance amounts to 54.4 percent. Table 15 presents the data for the regression of overall performance IQ-B on the 2024 proportion of students with a migration background, while Figure 9 illustrates the profile of the federal states after removing the influence of migration background.

This yields the final result that is already familiar from our separate analyses of the mathematics–natural sciences and linguistic domains. After controlling for migration background, Bavaria (+21), Saxony (+14), and Baden-Wurttemberg (+14) clearly outperform the average, whereas Bremen (–15) and Mecklenburg-Western Pomerania (–11) perform markedly below expectation. In particular, the gap between Saxony (11.8% migrant proportion) and Bremen (61.3%) has shrunk from 61 to 29 points. One further point is noteworthy: the correlation of absolute performance values with the longitude of each state's geographic centroid is .49, but after controlling for migration background this association disappears (.11); the correlation with latitude is -.39 for absolute values but rises to -.68 after controlling for migration background. We therefore conclude with three central findings:

- *The competencies assessed in the IQB Education Trend from 2009 to 2024 — mathematics, natural sciences (biology, chemistry, physics), and German (reading, listening, orthography) — can be represented by a single factor that very reliably captures their common variance.*

- *There is a strong negative association between the performance level of the federal states and the proportion of students with a migration background.*

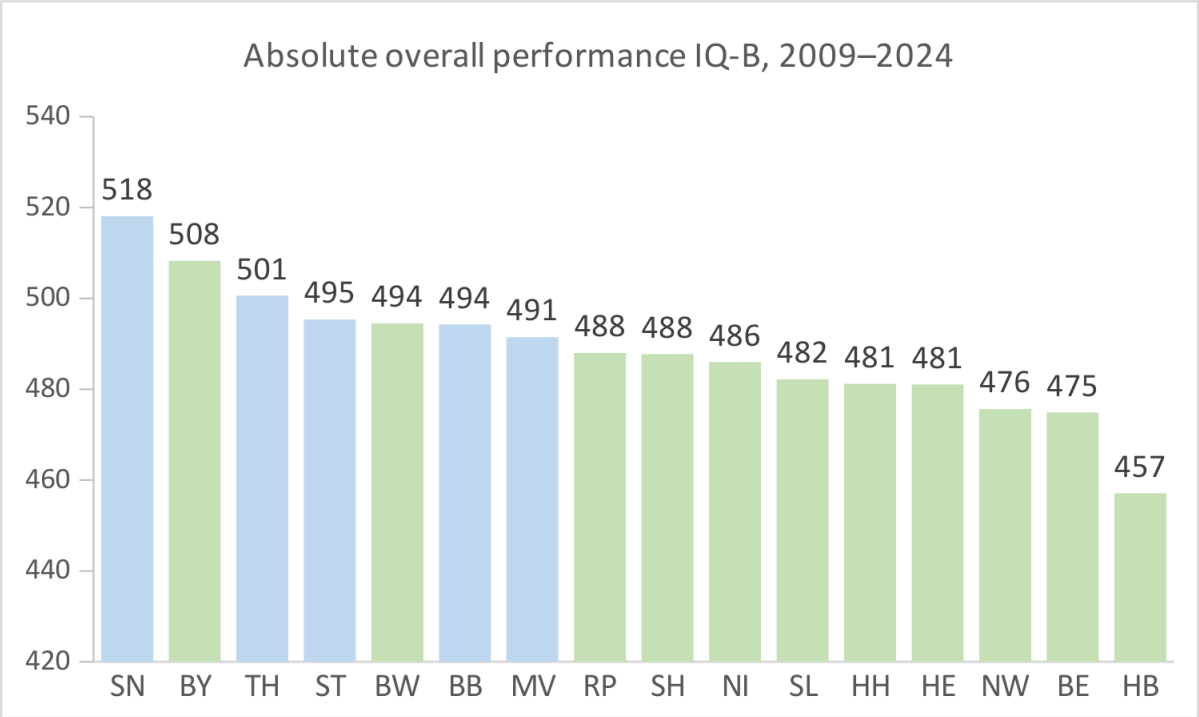

Figure 7: Absolute overall performance IQ-B, 2009–2024.

- *Once the proportion of students with a migration background is taken into account, the difference between western and eastern federal states vanishes entirely; in its place emerges a pronounced South–North gradient.*

4 Discussion

The subject of this study is not merely of academic interest; it is of the utmost relevance to Germany's future in three respects. First, the educational attainment of a population is of paramount importance for the standing of a modern industrial and information society and is a primary determinant of national prosperity — in both the mathematics and natural sciences domain and the linguistic domain. Second, the ninth-grade cohorts assessed in 2009, 2012, 2015, 2018, 2022, and 2024 will shape Germany's development in the coming decades. Third, the demographic composition of the population exerts an enormous influence on the cognitive capacity of a society. The official definition of migration background focuses primarily on place of birth. Far more relevant to performance differences, however, are ethno-cultural background and closely related factors such as region of origin, parental socioeconomic status, and parental education. In this regard, Germany has already undergone a fundamental transformation due to sharply increased immigration since 2015, and the present century will witness a demographic shift in which the proportion of ethnic Germans is projected to decline to 20–30 percent by 2100.

The present study can contribute only a minuscule piece to this complex mosaic. We structure the following discussion around three perspectives: first, the unit of observation; second, the performance measures derived from the IQB studies; and third, external variables, where we exercise extreme restraint. Our principal interest lies in the migration background of the student population, but this necessarily brings the geographic East–West and North–South divisions into view as well.

