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The IQB National Assessment Study 2012

Competencies in Mathematics and the Sciences at the End of Secondary Level I

Summary

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The IQB National Assessment Study 2012

In 2003 and 2004, the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK) introduced educational standards for the primary level and for secondary level I detailing which competencies and skills students are expected to have developed by the time they reach certain points in their school career (KMK, 2004, 2005a-d). At the primary level, the focus of these standards was on the core subjects of German and mathematics. At secondary level I, the focus was on German, mathematics, and the first foreign languages (English, French), with different standards for the lower secondary school-leaving certificate (HSA), which is normally attained at the end of the ninth grade, and for the intermediate secondary school-leaving certificate (MSA), which is usually attained at the end of the tenth grade. For the science subjects biology, chemistry, and physics, educational standards were developed only for the intermediate secondary school-leaving certificate (MSA). In accordance with the long-term strategy of the Standing Conference (KMK, 2006) on educational monitoring in Germany, the 16 federal states (Länder) also decided to conduct regular studies assessing the extent to which educational standards are being met at the state level. These sample-based comparative assessments of state-level educational performance, which are administered by the Institute for Educational Quality Improvement (IQB) at the Humboldt-Universität zu Berlin, are carried out in parallel with various international large-scale assessments of student achievement at the primary level (PIRLS[1], TIMSS[2]) and secondary level I (PISA[3]). In 2009, the IQB National Assessment Study was conducted in the subjects of German and the first foreign language at secondary level I (Köller, Knigge & Tesch, 2010), followed in 2011 by assessments at the primary level in German and mathematics (Stanat, Pant, Böhme & Richter, 2012). The National Assessment Study 2012 examines student competencies in the ninth grade – that is, at the end of secondary level I – in mathematics, biology, chemistry, and physics, and thus concludes the first cycle of surveys in the IQB's standards-based national assessment. In the following, the results of the IQB National Assessment Study 2012 are summarized.

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[1] The acronym PIRLS stands for *Progress in International Reading Literacy Study.*

[2] The acronym TIMSS originally stood for *Third International Mathematics and Science Study*. Since 2003, however, it has referred to the revised name: *Trends in International Mathematics and Science Study*.

[3] The acronym PISA stands for *Programme for International Student Assessment*.

Sample and Areas of Assessed Proficiency

A total of 44,584 ninth grade students from 1,326 schools[4] across Germany participated in the 2012 IQB National Assessment Study. This stratified random sample allows general conclusions to be drawn at the level of each of the 16 German federal states.

In addition to the proficiency tests used in mathematics and the science subjects biology, chemistry, and physics, questionnaires were used to survey students, teachers, and school principals. The weighted participation rate in the proficiency tests was 92% and thus the same as in PISA 2009 (Jude & Klieme, 2010, p. 16) and only slightly below the participation rate in the National Assessment Study 2009 (95%; Böhme, Leucht, Schipolowski, Porsch, Knigge & Köller, 2010, p. 79). The rate of test participation within the individual states was also consistently high. The 79% mean rate of participation in the student questionnaire, however, was significantly below the rate of participation in the proficiency test and also well below the participation rate in the student questionnaire in the 2009 National Assessment Study (88%; Böhme et al., 2010, p. 79).

The rate of student questionnaire completion differed substantially from state to state – in contrast to the rate of completion of the achievement test itself. The percentage of missing answers to key questions about social and immigration background was especially high in the states of Berlin, Bremen, and Saarland. In these three states, analyses of the relationship between achievement differences (disparities) and information from the background questionnaires may suffer from validity issues. Due to the unfavorable data situation and the concomitant limited validity of the findings, the data on social and immigration background factors are presented separately for these three states.

The educational standards in *mathematics* for the lower secondary school-leaving certificate (HSA) and for the intermediate secondary school-leaving certificate (MSA) differentiate five content areas (core competencies) and the mathematical content that students are expected to learn in each. These core competencies were developed as a means of capturing and structuring phenomena observable in the natural world when viewed from a mathematical perspective (Freudenthal, 1983). The core concepts used here are: *numbers*, *measurement*, *space and shape*, *functional relationships*, and finally, *data and chance*. The results of the National Assessment Study 2012 for mathematics are reported, first, based on a *global scale* covering all of the tasks in all five content areas. In addition, a few key results from the five content areas are discussed in more detail.

In the *sciences*, the educational standards for the intermediate school-leaving certificate (MSA) differentiate four content areas for each of the subjects biology, chemistry, and physics. The National Assessment Study 2012 focuses on two of these areas – *content knowledge* and *scientific inquiry*. The content area of *content knowledge* does not deal with knowledge recall, but rather – in accordance with the concept of content competency as defined by Weinert (2001) – corresponds to an active engagement with scientific content in order to solve specific scientific problems. The competency expectations as they are formulated in the educational standards for the area of *content knowledge* refer to the content of the particular subject as a set of *basic concepts* under which diverse con-

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[4] The national assessment studies were carried out at lower secondary schools, schools with multiple educational tracks, intermediate secondary schools, upper secondary schools, integrated comprehensive schools, free Waldorf schools, and special needs schools (focused on learning, social and emotional development, and language).

tent can be subsumed. The educational standards for the content area of *scientific inquiry* include the sub-areas of *scientific investigation, scientific modeling,* and *scientific theorizing*, which are broken down further into additional areas of content (Wellnitz et al., 2012). The results of the National Assessment Study 2012 in the science subjects biology, chemistry, and physics are reported for both of the aforementioned proficiency areas (*content knowledge* and *scientific inquiry*).

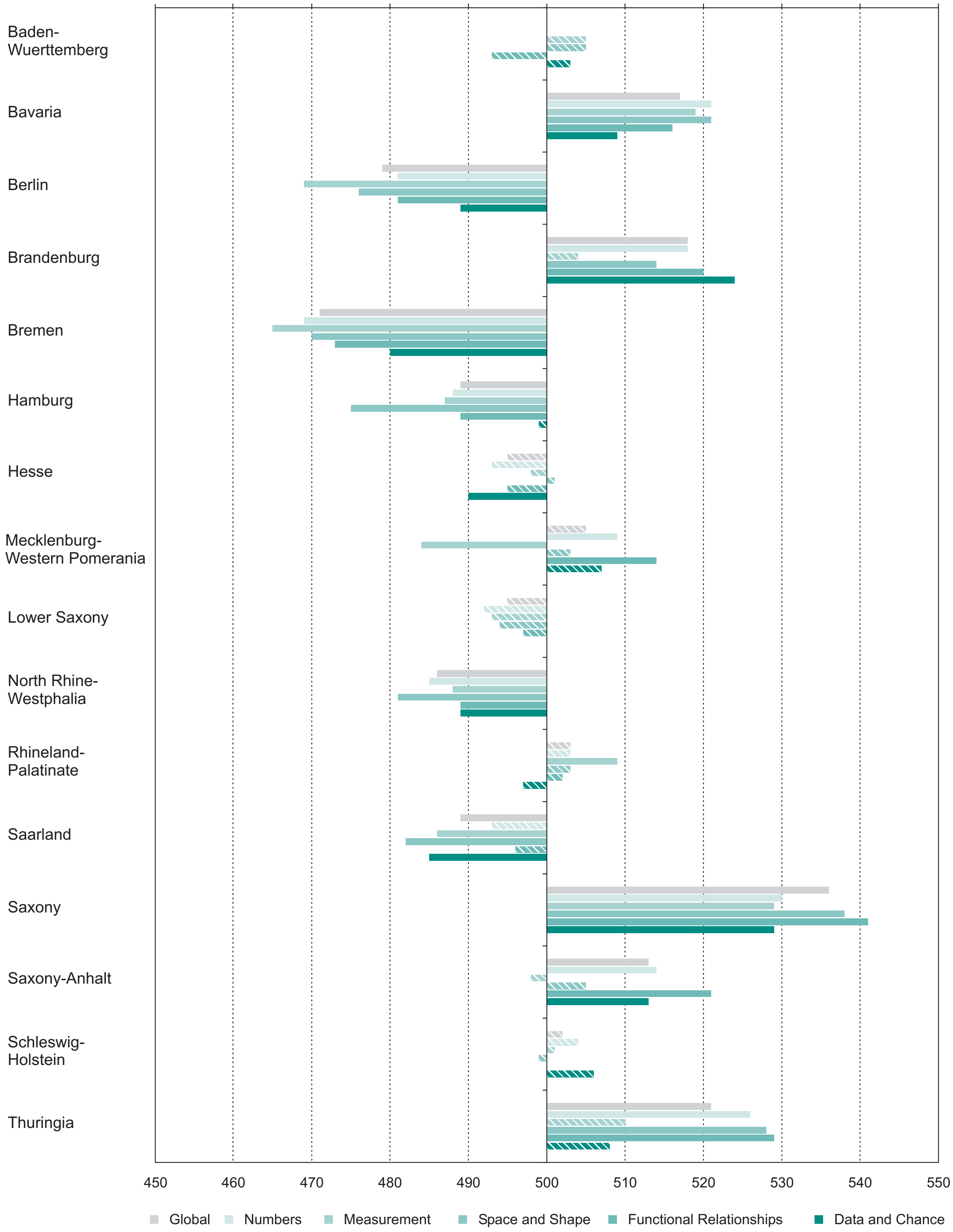
The National Assessment of Competency Levels in Mathematics and the Sciences

The IQB National Assessment 2012 describes average proficiencies as well as their distributions in the subjects mathematics and science. First, this document presents an examination of content competency levels achieved across all ninth-grade students in each German state, as well as the differences between state and national averages. The differences in point averages can be interpreted on a "metric" of learning gains that can be expected in a given school year. Estimates from a variety of empirical studies strongly suggest that at the end of secondary level I, a learning gain of 25 to 30 points per school year can be expected in mathematics and in the natural sciences (Beaton, Martin, Mullis, Gonzalez, Smith & Kelly, 1996; Köller & Baumert, 2012). In addition, the assessment compares achievement levels and achievement heterogeneity in the individual states. A desirable pattern would include a high mean proficiency level accompanied by a relatively low level of heterogeneity. In particular, students at the lower end of the achievement distribution should achieve as high a level of competency as possible.

The National Assessment in Mathematics

In Figure 1, students' mean proficiency levels in mathematics at the state level are presented both in the aggregate (*global scale*) and broken down into the five mathematical content areas depicted in terms of their deviation from the national mean ($M = 500$, $SD = 100$). The results clearly show that proficiency levels vary widely from one state to the next. On the *global scale*, the difference between the highest-performing state (Saxony) and the lowest (Bremen) is 65 points, placing students in Saxony on average approximately two school years ahead of their peers in Bremen. In relation to individual content areas, differences between states range from 49 points for *data and chance* all the way to 68 points for *space and shape* and *functional relationships*.

Figure 1: State-Level Deviations in Ninth-Grade Students' Mathematics Proficiency Levels from the German National Average



Note. Hatched bars indicate no significant difference from the German national mean in the particular content area.

In the following, students' proficiency levels in mathematics are described in greater detail, showing not only mean values but also the distribution of values. In Figure 2, the states are listed in order of their mean proficiency levels, from highest to lowest on the *global scale*. In addition to the means (*M*), we also give the standard deviations (*SD*), selected percentiles[5], and the difference between the 95th and the 5th percentile (95-5) as measures of dispersion. These are also expressed in graphic form to visualize the proficiency distributions among the states. For each of the competency areas, the 16 individual states are assigned to one of three groups, based on their mean competency scores: one group whose mean scores lie significantly above the German mean; one group of states whose mean scores do not differ significantly from the German mean; and one group of states whose mean scores lie significantly below the German mean.

For the *global scale* in the subject of mathematics, a group of five states can be identified whose proficiency levels lie significantly above the German mean. The group is led by Saxony, with 536 points, which shows a significant lead even over the other states in the top group. The group also includes Thuringia, Brandenburg, Bavaria, and Saxony-Anhalt with point values ranging from 521 to 513. This group is followed by a tightly clustered group of six states whose mean values range between 505 and 495 points and do not differ significantly from the German mean (Mecklenburg-Western Pomerania, Rhineland-Palatinate, Schleswig-Holstein, Baden-Wuerttemberg, Lower Saxony, and Hesse). The group of states whose students display significantly below-average proficiency levels, with values between 489 and 471 points, includes Saarland, Hamburg, North Rhine-Westphalia and the city-states of Berlin and Bremen.

The findings on individual content areas are very similar to those on the *global scale* overall, but in the case of certain core competencies, differential patterns can be observed that are indicative of relative strengths and weaknesses within the states. In the five Eastern German states and the city-state of Berlin, proficiency levels are strikingly lower in the area of *measurement* than on the *global scale*. Conversely, this group of states shows relative strength in the area of *functional relationships*, although here the difference is not as clear or consistent. The city-states of Hamburg, Berlin, and Bremen all show relative strength in the core competency *data and chance*, in which these three states each achieved their best results.

