PISA mathematics performance by decile of social background

Source: PISA 2012
Exposure to deep math learning and social background

Index of exposure to pure mathematics

- Bottom quarter (disadvantaged students) • Second quarter ★ Third quarter ▲ Top quarter (advantaged students)

Source: Figure 2.5b
QUESTION 1: HOW MUCH SHOULD I DIRECT STUDENT LEARNING IN MY MATHEMATICS CLASSES?
What knowledge, skills and character qualities do successful teachers require?

96% of teachers: My role as a teacher is to facilitate students own inquiry
What knowledge, skills, and character qualities do successful teachers require?

86%: Students learn best by finding solutions on their own.
What knowledge, skills, and character qualities do successful teachers require?

74%: Thinking and reasoning is more important than curriculum content.
Prevalence of **memorisation**
rehearsal, routine exercises, drill and practice and/or repetition

- United Kingdom
- Netherlands
- Spain
- Norway
- United States
- Singapore
- Canada
- Shanghai-China
- Sweden
- France
- Korea
- Japan
- Germany
- Poland
- Switzerland

Prevalence of **elaboration**
reasoning, deep learning, intrinsic motivation, critical thinking, creativity, non-routine problems

- High
- Low
Teacher-directed strategies are used more often ...

OECD average of students who responded “in every lesson” or “in most lessons”

- At the beginning of a lesson, the teacher presents a short summary of the previous lesson
- The teacher asks me or my classmates to present our thinking or reasoning at some length
- The teacher sets clear goals for our learning
- The teacher asks questions to check whether we have understood what was taught
- The teacher tells us what we have to learn

Source: Figure 1.1
The teacher gives different work to classmates who have difficulties and/or who can advance faster.

The teacher assigns projects that require at least one week to complete.

The teacher asks us to help plan classroom activities or topics.

The teacher has us work in small groups to come up with joint solutions to a problem or task.

The teacher gives different work to classmates who have difficulties and/or who can advance faster.

OECD average of students who responded “in every lesson” or “in most lessons”

Source: Figure 1.1
Teaching and learning strategies in mathematics around the world

Memorisation most frequently used compared to elaboration strategies

Teacher-directed instruction most frequently used compared to student-oriented instruction

Are East Asian education systems really so traditional?

Source: Figure 1.2
Teacher-directed strategies are related with higher solution rates \((OECD\ average)\).

Source: Figure 1.4
Teaching strategies and learning outcomes

Students below Level 2 have difficulties using basic algorithms, formulae, procedures or convention.

Students at Level 5 and 6 can develop and work with models for complex situations, and work strategically with advanced reasoning skills.

Mean Index

-Index of student-oriented instruction
-Index of teacher-directed instruction
-Index of cognitive-activation instruction

Students' proficiency level in PISA mathematics
What can teachers do?

- Plan mathematics lessons that strive to reach all levels of learners in a class
- Provide a mix of teacher-directed and student-oriented teaching strategies
- Let the difficulty of the mathematics problem guide the teaching strategy
QUESTION 2: WHAT DO WE KNOW ABOUT MEMORISATION AND LEARNING MATHEMATICS?
Students’ use of memorisation strategies

- Below the OECD average
- At the same level as the OECD average
- Above the OECD average

More

Less

% of students who report they learn by heart

Source: Figure 4.1
The index of memorisation, with values ranging from 0 to 4, reflects the number of times a student chose the following memorisation-related statements about how they learn mathematics.

1. When I study for a mathematics test, I learn as much as I can by heart.
2. When I study mathematics, I make myself check to see if I remember the work I have already done.
3. When I study mathematics, I go over some problems so often that I feel as if I could solve them in my sleep.
4. In order to remember the method for solving a mathematics problem, I go through examples again and again.

Source: Figure 4.1
Memorisation is less useful as problems become more difficult *(OECD average)*

Greater success  Odds ratio

Easy problem

R² = 0.81

Memorisation is associated with a lower chance of success as problems become more difficult

Less success

Difficult problem

Source: Figure 4.3
‘Weaker’ students tend to use memorisation more (OECD average)

Correlation with the index of memorisation

- Higher self-efficacy in mathematics
- More openness to problem solving
- Higher score in mathematics
- More interested in mathematics
- Better self-concept in mathematics
- More instrumental motivation for learning mathematics
- More perseverance
- Greater mathematics anxiety

Source: Figure 4.2
What can teachers do?