4.1 Unit of observation: Federal states

The IQB studies exhibit a clear hierarchy of observational units, ranging from individual students through school classes and federal states to Germany as a whole. We confine our analyses to the macro level

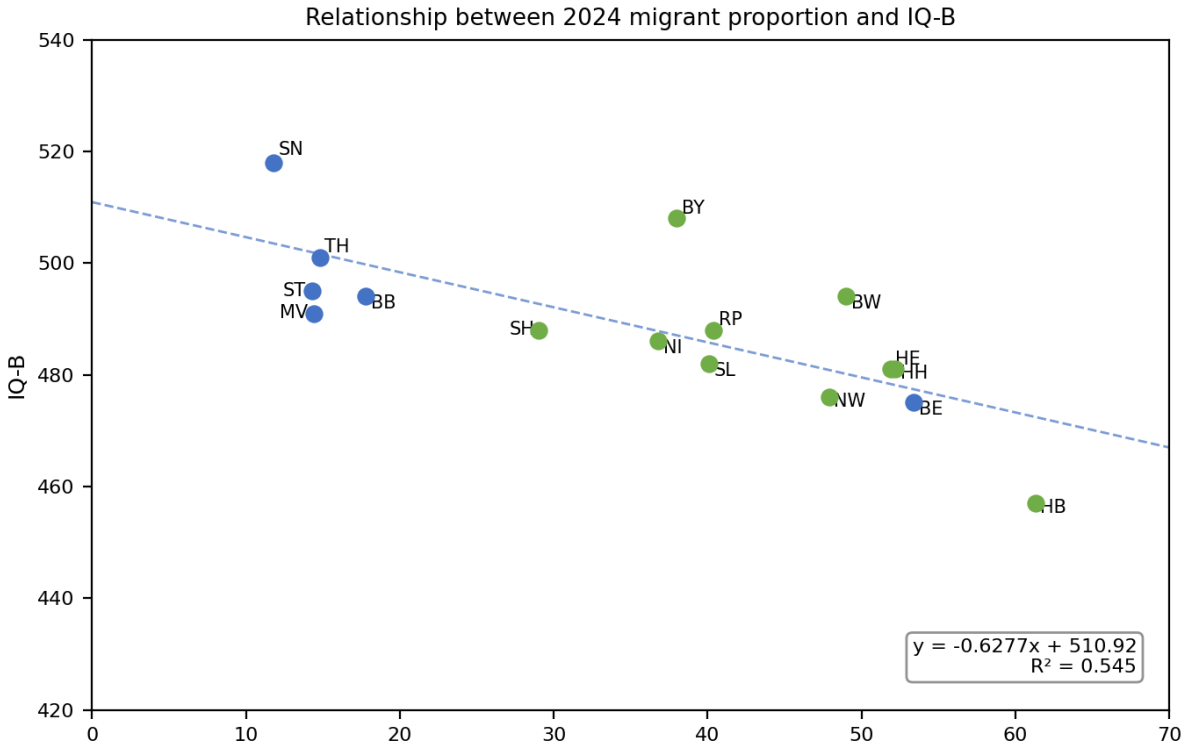

Figure 8: Relationship between 2024 migrant proportion and IQ-B.

of the federal states, with occasional reference to Germany overall. This is not solely because individual- and school-level data are unavailable to us; the macro level is also the explicit focus of the IQB studies themselves — and for good reason. Although Germany occupies a relatively small geographic area, its federal states differ profoundly in numerous respects owing to historical circumstances. Moreover, authority over education policy resides not with the federal government but with the individual states. We cannot address the countless differences among the states here (for the fragmented educational landscape, see Autor:innengruppe Bildungsberichterstattung, 2024); our concern at this point is methodological.

With only 16 federal states, the sample size at the unit-of-observation level is very small (N = 16). On the other hand, the state-level means we analyse are based on very large student samples, yielding exceptionally high reliability. Two implications for interpretation merit emphasis. First, correlations at the state level are considerably higher than at the individual-student level. Second, because of the large underlying student samples, even small differences can attain statistical significance despite limited practical importance. Since our primary focus is on structural relations among subjects, this distinction is of minor consequence for us.

The global performance factor IQ-B

Our central concern is the structural relationship among student performance in mathematics, the natural-science subjects (biology, chemistry, and physics), the German subdomains of reading, listening, and orthography, and the English subdomains of reading comprehension and listening comprehension. Due to the IQB's methodological design — different domains assessed in different samples at different time points — this question can be investigated only at the level of the federal states. The IQB itself provides an initial aggregation by combining the five guiding ideas in mathematics (number, measurement, space and shape, functional relationships, data and chance) into a global mathematics score and by focusing in the natural sciences primarily on subject knowledge, since the subdomain of scientific inquiry yields nearly identical state profiles.

We extended this aggregation systematically. First, we combined biology, chemistry, and physics into

Table 15: Regression of overall performance IQ-B on the 2024 proportion of students with a migration background: expected values and residuals.

	Migr2024	IQ-B	Fitted	Residual
Baden-Württemberg	49.0	494	480	14
Bavaria	38.0	508	487	21
Berlin	53.4	475	477	-3
Brandenburg	17.8	494	500	-6
Bremen	61.3	457	472	-15
Hamburg	52.2	481	478	3
Hesse	51.9	481	478	3
Mecklenburg-W. P.	14.4	491	502	-11
Lower Saxony	36.8	486	488	-2
North Rhine-Westphalia	47.9	476	481	-5
Rhineland-Palatinate	40.4	488	486	2
Saarland	40.1	482	486	-4
Saxony	11.8	518	504	14
Saxony-Anhalt	14.3	495	502	-7
Schleswig-Holstein	29.0	488	493	-5
Thuringia	14.8	501	502	-1

a Natural Sciences factor and then merged it with mathematics to form the overall Mathematics–Natural Sciences Competencies factor. In the linguistic domain, we aggregated reading, listening, and orthography into a German factor and reading comprehension and listening comprehension into an English factor. Finally, we combined the Mathematics–Natural Sciences Competencies factor with German to create an overall ninth-grade educational attainment factor designated IQ-B. Each step rested on very high correlations at the subordinate level, and the higher-order factors in turn reflect the common variance of their constituent subcompetencies to a very high degree. We deliberately excluded English because — owing especially to the markedly divergent performance in listening comprehension — it correlates only modestly with IQ-B. This brings us to the core question of the analysis: What exactly does our overall factor IQ-B measure?

Educational studies from the perspective of psychometric intelligence research

To approach this question, we first give voice to the IQB authors themselves. In their descriptions of the abilities required at successive competence levels in German reading (adapted from Stanat et al., 2023a, pp. 56, 58).[‖] we find the following ascending demands:

> *Ia: Locating and reproducing a single piece of information.*
>
> *Ib: Linking adjacent pieces of information that must be reproduced in paraphrased form.*
>
> *II: Inferring a key piece of information by establishing local coherence on the basis of linguistic and world knowledge and reproducing it independently.*
>
> *III: Performing a complex, independent inference that cannot be derived from sentence context but requires global text comprehension.*
>
> *IV: Reflecting on the relationship between linguistic form and content against the background of global text comprehension.*
>
> *V: Identifying a narrative strategy employed in the text and independently reflecting on its function.*

[‖] All direct quotations from the IQB authors (originally in German) have been translated into English for this text while preserving the exact wording and meaning as closely as possible.

