Chapter 3. Innovation in practices to develop technical skills in science

This chapter presents the change in science education teaching and learning practices aimed at developing student content and procedural knowledge: memorising rules and facts, using formulas, practising, watching teachers conducting an experiment and doing it oneself, etc. The change within countries is presented as an increase or decrease in the share of students exposed to the practice. The percentage point change is also expressed as a standardised effect size in the final table.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

6. Memorising rules, procedures and facts as a pedagogical technique in science

Why it matters

Memorising facts, rules and procedures is part of all learning strategies. Often associated to “traditional” and relatively “teacher-centred” approaches to teaching and learning, memorisation should be seen as part of the mix of pedagogical practices that teachers should use. Good teachers will find the right dosage with other, more active learning practices. An increase of these practices is often related to the existence of high-stakes exams or assessments in education systems.

Primary education

Change at the OECD level: moderate

OECD countries have increased the use of these memorisation exercises in 4th grade science lessons, from an average of 24% of students exposed to it in at least half their lessons in 2007 to 33% in 2015. Positive and negative trends together amount to an average absolute change of 10 percentage points, corresponding to a moderate effect size of 0.26. The frequency of its use varies significantly between countries. For instance, Northern Ireland had 7% of its 4th grade students regularly memorising rules, procedures and facts in their science lessons in 2015, against 76% in Lithuania.

Countries where there has been the most change

Lithuania stands out with an increase in the use of this learning technique by 29 percentage points between 2007 and 2015, trailed closely by Slovenia (25 percentage points). A few large declines in the use of this practice were also witnessed, especially in Turkey with a decrease of 32 percentage points between 2011 and 2015.

Secondary education

Change at the OECD level: moderate

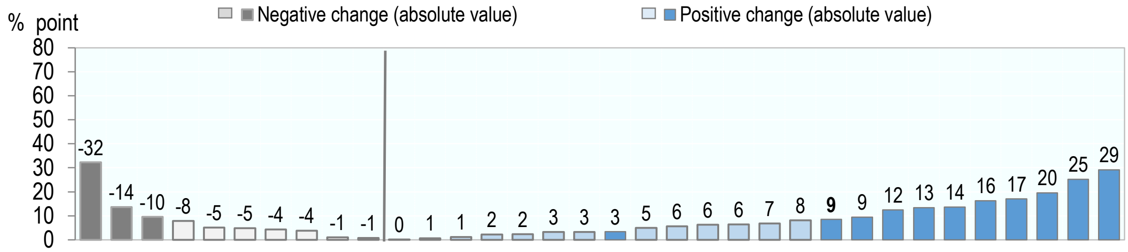
Most OECD education systems have seen greater use of memorisation of rules, procedures and facts during 8th grade science lessons, resulting on an average increase of 15 percentage points in the share of students regularly exposed to it between 2007 and 2015. Regardless of the direction of innovation, the absolute change in the use of this pedagogical technique amounted to 15 percentage points as well, with a rather large effect size of 0.34. In 2015, the share of 8th grade students exposed to this learning practice in at least half their lessons ranged from 23% in Norway against 78% in Lithuania.

Countries where there has been the most change

Italy experienced the largest increase in the use of this learning technique in 8th grade science, of 42 percentage points. Moreover, strong positive changes of around 30 percentage points were also witnessed in Quebec (Canada) and Singapore. Only two negative changes in this practice were recorded, none of which was above 10 percentage points.

Figure 3.1. 4th grade students memorising rules, procedures and facts in science

Change in and share of students whose teachers ask them to memorise rules, procedures and facts in at least half the lessons, 2007-2015, teachers report



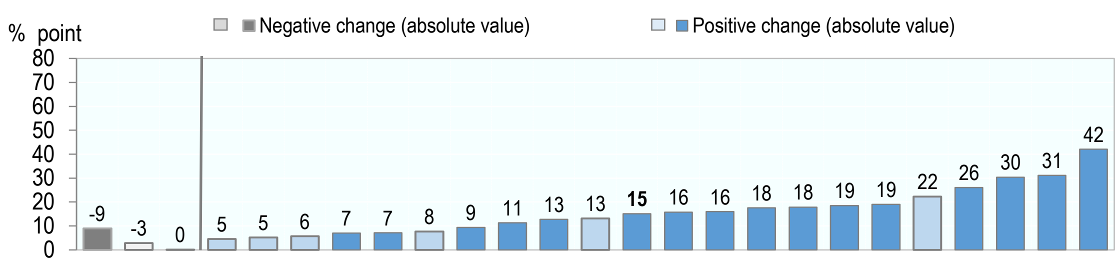
% of students		Turkey*	Poland*	United States	Korea*	Germany	Chile*	Belgium (Fl.)*	Spain*	Alberta (CAN)*	Northern Ireland (UK)*	Finland*	Singapore	Russian Federation	Australia	Austria*	Ontario (CAN)	Portugal*	New Zealand	Denmark	Ireland*	Hungary	Netherlands	Italy	Hong Kong, China	**OECD average**	England (UK)	Sweden	Czech Republic	Japan	Slovak Republic	Norway	Quebec (CAN)	Slovenia	Lithuania
	2015	38	52	25	62	16	53	26	55	m	7	30	41	62	13	m	18	63	8	14	24	73	24	73	46	**33**	20	26	22	69	33	21	38	63	76
	2011	70	66	33	69	17	58	30	58	9	8	30	51	68	10	7	16	60	4	17	18	67	24	69	56	**31**	12	17	19	74	31	20	31	66	71
	2007	m	m	34	m	21	m	m	m	10	m	m	40	61	11	4	15	m	5	9	m	67	18	67	38	**24**	10	14	9	55	17	4	18	37	47

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903783

Figure 3.2. 8th grade students memorising rules, procedures and facts in science

Change in and share of students whose teachers ask them to memorise rules, procedures and facts in at least half the lessons, 2007-2015, teachers report



% of students		New Zealand*	Chile*	Israel	Hungary	Massachusetts (USA)*	South Africa*	Lithuania	United States	Ontario (CAN)	England (UK)	Slovenia	Japan	Minnesota (USA)*	**OECD average**	Sweden	Turkey	Norway	Australia	Russian Federation	Korea	Indonesia*	Hong Kong, China	Singapore	Quebec (CAN)	Italy
	2015	23	46	31	69	m	64	78	31	27	31	75	75	m	**47**	32	37	23	36	74	75	m	60	54	62	58
	2011	32	49	33	76	29	59	80	38	27	36	67	84	36	**54**	45	77	31	36	76	74	67	59	52	59	78
	2007	m	m	31	64	24	m	71	24	20	22	64	62	23	**32**	16	21	6	18	55	56	45	34	24	31	16

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903802

7. Using scientific formulas and laws to solve routine problems

Why it matters

In science, applying formulas and laws in the right way and for the appropriate problems is part of the technical knowledge students have to learn. Memorising the rules would mean nothing if they cannot apply them in simple problems. This practice is important for understanding the concepts learnt and should typically be considered as one tool among others in teachers' "directed teaching" repertoire.