- Encourage students to complement memorisation with other learning strategies
- Use memorisation strategies to build familiarity and confidence
- Notice how your students learn
QUESTION 3: CAN I HELP MY STUDENTS LEARN HOW TO LEARN MATHEMATICS?
There are large international differences in the use of control strategies.
There are large international differences in the use of **control strategies**

The *index of control strategies*, with values ranging from 0 to 4, reflects the number of times a student chose the following *control-related statements* about how they learn mathematics.

1. When I study for a mathematics test, I try to work out what the most important parts to learn are.
2. When I study mathematics, I try to figure out which concepts I still have not understood properly.
3. When I study mathematics, I start by working out exactly what I need to learn.
4. When I cannot understand something in mathematics, I always search for more information to clarify the problem.

Source: Figure 5.1
Control strategies are always helpful but less so as problems become more difficult (OECD average).

\[ R^2 = 0.31 \]

Source: Figure 5.2
What can teachers do?

- Make sure that your own teaching doesn’t prevent students from adopting control strategies.
- Familiarise yourself with the specific activities to use of “control strategies”.
- Encourage students to reflect on how they learn.
QUESTION 4: SHOULD I ENCOURAGE MY STUDENTS TO USE THEIR CREATIVITY IN MATHEMATICS?
Students’ use of elaboration strategies

- Below the OECD average
- At the same level as the OECD average
- Above the OECD average

% of students who understand new concepts by relating them to things they already know

Source: Figure 6.1
The index of elaboration strategies, with values ranging from 0 to 4, reflects the number of times a student chose the following elaboration-related statements about how they learn mathematics.

1. When I study for a mathematics test, I try to understand new concepts by relating them to things I already know.
2. When I study mathematics, I think of new ways to get the answer.
3. When I study mathematics, I try to relate the work to things I have learned in other subjects.
4. I think about how the mathematics I have learned can be used in everyday life.
Elaboration strategies are more useful as problems become more difficult (OECD average)

Using elaboration strategies is associated with a greater chance of success as problems become more difficult.

Source: Figure 6.2
Combining elaboration and control strategies leads to success on difficult items

Elaboration strategies

Control strategies

Combining memorisation and elaboration strategies

Combining memorisation and control strategies

Combining elaboration and control strategies

- Students using these strategies are less likely to answer items correctly than students using mainly memorisation.

- Students using these strategies are more likely to answer items correctly than students using mainly memorisation.

Students who combine elaboration and control strategies are about twice as successful on difficult items as students who mainly use memorisation strategies.

Source: Figure 6.3
What can teachers do?

- Emphasise the use of elaboration strategies on challenging tasks
- Challenge all of your students, without raising mathematics anxiety
- Develop versatile learners
- Create assessments that challenge students to prepare them for deeper learning
QUESTION 5: ARE SOME MATHEMATICS TEACHING METHODS MORE EFFECTIVE THAN OTHERS?
Students perform better when teachers use cognitive-activation instruction more often.
Students are exposed to a variety of cognitive-activation strategies

OECD average of students who responded “in every lesson” or “in most lessons”

- The teacher asks us to decide on our own procedures for solving complex problems
- The teacher presents problems for which there is no immediately obvious method of solution
- The teacher gives problems that require us to think for an extended time
- The teacher presents problems in different contexts so that we know whether we have understood the concepts
- The teacher asks questions that make us reflect on the problem
- The teacher gives problems that can be solved in several different ways
- The teacher helps us to learn from mistakes we have made
- The teacher presents problems that require us to apply what we have learned to new contexts
- The teacher asks us to explain how we have solved a problem

Source: Figure 2.1
Cognitive-activation strategies are related to performance, particularly for advantaged students.

The teacher...

- helps students learn from mistakes
- gives problems that require thinking for an extended time
- lets students decide on their own procedures
- makes students reflect on the problem
- gives problems that can be solved in different ways
- presents problems in different contexts
- asks students to explain how they solved a problem
- gives problems with no immediate solution
- asks students to apply what they have learned to new contexts

Score-point difference

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Source: OECD, PISA 2012 Database
What can teachers do?

Find ways to use cognitive-activation strategies in all of your classes

Look at what the research says about how students best learn mathematics

Collaborate with other teachers
QUESTION 6: AS A MATHEMATICS TEACHER, HOW IMPORTANT IS THE RELATIONSHIP I HAVE WITH MY STUDENTS?
Better teacher-students relations are associated with greater students’ sense of belonging to school

Change in the index of sense of belonging that is associated with a one-unit increase in the index of teacher-student relations

- After accounting for differences in mathematics performance

Source: Table III.5.19; OECD, PISA 2012 Database
A better **disciplinary climate** is associated with **greater mathematics familiarity**

Source: Figure 3.1
Teachers report **higher job satisfaction** when fewer students have behavioural problems.