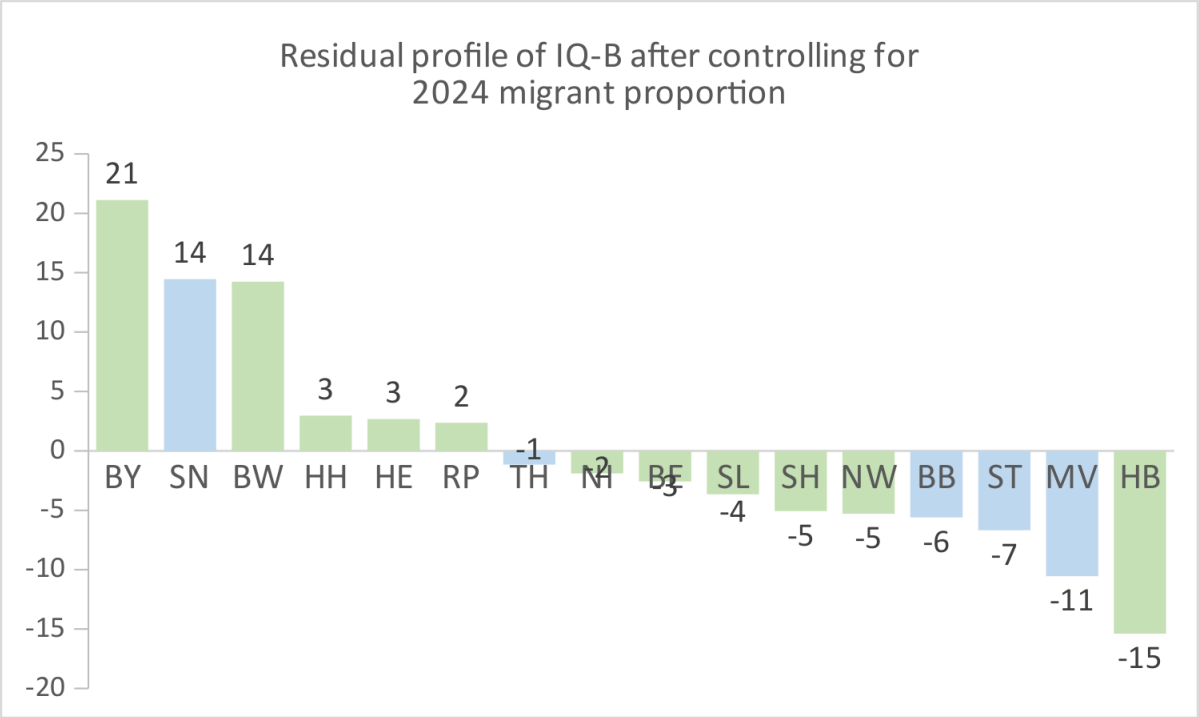

Figure 9: Residual profile of IQ-B after controlling for 2024 migrant proportion.

In mathematics the progression is analogous (adapted from Stanat et al., 2025, p. 55):

Ia: Extracting single pieces of information from short, simple mathematical texts or representations; argumentation and justification not yet required.

Ib: Following given standard arguments.

II: Executing the simplest standard arguments and selecting relevant information.

III: Independently presenting manageable reasoning, solution paths, and results.

IV: Purposefully extracting information from longer mathematical texts and solving problems that require a self-developed strategy.

V: Solving extensive or logically complex mathematical problems, reflecting on solution paths, and critically evaluating models employed.

These are abbreviated excerpts; detailed descriptions appear in the respective report volumes. Even a brief comparison reveals that although the specific content of tasks in German reading and mathematics differs greatly, all require cognitive abilities whose difficulty varies dramatically across tasks—from identifying simple information and linking pieces of information to highly complex performances involving abstract reasoning, intricate inference, flexible problem-solving, and metacognitive reflection. The same applies to the other assessed domains. Educational studies refer to these as competencies.

The great strength of large-scale educational assessments lies in their detailed description of enormous inter-individual differences in performance along each domain-specific continuum, with the six competence levels serving a role analogous to school grades. This differentiated, subject-specific perspective deserves explicit acknowledgment. For our purposes, however, a different aspect is decisive, and we turn to another definition:

- *"... is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience. It is not merely book learning, a narrow academic skill, or*

> *test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings — 'catching on', 'making sense' of things, or 'figuring out' what to do" (Gottfredson, 1997, p. 13).*

It is evident that this cognitive ability overlaps to a very high degree — albeit not perfectly — with what laypersons in Finland call Älykkys, in Greece Νοημοσυνη (Noimosyne), and in Iceland Greind. Every other European national language employs a common root, for example: Inteligencija (Bosnia-Herzegovina), Inteligentsnost (Bulgaria), Intelektas (Lithuania), Intelligentie (Netherlands), Inteligencja (Poland), or Intellekt (Russia). In German we call this ability *Intelligenz* and in English *Intelligence*.

The competencies assessed across all IQB domains — whether German, mathematics, or the natural sciences — require precisely the cognitive processes identified in Gottfredson's definition as core features of intelligence. This holds at every competence level, but especially at the higher ones: abstract thinking, complex inference, flexible problem-solving, and metacognitive reflection.

We thereby enter a far older research tradition whose foundations have been secure for over a century. As early as the beginning of the twentieth century, psychometric intelligence research empirically demonstrated that tasks requiring cognitive ability, regardless of specific content, consistently correlate positively with one another (the positive manifold) and that these correlations can be explained at the highest level of aggregation by a single common factor. Spearman (1904, 1927) termed this the general factor or *g* and laid the groundwork for modern factor analysis. This holds even for seemingly simple sensory discrimination tasks; Spearman (1904) already showed that pitch or weight discrimination correlates positively with school performance and loads substantially on *g*. The principle of the indifference of the indicator was thus established: the common factor is not tied to particular content or curriculum but reflects a general, domain-transcending cognitive efficiency.