Change at the OECD level: moderate

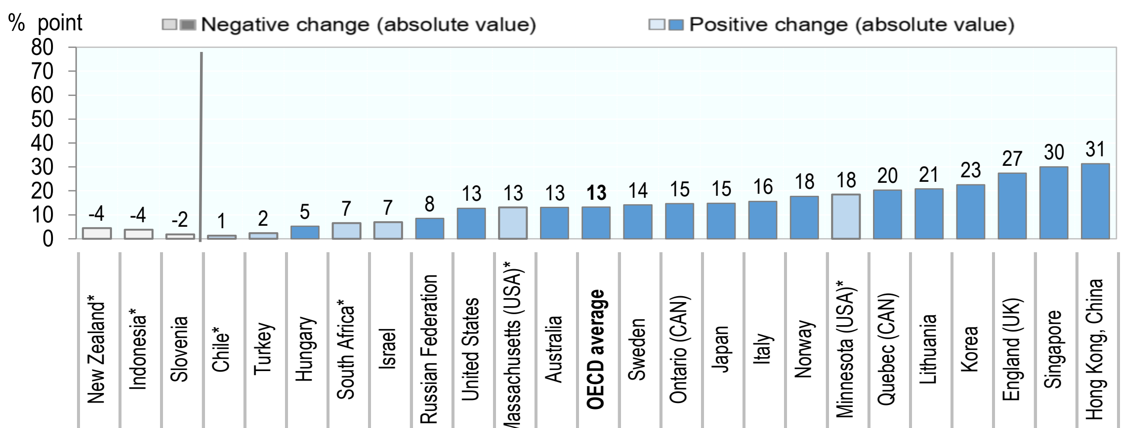
In secondary education, this pedagogical practice spread in almost all OECD countries covered. Between 2007 and 2015, the percentage of students frequently asked to apply scientific formulas to routine problems rose by 13 percentage points on average. Only in New Zealand and Slovenia was there a small contraction. The mean change, be it positive or negative, reached 14 percentage points on average, corresponding to a moderate effect size of 0.31. The use of this pedagogical exercise widely varied across OECD education systems in 2015. For instance, this practice is very common in Korea, but rather unusual in Sweden.

Countries where there has been the most change

This practice has been an area of strong innovation in Hong Kong, China, Singapore and England with increases above 25 percentage points. Only three countries in the sample recorded negative changes, all of them below 5 percentage points.

Figure 3.3. 8th grade science students using formulas and laws to solve routine problems

Change in and share of students whose teachers ask them to use scientific formulas and laws to solve routine problems in at least half the lessons, 2007-2015, teachers report



% of students		New Zealand*	Indonesia*	Slovenia	Chile*	Turkey	Hungary	South Africa*	Israel	Russian Federation	United States	Massachusetts (USA)*	Australia	**OECD average**	Sweden	Ontario (CAN)	Japan	Italy	Norway	Minnesota (USA)*	Quebec (CAN)	Lithuania	Korea	England (UK)	Singapore	Hong Kong, China
	2015	28	m	46	54	64	57	70	40	68	48	m	26	**46**	20	36	61	55	24	m	41	71	84	48	62	50
	2011	33	65	36	53	63	54	63	38	63	51	32	28	**44**	26	33	66	55	19	36	39	66	77	35	59	44
	2007	m	69	48	m	62	52	m	33	59	36	19	13	**33**	6	21	46	39	6	18	21	50	61	20	32	18

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

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8. Processing and analysing data on computers in science

Why it matters

Analysing scientific data on computers allows students to acquire both computer and scientific skills. While they have other tools at their disposal, most scientists now use computers to identify patterns in their observations or see if they fit a theory. While the use of computer could only involve computations, with pedagogical imagination much more could now easily be done to allow students to reason like scientists.

Change at the OECD level: moderate

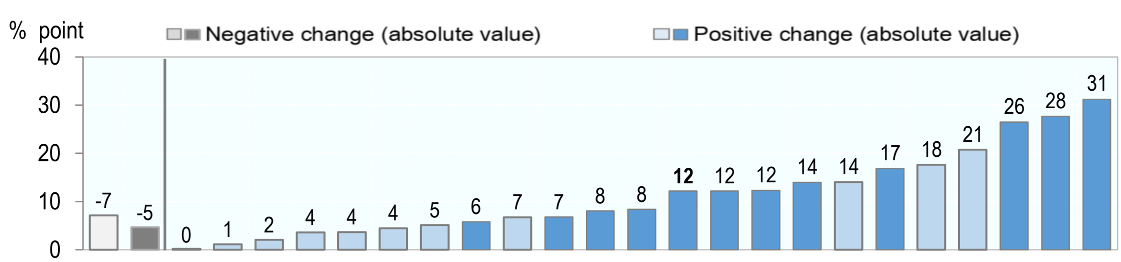
The share of students systematically using computers to process and analyse data during 8th grade science lessons increased by 12 percentage points on average in OECD education systems between 2015 and 2007. The overall absolute change, regardless of change direction, amounted to 12 percentage points as well, corresponding to a moderate effect size of 0.34. This practice remains uncommon, with large disparities observed across systems: 7% of students were exposed to it in Lithuania against 44 in Turkey.

Countries where there has been the most change

Australia experienced the most innovation in this domain: the share of students exposed to the practice gained ground by 31 percentage points between 2007 and 2015. Similarly, Israel and the United States saw increases above 25 percentage points.

Figure 3.4. 8th grade science students processing and analysing data on computers

Change in and share of students who frequently process and analyse data on computers during science lessons, 2007-2015, teachers report



% of students		Chile*	Lithuania	South Africa*	Korea	Norway	Japan	Hong Kong, China	Italy	Minnesota (USA)*	Slovenia	Turkey	Singapore	New Zealand*	England (UK)	**OECD average**	Sweden	Hungary	Ontario (CAN)	Quebec (CAN)	Russian Federation	Massachusetts (USA)*	Indonesia*	United States	Israel	Australia
	2015	25	7	22	21	7	5	19	12	m	13	44	12	16	12	**23**	15	20	22	25	24	m	m	39	39	40
	2011	32	12	22	27	4	3	15	10	11	6	46	6	8	12	**14**	9	16	10	6	12	20	30	20	15	18
	2007	m	12	m	20	5	1	15	8	6	8	37	6	m	3	**10**	3	8	8	11	7	3	9	12	11	9

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903916

9. Practising skills and procedures on computers in science

Why it matters

Practice makes perfect. In science, the use of computers can allow students to repeat and apply the scientific knowledge they have learnt in class to multiple problems and contexts. The use of computers is compelling for such "drilling" activities, which is part of the understanding process. And it also develops computer skills.