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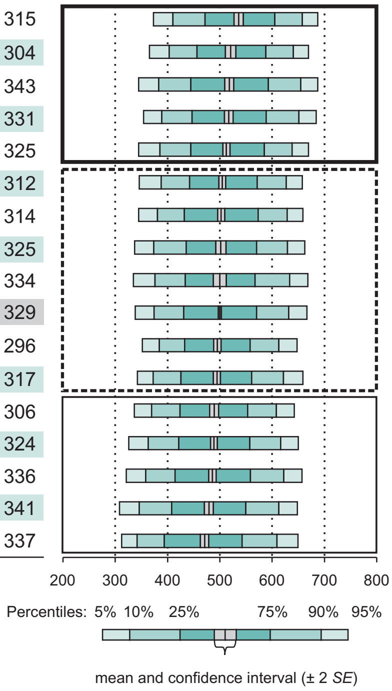
[5] Percentiles are point values that divide the performance distributions on the reporting scales into two areas. To the left of the *p*-th percentile are *p* percent of the students. A high value for the fifth percentile indicates that the lowest-performing students in a state still have fairly high proficiency scores. If a high value appears for the 95th percentile at the other end of the proficiency spectrum, this indicates an extremely well performing peak of the distribution.

Figure 2: Means, Distributions, Percentiles, and Percentile Bands for Ninth-Grade Students' Mathematics Proficiency Levels (*Global Scale*)

State					Percentile						
	M	*(SE)*	*SD*	*(SE)*	*5*	*10*	*25*	*75*	*90*	*95*	*95-5*
Saxony	536	(4.5)	96	(2.9)	373	410	472	606	658	688	315
Thuringia	521	(5.1)	93	(4.3)	365	403	456	588	641	670	304
Brandenburg	518	(4.3)	105	(3.9)	345	383	444	593	655	688	343
Bavaria	517	(4.1)	101	(2.9)	354	389	447	589	652	685	331
Saxony-Anhalt	513	(3.4)	99	(2.3)	345	385	444	585	638	670	325
Mecklenburg-Western Pomerania	505	(3.3)	95	(2.0)	346	388	442	572	627	658	312
Rhineland-Palatinate	503	(3.5)	97	(2.6)	345	381	432	573	629	659	314
Schleswig-Holstein	502	(4.9)	98	(3.9)	337	374	436	571	629	663	325
Baden-Wuerttemberg	500	(6.4)	100	(3.4)	335	376	434	568	634	669	334
Germany	500	(1.6)	100	(1.1)	338	374	431	570	632	667	329
Lower Saxony	495	(3.7)	91	(2.9)	352	384	433	558	613	648	296
Hesse	495	(3.5)	97	(2.6)	342	373	425	561	622	659	317
Saarland	489	(4.4)	93	(2.7)	336	370	424	553	608	643	306
Hamburg	489	(3.3)	99	(2.4)	326	363	422	558	617	650	324
North Rhine-Westphalia	486	(3.7)	102	(2.9)	321	358	415	559	623	657	336
Berlin	479	(4.4)	104	(3.5)	308	346	408	550	613	648	341
Bremen	471	(4.1)	103	(3.4)	312	342	394	543	610	649	337



☐ States lie significantly ($p < .05$) above the German mean.
⬚ States do not differ significantly from the German mean.
☐ States lie significantly ($p < .05$) below the German mean.

Notes. M = mean; *SE* = standard error; *SD* = standard deviation. Figures in the table are rounded. The figures in the column 95-5 may therefore deviate minimally from the difference between the corresponding percentiles.

Regarding the heterogeneity in mathematics proficiency scores, we find fairly similar standard deviations across states on the *global scale*. They range from 91 points in Lower Saxony to 105 points in Brandenburg. The wider dispersion of proficiency scores in Brandenburg is also evident from the very large 343-point difference between the 5th and 95th percentile; in Lower Saxony, in contrast, the difference between the 5th and 95th percentile is comparatively small at 296 points. Overall, there are only small differences in the dispersion of proficiency scores in mathematics between states. Similar results are found for the individual content areas in mathematics.

The academically oriented upper secondary school (Gymnasium) is the only school type in Germany's otherwise very heterogeneous school system that exists in all 16 federal states. Students at upper secondary schools show significantly better performance than their peers in all other school types. Mean performance in mathematics among upper secondary students across Germany was 586 points on the *global scale*. Furthermore, upper secondary students in Bavaria, Saxony, and Saxony-Anhalt achieved proficiency scores ranging from 610 to 598 points, which are significantly above the mean scores for upper secondary students in Germany as a whole. Baden-Wuerttemberg, Brandenburg, North Rhine-Westphalia, Rhineland-Palatinate, Schleswig-Holstein, and Thuringia form a group of six states whose proficiency scores, ranging from 596 to 581 points, do not differ statistically from the German mean for upper secondary students. In the seven states of Berlin, Bremen, Hamburg, Hesse, Mecklenburg-Western Pomerania, Lower Saxony, and Saarland, mean competency scores for upper secondary students in mathematics, ranging from 572 to 551 points, were significantly below average.

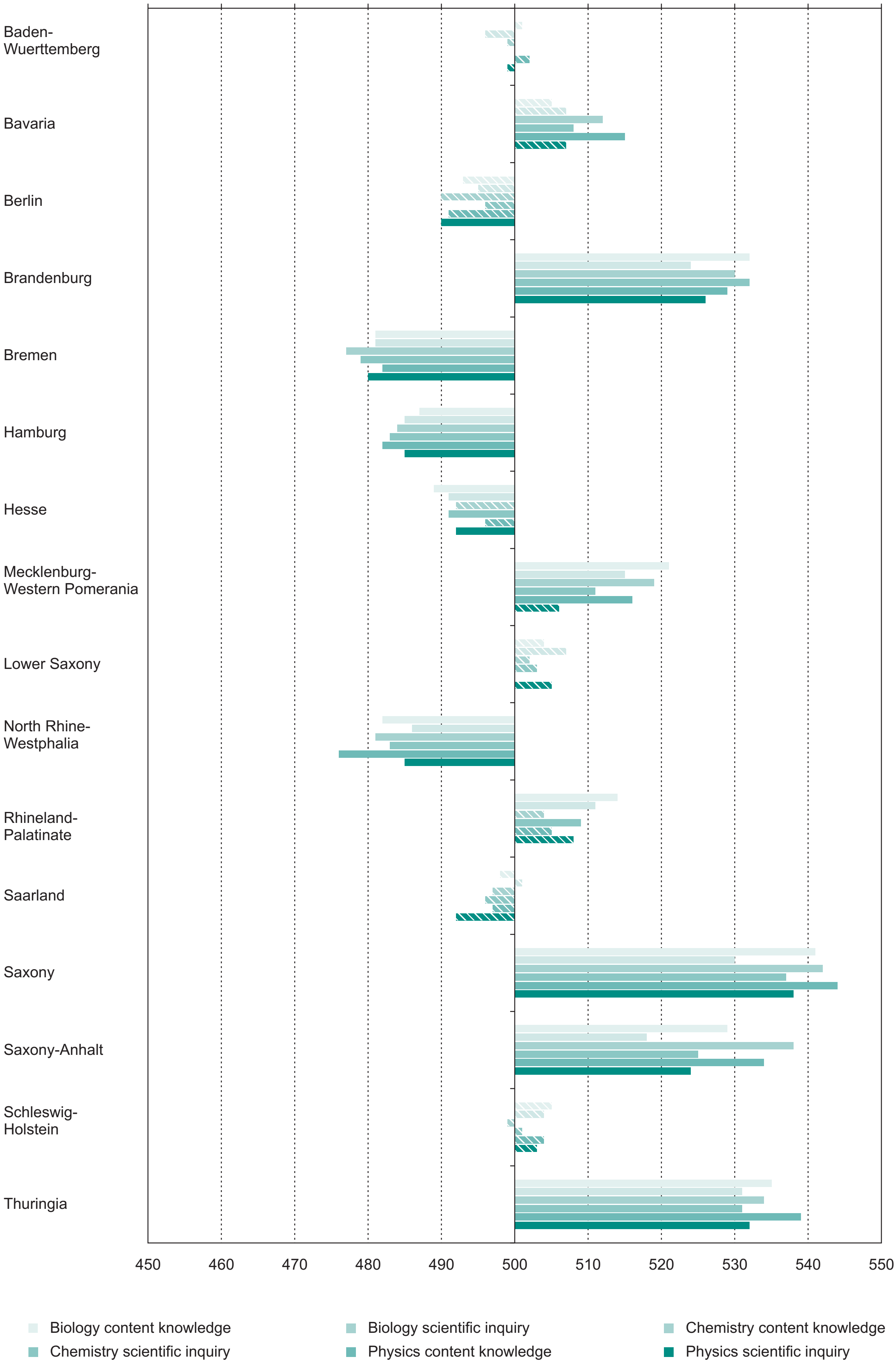
Another noteworthy finding from the National Assessment Study 2012 is the very weak association found between the rate of participation by upper secondary students – that is, the proportion of students in a specific grade level who are attending the upper secondary school type – and mean proficiency scores at the state level. Across the 16 states, the correlation between the rate of upper secondary attendance and the mean proficiency scores on the *global scale* turned out to be weak ($r = -.35$). However, if the four Eastern German states of Brandenburg, Saxony, Saxony-Anhalt, and Thuringia were excluded from this analysis, a close correlation would appear for the other 12 states: in this case, larger shares of students attending upper secondary school are associated with lower mean proficiency scores ($r = -.89$). The four Eastern German states of Brandenburg, Saxony, Saxony-Anhalt, and Thuringia therefore undermine this correlation because their students achieved above-average proficiency levels despite a high rate of students in upper secondary schools. In Saxony, for example, the mean competency score in mathematics at upper secondary schools is comparable with the corresponding mean score in Bavaria, although the percentage of students attending upper secondary schools in Saxony is around one-third higher.

The National Assessment in Science

In contrast to the national assessment studies carried out previously in the PISA framework, the National Assessment Study 2012 was the first to measure students' proficiency levels in science at the end of secondary level I both from a domain-specific perspective in the content areas of *content knowledge* and *scientific inquiry* as well as from a subject-specific perspective – that is, separately for each of the subjects of biology, chemistry, and physics.

The results for the science scales are very similar to those for mathematics: mean competency scores vary substantially between states. Figure 3 shows mean competency scores of students by state and their deviation from the national mean in the three science subjects, separated by content area (*content knowledge* and *scientific inquiry*). The differences between the highest-performing state and the lowest range from 50 points in *biology scientific inquiry* to 68 points in *physics content knowledge*. In the sciences, as in mathematics, this puts students in the states with largest differences approximately two school years apart from one another. Within each state, however, mean proficiency scores are fairly homogeneous along the six natural science scales. This means that in all of the states, a statistically significant deviation of mean state scores from the corresponding national score in one content area is frequently accompanied by a significant deviation in the same direction in other content areas.

Figure 3: State-Level Deviations in Ninth-Grade Students' Science Proficiency Levels from the German Mean



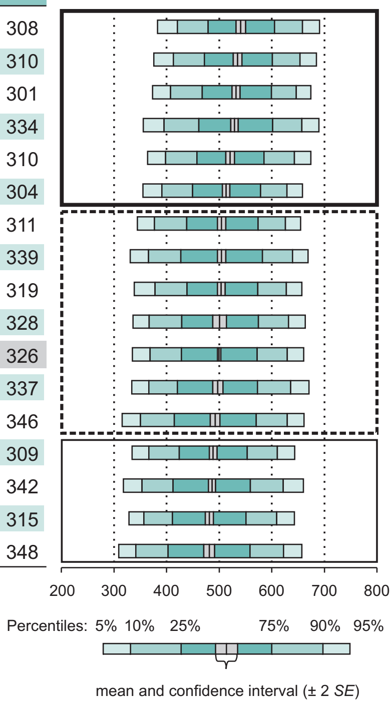
Note. Hatched bars indicate no significant difference from the German mean in the particular content area.

In Figures 4 to 6, students' average proficiency levels in biology, chemistry, and physics and their distributions are illustrated by students' results in the area of *content knowledge*. The corresponding means (*M*), standard deviations (*SD*), selected percentiles, and differences between the 95th and 5th percentiles (95-5) are given as measures of dispersion. These are also represented graphically to illustrate the proficiency distributions among the states. The states are again assigned to one of three groups for each content area based on their scores.

Students in the states of Brandenburg, Saxony, Saxony-Anhalt, and Thuringia achieve mean scores significantly above the German average in all six natural science content areas. Other states also rank in this top group in selected content areas. These include, in particular, Mecklenburg-Western Pomerania (in *biology* and *chemistry* for both *content knowledge* and *scientific inquiry* as well as in *physics* for *content knowledge*), but also Bavaria (*chemistry content knowledge* and *scientific inquiry*, *physics content knowledge*) and Rhineland-Palatinate (*biology content knowledge* and *scientific inquiry*, *chemistry scientific inquiry*) fall into this category. In contrast, students' mean proficiency scores in all content areas in the states of Bremen, Hamburg, and North Rhine-Westphalia lie significantly below the German average. The group of states with significantly below-average levels of student proficiency in particular areas includes Hesse (*biology content knowledge* and *scientific inquiry*, *chemistry scientific inquiry*, and *physics scientific inquiry*) and Berlin (*physics scientific inquiry*). Noteworthy discrepancies between strengths and weaknesses, as would be the case if students in a state showed high competency scores in one area but significantly below-average competencies in any others, could not be identified.