Although competing models exist for describing the full breadth of human intelligence (e.g., Cattell-Horn-Carroll, Berlin Model of Intelligence Structure), there is broad consensus that the factor at the apex of the hierarchy — whether termed *g*, general intelligence, or general cognitive ability — possesses far greater explanatory power than any subordinate factor (Haier et al., 2024; Rindermann, 2018; Warne, 2020). Two points are crucial for our topic. First, at the highest level of aggregation, performance in large-scale educational assessments and in psychometric intelligence tests is virtually identical. Second, both educational performance and psychometrically measured intelligence exert powerful effects on nearly all major life outcomes—from educational attainment and occupational status through income and health to societal innovation and national prosperity.

The close link between school performance and psychometrically measured intelligence has been foundational knowledge in intelligence research since its inception. Only the advent of large-scale international assessments (PISA, TIMSS, PIRLS) provided an unprecedentedly broad and representative empirical foundation for this relationship. The greatest credit here belongs to Richard Lynn, who — first alone and later with an international network — demonstrated that national profiles in psychometric intelligence tests and educational assessments are nearly identical (Lynn & Becker, 2019; Lynn & Vanhanen, 2002, 2006). In Germany, Weede and Kämpf (2002), Weede (2004), and Volkmar Weiss (Weiss, 2002, 2019, 2022; Weiss, 2012) drew early attention to this fact following the initial PISA results, and Heiner Rindermann has repeatedly confirmed it with ever-new data since 2006 (e.g., Rindermann, 2007, 2018, 2024, 2025a, 2025b). Particularly relevant for the present study is Rindermann's finding that the global factor derived from the IQB Education Trends 2009–2016 correlates $r = .94$ with a Cognitive Ability factor based on student assessment and intelligence test data (Rindermann, 2024, p. 5). It should therefore be clear:

- *Our overall factor IQ-B constitutes a highly reliable and valid measure of the general intelligence of ninth-grade students across German federal states as assessed by the IQB Education Trends.*

With regard to the second point — the enormous real-world significance of general intelligence — Richard Lynn again deserves principal credit. In landmark works such as *IQ and Global Inequality* (Lynn & Vanhanen, 2006), (Lynn & Vanhanen, 2012), and (Lynn & Becker, 2019), he showed that national IQs correlate strongly

with important outcomes across diverse life domains and typically outperform competing predictors. We confirmed this in our own analysis of more than 200 indicators from the Human Development Index, Social Progress Index, Global Innovation Index, Global Talent Competitiveness Index, Democracy Index, Index of Economic Freedom, World Happiness Report, Positive Peace Index, Global Peace Index, and Total Fertility Rate (Henss, 2025b). The conclusion is unequivocal:

- *"Intelligence is by far the most important human trait. No one will be able to dig up a variable that is independent of intelligence and has greater explanatory power than that" (Henss, 2025b, p. 89).*

4.2 Methodological clarifications, the special case of English, and the loss of entire years of learning

Having established what the IQ-B measures and underscored the exceptional importance of general intelligence across nearly all domains of life, it is now appropriate to address several concrete findings from our analysis of the IQB Education Trends 2009–2024.

Methodological notes on IQ-B

We constructed IQ-B through stepwise aggregation — a procedure that is immediately transparent. Hierarchical structure is typically determined using factor-analytic techniques. For comparison, we subjected the subjects mathematics, biology, chemistry, physics, German reading, German listening, and German orthography to a principal component analysis with varimax rotation. As expected, a clear single-factor solution emerged, accounting for 84.1 percent of the variance. The correlation between our manually computed IQ-B and the factor scores is r = .997. In the Results section we reported the correlations of individual subjects with the overall composite; the factor-analytic equivalents are the loadings. The values (IQ-B correlation / loading) are: mathematics .98 / .96, reading .97 / .97, physics .95 / .95, chemistry .93 / .93, biology .92 / .92, listening .85 / .86, orthography .80 / .81. Both perspectives yield a practically identical pattern — the results are empirically indistinguishable from one another.

It should further be noted that IQ-B represents aggregation not only across subjects but also across time (2009–2024). Because the most pronounced changes occurred between 2018 and 2024, the composite does not primarily reflect the current state but rather the relatively stable pattern over fifteen years. Should a substantial portion of the recent declines prove attributable to pandemic-related disruptions and be recouped in the near future, the temporal aggregation would constitute a desirable smoothing.

Finally, it must be explicitly stated that focusing on the highest level of aggregation in no way denies the importance of subordinate factors and individual time points. For most research questions, differentiated examination of specific subjects and years remains indispensable. At the same time, the common core must not be lost from view — and it is precisely this common core that IQ-B captures with extraordinary reliability, making it an outstanding measure of general intelligence.

The special case of English

In constructing IQ-B, we deliberately excluded English. Since international large-scale assessments either omit foreign-language competencies entirely or treat them only marginally, this exclusion represents no substantial limitation. Nevertheless, the subject merits particular attention for several reasons.

Most striking is English listening comprehension, which correlates essentially zero with IQ-B (r = -.08). Given the positive manifold — the empirical regularity that nearly all cognitively demanding tasks correlate positively with general intelligence —, this constitutes a remarkable anomaly. By contrast, English reading comprehension exhibits a substantial correlation of r = .52.

In general, reading competence can be expected to serve as a stronger indicator of general intelligence than listening comprehension: Written text is permanently available and permits repeated processing, whereas spoken language is ephemeral. The development of higher cognitive abilities was decisively

enabled by the invention of writing, which for the first time allowed undistorted knowledge storage and cumulative expansion across generations. Reading competence is a foundational pillar of intelligence; students who cannot adequately read and comprehend task instructions will also fail to produce adequate solutions. Correspondingly, mathematics (r = .98) and German reading (r = .97) carry the greatest weight in IQ-B.

A key to understanding these peculiarities lies in the state-level performance profile. Whereas the eastern German states — without controlling for migration background — lead in all other subjects, they rank at the very bottom in English. Only Saarland performs even more poorly, despite otherwise placing in the lower mid-range. Historical legacies are clearly at work here.

