



Winds of change in math education

**Prof. Zbigniew Marciniak
Faculty of Mathematics, Informatics and Mechanics, University of Warsaw**

Winds of change...



Winds of change...



He must be really smart!



Winds of change...

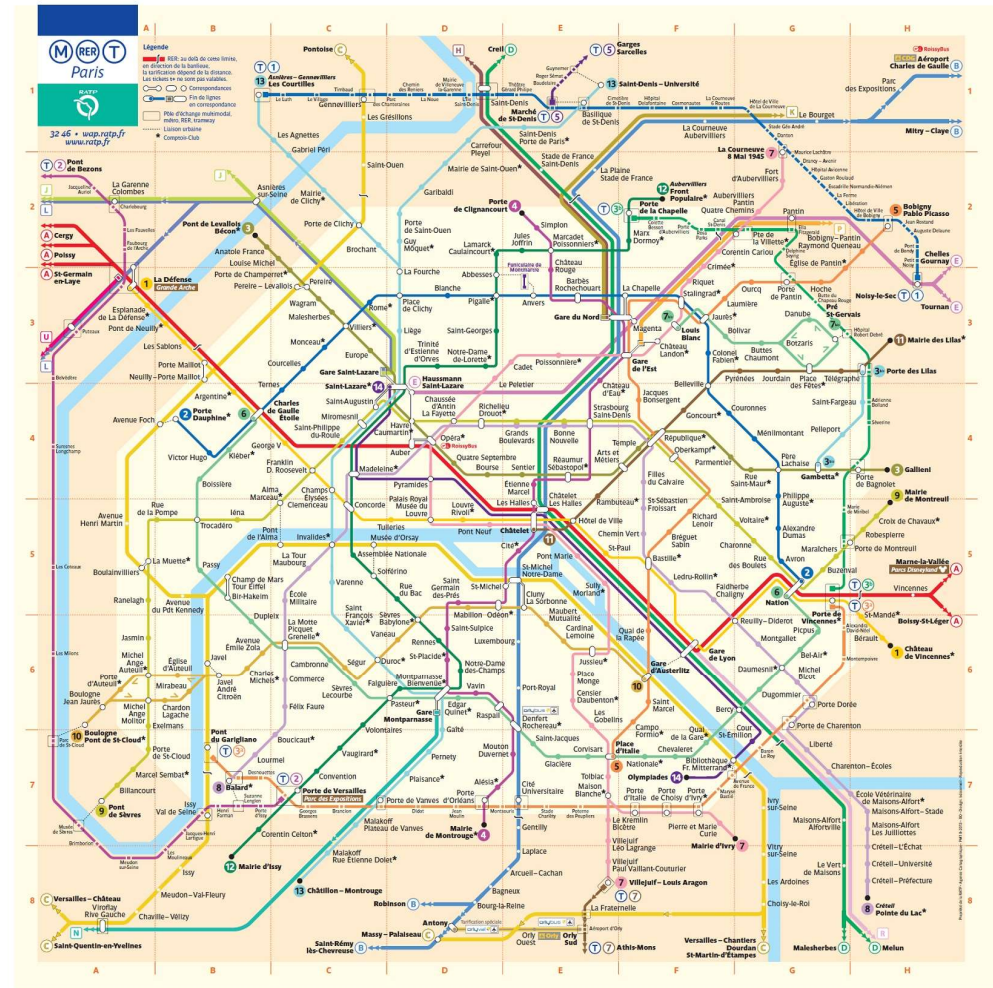
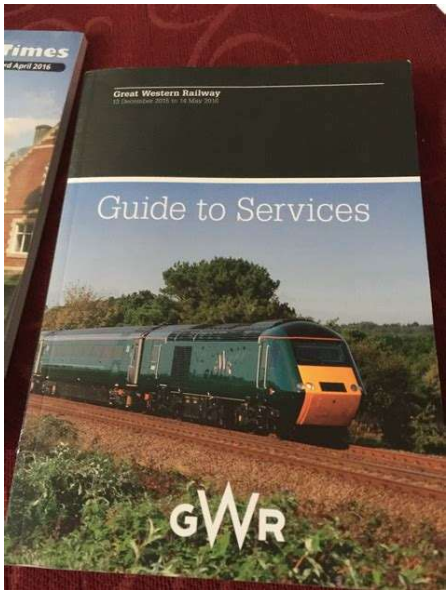
Surveyor at Stanford U.