Primary education

Change at the OECD level: large

At the OECD level, much greater use of computers for practising skills and procedures in 4th grade science lessons was observed. Between 2007 and 2015, the proportion of students regularly involved in this activity has increased by 15 percentage points on average. 15 percentage points stands also for the overall absolute change in the use this practice during this period, corresponding to a large effect size of 0.44. This computer-based practice is not very widespread among OECD systems. Only in Turkey and Italy were more than 50% of 4th grade students frequently learning this way during their science lessons in 2015.

Countries where there has been the most change

Change has taken the form of expansion in most of the education systems. This is particularly true for Italy (48 percentage points), the Netherlands (37 percentage points) and the Russian Federation (37 percentage points). Significant contraction happened observed in Portugal with a decline in this pedagogical practice by 28 percentage points (between 2011 and 215). A significant innovation in all these cases.

Secondary education

Change at the OECD level: large

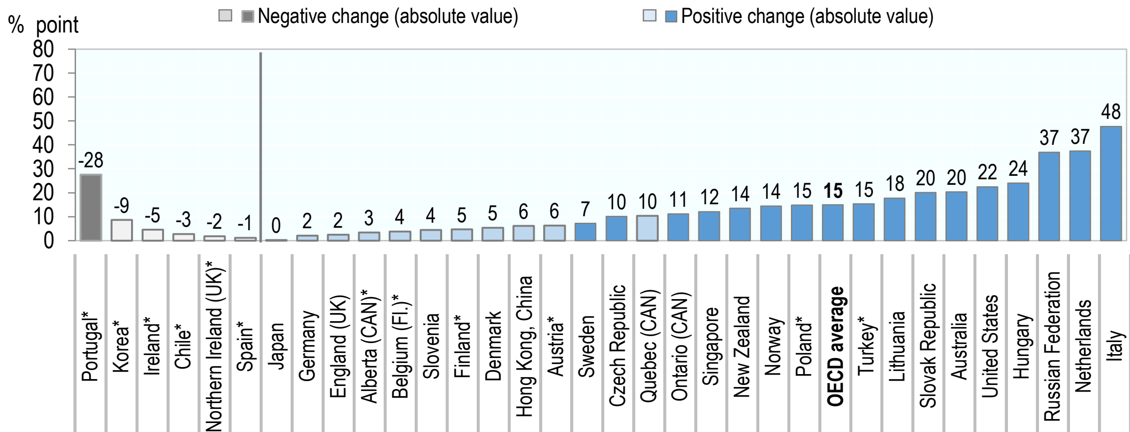
The share of students frequently using computers for practising skills and procedures in 8th grade science lessons through has increased by 17 percentage points on average between 2007 and 2015. The absolute change taking into account increases and decreases was the same, corresponding to a large effect size of 0.48. Like in primary education, the use of this learning practice remains low. Only in Turkey were more than 50% of the students using it in 2015.

Countries where there has been the most change

Innovation has been large and corresponded to an expansion of this practice. Students in Quebec (Canada), Australia, Israel and the United States have experienced the most innovation in this domain, with expansions above 30 percentage points in each case.

Figure 3.5. 4th grade science students practising skills and procedures on computers

Change in and share of students who frequently practise skills and procedures on computers during science lessons, 2007-2015, teachers report



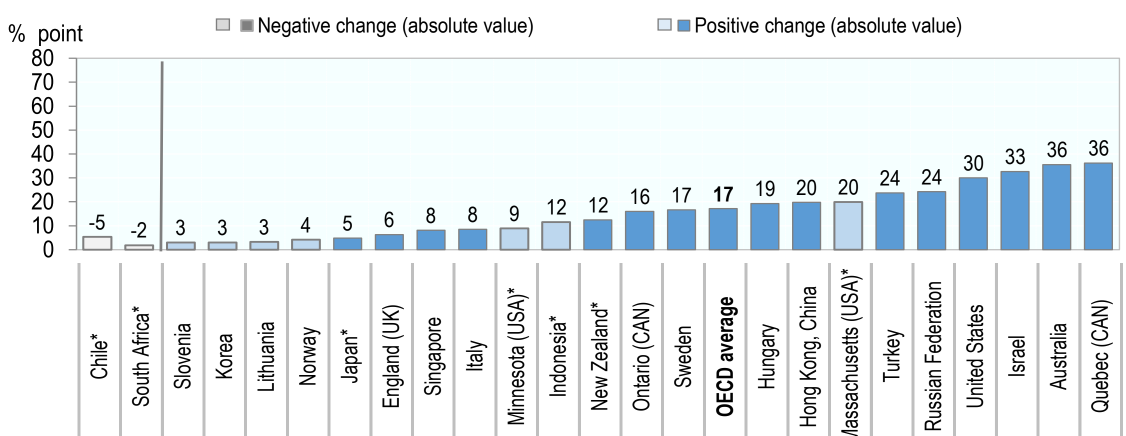
		Portugal*	Korea*	Ireland*	Chile*	Northern Ireland (UK)*	Spain*	Japan	Germany	England (UK)	Alberta (CAN)*	Belgium (Fl.)*	Slovenia	Finland*	Denmark	Hong Kong, China	Austria*	Sweden	Czech Republic	Quebec (CAN)	Ontario (CAN)	Singapore	New Zealand	Norway	Poland*	**OECD average**	Turkey*	Lithuania	Slovak Republic	Australia	United States	Hungary	Russian Federation	Netherlands	Italy
% of students	2015	24	27	5	24	13	30	1	5	13	m	18	11	15	17	20	m	10	16	18	23	34	19	15	28	**22**	88	25	32	28	32	32	46	38	58
	2011	51	36	9	27	15	31	2	7	9	13	14	7	11	9	28	10	9	23	18	8	34	14	9	14	**14**	73	32	24	18	23	17	41	9	32
	2007	m	m	m	m	m	m	0	3	10	10	m	7	m	12	14	4	3	5	8	12	22	6	1	m	**7**	m	7	11	8	10	8	9	0	10

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903840

Figure 3.6. 8th grade science students practising skills and procedures on computers

Change in and share of students who frequently practise skills and procedures on computers during science lessons, 2007-2015, teachers report



		Chile*	South Africa*	Slovenia	Korea	Lithuania	Norway	Japan*	England (UK)	Singapore	Italy	Minnesota (USA)*	Indonesia*	New Zealand*	Ontario (CAN)	Sweden	**OECD average**	Hungary	Hong Kong, China	Massachusetts (USA)*	Turkey	Russian Federation	United States	Israel	Australia	Quebec (CAN)
% of students	2015	16	28	7	19	15	9	5	10	14	16	m	m	22	23	18	**26**	25	30	m	58	34	44	48	43	41
	2011	21	30	6	30	20	7	4	6	9	9	13	27	10	10	9	**16**	21	21	31	50	25	19	29	21	9
	2007	m	m	5	16	12	5	m	3	6	8	4	16	m	7	1	**9**	6	10	11	34	9	14	15	8	5

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903859

10. Studying natural phenomena through computer simulations

Why it matters

Computer simulations allow students to work on phenomena that they could not necessarily study in their classroom or school lab, for example because they are dangerous for their health (radioactivity) or not available in their immediate environment. They can also be a good substitute for expensive observation material. Remote and virtual labs and relevant pedagogical resources are not widely available.