Figure 4: Means, Distributions, Percentiles, and Percentile Bands for Ninth-Grade Students' Proficiency Levels in *Biology Content Knowledge*

State					**Percentile**						
	M	*(SE)*	*SD*	*(SE)*	*5*	*10*	*25*	*75*	*90*	*95*	*95-5*
Saxony	541	(4.6)	93	(3.7)	383	421	479	606	659	691	308
Thuringia	535	(4.3)	95	(2.4)	376	413	472	602	654	685	310
Brandenburg	532	(4.0)	93	(3.1)	373	408	468	600	647	675	301
Saxony-Anhalt	529	(3.6)	102	(3.0)	356	395	462	602	658	690	334
Mecklenburg-Western Pomerania	521	(4.2)	94	(2.6)	364	398	458	586	643	674	310
Rhineland-Palatinate	514	(3.7)	93	(2.5)	355	391	450	579	629	658	304
Schleswig-Holstein	505	(4.0)	95	(2.8)	345	377	438	575	626	655	311
Bavaria	505	(4.0)	105	(2.6)	331	366	427	583	640	669	339
Lower Saxony	504	(3.8)	97	(3.6)	339	378	439	574	628	658	319
Baden-Wuerttemberg	501	(6.6)	101	(3.8)	336	367	429	575	632	664	328
Germany	500	(1.7)	100	(1.1)	335	368	429	572	629	661	326
Saarland	498	(5.0)	105	(3.2)	334	366	420	573	636	671	337
Berlin	493	(4.7)	106	(2.9)	316	351	415	571	630	662	346
Hesse	489	(3.9)	94	(2.6)	334	366	424	554	611	644	309
Hamburg	487	(3.6)	105	(2.7)	318	353	413	559	622	661	342
North Rhine-Westphalia	482	(3.9)	97	(2.6)	329	357	411	551	610	643	315
Bremen	481	(5.3)	107	(4.1)	309	342	403	559	623	657	348



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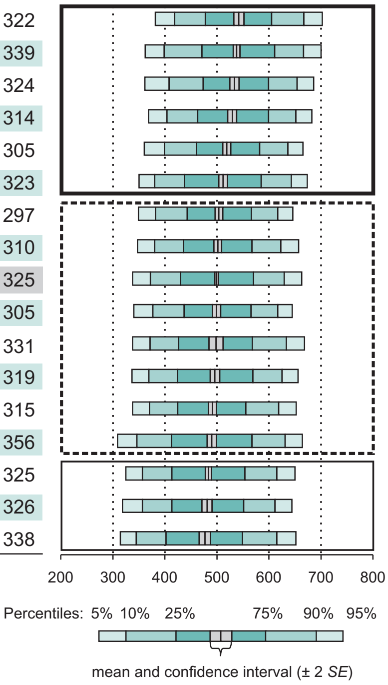
Notes. M = mean; *SE* = standard error; *SD* = standard deviation. Figures in the table are rounded. The figures in the column 95-5 may therefore deviate minimally from the difference between the corresponding percentiles.

Figure 5: Means, Distributions, Percentiles, and Percentile Bands for Ninth-Grade Students' Proficiency Levels in *Chemistry Content Knowledge*

State	*M*	*(SE)*	*SD*	*(SE)*	Percentile 5	10	25	75	90	95	95-5
Saxony	542	(5.0)	97	(4.2)	381	419	478	606	668	703	322
Saxony-Anhalt	538	(3.3)	102	(2.7)	362	399	471	612	667	701	339
Thuringia	534	(4.6)	96	(3.1)	362	408	474	600	655	686	324
Brandenburg	530	(4.3)	97	(3.3)	369	404	463	600	652	683	314
Mecklenburg-Western Pomerania	519	(3.9)	92	(2.9)	361	400	461	583	637	666	305
Bavaria	512	(4.1)	100	(2.7)	351	381	438	586	644	674	323
Rhineland-Palatinate	504	(3.8)	90	(2.5)	349	382	443	566	617	647	297
Lower Saxony	502	(3.7)	94	(2.6)	348	381	436	568	623	657	310
Germany	500	(1.8)	100	(1.8)	338	372	430	571	630	663	325
Schleswig-Holstein	499	(4.0)	94	(3.2)	340	377	437	566	617	645	305
Baden-Wuerttemberg	499	(6.9)	101	(4.2)	338	372	426	569	634	669	331
Saarland	497	(4.7)	98	(3.1)	337	370	424	569	626	656	319
Hesse	492	(4.0)	95	(2.8)	338	371	425	556	619	653	315
Berlin	490	(4.6)	109	(3.1)	309	346	413	568	632	665	356
Hamburg	484	(3.1)	100	(2.6)	325	357	414	554	616	651	325
North Rhine-Westphalia	481	(4.9)	101	(5.7)	319	357	413	552	612	645	326
Bremen	477	(5.6)	103	(4.4)	314	345	403	550	616	652	338



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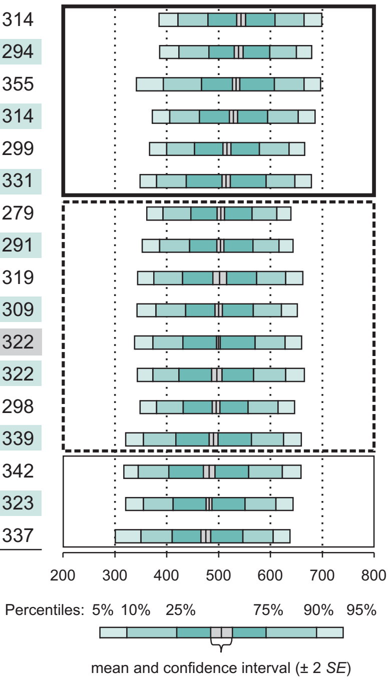
Notes. M = mean; *SE* = standard error; *SD* = standard deviation. Figures in the table are rounded. The figures in the column 95-5 may therefore deviate minimally from the difference between the corresponding percentiles.

Figure 6: Means, Distributions, Percentiles, and Percentile Bands for Ninth-Grade Students' Proficiency Levels in *Physics Content Knowledge*

State	*M*	*(SE)*	*SD*	*(SE)*	Percentile 5	10	25	75	90	95	95-5
Saxony	544	(4.2)	95	(3.5)	386	422	480	609	665	700	314
Thuringia	539	(4.3)	88	(3.0)	386	424	481	599	650	680	294
Saxony-Anhalt	534	(3.7)	105	(2.8)	342	393	467	608	665	697	355
Brandenburg	529	(4.0)	96	(3.3)	372	406	463	595	654	686	314
Mecklenburg-Western Pomerania	516	(3.9)	91	(2.4)	367	400	454	579	636	666	299
Bavaria	515	(4.0)	102	(2.5)	348	381	438	592	648	679	331
Rhineland-Palatinate	505	(3.6)	85	(2.2)	361	393	447	565	613	640	279
Schleswig-Holstein	504	(3.4)	89	(2.8)	353	386	444	567	617	644	291
Baden-Wuerttemberg	502	(6.8)	98	(3.5)	344	375	431	574	630	663	319
Lower Saxony	500	(3.7)	95	(2.7)	343	379	436	567	622	652	309
Germany	500	(1.8)	100	(1.7)	338	373	431	571	628	661	322
Saarland	497	(5.1)	100	(3.8)	343	373	423	568	630	666	322
Hesse	496	(3.7)	91	(2.7)	349	381	432	557	615	647	298
Berlin	491	(4.5)	103	(3.2)	321	355	418	564	626	660	339
Bremen	482	(5.6)	105	(4.3)	317	345	404	558	624	660	342
Hamburg	482	(2.8)	99	(2.4)	321	355	413	551	611	644	323
North Rhine-Westphalia	476	(4.7)	104	(5.2)	301	350	411	547	606	638	337



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Notes. M = mean; *SE* = standard error; *SD* = standard deviation. Figures in the table are rounded. The figures in the column 95-5 may therefore deviate minimally from the difference between the corresponding percentiles.

Comparing the distributions within the states across all six areas of science competency, the following results appear. The widest proficiency dispersions are found in the city-states of Berlin and Bremen and to some extent in Hamburg. The variation in student proficiency is relatively low in the states of Hesse, Mecklenburg-Western Pomerania, Rhineland-Palatinate, Schleswig-Holstein, and Thuringia.

Comparing upper secondary students' mean proficiency scores with the scores of ninth-grade students across all school types, significant differences are evident: the mean proficiency score for upper secondary students in the sciences is approximately 580 points. In the states of Brandenburg, Saxony, Saxony-Anhalt, and Thuringia, upper secondary students' science proficiency scores are substantially above average, at 600 points and higher. At the lower end of the distribution, upper secondary students' proficiency scores are similar to average scores of students across all school types. Upper secondary students in Bremen, Hamburg, Hesse, and North Rhine-Westphalia performed significantly below average on at least three of six scales. In addition to these similarities across school types, some results are specific to upper secondary school students: those in Berlin and Mecklenburg-Western Pomerania achieved lower scores compared to each state's mean score across school types, whereas in Bavaria, their outcomes were higher.

As in mathematics, the sciences show a weak correlation between upper secondary attendance rates and statewide proficiency scores, ranging from $r = -.08$ (*biology content knowledge* and *chemistry content knowledge*) and $r = -.32$ (*biology scientific inquiry*). These weak correlations are primarily the result of above-average proficiency levels in the East German group of top-performing states (Brandenburg, Saxony, Saxony-Anhalt, Thuringia), despite their high upper secondary school attendance rate of around 40 percent.

A Look at the Results by State

The IQB National Assessment Study focuses on the distribution of student outcomes across the competency levels defined by KMK educational standards. These distributions of proficiency levels reveal the extent to which states have succeeded in ensuring the achievement of minimum standards and in guaranteeing that the highest possible share of students are reaching the normative levels established by the Standing Conference (KMK).

The educational standards for secondary level I were defined by the Standing Conference (KMK) in relation to the final qualification at the end of specific educational tracks. For mathematics and each of the science subjects of biology, chemistry, and physics, a *five-level* proficiency model was developed for the intermediate secondary school-leaving certificate (MSA). According to these proficiency level models, students who are working towards the MSA achieve the "normative standard" established by the Standing Conference (KMK) at proficiency level III. Proficiency level II is considered a "minimum standard" of competency. Students whose learning outcomes correspond only to proficiency level I have failed to achieve the national minimum educational requirements for the MSA at the end of secondary level I. At proficiency levels IV and V – which are referred to as "normative standard plus" and "optimal standard" respectively – students exceed the normative expectations of the Standing Conference (KMK). At the top level (proficiency level V), they show outstanding learning outcomes.

Additionally, further achievement standards for mathematics were established regarding the lower secondary school-leaving certifacte (HSA). Therefore the results for mathematical proficiencies are presented according to an integrated *six-level* proficiency model for all ninth-grade students, regardless of them working towards the MSA or the HSA. In mathematics, students working towards an HSA reach the aforementioned proficiency levels one level below the corresponding levels for the MSA. Thus, the HSA "minimum standard" is achieved at proficiency level I.b, the "normative standard" at level II, "normative standard plus" at level III, and the "optimal standard" at proficiency level IV.

As with the IQB National Assessments of 2009 and 2011, proficiency level distributions are reported separately for each of the states. In the case of students with special educational needs, only those were included who were subject to the same learning expectations as students without special needs (the German term for these students, "zielgleich unterrichtete Schülerinnen und Schüler," refers to special-needs students in "inclusive classrooms" who have the same learning goals as children without special needs).

Across all federal states, the results show that on the *global scale* in *mathematics*, 25% of the total population of ninth-graders, including special-needs students who are subject to the same learning expectations as typical students, fall below the minimum standard for the MSA. This share is at its largest in Bremen, with it making up almost 39%, and at its smallest in Saxony with it at barely 12%. Across all states, well over 44% of students reach at least the normative level defined by the Standing Conference (KMK) for the MSA (proficiency level III and higher). This percentage varies between 34% in Bremen and well over 61% in Saxony. Across Germany, roughly 4% of young people achieve the MSA optimal standard, ranging from around 2% in Saarland to well over 7% in Saxony. Within the group of upper secondary school students, more than 11% of all students reach the MSA optimal standard, with figures here ranging from well over 6% (Saarland, Berlin, Lower Saxony, Hamburg) to almost 19% (Bavaria). When considering these percentages, it should be noted that students working towards an HSA were also included. If one uses the educational standards for the HSA as a benchmark, nationwide 6% of all ninth-grade students, including special-needs students who are subject to the same learning expectations as typical students, failed to achieve the minimal standards while 75% reached the HSA normative standard. The percentage of failure to reach the HSA minimum standard varies from well over 1% in Saxony to over 11% in Bremen; furthermore the percentage of successfull compliance to the HSA normative standards varies from over 88% in Saxony to over 61% in Bremen.