Me: "How do you use ArcSecant?"

Him: "I don't – it's computerized"



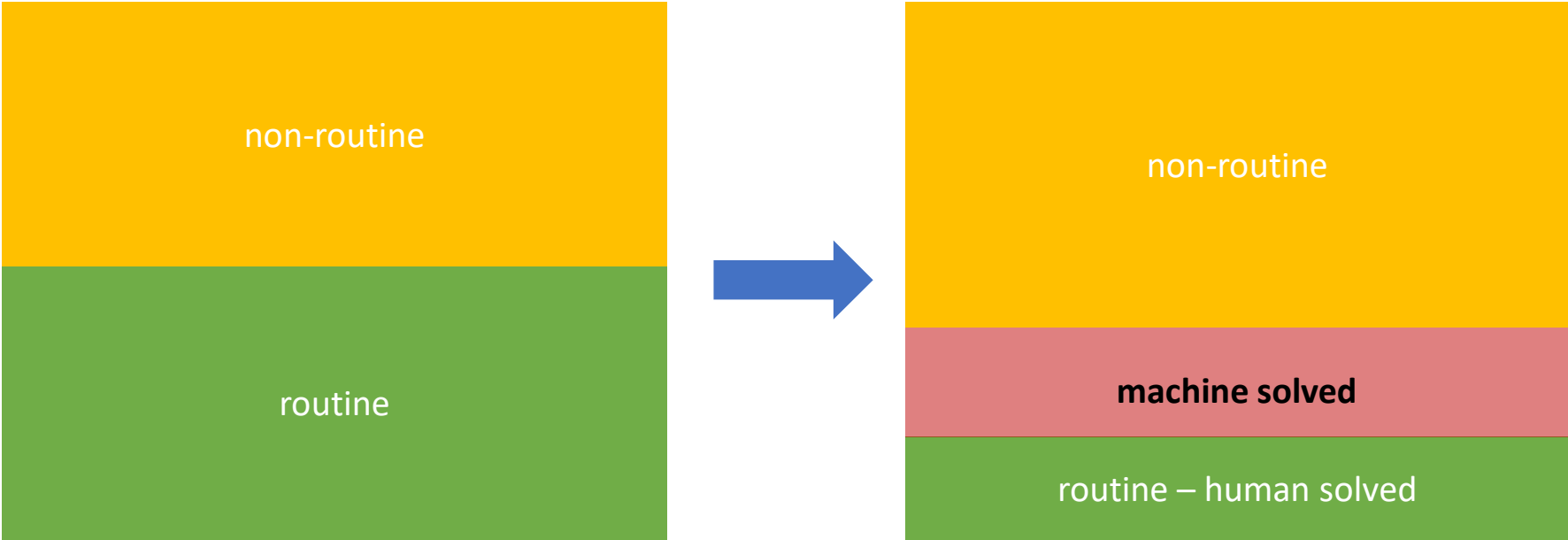
Winds of change...



Winds of change...



Winds of change...



Winds of change...

The New York Times

Trump's Lies

Many Americans have become accustomed to President Trump's lies. But as regular as they have become, the country should not allow itself to become numb to them. So we have catalogued nearly every outright lie he has told publicly since taking the oath of office. Updated: The president is still lying, so we've added to this list, taking it through Nov. 11, and provided links to the facts in each case.