Primary education

Change at the OECD level: moderate

This practice expanded in most OECD systems. The share of students regularly using computer simulations increased by 8 percentage points on average between 2007 and 2015. The absolute change amounted to almost 9 percentage points, including positive and negative variations, corresponding to a moderate effect size of 0.32. Using computer simulations at the primary level remains uncommon. This activity is especially rare in Germany and Ireland where less than 4% students carried out simulations on a regular basis in 2015. In contrast, it is quite common in Turkey (52% of students do it weekly).

Countries where there has been the most change

The use of computer simulations to study natural phenomena has increased simultaneously in several countries. Italy stands out with a large increase of 30 percentage points. Increase has also been notable in the United States (over 15 percentage points). By contrast, Ireland and Chile saw a decreased use of this science education practice (8 percentage point contraction between 2011 and 2015).

Secondary education

Change at the OECD level: large

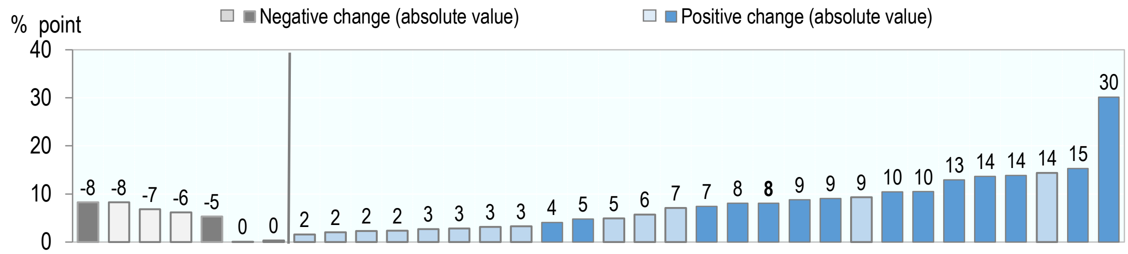
With the exception of Korea, all OECD systems made greater use of computer simulations to study natural phenomena in science lessons. The share of students frequently participating in this pedagogical activity rose by 12 percentage points on average between 2007 and 2015. Positive and negative variations resulted in a mean absolute change of 13 percentage points, that is, a large effect size of 0.43. The share of students regularly participating in these simulations remained low within OECD countries in 2015, but with relatively large differences between them, ranging from 7% of students in Norway to 48% in Turkey.

Countries where there has been the most change

Secondary schools innovated mainly by adopting this teaching practice. Notably Israel, Indonesia and the United States experienced expansions above 25 percentage points (the change being between 2007 and 2011 for Indonesia). Korea experienced the only observed contraction of the practice, which contracted by 9 percentage points.

Figure 3.7. 4th grade science students studying natural phenomena by computer simulations

Change in and share of students who frequently study natural phenomena through computer simulations during science lessons, 2007-2015, teachers report



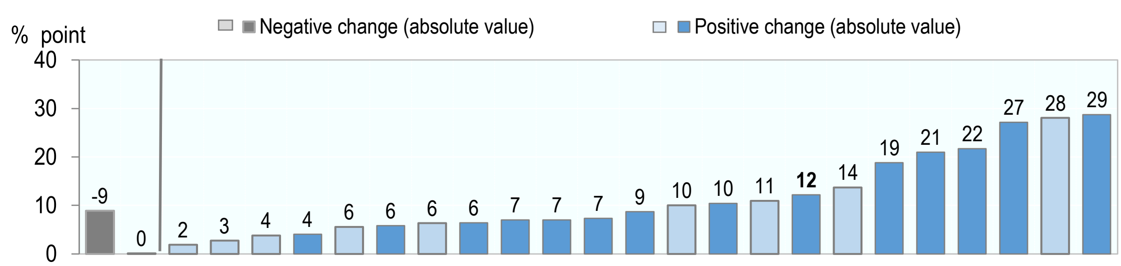
% of students	Ireland*	Chile*	Korea*	Spain*	Japan	Austria*	Portugal*	Northern Ireland (UK)*	Turkey*	England (UK)	Germany	Hong Kong, China	Norway	Finland*	Belgium (Fl.)*	Netherlands	Denmark	Slovenia	Russian Federation	Quebec (CAN)	Lithuania*	Sweden	**OECD average**	Hungary	Czech Republic	Ontario (CAN)	Australia	New Zealand	Slovak Republic	Poland*	Singapore	Alberta (CAN)*	United States	Italy
2015	4	12	35	10	4	m	25	15	52	15	4	13	6	6	5	4	8	7	17	14	7	9	**13**	10	10	23	15	17	15	21	23	m	21	43
2011	12	21	42	16	1	2	25	13	50	9	1	21	6	3	2	2	6	6	16	7	6	2	**8**	3	3	7	19	16	6	8	21	19	16	27
2007	m	m	m	m	10	2	m	m	m	12	2	10	3	m	m	0	3	3	11	7	m	1	**5**	1	1	14	4	7	2	m	9	5	6	13

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903878

Figure 3.8. 8th grade science students studying natural phenomena by computer simulations

Change in and share of students who frequently study natural phenomena through computer simulations during science lessons, 2007-2015, teachers report



% of students	Korea	Minnesota (USA)*	South Africa*	Chile*	New Zealand*	Lithuania	Japan	England (UK)	Ontario (CAN)	Norway	Sweden	Italy	Singapore	Russian Federation	Hong Kong, China	Slovenia	Massachusetts (USA)*	**OECD average**	Turkey	Hungary	Australia	Quebec (CAN)	United States	Indonesia*	Israel
2015	19	m	21	21	16	8	9	11	12	7	7	13	12	14	24	13	m	**20**	48	22	24	26	34	m	35
2011	27	5	19	18	13	6	4	11	11	5	4	7	7	9	13	5	18	**15**	60	16	14	7	18	32	16
2007	28	5	m	m	m	4	3	5	6	0	0	6	5	5	14	3	7	**8**	34	3	3	4	7	4	6

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903897

11. Watching teachers demonstrate experiments

Why it matters

Watching teachers demonstrate an experiment or investigation should happen in a good science classroom. Imitation is an important way to learn, that should precede or balance (rather than substitute for) students trying by themselves to carry out an even design experiments – a more active way of learning.