In the *natural sciences*, depending on the content area, between 16% (*chemistry content knowledge*) and 6% (*biology content knowledge*) of all students who are working towards at least an MSA fail to achieve the Standing Conference's (KMK) minimum standards. This share is highest in Bremen (*chemistry content knowledge*) at 22% and lowest in Saxony (*biology content knowledge*) at barely 2%. Between 58% (*chemistry content knowledge*) and 75% (*physics scientific inquiry*) of all students working towards at least an MSA across all federal states reach or surpass the normative standards. This percentage varies from over 47% in North Rhine-Westphalia (*chemistry scientific inquiry*) to over 82% in Brandenburg (*biology content knowledge*). Between 1% (*biology scientific inquiry*) and barely 11% (*chemistry scientific inquiry*) of students show outstanding learning outcomes, as defined by MSA optimal standards, although the scores here range all the way from barely 1% in Bavaria and North Rhine-Westphalia (both in *biology scientific inquiry*) to 19% in Brandenburg (*chemistry scientific inquiry*). At upper secondary schools, between just 2% of students across all states achieve the MSA optimal standard in *biology scientific inquiry* and 22% in *chemistry scientific inquiry*, although the scores here range from over 1% in Mecklenburg-Western Pomerania (*biology scientific inquiry*) to more than 34% in Saxony-Anhalt (*chemistry scientific inquiry*).

Gender Disparities

In the public and educational policy debates about equal participation of all student groups in educational processes, there is particular interest in gender disparities, that is, differences in learning outcomes between girls and boys in what are known as the MINT subjects[6]. In the report on the 2012 National Assessment Study, gender disparities in mathematics and the natural sciences are examined and presented separately for each of the different school types.

Figure 7 gives the nationwide means for boys (M_J) and girls (M_M) as well as the difference between them ($M_J - M_M$) and the corresponding standard error (*SE*) for all of the content areas examined in the National Assessment Study. Here, as in other school achievement studies, boys achieve higher scores in mathematics than girls both on the *global scale* and on the scales of all content-related sub-areas of competency. The 16-point average proficiency lead for boys at the end of secondary level I corresponds roughly to them being approximately two-thirds of a school year ahead.

In the natural science content areas, however, girls achieve higher scores than boys on average. Girls have an especially strong lead in learning outcomes over boys in biology, with more than 20 points. In the subjects of chemistry and physics, gender differences in proficiency levels are much lower (see Figure 7). In contrast to mathematics, boys' learning outcomes in science show a much wider distribution than girls'.

Furthermore, there are significant differences between school types in relation to science achievement: at upper secondary schools, the advantage of girls decreases for all science areas compared to other types of secondary schools. A breakdown of the gender disparities by state does not reveal any significant outliers. Only in Brandenburg, Saxony, and Thuringia, which are all in the top-performing group of states in science proficiencies, are boys' scores significantly above the German average.

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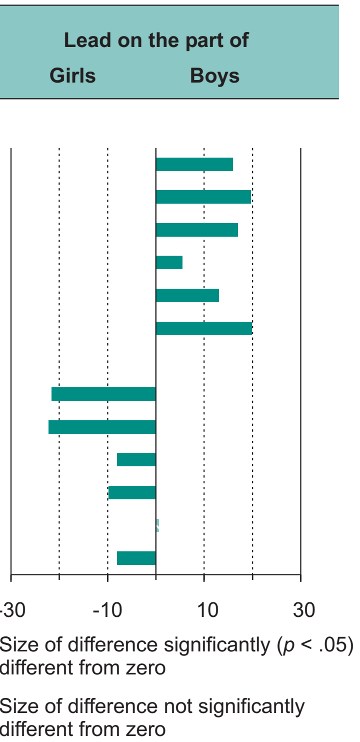
[6] MINT stands for Mathematics, Informatics, Natural Sciences, and Technology.

Figure 7: Mean Proficiency Differences between Boys and Girls in Mathematics and Science at the End of the Ninth Grade

	Boys		**Girls**		**Difference**[3]		
	M_J	(*SE*)	M_M	(*SE*)	M_J-M_M	(*SE*)	*d*
Mathematics[1]							
Global	508	(2.1)	492	(2.1)	16	(2.7)	0.16
Numbers	510	(2.0)	490	(2.2)	20	(2.6)	0.20
Measurement	508	(2.1)	491	(2.1)	17	(2.6)	0.17
Space and Shape	503	(2.0)	497	(2.2)	5	(2.7)	0.05
Functional Relationships	506	(2.0)	493	(2.1)	13	(2.7)	0.13
Data and Chance	510	(1.9)	490	(2.2)	20	(2.7)	0.20
Science[2]							
Biology content knowledge	489	(2.4)	511	(1.8)	-22	(2.7)	-0.22
Biology scientific inquiry	489	(2.4)	511	(1.8)	-22	(2.7)	-0.22
Chemistry content knowledge	496	(2.7)	504	(1.7)	-8	(2.8)	-0.08
Chemistry scientific inquiry	495	(2.3)	505	(1.7)	-10	(2.6)	-0.10
Physics content knowledge	500	(2.9)	500	(1.8)	0	(3.3)	0.00
Physics scientific inquiry	496	(2.4)	504	(1.7)	-8	(2.7)	-0.08



Notes. M = mean; *SE* = standard error of the mean; *d* = Cohen's effect size *d*.

[1] N_J = 12,613; N_M = 12,089. [2] N_J = 12,650; N_M = 12 144. [3] The difference between the rounded means (M_J and M_M) may differ from the difference displayed between M_J-M_M due to rounding.

Social Disparities

Since PISA 2000 at the very latest, the broader public has become acutely aware of the social disparities in Germany and their effects of learning outcomes. A concept that can be used to describe this connection is the *social gradient*. It is used to describe how closely students' proficiencies are linked to their parents' socioeconomic status[7]. The steepness of the social gradient (*b*) gives a direct indication of the number of points by which student proficiency increases with an increase of one standard deviation in the parents' socioeconomic status. Tables 1 and 2 present the social gradients for mathematics and the sciences.

Table 1: Social Gradients for Ninth-Grade Students' Proficiencies in Mathematics (*Global Scale*) by State (in Descending Order from Highest to Lowest Social Gradient)

State			**Steepness of social gradient**		**Explained variance**
	Axis intercept	*(SE)*	*b*	*(SE)*	R^2
Brandenburg	516	(3.4)	49	(5.0)	24.8
Baden-Wuerttemberg	499	(5.4)	43	(3.9)	19.8
North Rhine-Westphalia	489	(3.5)	41	(3.0)	16.7
Hamburg	486	(2.7)	41	(3.1)	20.6
Schleswig-Holstein	502	(4.3)	40	(4.6)	17.7
Hesse	493	(3.5)	40	(2.8)	19.4
Germany	500	(1.4)	40	(1.2)	16.8
Saxony-Anhalt	519	(3.7)	39	(2.9)	16.2
Bavaria	516	(3.9)	37	(3.2)	14.5
Lower Saxony	495	(3.8)	36	(3.2)	17.1
Rhineland-Palatinate	503	(3.0)	35	(3.3)	13.3
Mecklenburg-Western Pomerania	508	(3.1)	35	(3.1)	14.0
Thuringia	521	(4.8)	33	(4.4)	12.7
Saxony	537	(4.3)	33	(3.8)	12.2
Berlin[1]	471	(3.6)	44	(4.2)	22.2
Bremen[1]	476	(3.7)	44	(3.9)	19.2
Saarland[1]	490	(3.9)	36	(3.5)	15.0

Notes. The steepness of the social gradient is significantly ($p < .05$) different from 0 for every state in Germany and for Germany as a whole. None of the state-specific regression coefficients is significantly different from the regression coefficient for Germany. Missing values for the HISEI were estimated through multiple imputation. *b* = unstandardized regression coefficient; *SE* = standard error; R^2 = determination coefficient.

[1] The results should be interpreted with caution due to the large share of missing data.

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[7] The HISEI (*Highest International Socio-Economic Index*) was used to determine socio-economic status. The ISEI is an indicator of occupational status, taking into account income and educational level. The HISEI is the highest ISEI between both parents.

Table 2: Social Gradients in Science by State (in Descending Order for Each Subject by Social Gradient in the Proficiency Area of *Content Knowledge*)

State			**Steepness of social gradient**		**Ex-plained variance**			**Steepness of social gradient**		**Ex-plained variance**
	Axis intercept	*(SE)*	*b*	*(SE)*	*R²*	Axis intercept	*(SE)*	*b*	*(SE)*	*R²*
	Biology content knowledge					**Biology scientific inquiry**				
Hamburg	483	(3.2)	**43**	(2.9)	20.3	481	(3.0)	**43**	(2.9)	20.1
Lower Saxony	504	(3.7)	38	(3.6)	16.5	507	(3.9)	37	(3.6)	14.1
Saxony-Anhalt	536	(3.5)	37	(3.6)	14.0	526	(3.5)	38	(4.0)	14.1
Hesse	488	(3.4)	36	(3.0)	16.2	490	(3.6)	36	(3.0)	15.4
Bavaria	504	(3.9)	36	(3.0)	12.6	506	(3.7)	35	(3.1)	13.7
Germany	500	(1.6)	35	(1.1)	13.0	500	(1.5)	36	(1.2)	13.5
Baden-Wuerttemberg	498	(5.8)	35	(4.2)	12.8	493	(6.0)	38	(4.2)	14.9
North Rhine-Westphalia	484	(3.6)	34	(3.3)	12.7	489	(3.6)	37	(3.4)	14.1
Schleswig-Holstein	505	(3.7)	34	(3.8)	13.0	504	(4.0)	32	(3.8)	10.4
Mecklenburg-Western Pomerania	524	(3.6)	33	(3.8)	13.1	517	(3.9)	30	(3.9)	11.3
Brandenburg	532	(3.6)	32	(3.7)	12.2	523	(3.1)	37	(4.0)	15.8
Rhineland-Palatinate	513	(3.4)	30	(3.3)	10.8	510	(4.0)	30	(3.4)	9.3
Thuringia	537	(4.1)	28	(3.3)	8.7	532	(3.9)	30	(3.5)	11.6
Saxony	542	(4.5)	28	(3.8)	9.2	531	(4.7)	31	(4.2)	10.5
Berlin[1]	491	(4.0)	39	(3.5)	15.0	493	(4.3)	37	(3.6)	13.2
Bremen[1]	482	(4.5)	**45**	(4.8)	21.3	481	(4.3)	**49**	(5.2)	25.7
Saarland[1]	499	(4.6)	40	(3.9)	14.2	502	(4.6)	38	(4.0)	13.2
	Chemistry content knowledge					**Chemistry scientific inquiry**				
Hamburg	480	(2.7)	40	(3.0)	19.1	479	(3.0)	42	(2.9)	19.9
Baden-Wuerttemberg	496	(6.0)	39	(4.4)	15.7	497	(5.2)	38	(3.9)	15.1
North Rhine-Westphalia	484	(4.3)	38	(4.7)	15.5	486	(3.7)	35	(3.6)	11.5
Lower Saxony	502	(3.5)	37	(3.4)	16.8	503	(4.0)	38	(3.4)	16.0
Saxony-Anhalt	546	(3.2)	37	(3.9)	13.5	531	(3.9)	30	(4.3)	8.5
Germany	500	(1.7)	36	(1.4)	14.0	500	(1.5)	36	(1.2)	13.9
Bavaria	511	(3.9)	36	(3.0)	13.8	507	(3.7)	39	(3.0)	15.8
Hesse	491	(3.6)	35	(2.9)	14.3	490	(3.6)	37	(3.0)	16.0
Thuringia	535	(4.3)	34	(3.7)	12.2	533	(3.5)	30	(3.0)	12.2
Brandenburg	530	(4.1)	33	(4.2)	12.4	532	(3.6)	34	(4.7)	12.7
Rhineland-Palatinate	504	(3.4)	31	(3.3)	12.2	508	(3.8)	30	(3.2)	11.2
Mecklenburg-Western Pomerania	521	(3.6)	29	(3.7)	10.9	514	(3.2)	31	(3.4)	11.7
Saxony	543	(4.8)	29	(4.3)	9.2	537	(4.5)	29	(3.7)	9.7
Schleswig-Holstein	499	(3.9)	29	(3.8)	9.6	501	(3.6)	31	(3.7)	11.4
Berlin[1]	488	(3.8)	40	(3.8)	15.1	494	(4.0)	36	(3.7)	13.1
Bremen[1]	478	(4.3)	47	(5.1)	24.8	479	(3.7)	**47**	(5.2)	23.8
Saarland[1]	498	(4.4)	34	(4.2)	12.2	497	(4.5)	37	(3.7)	15.6
	Physics content knowledge					**Physics scientific inquiry**				
North Rhine-Westphalia	479	(4.1)	40	(4.5)	17.1	488	(3.4)	38	(3.5)	15.0
Hamburg	478	(2.6)	39	(2.8)	19.3	482	(2.6)	38	(2.8)	18.1
Brandenburg	529	(3.4)	39	(4.0)	17.3	526	(3.9)	38	(5.0)	15.2
Bavaria	514	(3.7)	37	(3.0)	14.2	505	(3.5)	38	(2.8)	14.6
Germany	500	(1.6)	36	(1.4)	14.6	500	(1.5)	37	(1.2)	14.6
Lower Saxony	501	(3.6)	36	(3.3)	15.4	506	(4.3)	41	(3.6)	18.1
Saxony-Anhalt	541	(3.6)	36	(3.9)	12.8	530	(3.2)	**29**	(3.9)	8.6
Baden-Wuerttemberg	500	(5.9)	35	(3.9)	13.7	496	(5.6)	40	(4.1)	15.3
Hesse	495	(3.3)	34	(2.8)	15.2	491	(3.4)	33	(3.0)	14.1
Schleswig-Holstein	504	(3.2)	32	(3.6)	12.9	503	(3.9)	35	(3.9)	13.5
Mecklenburg-Western Pomerania	519	(3.5)	31	(3.2)	12.2	508	(3.6)	33	(3.6)	12.5
Saxony	544	(4.1)	30	(4.0)	10.6	539	(4.3)	29	(4.3)	8.8
Thuringia	540	(3.9)	29	(3.6)	10.7	533	(4.0)	32	(3.4)	13.2
Rhineland-Palatinate	505	(3.5)	**28**	(2.9)	10.9	508	(4.0)	30	(3.5)	10.3
Berlin[1]	489	(3.8)	39	(3.8)	15.6	488	(4.0)	36	(3.5)	12.8
Bremen[1]	483	(4.5)	47	(5.3)	24.5	480	(4.3)	46	(5.1)	26.4
Saarland[1]	498	(5.0)	38	(3.7)	14.8	493	(4.2)	36	(3.8)	12.7

Notes. The steepness of the social gradient is significantly ($p < .05$) different from 0 for every state in Germany and for Germany as a whole. Regression coefficients marked in bold differ significantly ($p < .05$) from the regression coefficient for Germany. Missing values for the HISEI were estimated through multiple imputation. *b* = unstandardized regression coefficient; *SE* = standard error; R^2 = determination coefficient.