JAN. 21 "I wasn't a fan of Iraq. I didn't want to go into Iraq." (He was for an invasion before he was against it.) JAN. 21 "A reporter for Time magazine — and I have been on their cover 14 or 15 times. I think we have the all-time record in the history of Time magazine." (Trump was on the cover 11 times and Nixon appeared 55 times.) JAN. 23 "Between 3 million and 5 million illegal votes caused me to lose the popular vote." (There's no evidence of illegal voting.) JAN. 25 "Now, the audience was the biggest ever. But this crowd was massive. Look how far back it goes. This crowd was massive." (Official aerial photos show Obama's 2009 inauguration was much more heavily attended.) JAN. 25 "Take a look at the Pew reports (which show voter fraud)." (The report never mentioned voter fraud.) JAN. 25 "You had millions of people that now aren't insured anymore." (The real number is less than 1 million, according to the Urban Institute.) JAN. 25 "So, look, when President Obama was there two weeks ago making a speech, very nice speech. Two people were shot and killed during his speech. You can't have that." (There were no gun homicide victims in Chicago

Winds of change...

The New York Times

The Age of Post-Truth Politics

By WILLIAM DAVIES AUG. 24, 2016

NO BREXIT
PLEASE,
WE'RE
BRITISH



People demonstrated in London against Brexit in July. Andrew Testa for The New York Times

Lies

President Trump's lies. The country should not allow the catalogued nearly every the oath of office. Updated: to this list, taking it through in each case.

(before he was against it.) JAN. 21 "A reporter for Time magazine — and I have of Time magazine." *(Trump was on the cover 11 times and Nixon appeared 55 e popular vote.)* *(There's no evidence of illegal voting.)* JAN. 25 "Now, the audience owd was massive." *(Official aerial photos show Obama's 2009 inauguration was much oter fraud.)* *(The report never mentioned voter fraud.)* JAN. 25 "You had millions of *according to the Urban Institute.*" JAN. 25 "So, look, when President Obama was there lled during his speech. You can't have that." *(There were no gun homicide victims in Chicago*

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The Age of Post-Truth Politics

By WILLIAM DAVIES AUG. 24, 2016

The New York Times

What is fake news? How to spot it and what you can do to stop it

'Fake news' has rapidly become a catch-all term to discredit all kinds of stories. We need to be smarter at recognising and combating outright fabrication

NO BREXIT PLEASE, WE'RE BRITISH



People demonstrated in London against Brexit in July. Andrew Testa for The New York Times

facebook



Fake news reports soar on social media, where links are given the same weighting regardless of source, and... on Facebook, where there is a potential audience of 1.89bn. Photograph: Niall Carson/PA

Conclusions for education

Prepare students to be ready to deal also with **non-routine tasks**

Prepare students to recognize and deal with **lies**

How to achieve that?

Motivation issue



Why do we have to learn mathematics?!

Practice patiently – you will see why later!



Practice patiently – you will see why this makes sense later!



Motivation issue



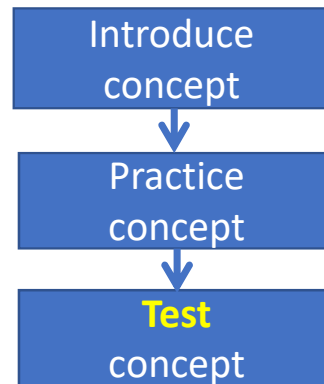
- *Mr. Jones, will I ever use this algebra?*
- *You won't, but some smarter kids might!*