Primary education

Change at the OECD level: large

The share of primary students watching their teachers demonstrating a experiment in at least half of their science lessons increased by 21 percentage points on average between 2007 and 2015. This increase represents a significant innovation, amounting to a large effect size of 0.54. The extent to which students are systematically exposed to this practice ranged from 7% in Belgium (Fl.) to 78% in Turkey in 2015.

Countries where there has been the most change

The direction of change is rather consistent with almost all education systems registering greater use of this teaching practice. Quebec (Canada) stands out with a large increase of about 38 percentage points, followed closely by Hungary and England recording around 35 percentage point increases. Poland also registered an increase of similar magnitude between 2011 and 2015 (instead of 2007-2015).

Secondary education

Change at the OECD level: moderate

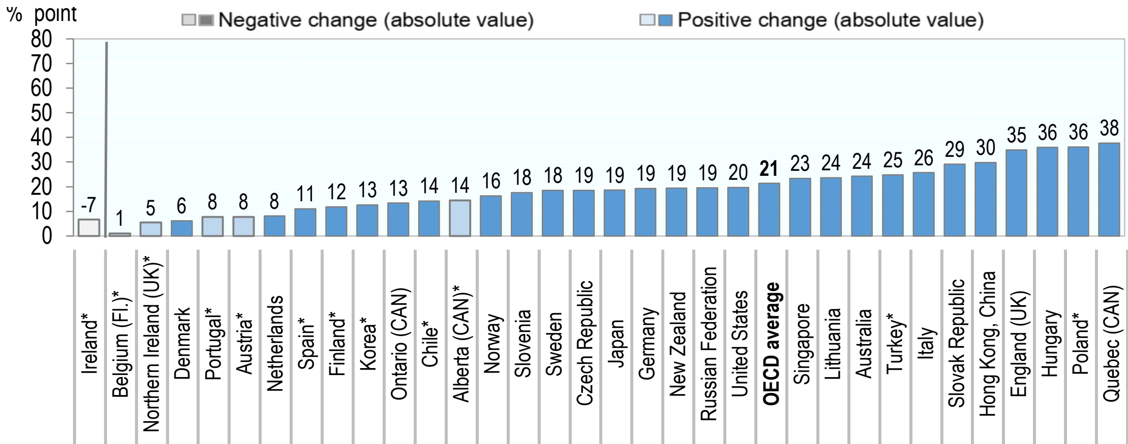
This teaching practice is increasingly being used in secondary schools within OECD countries or systems. The average share of students regularly exposed to it has risen by 15 percentage points between 2007 and 2015. The magnitude of the change, including expansions and contractions, amounted to 16 percentage points and corresponded to a moderate effect size of 0.34. This teaching method is evenly used across countries, with medium and relatively large shares of students exposed to it.

Countries where there has been the most change

Innovation mainly took the form of a spread of this teaching practice, particularly in Hong Kong, China, Israel, Singapore and Australia where it gained ground by over 25 percentage points. Contractions never exceeded 10 percentage points, showing more stability in that direction.

Figure 3.9. 4th grade science students watching their teachers demonstrate an experiment

Change in and share of students who watch their teachers demonstrate an experiment or investigation in at least half the lessons, 2007-2015, teachers report



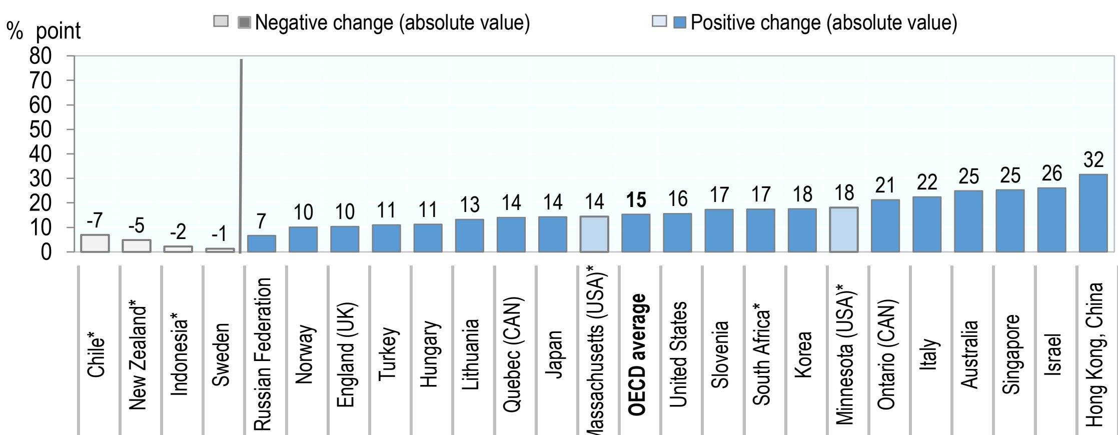
% of students	Ireland*	Belgium (Fl.)*	Northern Ireland (UK)*	Denmark	Portugal*	Austria*	Netherlands	Spain*	Finland*	Korea*	Ontario (CAN)	Chile*	Alberta (CAN)*	Norway	Slovenia	Sweden	Czech Republic	Japan	Germany	New Zealand	Russian Federation	United States	**OECD average**	Singapore	Lithuania	Australia	Turkey*	Italy	Slovak Republic	Hong Kong, China	England (UK)	Hungary	Poland*	Quebec (CAN)
2015	49	7	14	14	37	m	12	23	25	56	32	51	m	18	39	24	27	54	22	25	40	36	**35**	59	33	35	78	48	57	36	45	44	49	53
2011	56	6	9	15	30	10	10	12	13	43	34	37	33	7	33	21	14	51	13	20	27	37	**27**	56	23	33	53	36	31	17	26	28	13	45
2007	m	m	m	8	m	3	4	m	m	m	19	m	18	2	21	6	9	36	3	5	20	16	**13**	36	9	10	m	23	28	6	10	8	m	16

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903935

Figure 3.10. 8th grade science students watching their teachers demonstrate an experiment

Change in and share of students who watch their teachers demonstrate an experiment or investigation in at least half the lessons, 2007-2015, teachers report



% of students	Chile*	New Zealand*	Indonesia*	Sweden	Russian Federation	Norway	England (UK)	Turkey	Hungary	Lithuania	Quebec (CAN)	Japan	Massachusetts (USA)*	**OECD average**	United States	Slovenia	South Africa*	Korea	Minnesota (USA)*	Ontario (CAN)	Italy	Australia	Singapore	Israel	Hong Kong, China
2015	39	26	m	18	49	20	46	65	53	36	36	41	m	**43**	39	56	56	48	m	40	30	39	42	69	51
2011	46	31	44	34	57	16	52	64	50	30	40	47	33	**41**	43	43	39	42	32	27	19	34	36	61	49
2007	m	m	46	19	42	10	36	54	42	23	22	27	19	**28**	23	39	m	30	14	18	8	14	16	43	19

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903954

12. Students conducting experiments and investigations

Why it matters

Conducting experiments and investigations gives students an entry point into the work life of scientists, and a better understanding of its empirical dimension. Depending on whether the conducted experiments and investigations have been designed by the students themselves, or are just an application of learnt science concepts, they can have more or less value to students' learning. But conducting experiments and investigations in science is a valuable learning strategy.