After the division of Charlemagne's empire, Saarland lay for centuries in the contested border region between West and East Francia and was temporarily part of France again after 1945; it did not join the Federal Republic until 1957. Many parents and nearly all grandparents of students tested in earlier cycles had spent part of their lives under French administration. Even today, French continues to receive strong promotion in Saarland; for linguistically gifted students, attractive career opportunities open up in the cross-border Greater Region (Grande Region / SaarLorLux).

In the East German federal states, the decades-long isolation from the West and the prioritization of Russian language instruction in the GDR have left lasting traces. Particularly striking is the disparity between reading and listening comprehension. In reading comprehension, the gap amounts to a mere 5 points. In listening comprehension, however — where performance benefits substantially from early and intensive exposure — the gap reaches 27 points. The grandparents, parents, and teachers of the 15-year-old students surveyed in 2009, 2015, and to some extent also in 2022 grew up in the GDR without systematic English instruction and without the pervasive influence of English-language pop music that had shaped the auditory landscape of West Germany since the 1960s. The students themselves were presumably far less frequently immersed in this acoustic environment during their early childhood years than their West German peers. This historical context likely provides an important partial explanation for the gap in listening comprehension: it stood at 35 points in 2009 and subsequently decreased to 23 points in 2015 and 22 points in 2022.

English is noteworthy in a third respect as well: Whereas all other subjects show stagnation from 2009 to 2012 and 2015 to 2018 followed by sharp declines from 2015 to 2022 and 2018 to 2024 — a pattern mirrored worldwide in PISA 2022 (OECD 2023) and unambiguously attributable to pandemic-related instructional disruptions —, English performance improved continuously and substantially over the full thirteen-year period. This exceptional gain suggests that English instruction in Germany underwent a lasting qualitative improvement during this time. We will, however, qualify this impression in the next section.

Competence levels and age-typical learning gains

Thus far we have described student performance exclusively in terms of means. A more differentiated perspective is essential for assessing practical significance.

The educational standards of the Standing Conference of the Ministers of Education and Cultural Affairs (Kultusministerkonferenz, KMK) are aligned with the IQB competence levels. The minimum standard for the lower secondary school leaving certificate (Erster Schulabschluss, ESA) corresponds to level Ib (355–434 points), the regular standard to level II (435–514 points). Requirements for the intermediate school leaving certificate (Mittlerer Schulabschluss, MSA) are shifted upward by one level. Students who fail to reach the MSA minimum standard face severely restricted prospects for adequate participation in a modern industrial and knowledge-based society.

The most recent IQB assessments paint an alarming picture: In mathematics, the proportion of students failing to attain the MSA minimum standard rose from 9 percent (2018) to 24 percent (2024); in chemistry from 9 to 25 percent, in physics from 7 to 10 percent, and in biology from 5 to 10 percent.

Among students pursuing the MSA, the failure rate ranges from 12.0 percent in Bavaria to 34.1 percent in Bremen. At the upper end, the proportion reaching the optimal standard ranges only from 0.7 percent in Lower Saxony to 5.2 percent in Saxony. Thus, the group from whom the most valuable societal contributions might be expected remains very small.

The IQB authors themselves draw a sobering conclusion: "Taken together, the findings reveal predominantly negative trends between 2015 and 2022 both for Germany as a whole and for the individual states across all competence domains. In part these appear to continue unfavorable developments already observable from 2009 to 2015, but since 2015 they have generally intensified markedly" (Stanat et al., 2023a, p. 95).

Another illuminating perspective is provided by comparison with age-typical learning gains. "Estimates suggest that the learning gains typically achieved between grades 9 and 10 at the end of lower secondary education amount to approximately 20 points in German reading and about 15 points each in listening and orthography on the reporting metric. These values, however, offer only a rough orientation" (Stanat et al., 2023a, p. 149). In English, the corresponding figures are approximately 40 points for both reading and listening comprehension.[††]

The actual changes from 2009 to 2022 can thus be contextualized as follows: The gains in English (+41 and +47 points) correspond to roughly one year of normal learning progress. The losses in German (–31, –52, and –29 points), by contrast, equate to the loss of one-and-a-half to three-and-a-half years of regular learning progress.

Even if these estimates must be treated with caution, they underscore the dramatic magnitude of the observed performance declines, especially in the core subject German. On the other hand, they put the gap in English listening comprehension in the East German federal states into perspective: It currently amounts to little more than half of the annual learning gains.

4.3 The influence of migration background

Student performance is shaped by a complex web of countless variables. In this study we deliberately confine ourselves to a single external variable: the proportion of students with a migration background. Before presenting our own findings, we briefly review the background variables considered in the IQB Education Trend.

Background variables in the IQB Education Trend

To explain performance differences, the IQB collects a wide array of background characteristics via student, parent, and teacher questionnaires as well as official statistics. Two are of particular relevance to our inquiry: family socioeconomic status and cultural capital.

Socioeconomic status is indexed by the HISEI (Highest International Socio-Economic Index of Occupational Status), which reflects the higher socioeconomic score of the two parents (Ganzeboom, 2010; Ganzeboom et al., 1992). The HISEI combines income and internationally comparable occupational prestige, which has proven remarkably stable across nations and over a century (Henss, 2025a; Treiman, 1977).

Cultural capital is measured by the number of printed books in the household. The IQB itself describes this variable as follows: "As an indicator of cultural capital, the number of printed books in the household was recorded. This aspect primarily characterizes the family's objectified cultural capital. It can also be interpreted as an indicator of incorporated cultural capital, encompassing acquired knowledge and skills, as well as of the economic capital that enables families to acquire books" (Stanat et al., 2025, p. 240).

As expected for Germany, students with a migration background exhibit on average both lower HISEI values and fewer books at home. For our analysis, however, a different aspect is decisive: Occupational prestige, income, and the number of books in the home are not only highly intercorrelated, but are all indicators of parental intelligence. More intelligent parents typically attain higher educational qualifications, occupy more prestigious and better-paid positions, and provide a richer cultural and material environment. Because general intelligence is substantially heritable (heritability approximately 0.5–0.8 in adulthood), their children benefit both genetically and environmentally.

[††] Regarding the growth of intelligence during childhood and adolescence, see also Rindermann (2011).