[1] The results should be interpreted with caution due to the large share of missing data.

In Germany as a whole, the steepness of the social gradient is between 35 points in *biology content knowledge* and 40 points on the *global scale* in mathematics. In mathematics (*global scale*) the social gradient ranges between 33 points in Saxony and 49 points in Brandenburg, although no state-specific coefficient deviates significantly from the social gradient estimated for Germany as a whole. In the sciences, the figures for the social gradient range from 28 points in Rhineland-Palatinate (*physics content knowledge*) and Saxony (*biology content knowledge*) to 43 points in Hamburg (*biology content knowledge* and *scientific inquiry*) or – with some caveats – 49 points in Bremen[8] (*biology scientific inquiry*). Based on the explained variance, it is apparent that in mathematics and in the natural sciences nationwide, between approximately 13% and 17% of the differences in proficiency scores between students can be attributed to the socioeconomic status of the parents. Thus, socioeconomic status continues to play a substantial role in explaining proficiency differences between students in Germany.

Similar to the PISA studies and the previous IQB National Assessment Studies, we analyze the effects of social background based on the EGP classification[9], which makes it possible to directly compare the proficiencies of students with a high socioeconomic status (EGP classes I and II) and a low socioeconomic status (EGP classes V to VII). Across Germany, students from families with a higher socioeconomic status score on average 82 points higher in mathematics than students from families with a lower socioeconomic status. This corresponds to a learning advantage of almost three school years for students with a higher socioeconomic status. The results also show that Lower Saxony is the only state with a significantly smaller difference in mathematics scores than Germany as a whole when comparing students with a high and low socioeconomic status. Brandenburg, on the other hand, shows a relatively large difference between these groups.

In the Eastern German states with the exception of Berlin, the results for the sciences show a comparatively weak link between proficiency levels and social background, while the results for Hamburg and – with some caveats – Bremen show very pronounced social disparities in these subjects.

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[8] The results for Bremen should be interpreted with caution due to the large share of missing data.

[9] The EGP classification is a measure used to determine effects of social origin and takes into account qualitative differences between various occupational groups.

Immigration-Related Disparities

In addition to the disparities outlined above, the 2012 National Assessment Study also analyzes the relationship between immigration-related disparities and academic performance. To this end, students are grouped by *immigration status* based on answers provided about the birth country of their parents (students without an immigration background, students with one foreign-born parent, and students with both parents of foreign birth). In addition, students were grouped according to their parents' countries of origin (students whose parents immigrated from Turkey, the territory of the former Soviet Union, Poland, the territory of the former Yugoslavia, and other countries[10]).

In Figures 8 and 9, the average competency achieved by students in the different immigration groups are presented by state on the *global scale* in mathematics and natural sciences, using *biology content knowledge* as an example. The results show that, across Germany, students with parents who were born in Germany achieve higher proficiency levels in all subjects that were examined in this study than students with an immigration background. Students without an immigration background score between 54 points in *biology content knowledge* and 62 points in *biology scientific inquiry* higher than those with both parents of foreign birth, which corresponds to a considerable lead of around two school years. The performance gap in competency scores of students with one foreign-born parent compared to those without foreign-born parents is much smaller but remains statistically significant. It varies between 27 points in *biology scientific inquiry* and *physics scientific inquiry* and 38 points in *physics content knowledge* and thus corresponds to a learning gap of one to one and a half school years. The average lag in proficiency scores for students with both parents of foreign birth compared to students without an immigration background was especially large in Bremen[11] as well as in Hamburg and Hesse, while it was comparatively small in Lower Saxony.

Students' proficiency levels were also studied in relation to their parents' countries of origin. The results show substantial differences between groups, with children of Turkish immigrants showing the lowest, and children of immigrants from the territory of the former Soviet Union the highest average competency scores.

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[10] Students with at least one parent who was not born in Germany, Turkey, the territory of the former Soviet Union, Poland, or the territory of the former Yugoslavia, and those whose parents were born in two different countries, were assigned to the category "other country."

[11] The results for Bremen should be interpreted with caution due to the large share of missing data.

Figure 8: Means and Deviations of the Proficiency Scores as well as Group Differences and Deviations from the German Mean in Mathematics (*Global Scale*) by Immigration Status and State

State	Valid%	*M*	*(SE)*	*SD*	*d*
Baden-Wuerttemberg	70.3	518	(7.6)	100	
	14.0	**482**	(13.4)	92	**0.37**
	15.7	**449**	(10.2)	86	**0.74**
Bavaria	74.5	543	(4.5)	95	
	10.8	**519**	(10.2)	103	**0.24**
	14.8	**479**	(10.1)	98	**0.66**
Brandenburg	92.9	524	(4.4)	103	
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Hamburg	56.3	529	(4.1)	91	
	14.0	**494**	(8.4)	92	**0.38**
	29.7	**467**	(6.7)	94	**0.67**
Hesse	64.0	516	(4.0)	96	
	12.9	**488**	(6.3)	87	**0.30**
	23.1	**457**	(7.0)	88	**0.64**
Mecklenburg-Western Pomerania	91.9	512	(5.2)	96	
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Lower Saxony	78.3	503	(4.6)	88	
	8.1	488	(11.9)	97	0.16
	13.6	**475**	(9.8)	92	**0.31**
North Rhine-Westphalia	65.8	512	(5.2)	98	
	11.9	**467**	(9.9)	101	**0.45**
	22.3	**463**	(7.5)	98	**0.50**
Rhineland-Palatinate	75.7	521	(4.4)	94	
	10.1	513	(9.8)	99	0.09
	14.2	**467**	(8.3)	89	**0.60**
Saxony	90.6	549	(4.7)	95	
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Saxony-Anhalt	92.6	517	(3.3)	98	
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Schleswig-Holstein	82.5	525	(4.4)	93	
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Thuringia	92.3	528	(5.5)	92	
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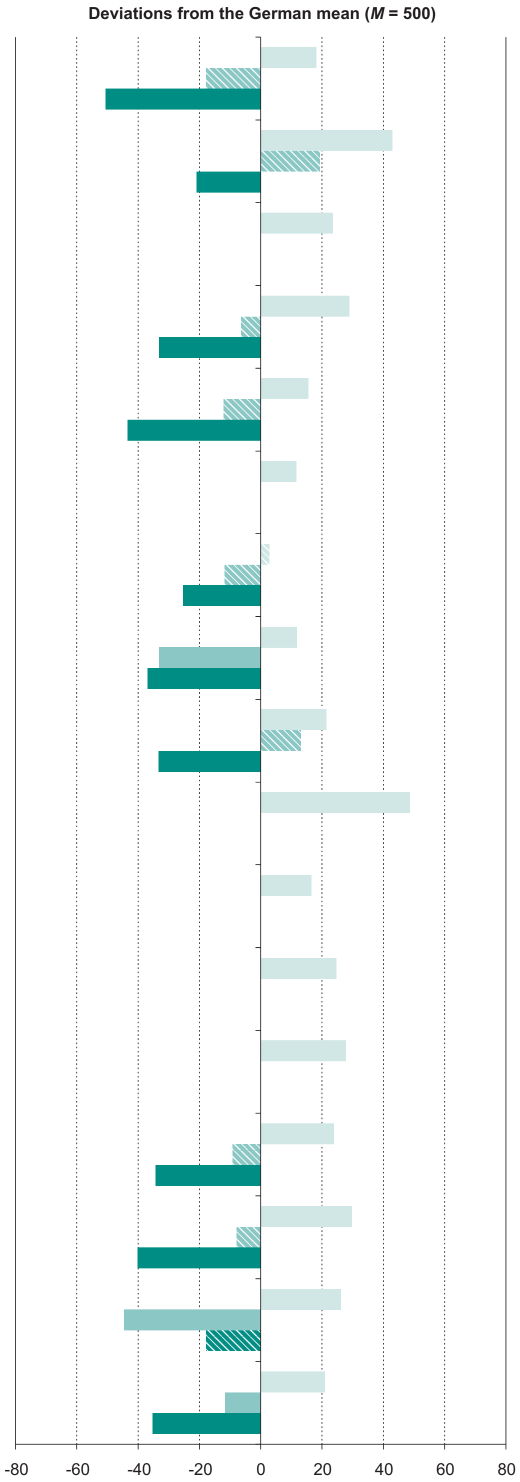
Berlin[1]	62.6	524	(5.8)	95	
	15.1	**491**	(10.7)	105	**0.33**
	22.3	**466**	(10.6)	103	**0.59**
Bremen[1]	61.0	530	(6.2)	100	
	15.3	**492**	(17.7)	88	**0.40**
	23.7	**460**	(9.3)	89	**0.74**
Saarland[1]	79.9	526	(6.4)	84	
	8.5	**455**	(18.8)	100	**0.77**
	11.6	**482**	(13.7)	90	**0.50**
Germany	73.1	521	(2.0)	97	
	10.7	**488**	(4.2)	98	**0.33**
	16.2	**465**	(4.0)	95	**0.59**



🟦 No immigration background 🟦 One foreign-born parent 🟦 Both parents of foreign birth

Notes. For countries in which the share of immigrants in both groups is below 10 percent, only results for young people without an immigration background are reported.

Valid %: Percentages are based only on students who can be unambiguously assigned to one of the three categories.

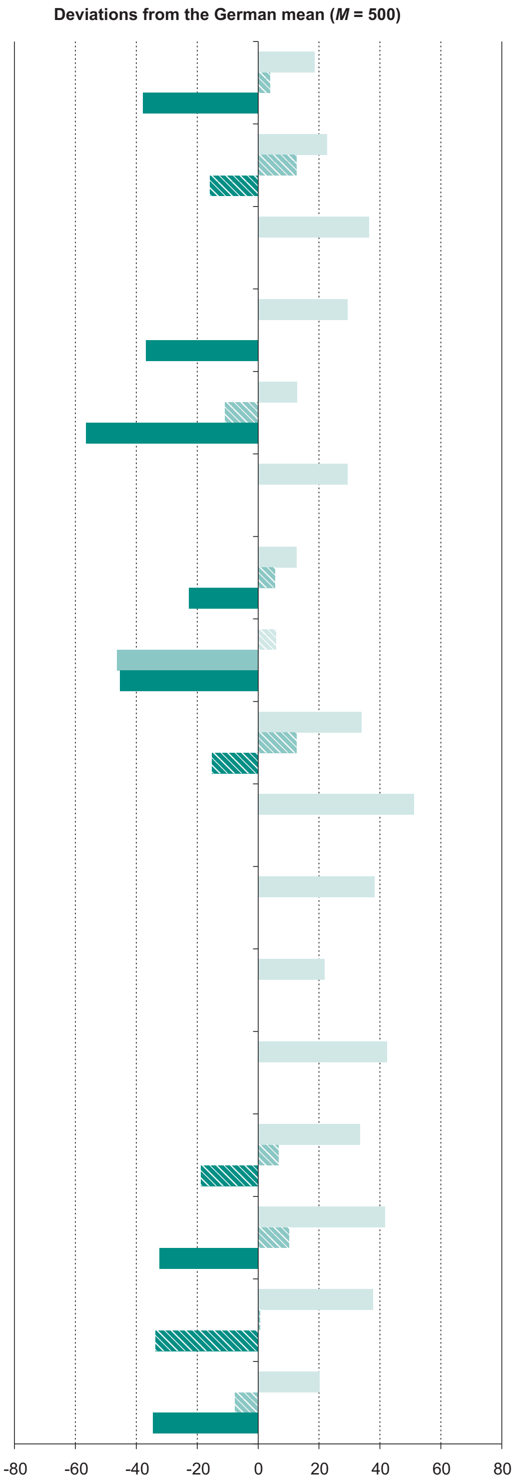
Bold: significant difference ($p < .05$) from young people without an immigration background.
1st line: Students without an immigration background (both parents born in Germany)
2nd line: Students with one parent of foreign birth
3rd line: Students with both parents of foreign birth

M = mean, *SE* = standard error, *SD* = standard deviation, *d* = standardized mean difference from young people without an immigration background.
Hatched bars: non-significant difference from the German mean (*M* = 500).