Primary education

Change at the OECD level: moderate

With the exception of Chile, all OECD systems registered an increase in the share of students conducting experiments and investigations in at least half of their science lessons, from an average of 33% in 2007 to 46% in 2015. The average absolute change was of a similar magnitude, i.e. 13 percentage points, corresponding to a modest effect size of 0.3. Large cross-country disparities in the use of this pedagogical technique are observed, from only 11% of 4th grade students being regularly exposed to this pedagogy in the Netherlands in 2015, to 96% in Japan.

Countries where there has been the most change

Innovation took the form of the spread of this science learning method. Australia and Singapore saw increases of 31 and 28 percentage points respectively, closely followed by Poland and Norway (24 percentage points). No covered country registered a significant contraction of the practice between 2007 and 2015.

Secondary education

Change at the OECD level: moderate-low

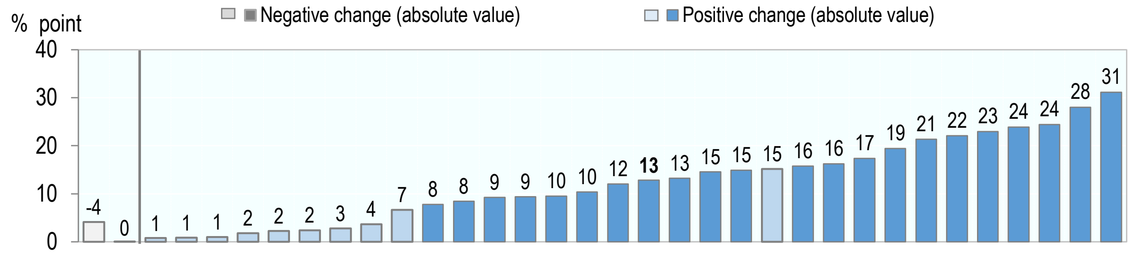
Expansions have outweighed contractions of the practice in the OECD area, leading on average to a 5 percentage point increase in the share of students participating in these activities in half of their science classes or more. When increases and decreases are accounted for, innovation in this learning practice amounted to 11 percentage points between 2007 and 2015, corresponding to a moderate-low effect size of 0.24. Concerning about 45% of students on average in 2015, disparities marked OECD countries: from 17% of students in Lithuania through to almost 72% in Japan conducted experiments.

Countries where there has been the most change

Although the majority of countries saw an increase in this practice between 2007 and 2015, the direction of innovation was not fully consistent. Sweden and Quebec (Canada) saw considerable declines in the use of this pedagogy, of above 15 percentage points between 2007 and 2015. On the contrary, South Africa registered a large increase of 27 percentage points between 2011 and 2015, followed by Italy and Ontario (Canada) with respective increases of 19 and 18 percentage points during the 2007-2015 period.

Figure 3.11. 4th grade students conducting experiments and investigations in science

Change in and share of students whose teachers ask them to conduct experiments or investigations in at least half the lessons, 2007-2015, teachers report



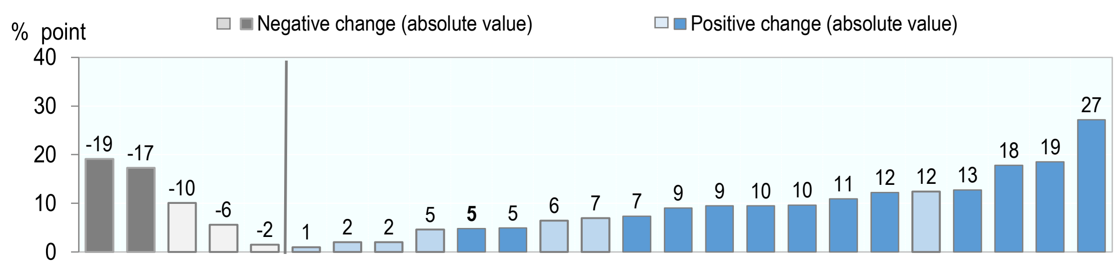
% of students	Chile*	Netherlands	Denmark	Slovenia	Austria*	Finland*	Portugal*	Ontario (CAN)	Northern Ireland (UK)*	Turkey*	Korea*	United States	Belgium (Fl.)*	Hungary	Japan	Ireland*	Italy	Quebec (CAN)	**OECD average**	Russian Federation	Spain*	Czech Republic	Alberta (CAN)*	England (UK)	Slovak Republic	Lithuania	Germany	New Zealand	Sweden	Hong Kong, China	Norway	Poland*	Singapore	Australia
2015	35	11	50	40	m	13	28	50	25	55	87	53	16	15	96	64	42	57	**46**	27	21	22	m	74	44	22	34	53	44	29	29	27	77	60
2011	39	7	53	36	7	11	26	46	23	51	80	48	7	9	91	55	44	57	**39**	16	7	18	68	69	23	16	23	39	44	20	6	2	71	51
2007	m	11	50	39	6	m	m	48	m	m	m	45	m	6	86	m	31	45	**33**	13	m	7	53	58	28	4	15	31	22	6	5	m	49	29

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903973

Figure 3.12. 8th grade students conducting experiments and investigations in science

Change in and share of students whose teachers ask them to conduct experiments or investigations in at least half the lessons, 2007-2015, teachers report



% of students	Sweden	Quebec (CAN)	Indonesia*	Korea	Chile*	Massachusetts (USA)*	Singapore	Turkey	Australia	**OECD average**	Hungary	Japan	Hong Kong, China	Russian Federation	New Zealand*	England (UK)	United States	Lithuania	Slovenia	Norway	Minnesota (USA)*	Israel	Ontario (CAN)	Italy	South Africa*
2015	37	38	m	31	36	m	37	52	70	**45**	17	72	78	25	70	67	57	17	24	40	m	40	56	27	54
2011	58	50	20	32	38	48	38	38	68	**43**	11	74	73	23	61	71	60	15	17	30	64	35	43	16	27
2007	57	56	30	36	m	47	35	50	66	**40**	12	66	71	17	m	58	48	7	13	28	52	27	38	9	m

Note: Darker tones correspond to statistically significant values.
* refers to calculations based on other years, based on data availability.
The OECD average is based on OECD countries with available data in 2007, 2011 and 2015.
Source: Authors' calculations based on TIMSS Databases.