Crucially, modern behavioural genetics has established that even ostensibly "pure" environmental variables such as the number of books in the home or parental occupational status and income contain a genetic component (genotype–environment correlation).‡‡ Plomin succinctly states:

- *"The evidence from twin studies suggests that genetics accounts for about a third of the variance of environmental measures. This phenomenon is called genotype-environment correlation because it literally means that there is a correlation between genotype . . . and environment . . . Genotype-environment interaction is not about the correlation between genes and environments but their interaction" (Plomin, 2018, 170f).*

The IQB authors' conclusion that "immigration-related disparities are markedly reduced in all subjects and competence domains once the socioeconomic and cultural resources of families are taken into account" (Stanat et al., 2025, p. 296) is therefore implicitly also a statement about the effects of genetically and environmentally transmitted parental intelligence.

Migration as an intervening variable

We now turn to the central empirical finding: the relationship between the proportion of students with a migration background and the educational attainment of the federal states.

Regressing IQ-B on migrant proportion yields two contrasting results. First, the pronounced performance advantage of the eastern over the western federal states virtually disappears: the raw correlation of IQ-B with geographic longitude is r = .49; after controlling for migrant proportion, the correlation of the residuals with longitude drops to r = .11. Second, the South–North gradient becomes far more pronounced: The raw correlation of IQ-B with latitude is r = -.39; after controlling for migrant proportion, the correlation of the residuals with latitude rises to r = -.69 ($p < .01$).

The East–West gradient is thus primarily an artifact of differing migrant proportions rather than an intrinsic regional difference. The South–North gradient, by contrast, is partly masked by the higher migrant proportions in northern states and becomes visible only after they are controlled.

This example illustrates how failure to consider an intervening variable can lead to distorted interpretations. In public discourse, performance differences between East and West or North and South are frequently discussed without mentioning the decisive influence of migration background — with the result that erroneous conclusions are drawn about regional education policy or demographic factors.

As Figure 9 shows, the remaining residual differences are essentially attributable to five federal states: Bavaria (+21), Saxony (+14), and Baden-Wurttemberg (+14) achieve far above-average performance, whereas Mecklenburg-Western Pomerania (–11) and Bremen (–15) fall markedly below expectation. Alongside the South–North gradient, it is noteworthy that the three top performers have never been governed by the "socialist" party SPD for decades, whereas the two bottom performers have had continuous SPD-led governments.

Our findings receive impressive confirmation and extension in a recent analysis by Rindermann (2024). Drawing on a much broader database — student performance and cognitive ability tests from four sources (PISA, PIRLS, IQB, and Bundeswehr conscript testing) between 1998 and 2016 —, the aggregated IQB factor correlates r = .94 with the Cognitive Ability factor, underscoring the high convergent validity of the IQB data.

After controlling for numerous background variables (e.g., socioeconomic status, migrant proportion, education policy), the same pattern of regional differences emerges, supplemented by robust correlations with bourgeois-conservative political and lifestyle factors. Rindermann's summary conclusion is:

- *"Three factors turned out to be decisive: a more traditional and achievement-based education policy, e.g. central exams and high requirements, behind this, rather burgher-conservative state policy and society, and finally the percentage of students with no migration background" (Rindermann, 2024, p. 18).*

‡‡ Plomin (2018), Reich (2018), von Stumm et al. (2023).

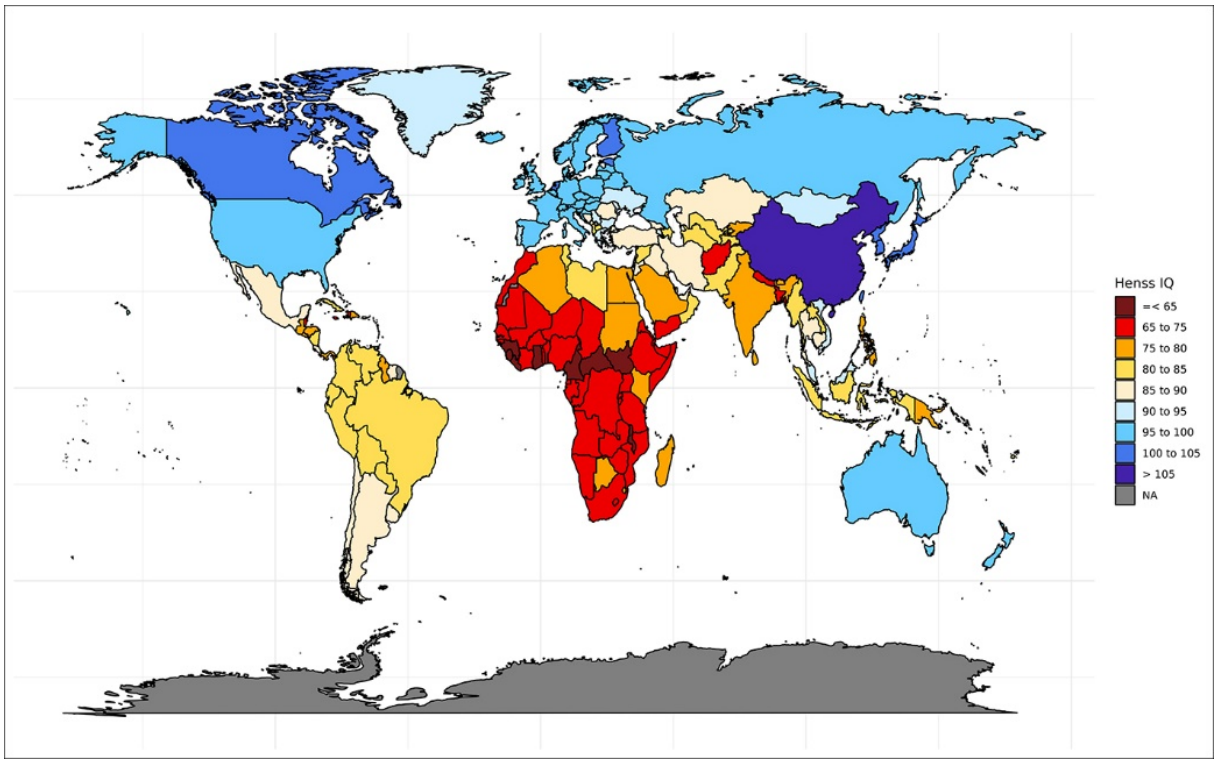

Figure 10: Heatmap of national IQs worldwide.