![Graph showing teacher job satisfaction vs. percentage of students with behavioural problems]

- **More satisfied**
- **Less satisfied**

*Having fewer students with behavioural problems is associated with greater job satisfaction among teachers.*

Source: Figure 3.2; OECD, Talis 2013 Database
What can teachers do?

Focus time and energy on creating a positive classroom climate

Invest time in building strong relationships with your students
QUESTION 7: DO STUDENTS’ BACKGROUNDS INFLUENCE HOW THEY LEARN MATHEMATICS?
Disadvantaged students have less exposure to both applied math....

Source: Figure 7.1a
... and deep mathematics

More exposure

Less exposure

Bottom quarter (disadvantaged students)

Top quarter (advantaged students)

Source: Figure 7.1a
Disadvantaged students more likely to have negative view of their own capabilities in mathematics

Disadvantaged students ▼ Advantaged students ▲

Source: Figure 7.3
What can teachers do?

- Review the curriculum you are covering for the year
- Don’t shy away from challenging mathematics topics
- Make your students aware of the importance of mathematics for their future careers, particularly students from disadvantaged backgrounds
QUESTION 8: SHOULD I BE CONCERNED ABOUT MY STUDENTS’ ATTITUDES TOWARDS MATHEMATICS?
Girls are more anxious about mathematics than boys

Source: Figure 9.1
More exposure to pure mathematics problems in tests than in lessons is associated with **greater** anxiety.

Students who are *more exposed* to pure mathematics in tests than in lessons are *more anxious* than students who are similarly exposed in tests and in lessons.

Source: Figure 9.2
Students frequently exposed to applied mathematics have better opinions about their own capabilities.

Source: Figure 9.3
What can teachers do?

In addition to what you teach, think about whom you teach and how you teach

Prepare students for what to expect on math tests

Explore innovative teaching tools for mathematics
QUESTION 9:
SHOULD MY TEACHING EMPHASISE CONCEPTS OR HOW THOSE CONCEPTS ARE APPLIED?
Weak relationship between exposure to applied and pure mathematics

Source: Figure 8.1
Frequent exposure to pure mathematics concepts is associated with better mathematics performance.

Score-point difference

Exposure to applied mathematics
Exposure to pure mathematics

Source: Figure 8.2
What can teachers do?

Cover core mathematics ideas in sufficient depth and show how they are related

Don’t just cover the fundamentals of the curriculum

Provide students with a variety of applied problems to solve
WHAT HAS PISA TAUGHT US?
What has PISA taught us?

Develop balanced assessments

How:

- Make sure your teaching and assessments are balanced
- Use multiple types of assessments, including oral tests, collaborative problem-solving and long-term projects
- Take advantage of questions from PISA that have been made public by the OECD or from PISA for Schools exams to serve this purpose
Focus on students’ abilities and skills

How:

- “What is important for citizens to know and be able to do in situations that involve mathematics?” This kind of thinking could help you decide which topics to present to your students – and how to present them.

- Reading some assessment questions released by PISA might give you additional ideas for your class.
What has PISA taught us?

A policy programme in 5 points

Develop balanced assessments

Focus on students’ abilities and skills

Collaborate with others

Innovate, innovate, innovate

Be fair

How:
- Teach and assess students in ways that are fair and inclusive for everyone
What has PISA taught us?

**Develop balanced assessments**

**Focus on students’ abilities and skills**

**A policy programme in 5 points**

**Innovate, innovate, innovate**

**Collaborate with others**

*How:*

- Listen to your students
- Collaborate with other teachers
- Participate in school decision-making
- Communicate with parents and learn from experts in your field
What has PISA taught us?

A policy programme in 5 points

- **Innovate, innovate, innovate**
- **Develop balanced assessments**
- **Focus on students’ abilities and skills**
- **Collaborate with others**
- **Be fair**

**How:**

- New approaches to teaching are tried and tested all the time, with varying degrees of success
- Read up on strategies that have been successful for other teachers
- Participate in innovation networks
- Once you’re more confident with the risks and rewards associated: you’ll be the one developing new strategies and resources for your colleagues to try

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**What has PISA taught us?**

A policy programme in 5 points

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**What has PISA taught us?**

A policy programme in 5 points

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- **Develop balanced assessments**
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Thank you

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and remember:

Without data, you are just another person with an opinion