[1] The results should be interpreted with caution due to the large share of missing data.

Figure 9: Means and Dispersions of the Proficiency Scores and Group Differences and Deviations from the German Mean in *Biology Content Knowledge* by Immigration Status and State

State	Valid %	*M*	*(SE)*	*SD*	*d*
Baden-Wuerttemberg	71.4	519	(7.8)	101	
	11.5	504	(12.2)	95	0.15
	17.1	**462**	(11.5)	88	**0.59**
Bavaria	76.0	523	(4.6)	100	
	9.5	513	(11.7)	118	0.09
	14.5	**484**	(10.1)	105	**0.38**
Brandenburg	91.3	536	(4.4)	92	
	--	--	--	--	
	--	--	--	--	
Hamburg	56.3	529	(4.6)	101	
	15.6	**500**	(7.8)	92	**0.30**
	28.2	**463**	(7.5)	98	**0.66**
Hesse	63.7	513	(4.3)	90	
	13.1	**489**	(8.3)	84	**0.27**
	23.2	**444**	(7.9)	87	**0.78**
Mecklenburg-Western Pomerania	91.6	529	(5.6)	94	
	--	--	--	--	
	--	--	--	--	
Lower Saxony	75.5	513	(4.7)	97	
	10.2	506	(9.5)	91	0.07
	14.2	**477**	(9.4)	94	**0.37**
North Rhine-Westphalia	67.4	506	(5.5)	97	
	11.5	**454**	(8.6)	95	**0.54**
	21.1	**455**	(6.2)	85	**0.56**
Rhineland-Palatinate	75.0	534	(4.8)	91	
	10.3	513	(10.6)	92	0.23
	14.7	**485**	(7.8)	83	**0.56**
Saxony	89.7	551	(4.6)	91	
	--	--	--	--	
	--	--	--	--	
Saxony-Anhalt	94.3	538	(3.4)	98	
	--	--	--	--	
	--	--	--	--	
Schleswig-Holstein	83.5	522	(4.7)	91	
	--	--	--	--	
	--	--	--	--	
Thuringia	92.4	542	(4.1)	93	
	--	--	--	--	
	--	--	--	--	
Berlin[1]	63.4	533	(6.3)	97	
	15.9	507	(14.7)	114	0.25
	20.6	**481**	(11.1)	102	**0.53**
Bremen[1]	59.7	542	(8.6)	97	
	17.4	510	(14.9)	105	0.31
	22.9	**468**	(10.9)	100	**0.75**
Saarland[1]	79.4	538	(7.2)	101	
	9.5	**501**	(14.4)	92	**0.38**
	11.1	**466**	(17.5)	107	**0.69**
Germany	73.5	520	(2.2)	97	
	10.4	**492**	(4.1)	100	**0.28**
	16.1	**466**	(3.3)	93	**0.57**



□ No immigration background ▨ One foreign-born parent ■ Both parents of foreign birth

Notes. For countries in which the share of immigrants in both groups is below 10 percent, only results for young people without an immigration background are reported.

Valid %: Percentages are based only on students who can be unambiguously assigned to one of the three categories.

Bold: significant difference ($p < .05$) from young people without an immigration background.
1st line: Students without an immigration background (both parents born in Germany)
2nd line: Students with one parent of foreign birth
3rd line: Students with both parents of foreign birth

M = mean, *SE* = standard error, *SD* = standard deviation, *d* = standardized mean difference from young people without an immigration background.
Hatched bars: non-significant difference from the German mean (*M* = 500).

[1] The results should be interpreted with caution due to the large share of missing data.

Table 3: Regression Model to Estimate Immigration-Related Disparities in Mathematics Achievement (*Global Scale*)

	Model I		Model II		Model III	
	b	*(SE)*	*b*	*(SE)*	*b*	*(SE)*
No immigration background	**535**	(2.0)	**530**	(1.7)	**531**	(1.7)
Turkey[1]						
One parent of foreign birth	**–84**	(8.2)	**–60**	(7.7)	**–49**	(7.7)
Both parents of foreign birth	**–92**	(6.8)	**–53**	(6.9)	**–37**	(7.9)
Former Soviet Union[1]						
One parent of foreign birth	2	(13.1)	–1	(12.0)	6	(12.0)
Both parents of foreign birth	**–51**	(6.5)	**–33**	(5.9)	**–19**	(6.0)
Poland[1]						
One parent of foreign birth	**–45**	(12.6)	**–40**	(12.4)	**–34**	(11.7)
Both parents of foreign birth	**–32**	(11.3)	–18	(10.4)	–5	(10.3)
Former Yugoslavia[1]						
One parent of foreign birth	**–89**	(13.7)	**–73**	(13.3)	**–65**	(14.2)
Both parents of foreign birth	**–69**	(15.5)	**–43**	(15.3)	–26	(14.7)
Other country[1]						
One parent of foreign birth	**–22**	(5.5)	**–24**	(4.9)	**–18**	(4.8)
Both parents of foreign birth	**–61**	(5.5)	**–39**	(5.0)	**–24**	(5.8)
Undeterminable[1]	**–56**	(6.4)	**–39**	(5.5)	**–33**	(5.7)
Social background						
HISEI[2]			**28**	(1.4)	**27**	(1.4)
Parents' educational level[2]			**14**	(1.4)	**13**	(1.4)
Language spoken at home[3]						
Sometimes German					**–26**	(4.5)
Never German					–14	(9.0)
N	13945		13945		13945	
R^2	.08		.22		.22	

Notes: bold: significant partial regression coefficients ($p < .05$). *b* = unstandardized regression coefficient; *SE* = standard error. [1] The reference group consists of students without an immigration background. [2] z-standardized. [3] Reference group: German always spoken at home.

Table 4: Regression Model to Estimate Immigration-Related Disparities in Biology Achievement

	Biology content knowledge						Biology scientific inquiry					
	Model I		Model II		Model III		Model I		Model II		Model III	
	b	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*
No immigration background	**530**	(2.4)	**525**	(2.3)	**526**	(2.3)	**530**	(2.3)	**525**	(2.3)	**526**	(2.2)
Turkey[1]												
One parent of foreign birth	**–75**	(10.0)	**–54**	(9.0)	**–44**	(9.3)	**–78**	(10.3)	**–57**	(9.0)	**–48**	(9.1)
Both parents of foreign birth	**–92**	(6.1)	**–60**	(6.4)	**–43**	(7.3)	**–104**	(6.4)	**–71**	(6.6)	**–56**	(7.0)
Former Soviet Union[1]												
One parent of foreign birth	20	(14.5)	22	(13.2)	**30**	(13.4)	21	(11.7)	**23**	(10.3)	**29**	(10.3)
Both parents of foreign birth	**–31**	(6.7)	**–14**	(6.3)	1	(6.7)	**–38**	(6.8)	**–21**	(6.6)	–7	(7.0)
Poland[1]												
One parent of foreign birth	**–33**	(11.4)	**–28**	(11.2)	**–26**	(11.4)	**–26**	(13.0)	–22	(13.0)	–20	(13.1)
Both parents of foreign birth	**–41**	(10.1)	**–29**	(9.8)	–10	(10.0)	**–37**	(9.4)	**–25**	(9.4)	–7	(9.3)
Former Yugoslavia[1]												
One parent of foreign birth	**–53**	(13.7)	**–33**	(13.5)	**–26**	(13.3)	**–43**	(13.6)	–23	(13.3)	–17	(13.1)
Both parents of foreign birth	**–58**	(14.3)	**–43**	(12.6)	–23	(13.1)	**–67**	(15.5)	**–51**	(13.6)	**–33**	(14.3)
Other country[1]												
One parent of foreign birth	**–17**	(5.4)	**–16**	(4.8)	**–10**	(4.6)	**–18**	(5.6)	**–16**	(4.9)	**–11**	(4.7)
Both parents of foreign birth	**–59**	(5.8)	**–40**	(5.6)	**–22**	(6.5)	**–58**	(6.5)	**–38**	(6.1)	**–22**	(6.5)
Undeterminable[1]	**–50**	(6.7)	**–37**	(6.8)	**–31**	(6.8)	**–52**	(6.8)	**–39**	(6.9)	**–34**	(6.9)
Social background												
HISEI[2]			**25**	(1.6)	**25**	(1.6)			**26**	(1.7)	**25**	(1.7)
Parents' educational level[2]			**9**	(1.4)	**9**	(1.4)			**10**	(1.6)	**10**	(1.5)
Language spoken at home[3]												
Sometimes German					**–25**	(4.4)					**–21**	(4.3)
Never German					**–50**	(9.5)					**–54**	(9.0)
N	14117		14117		14117		14117		14117		14117	
R^2	.07		.16		.17		.08		.18		.18	

Notes: bold: significant partial regression coefficients ($p < .05$). *b* = unstandardized regression coefficient; *SE* = standard error. [1] The reference group consists of students without an immigration background. [2] z-standardized. [3] Reference group: German always spoken at home.

Table 5: Regression Model to Estimate Immigration-Related Disparities in Chemistry Achievement

	Chemistry content knowledge						**Chemistry scientific inquiry**					
	Model I		**Model II**		**Modell III**		**Model I**		**Model II**		**Model III**	
	b	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*
No immigration background	**530**	(2.3)	**526**	(2.2)	**527**	(2.1)	**530**	(2.3)	**525**	(2.2)	**527**	(2.1)
Turkey[1]												
One parent of foreign birth	**–76**	(10.3)	**–54**	(9.1)	**–45**	(9.2)	**–81**	(9.9)	**–60**	(8.7)	**–48**	(8.7)
Both parents of foreign birth	**–86**	(5.7)	**–52**	(5.9)	**–37**	(6.7)	**–90**	(5.8)	**–57**	(6.2)	**–38**	(6.9)
Former Soviet Union[1]												
One parent of foreign birth	–6	(13.1)	–4	(11.4)	2	(11.6)	4	(13.9)	6	(12.5)	15	(12.8)
Both parents of foreign birth	**–36**	(7.0)	**–19**	(6.6)	–5	(7.1)	**–40**	(7.2)	**–23**	(6.9)	–6	(7.4)
Poland[1]												
One parent of foreign birth	**–29**	(12.9)	–24	(13.0)	–22	(13.2)	**–31**	(13.0)	**–27**	(13.3)	–24	(13.5)
Both parents of foreign birth	**–48**	(9.8)	**–35**	(9.4)	–18	(10.1)	**–53**	(9.9)	**–40**	(9.8)	**–20**	(9.6)
Former Yugoslavia[1]												
One parent of foreign birth	**–64**	(11.8)	**–43**	(12.2)	**–37**	(12.0)	**–48**	(13.0)	**–27**	(13.0)	–19	(12.7)
Both parents of foreign birth	**–54**	(14.2)	**–38**	(12.2)	–20	(12.8)	**–59**	(14.2)	**–43**	(12.2)	–21	(12.6)
Other country[1]												
One parent of foreign birth	**–23**	(5.0)	**–22**	(4.3)	**–17**	(4.1)	**–23**	(5.3)	**–22**	(4.7)	**–15**	(4.5)
Both parents of foreign birth	**–59**	(5.8)	**–38**	(5.4)	**–22**	(5.9)	**–62**	(6.3)	**–42**	(6.1)	**–23**	(6.5)
Undeterminable[1]	**–50**	(6.4)	**–36**	(6.5)	**–31**	(6.6)	**–48**	(7.0)	**–34**	(7.0)	**–29**	(7.0)
Social background												
HISEI[2]			**26**	(1.6)	**26**	(1.6)			**27**	(1.6)	**26**	(1.6)
Parents' educational level[2]			**10**	(1.4)	**10**	(1.4)			**9**	(1.4)	**9**	(1.4)
Language spoken at home[3]												
Sometimes German					**–23**	(4.1)					**–28**	(4.5)
Never German					**–44**	(9.5)					**–46**	(10.2)
N	14117		14117		14117		14117		14117		14117	
R^2	.07		.17		.18		.07		.17		.18	

Notes: bold: significant partial regression coefficients (*p* < .05). *b* = unstandardized regression coefficient; *SE* = standard error. [1] The reference group consists of students without an immigration background. [2] z-standardized. [3] Reference group: German always spoken at home.