Key variable: Region of origin of migrants

Rindermann's dataset extends only to 2016 and thus excludes three variables of overriding importance: the COVID-19 pandemic and — as a consequence of the 2015 border opening — the sharply increased proportion of students with a migration background together with the accompanying shift in composition by region of origin. With the available data it is impossible to disentangle the effects of these unprecedented factors, yet region of origin plays a highly significant role.

In the first assessment (2009), Turkey, the former Soviet Union, and Poland dominated as countries of origin (Köller et al., 2010, p. 25). By 2015 these were joined by the former Yugoslavia, Arab countries, and others (Stanat et al., 2016, p. 454). The most recent 2024 report highlights that the proportion of first-generation students has risen sharply, with Syria, Ukraine, Poland, Romania and Afghanistan as the main sources; among second-generation students, Turkey, Russia, Kazakhstan, Poland, and Kosovo predominate. The IQB authors conclude: "Both in the first and second generations, however, the largest group consists of students originating from many different countries. This once again underscores how heterogeneous the group of children and adolescents with an immigration background in German schools is" (Stanat et al., 2025, p. 273).

That these changes have greatly increased cultural heterogeneity is undisputed. From our perspective, however, another aspect is of even greater importance: Nations differ substantially in their average intelligence level, and immigration is increasingly from countries with markedly lower cognitive competence.

Thanks to a century of psychometric intelligence research and large-scale national and international student assessments, we possess a reliable picture of the average cognitive competence of individual nations (national IQs). Figure 10 illustrates these differences in the form of a heatmap.[§§]

With respect to the most important countries of origin for immigration to Germany, the following holds: Russia and Poland lie only a few points below the German value of 100, the Balkans in the mid-to-low 90s, the Near East in the mid-to-low 80s, and sub-Saharan Africa in the mid-to-low 70s. Assuming a normal distribution with a standard deviation of 15, 50 percent of the German population attains at least IQ 100,

[§§] Heatmap provided by Sebastian Jensen

compared to roughly 16 percent in the Near East (mean 85) and only about 5 percent in sub-Saharan Africa (mean 75).

What matters, however, is not the mean of the country of origin but the actual cognitive competence of the immigrant subgroup. Concrete data are available: Rindermann et al. (2024)[¶¶] tested 499 adult migrants from 15 countries in 2017 and 2018 using the language-free, figural BOMAT intelligence test (Hossiep & Hasella, 2010). The overall group yielded an IQ of 90, with Eastern/Northeastern Europe at 97, North Africa/Near East at 90, and sub-Saharan Africa at 77. Thus, although migrants scored 5 to 10 points higher than the average of their countries of origin, they remain well below the German population mean; this constitutes a lose-lose situation for both the countries of origin and Germany. Incorporating two further German studies, the authors summarize the situation as follows: "This corresponds to a level for the profession of baker or hairdresser. The level is too low to form the basis for a second economic miracle, especially not in an increasingly complex technological, social and cultural modernity" (Rindermann et al., 2024, p. 2). The decisive point for our topic is:

- *The markedly more effective German education system undoubtedly offers the children of immigrants far better opportunities than the systems of their countries of origin. Nevertheless, the IQB Education Trends — as well as PISA, TIMSS, and PIRLS — consistently show that even second-generation students achieve substantially lower performance than students without a migration background. Even after years of intensive support within the German school system, a considerable performance gap persists.*

Demographic upheaval in Germany — A conservative projection

Figure 11 depicts a regularity that will profoundly reshape not only Germany but the entire world in the course of this century. On the x-axis is average national intelligence (national IQ), on the y-axis the total fertility rate (TFR) according to United Nations (2025). The blue dotted line represents the linear regression on intelligence (Henss, 2025b). The dotted horizontal line marks TFR = 2.1, the rate required for long-term population replacement.

The evidence is unequivocal: There exists a negative correlation between intelligence and total fertility rate (TFR). More critically, in numerous countries, the total fertility rate falls below the replacement level of 2.1, often substantially so. These populations will therefore shrink massively in the twenty-first century, not only because of low birth rates but also because of already advanced population aging. To maintain or even approximate stable population levels, virtually all highly developed countries — along with many middle-income nations and some lower-income ones — depend heavily on substantial net immigration. Mutual "cannibalization" among countries with high cognitive levels is impossible. The only remaining source is immigration from countries with substantially lower average cognitive competence.

- *The demographic dynamic of the twenty-first century is thus inexorably predetermined: a worldwide demographic replacement process from below upward — with profound consequences for the cognitive level and performance capacity of receiving societies.*

To illustrate the profound implications of these global demographic dynamics for Germany, we have constructed a cohort-based projection of current trends using artificial intelligence. The starting point is the present age structure of the population, with the assumption of a constant total fertility rate of 1.4. Drawing on estimates generated by Grok, ChatGPT, and Perplexity, we computed the mean values.

Under these conditions, the population without a migration background (defined as individuals both of whose parents were born in Germany) is projected to decline from approximately 58 million today to roughly 47 million by 2050, 35 million by 2075, and only 27 million by 2100.

Assuming that the total population of Germany remains constant at 84 million through sustained net immigration, the relative share of residents without a migration background would fall from 69.0% at present to 55.4% in 2050, 41.5% in 2075, and 31.7% by the year 2100. This profound demographic upheaval is

[¶¶] See also Rindermann (2025c).