StatLink https://doi.org/10.1787/888933903992

13. Students doing practical experiments in laboratories

Why it matters

Science lessons sometimes take place in laboratories equipped for practical experiments. Doing practical experiments in laboratories is a critical activity of scientific reasoning and practice, which should ideally be balanced with experiments in real-life settings. Computers now also allow students and teachers to use remote or virtual labs, another way to expand the topics addressed by this widespread teaching practice.

Change at the OECD level: small

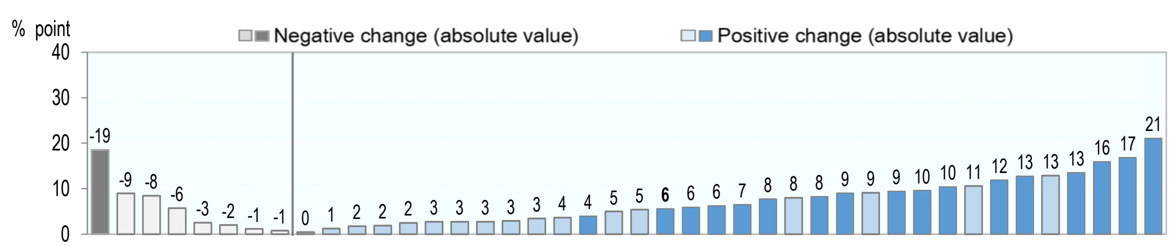
Doing practical experiments in laboratories became a more widespread practice in most OECD systems, with a 6-percentage point expansion on average between 2006 and 2015. Innovation has been modest in this area, with positive and negative changes amounting to 7 percentage points in the change of students' exposure to this activity, representing a small effect size of 0.14. Doing practical experiments in all or most of the lessons is relatively common among the OECD countries covered: on average, 69% of students do it, with levels ranging from 44% in Korea to almost 84% in Portugal in 2015.

Countries where there has been the most change

In most countries these practical laboratory experiments expanded. Korea stands out with an increase of 21 percentage points, followed by the Slovak Republic (17 percentage points) and Hong Kong, China (16 percentage points). On the contrary, Israel and to a less extend Indonesia and Colombia registered declines of 19, 9 and 8 percentage points respectively.

Figure 3.13. 15 year old science students doing practical experiments in laboratories

Change in and share of students doing practical experiments in the laboratory in all or most of the their lessons, 2006-2015, students report



% of students		Israel	Colombia	Indonesia	Brazil	Belgium	Mexico	Italy	Chile	United States	Turkey	Slovenia	United Kingdom	Estonia	Australia	Spain	Latvia	New Zealand	Czech Republic	Russian Federation	Canada
	2015	60	70	60	44	65	76	75	71	74	75	72	74	70	74	71	68	74	73	68	77
	2006	79	79	68	50	68	78	76	71	74	74	71	72	68	71	69	65	71	70	65	73

% of students		Hungary	Netherlands	**OECD average**	Norway	Switzerland	Lithuania	Finland	France	Austria	Sweden	Poland	Greece	Portugal	Iceland	Germany	Ireland	Denmark	Japan	Luxembourg	Hong Kong, China	Slovak Republic	Korea
	2015	62	53	**69**	67	72	73	72	74	62	72	59	69	84	72	70	63	67	47	73	57	68	44
	2006	57	48	**63**	61	65	67	64	66	54	63	50	59	74	62	59	51	54	34	59	42	51	23

Note: Darker tones correspond to statistically significant values.
Source: Authors' calculations based on PISA Databases.

StatLink https://doi.org/10.1787/888933904011

Table 3.1. Effect sizes for changes in practices to develop technical skills in science

	Memorising rules, procedures and facts as a pedagogical technique		Watching teachers demonstrate an experiment		Students conducting scientific experiments and investigations		Using scientific formulas & laws to solve routine problems	Students doing practical experiments in laboratories
	4th Grade	8th Grade	4th Grade	8th Grade	4th Grade	8th Grade	8th Grade	8th grade
Australia	0.07	0.41	0.60	0.58	0.64	0.10	0.33	0.06
Austria	0.10	m	0.32	m	0.04	m	m	0.17
Belgium	m	m	m	m	m	m	m	-0.05
Belgium (Fl.)	-0.10	m	0.04	m	0.27	m	m	m
Canada	m	m	m	m	m	m	m	0.09
Canada (Alberta)	-0.03	m	0.34	m	0.31	m	m	m
Canada (Ontario)	0.09	0.18	0.31	0.48	0.05	0.36	0.33	m
Canada (Quebec)	0.44	0.64	0.83	0.31	0.24	-0.35	0.44	m
Chile	-0.10	-0.06	0.29	-0.14	-0.09	-0.03	0.02	-0.02
Czech Republic	0.38	m	0.50	m	0.43	m	m	0.08
Denmark	0.15	m	0.19	m	0.02	m	m	0.26
Estonia	m	m	m	m	m	m	m	0.05
Finland	0.00	m	0.30	m	0.06	m	m	0.17
France	m	m	m	m	m	m	m	0.17
Germany	-0.13	m	0.64	m	0.46	m	m	0.22
Greece	m	m	m	m	m	m	m	0.20
Hungary	0.14	0.10	0.87	0.23	0.31	0.14	0.11	0.10
Iceland	m	m	m	m	m	m	m	0.22
Ireland	0.14	m	-0.13	m	0.19	m	m	0.24
Israel	m	0.00	m	0.53	m	0.27	0.14	-0.41
Italy	0.15	0.91	0.55	0.59	0.22	0.50	0.31	-0.03
Japan	0.28	0.28	0.38	0.30	0.34	0.14	0.30	0.26
Korea	-0.16	0.40	0.25	0.36	0.18	-0.12	0.51	0.45
Latvia	m	m	m	m	m	m	m	0.06
Lithuania	0.61	0.16	0.60	0.29	0.55	0.30	0.43	0.14
Luxembourg	m	m	m	m	m	m	m	0.29
Mexico	m	m	m	m	m	m	m	-0.05
Netherlands	0.16	m	0.31	m	0.00	m	m	0.11
New Zealand	0.13	-0.20	0.57	-0.11	0.44	0.19	-0.09	0.06
Norway	0.56	0.52	0.61	0.29	0.68	0.26	0.52	0.12
Poland	-0.28	m	0.82	m	0.78	m	m	0.18
Portugal	0.07	m	0.16	m	0.05	m	m	0.24
Slovak Republic	0.38	m	0.60	m	0.34	m	m	0.34