Table 6: Regression Model to Estimate Immigration-Related Disparities in Physics Achievement

	Physics content knowledge						**Physics scientific inquiry**					
	Model I		**Model II**		**Model III**		**Model I**		**Model II**		**Model III**	
	b	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*	*b*	*(SE)*
No immigration background	**532**	(2.2)	**528**	(2.1)	**529**	(2.1)	**530**	(2.3)	**526**	(2.2)	**527**	(2.2)
Turkey[1]												
One parent of foreign birth	**–80**	(10.8)	**–59**	(9.8)	**–50**	(9.9)	**–66**	(10.6)	**–44**	(9.5)	**–35**	(9.7)
Both parents of foreign birth	**–92**	(5.3)	**–58**	(5.7)	**–43**	(6.4)	**–92**	(6.1)	**–57**	(6.6)	**–41**	(7.0)
Former Soviet Union[1]												
One parent of foreign birth	–2	(14.4)	0	(12.5)	7	(12.7)	–1	(14.1)	1	(12.3)	8	(12.6)
Both parents of foreign birth	**–38**	(6.4)	**–21**	(6.1)	–8	(6.6)	**–45**	(7.0)	**–27**	(6.7)	–13	(7.0)
Poland[1]												
One parent of foreign birth	**–51**	(12.7)	**–47**	(12.7)	**–45**	(13.0)	**–37**	(13.3)	**–32**	(13.3)	**–30**	(13.5)
Both parents of foreign birth	**–55**	(9.6)	**–42**	(9.2)	**–26**	(10.2)	**–43**	(9.5)	**–30**	(9.0)	–12	(9.2)
Former Yugoslavia[1]												
One parent of foreign birth	**–52**	(13.3)	**–31**	(13.1)	–25	(12.9)	**–54**	(11.4)	**–33**	(11.2)	**–26**	(11.0)
Both parents of foreign birth	**–72**	(14.0)	**–57**	(12.4)	**–39**	(12.6)	**–55**	(13.5)	**–38**	(11.7)	–20	(12.3)
Other country[1]												
One parent of foreign birth	**–29**	(5.1)	**–28**	(4.6)	**–22**	(4.5)	**–19**	(5.4)	**–17**	(4.8)	**–11**	(4.6)
Both parents of foreign birth	**–64**	(5.8)	**–44**	(5.4)	**–28**	(5.8)	**–63**	(5.8)	**–42**	(5.6)	**–26**	(6.2)
Undeterminable[1]	**–56**	(7.4)	**–42**	(7.2)	**–37**	(7.2)	**–47**	(6.9)	**–33**	(6.9)	**–28**	(6.8)
Social background												
HISEI[2]			**25**	(1.7)	**25**	(1.7)			**27**	(1.7)	**27**	(1.7)
Parents' educational level[2]			**11**	(1.4)	**11**	(1.4)			**9**	(1.4)	**9**	(1.4)
Language spoken at home[3]												
Sometimes German					**–23**	(4.1)					**–24**	(4.1)
Never German					**–36**	(9.5)					**–47**	(9.5)
N	14117		14117		14117		14117		14117		14117	
R^2	.08		.18		.19		.07		.18		.19	

Notes: bold: significant partial regression coefficients (*p* < .05). *b* = unstandardized regression coefficient; *SE* = standard error. [1] The reference group consists of students without an immigration background. [2] z-standardized. [3] Reference group: German always spoken at home.

The results of multivariate regression analyses suggest that the immigration-related disparities are only partially attributable to socioeconomic background and to the frequency with which German is spoken at home (see Tables 3 to 6). After statistical control for the family's socioeconomic status, the parents' educational status, and the language spoken by the family at home, the gap in proficiency scores of students with an immigration background are reduced significantly, yet substantial disparities remain for some subgroups. In particular, young people of Turkish origin, and young people whose parents immigrated from a wide variety of other countries show a gap in proficiency scores corresponding to a learning lag of up to two years behind their peers without an immigration background. Young people whose families immigrated from the former Soviet Union are an exception: after controlling for social background and language spoken at home, this relatively large group achieves mean proficiency scores in chemistry and physics that are close to those of young people without an immigration background.

Effects of Context and Student Characteristics on Science Proficiencies

Proficiency in the sciences is not only considered to be of prime importance for entering numerous professions in technical and scientific fields, it is also viewed as a crucial foundation for a country's economic development. The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK) clearly expressed this idea in their recommendations to strengthen education in mathematics, the natural sciences, and technology (KMK, 2005e, 2009). Comparing educational curricula and class schedules in Germany's 16 federal states, it is clear that scientific subject matter is anchored differently in school curricula across the states, both in structural terms (science as a general subject versus individual subjects of biology, chemistry, and physics) and quantitative terms (number of lessons per year according to class schedules). To some extent there are also substantial differences between school types within a single state.

The 2012 National Assessment Study therefore investigated the association between *actual amount of time spent in the classroom* and the science proficiencies of students, taking into account other characteristics that are relevant to achievement. The database for this analysis was a standardized questionnaire administered to the principals of schools that had classes participating in the 2012 National Assessment Study. The survey dealt with the science classes taught at secondary level I. By measuring cumulative classroom time at the grade level, the choice of appropriate methods of analysis and subject-specific proficiency tests, it was possible to avoid some of the methodological and conceptual difficulties faced by previous studies that have examined the role of classroom time.

Using hierarchical multi-level analysis, the effects of classroom time and school type as well as additional relevant student characteristics (e.g., gender or subject interest) were estimated. While the gross effect of classroom time on proficiencies in biology and chemistry amounts to 8 and 9 points, respectively, and in physics to 15 points per additional hour of regular classroom instruction, these classroom time differences vanish almost entirely when controlling for school type. Thus, within the individual school types, there is no significant relationship between classroom time and academic performance. When considering other student characteristics such as social background and subject interest, the effect of classroom time is reduced further and remains significant only for the proficiency area of *physics scientific inquiry* although even here it is of little practical relevance. If one increased the average classroom time in physics over the entire course of secondary level I by 50 percent, which would correspond to around 3.3 additional hours of class per week, this would result *ceteris paribus* in an increase of around 13 proficiency points according to the findings presented here. Compared to other characteristics assessed, such as subject interest, the effect of a purely quantitative increase in classroom time offered to students – that is, without any qualitative change in instruction or an increase in the actual time-on-task – can be evaluated as low.

The results of these more extensive analyses of classroom time thus suggest that within the limits that are set in Germany by course schedules, the variability in lesson hours in the natural science subjects does not appear relevant *per se* for a differential development of proficiencies in students. Additional, more in-depth studies are needed to examine the extent to which the effective, cognitively activating design of existing classroom time is responsible for differences in learning outcomes.

Motivational Student Characteristics in Mathematics and Science

The acquisition of school-related skills and proficiencies is always related to personal attitudes, values, and motives (Klieme et al., 2007; Weinert, 2001). Yet motivational characteristics are not just the *result* of educational processes; they also influence the acquisition of cognitive competencies. In the IQB National Assessment Study 2012, two motivational aspects have been investigated in more detail: self-concept in relation to the subject, and interest in mathematics and science subject matter. In contrast to past national school assessments, the IQB National Assessment Study 2012 allows for a differentiated examination of motivational student characteristics in the subjects of biology, chemistry, and physics.

The results for the motivational characteristics show that in mathematics and all of the science subjects, a significant percentage of students possess a very positive subject-specific self-concept and high subject interest, and thus good preconditions for further acquisition of proficiencies in the natural sciences. Between subjects, however, systematic differences appear: interest in mathematics and biology is relatively high, whereas interest in chemistry and physics is lower. State-level analyses reveal that the mean self-concept or subject interest of students is similar across states, with few significant deviations from the German mean.

The gender differences in motivational student characteristics identified in the IQB National Assessment Study correspond to familiar stereotypes. In mathematics and physics – that is, in the natural science subject that tend to use mathematical concepts and definitions most extensively – the gender-specific differences are greatest. In these two subjects, boys estimate their skills and proficiencies substantially higher than girls and express a stronger interest in the subject matter. An important finding from the National Assessment Study 2012 is that the gender differences in self-concept do not correspond to the gender differences in proficiencies actually acquired by these students. In biology, for example, girls show significantly higher proficiency scores, yet still do not have a more positive self-concept than boys. In the subjects of chemistry and physics, the gender differences in proficiencies are low and tend to favor girls; nevertheless, stereotypical differences in self-concept appear, especially in the subject of physics. To put it in simple terms, girls substantially underestimate their abilities in the subjects of chemistry and physics.

At the student level, a higher self-concept and interest in the subject matter are accompanied on average by higher proficiency scores. Yet the findings also give indications that some students – despite high proficiency scores – lack faith in their own abilities and have little interest in mathematical and scientific topics. Girls are overrepresented in this group. For these young people, there is an urgent need to boost self-concept and encourage subject interest, given that their proficiency scores predestine them to pursue university studies in a MINT subject, yet they appear inadequately motivated to actually do so. This form of support could contribute to reducing the "gender gap," especially in the natural sciences.

Aspects of the Education and Further Professional Development of Mathematics and Science Teachers in the National Assessment Study

In recent years, a large number of studies have shown that the manner in which teachers design lessons and learning processes plays a crucial role in determining the learning outcomes and motivation of their students. In addition, empirical findings have shown that the use of occupational training opportunities, such as attendance of continuing professional education and training programs, can strengthen the professional skills of teachers and thereby ultimately help to improve student outcomes. In the IQB National Assessment Study 2012, a sample of 4,050 teachers of the students tested in the study has been used to obtain descriptive statistics of various characteristics of mathematics and science teachers and to investigate associations between indicators of teachers' subject proficiency and the proficiencies of their students.

One characteristic in which large differences appear between states is the teachers' age distribution. While the majority of the mathematics and science teachers in the East German states are over the age of 50, the teachers in the West German states show a more even age distribution. In the next several years, the East German states in particular will be faced with a wave of retirement and will have to meet an increasing need for teachers in these subjects.

The answers given by teachers regarding their subject-specific teaching qualifications reveal that the majority of teachers at upper secondary schools are teaching the subjects they were trained to teach, but in the other school types across Germany, as many as 18% of teachers are teaching subjects they are not qualified to teach. While the percentage of teachers lacking the appropriate subject training across mathematics and all science subjects appears fairly low in the East German states as well as in Berlin and Hesse (in biology and chemistry) and in North Rhine-Westphalia (in biology, chemistry, and physics), in the other states as many as 30% of all teachers surveyed are teaching a subject for which they lack the appropriate qualifications.

The large majority of teachers surveyed take part in further professional training. A breakdown of the individual training programs by content shows that mathematics and science teachers frequently attend training on topics of subject didactics, as well as on different forms and methods of teaching. If one explores the question of which training topics teachers select in relation to their teaching qualifications, a pattern emerges spanning the subjects under investigation: training programs dealing with subject didactics are attended mainly by teachers who are qualified to teach the subject. In other words, precisely the teachers that would most probably need further training in subject didactics – due to their lack of appropriate subject training – are precisely those who tend *not* to take advantage of these training opportunities.

Systematic associations between teaching qualifications and student proficiencies appear in the subjects of mathematics, biology, and physics, even after controlling for student and teacher background characteristics. The lack of specialized professional training in their subject appears particularly significant for teachers at school types other than upper secondary. An association between teacher participation in postgraduate professional education and student proficiency scores, however, can only be identified for a few subjects and training topics.

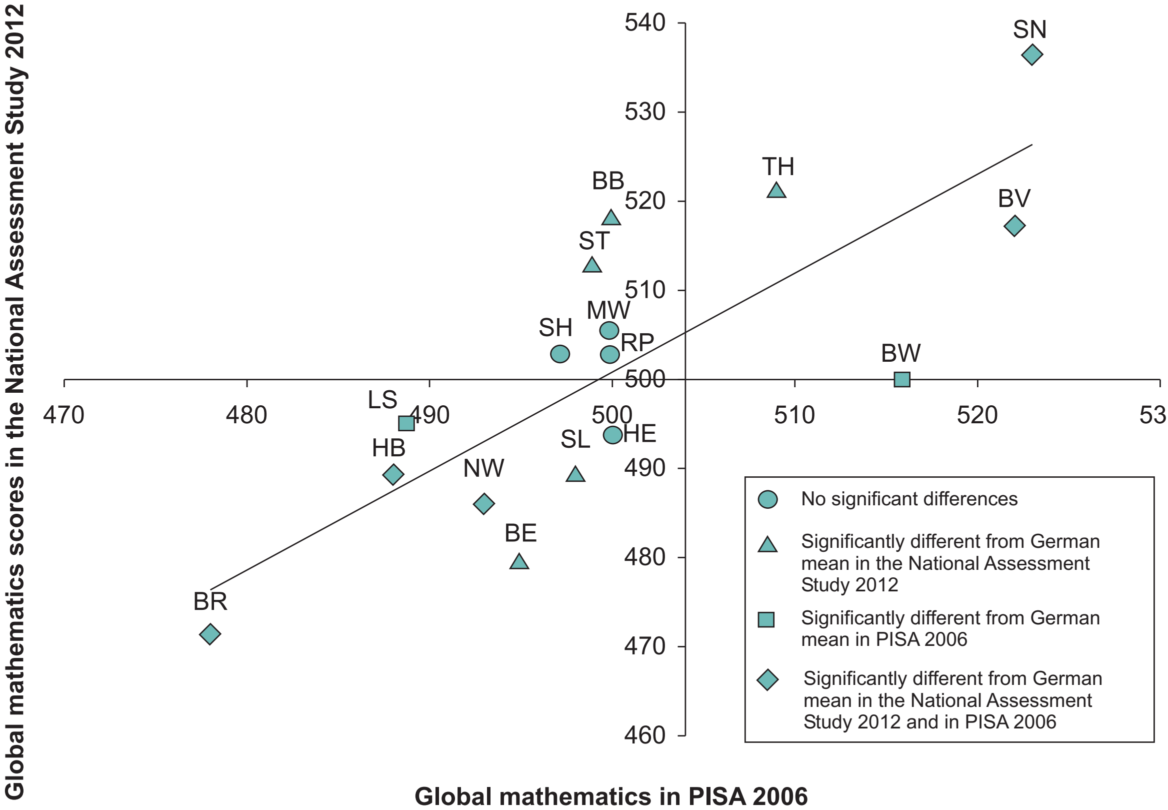
On the whole, the results of the National Assessment Study 2012 underscore that the use of teachers to teach mathematics and natural science subjects without the appropriate qualifications is widespread, especially at school types other than upper secondary schools, and that this is associated with a substantial performance lag on the part of their students.