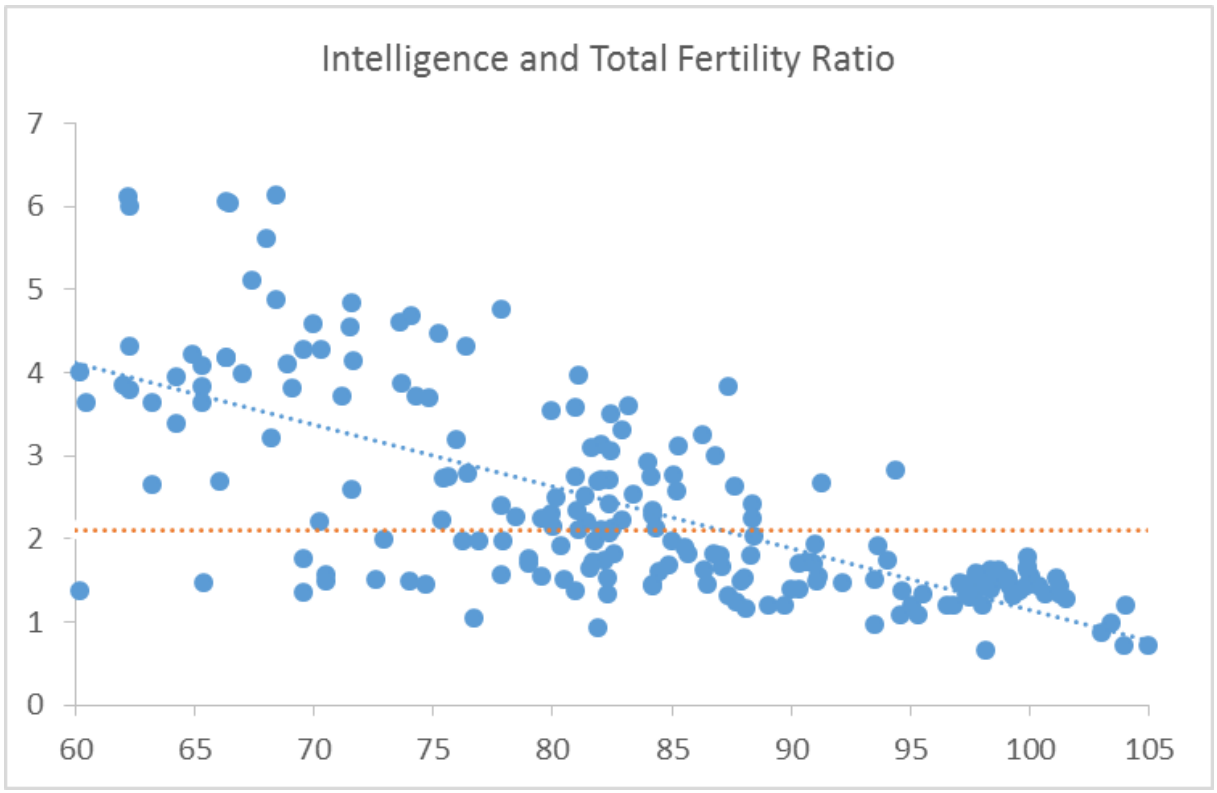

Figure 11: Intelligence and total fertility rate.

visually represented in Figure 12, in which the population without a migration background is depicted in blue and the population with a migration background is shown in red.

The present projection considers only the internal demography of the current population without migration background. In reality, increasing exogamous partnerships will cause the proportion of ethnic-German descendants to decline even faster than shown in this forecast. Barring technological, medical, or education-policy "miracles", the consequence is inevitable:

- *The average cognitive performance level of Germany — as measured by IQ-B — will necessarily and substantially decline over the course of this century.*

This is all the more grave because modern science, technology, industry, and the foundational institutions of Western civilization were created almost exclusively by ethnic Europeans — and among them, to an outstanding degree, by ethnic Germans. No other population group has yet produced comparable cognitive and cultural achievements at this level.

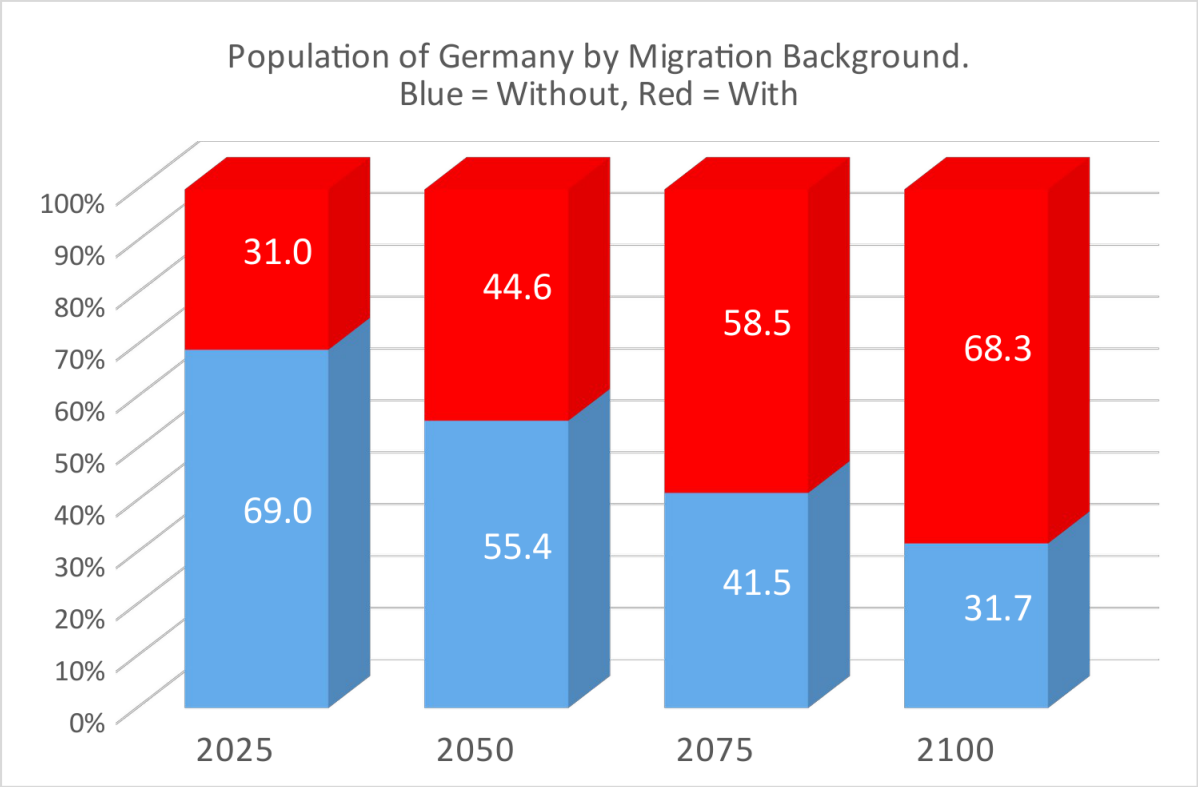

Figure 12: Population of Germany by migration background. Blue = without, Red = with

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