	Memorising rules, procedures and facts as a pedagogical technique		Watching teachers demonstrate an experiment		Students conducting scientific experiments and investigations		Using scientific formulas & laws to solve routine problems	Students doing practical experiments in laboratories
	4th Grade	8th Grade	4th Grade	8th Grade	4th Grade	8th Grade	8th Grade	8th Grade
Slovenia	0.51	0.25	0.39	0.35	0.02	0.28	-0.04	0.04
Spain	-0.08	m	0.29	m	0.43	m	m	0.06
Sweden	0.31	0.38	0.54	-0.03	0.47	-0.39	0.44	0.19
Switzerland	m	m	m	m	m	m	m	0.13
Turkey	-0.66	0.36	0.53	0.22	0.07	0.04	0.05	0.03
United Kingdom	m	m	m	m	m	m	m	0.04
UK (England)	0.27	0.22	0.82	0.21	0.33	0.20	0.59	m
UK (Northern Ireland)	-0.03	m	0.17	m	0.07	m	m	m
United States	-0.21	0.16	0.46	0.34	0.16	0.19	0.26	0.01
US (Massachusetts)	m	0.12	m	0.33	m	0.02	0.30	m
US (Minnesota)	m	0.29	m	0.44	m	0.25	0.42	m
OECD (average)	**0.19**	**0.31**	**0.51**	**0.32**	**0.26**	**0.10**	**0.27**	**0.12**
OECD (av. absolute)	**0.26**	**0.34**	**0.54**	**0.34**	**0.30**	**0.24**	**0.31**	**0.15**
Brazil	m	m	m	m	m	m	m	-0.11
Colombia	m	m	m	m	m	m	m	-0.21
Hong Kong, China	0.16	0.53	0.79	0.68	0.64	0.16	0.68	0.32
Indonesia	m	0.45	m	-0.04	m	-0.23	-0.08	-0.18
Russian Federation	0.02	0.39	0.43	0.13	0.33	0.18	0.18	0.08
Singapore	0.01	0.64	0.47	0.57	0.59	0.04	0.61	m
South Africa	m	0.12	m	0.35	m	0.56	0.14	m

Effect size from -0.5 to -0.2 and from 0.2 and 0.5
Effect size from -0.8 to -0.5 and from 0.5 and 0.8
Effect size equals or less than -0.8 and equals or greater than 0.8

Source: Authors' calculations based on TIMSS (2007, 2011 and 2015) and PISA (2006, 2009 and 2015).

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Table 3.2. Effect sizes for changes in ICT-based practices to develop technical skills in science

	Practising skills and procedures on computers		Study natural phenomena through simulations on computers		Processing and analysing data on computers
	4th Grade	8th Grade	4th Grade	8th Grade	8th Grade
Australia	0.55	0.87	0.37	0.68	0.76
Austria	0.25	m	0.00	m	m
Belgium	m	m	m	m	m
Belgium (Fl.)	0.10	m	0.18	m	m
Canada	m	m	m	m	m
Canada (Alberta)	0.10	m	0.46	m	m
Canada (Ontario)	0.30	0.46	0.24	0.23	0.40
Canada (Quebec)	0.31	0.94	0.23	0.66	0.37
Chile	-0.06	-0.14	-0.22	0.07	-0.16
Czech Republic	0.34	m	0.43	m	m
Denmark	0.15	m	0.21	m	m
Estonia	m	m	m	m	m
Finland	0.14	m	0.16	m	m
France	m	m	m	m	m
Germany	0.10	m	0.15	m	m
Greece	m	m	m	m	m
Hungary	0.63	0.56	0.43	0.62	0.37
Iceland	m	m	m	m	m
Ireland	-0.18	m	-0.32	m	m
Israel	m	0.73	m	0.77	0.66
Italy	1.08	0.26	0.70	0.24	0.15
Japan	0.04	0.44	-0.21	0.24	0.24
Korea	-0.19	0.08	-0.14	-0.21	0.03
Latvia	m	m	m	m	m
Lithuania	0.51	0.10	0.55	0.17	-0.16
Mexico	m	m	m	m	m
Netherlands	1.20	m	0.30	m	m
New Zealand	0.42	0.35	0.33	0.11	0.25
Norway	0.60	0.17	0.14	0.40	0.09
Poland	0.37	m	0.40	m	m
Portugal	-0.58	m	0.01	m	m
Slovak Republic	0.50	m	0.49	m	m
Slovenia	0.15	0.13	0.23	0.41	0.19

	Practising skills and procedures on computers		Study natural phenomena through simulations on computers		Processing and analysing data on computers
	4th Grade	8th Grade	4th Grade	8th Grade	8th Grade
Spain	-0.03	m	-0.19	m	m
Sweden	0.31	0.65	0.41	0.44	0.46
Switzerland	m	m	m	m	m
Turkey	0.39	0.48	0.04	0.28	0.14
United Kingdom	m	m	m	m	m
UK (England)	0.08	0.27	0.07	0.21	0.33
UK (Northern Ireland)	-0.05	m	0.04	m	m
United States	0.57	0.69	0.47	0.71	0.63
US (Massachusetts)	m	0.50	m	0.34	0.60
US (Minnesota)	m	0.34	m	0.00	0.19
OECD (average)	**0.44**	**0.46**	**0.29**	**0.36**	**0.33**
OECD (av. absolute)	**0.44**	**0.48**	**0.32**	**0.43**	**0.34**
Hong Kong, China	0.16	0.51	0.08	0.26	0.10
Indonesia	m	0.28	m	0.80	0.54
Russian Federation	0.88	0.62	0.17	0.31	0.49
Singapore	0.27	0.27	0.38	0.27	0.24
South Africa	m	-0.04	m	0.05	0.01

Effect size from -0.5 to -0.2 and from 0.2 and 0.5
Effect size from -0.8 to -0.5 and from 0.5 and 0.8
Effect size equals or less than -0.8 and equals or greater than 0.8

Source: Authors' calculations based on TIMSS (2007, 2011 and 2015) and PISA (2006, 2009 and 2015).

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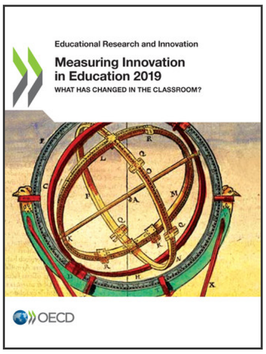

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