Interpreting the Findings in Relation to Results from Past National Assessment Studies

The IQB National Assessment Study 2012 is the first national assessment study for secondary level I that has been carried out on the basis of the Standing Conference's (KMK) educational standards in mathematics and the natural sciences and which thus enables evaluation of state educational systems' success in achieving the academic proficiency goals that are now in effect nationwide. The National Assessment Study 2012 offers baseline measurements against the benchmark of the educational standards – just as the assessments of proficiencies in the language subjects at the secondary level I (Köller et al., 2010) and proficiencies in German and mathematics did at the primary level (Stanat et al., 2012). The evaluation of trends in achievement – like those well-known from the PISA studies – will be possible in future waves of the IQB National Assessment Studies in the years 2015 (language competencies at the secondary level), 2016 (language and mathematical competencies at the primary level), and 2018 (mathematical and natural science competencies at the secondary level). Up to then, any trends observed across the various studies (PISA and IQB National Assessment Study) can only be approximations. Such observations show that the states' relative positions in mathematics and natural science proficiency scores are very similar between PISA 2006 (Frey, Asseburg, Ehmke & Blum, 2008; Rönnebeck, Schöps, Prenzel & Hamann, 2008) and the IQB National Assessment Study. This is expressed in a high correlation in mean scores across states (mathematics and chemistry: $r = .79$; biology and physics: $r = .78$) (see Figures 10 and 11).

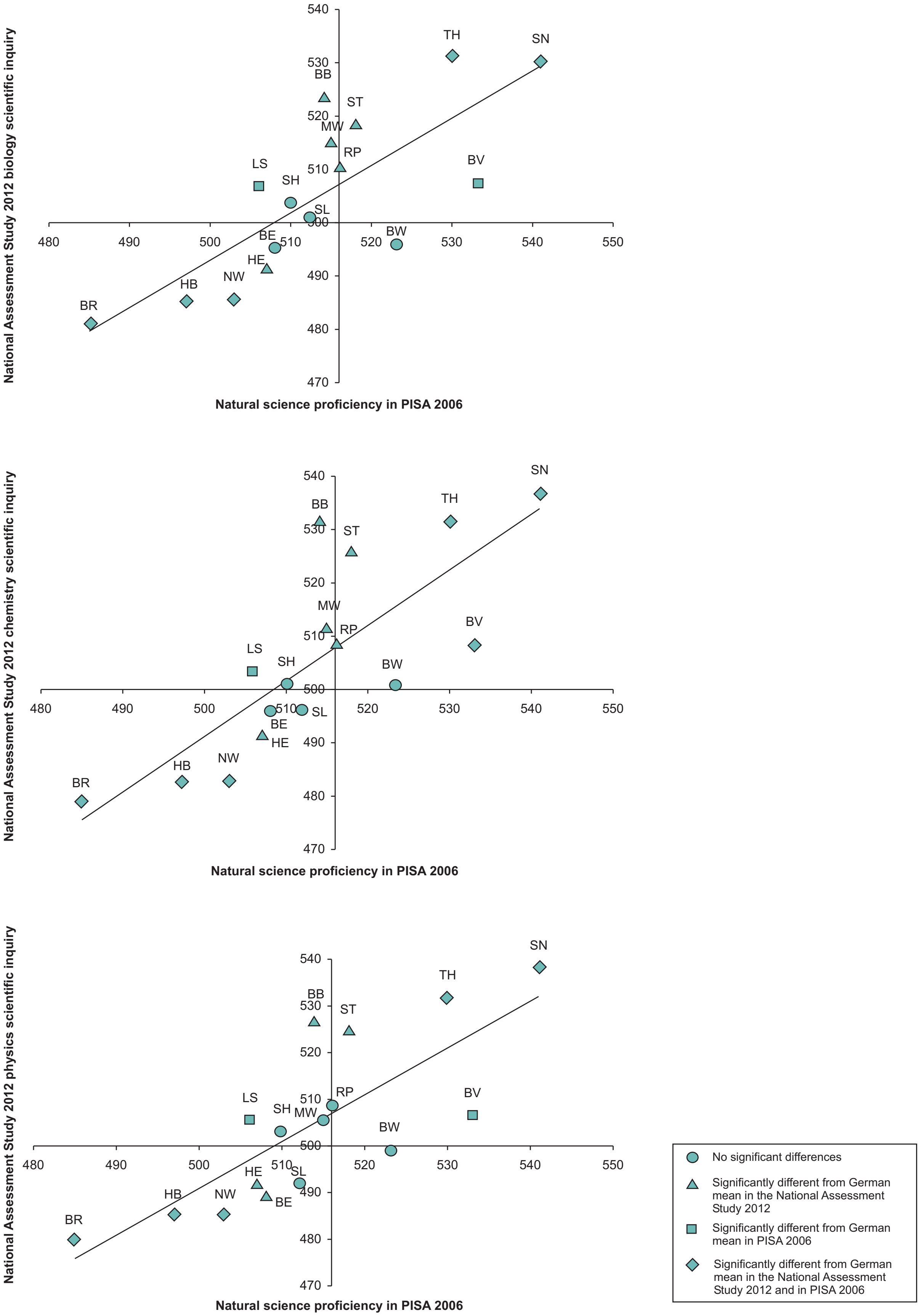
A strikingly divergent pattern in the IQB National Assessment Study 2012 is presented by four of the Eastern German states – Saxony, Thuringia, Brandenburg, and Saxony-Anhalt – which show substantially better mathematics results compared to the other states than in PISA 2006 and which now, together with Bavaria, form the top group. If one traces the results for these four states in mathematics back to the first assessment study carried out in the PISA framework in 2000, Thuringia and Saxony have placed consistently high, towards the top of the state ranking. Saxony-Anhalt and Brandenburg, however, show positive trends: These two states were in the lower third of the first National Assessment Study in 2000 and have improved their relative position gradually over the years. Similar trends are evident in the sciences as well.

Figure 10: State Means in Mathematics (*Global Scale)* in the National Assessment Study 2012 and in PISA 2006



Notes: BB = Brandenburg, BE = Berlin, BW = Baden-Wuerttemberg, BV = Bavaria, BR = Bremen, HE = Hesse, HB = Hamburg, MW = Mecklenburg-Western Pomerania, LS = Lower Saxony, NW = North Rhine-Westphalia, RP = Rhineland-Palatinate, SH = Schleswig-Holstein, SL = Saarland, SN = Saxony, ST = Saxony-Anhalt, TH = Thuringia.

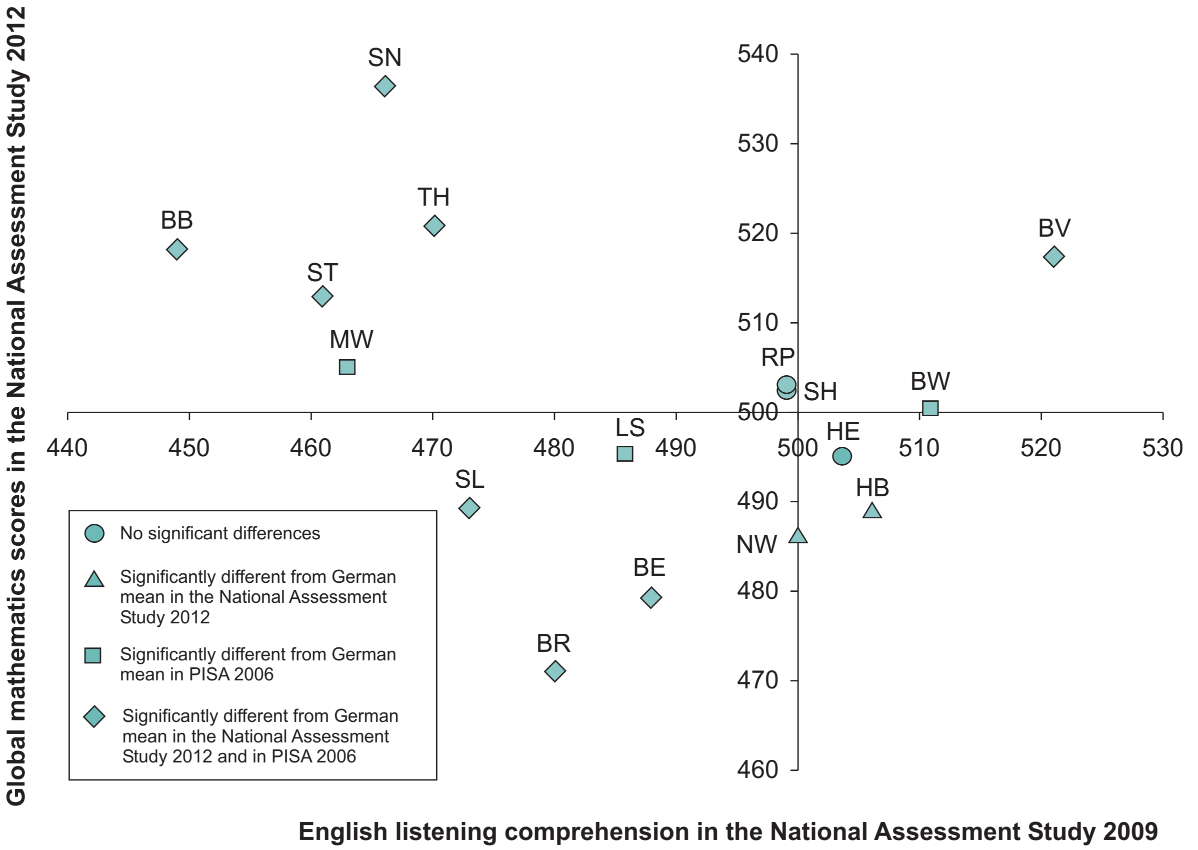
Figure 11: State Means on the Scales for *Scientific inquiry* in the Sciences in the National Assessment Study 2012 and in the Global Science Scale in PISA 2006



Notes: BB = Brandenburg, BE = Berlin, BW = Baden-Wuerttemberg, BV = Bavaria, BR = Bremen, HE = Hesse, HB = Hamburg, MW = Mecklenburg-Western Pomerania, LS = Lower Saxony, NW = North Rhine-Westphalia, RP = Rhineland-Palatinate, SH = Schleswig-Holstein, SL = Saarland, SN = Saxony, ST = Saxony-Anhalt, TH = Thuringia.

Comparing the relative positions of the states in the two IQB National Assessment Studies of language and mathematical and natural science proficiencies at secondary level I reveals pronounced discrepancies between strengths and weaknesses (see Figure 12). For the Eastern German states with the exception of Berlin, a clear pattern emerges by subject, showing substantial strengths in mathematics and the natural sciences and to some extent significant needs for improvement in English as a first foreign language. For the West German states and Berlin, in contrast, no clear profile emerges. Rather, the relative positions of these states are similar for all of the areas of competency examined at secondary level I. Bavaria is often found in the top group, and the average proficiency scores of students in the city-states (Berlin, Hamburg, Bremen) are often below average.

Figure 12: State Means in Mathematics (*Global Scale*) in the National Assessment Study 2012 and in English (Proficiency Area *Listening Comprehension*) in the National Assessment Study 2009



Notes: BB = Brandenburg, BE = Berlin, BW = Baden-Wuerttemberg, BV = Bavaria, BR = Bremen, HE = Hesse, HB = Hamburg, MW = Mecklenburg-Western Pomerania, LS = Lower Saxony, NW = North Rhine-Westphalia, RP = Rhineland-Palatinate, SH = Schleswig-Holstein, SL = Saarland, SN = Saxony, ST = Saxony-Anhalt, TH = Thuringia.

Overall, the IQB National Assessment Studies provide standards-based long-term observation of returns on investments in the school system – the kind of monitoring that has long since become a matter of course in other policy fields such as the labor market and health policy. Long-term observation cannot, however, serve the same function as scientific research on causes of specific issues and aspects. This clearly shows that a criticism heard occasionally in the public and educational policy debate – the assertion that school achievement studies like PISA or the IQB assessments do not produce any "new" results and also do not explain the causes of unequal returns on educational investments – is essentially unfounded. For the future, it will nevertheless be crucial to connect the results of educational monitoring more efficiently with targeted research on the causes of inequalities and the effectiveness of possible intervention measures that can be used to overcome them. This will require a strategically oriented dialogue around research to support policy involving educational researchers, educational policy makers, educational administrators, and educators themselves in order to arrive at a coordinated and coherent system of priorities.

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