Motivation issue

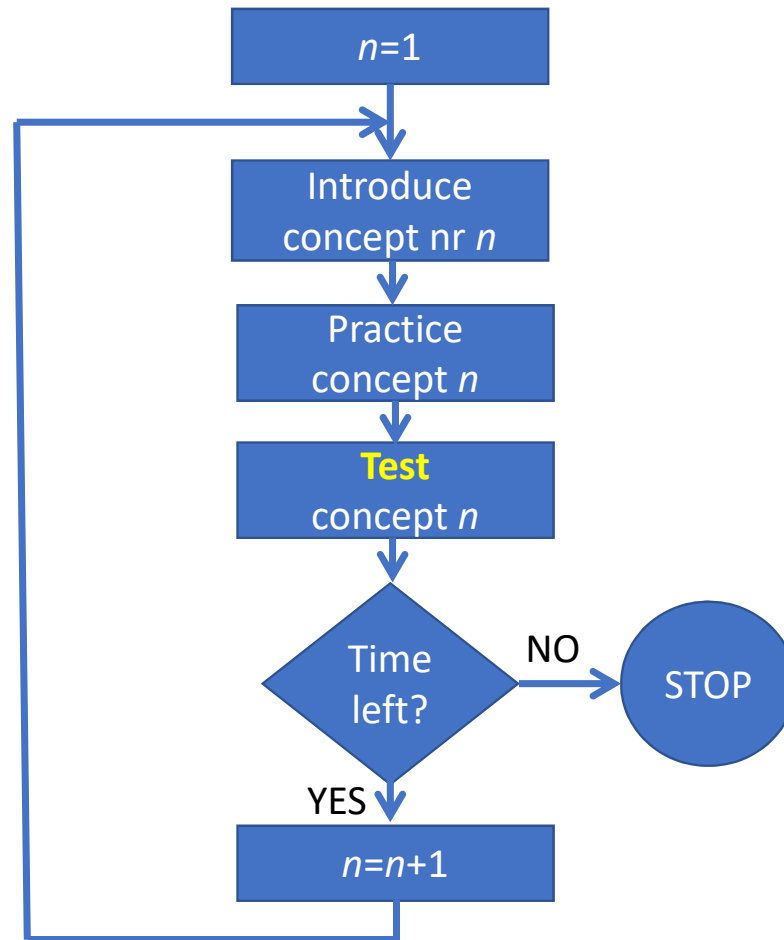


Why do I have to learn percentages?
... fractions?
... logarithms?
... ?

Concept oriented teaching



Concept oriented teaching



Motivation issue



Why do I have to learn percentages?
... fractions?
... logarithms?
... ?

You will need to balance your
check-book, calculate the
interest rate...



Motivation issue



My smartphone can do that for me!



Motivation issue



My smartphone can do that for me!

You will need all that to get a job!
And then to keep it!





*** AGENDA ***

MATHEMATICS FOR THE 21ST CENTURY

Friday May 25, 2018

Hosted by the International School of Geneva,

Route de Chêne 62, Centre des Arts, Genève, Switzerland

8:30 – 9:00	<i>Coffee/tea and light pastries</i>
9:00 – 9:30	<i>Introductions, welcome, setting the stage</i> <ul style="list-style-type: none">• Greetings and introduction: Fondation Helvetica Educatio, International School of Geneva, Jacobs Foundation, Gebert Ruf Foundation, Wright Foundation (10 mins)• Greetings, remarks on importance to OECD countries (10 mins): Andreas Schleicher (OECD).• TBD Swiss Federal representative for Mathematics (5 mins).• Greetings: Urs Lang (Swiss Mathematical Society) (5 mins).
9:30 – 10:00	Presentation: <i>Mathematics for the modern world</i> – Charles Fadel (Center for Curriculum Redesign)
10:00 – 10:45	Presentation: <i>Recommendations for PISA</i> – Michelle Bruniges (Australia; Chair of PISA Governing Board) including 15 minutes for Q&A
Break 15 minutes	<i>Coffee/tea and light pastries</i>
11:00 – 11:45	Presentation: <i>How Poland moved ahead</i> - Zbigniew Marciniak (Warsaw University) including 15 minutes for Q&A
11:45 – 12:45	Presentation: <i>Stop Teaching Calculating, Start Teaching Moths</i> – Conrad Wolfram (Wolfram Research) including 15 minutes for Q&A
Lunch @ 12:45 pm	<i>In cafeteria on-site at EcoInt/ISG</i>
13:45 – 14:45	Presentation: <i>Mathematics and the Brain</i> – Stanislas Dehaene (CNRS) including 15 minutes for Q&A
Break 15 minutes	<i>Coffee/tea</i>
15:00 – 16:00	Presentation: <i>What Mathematics do people really need?</i> Keith Devlin (Stanford University) including 15 minutes for Q&A
16:00 – 17:00	Presentation: <i>Algorithms do change the world!</i> – John MacCormick (Dickinson College) including 15 minutes for Q&A
17:00 – 17:30 then adjourn	Final remarks and Instant Poll: <i>What do we de-emphasize and remove?</i> Charles Fadel (Center for Curriculum Redesign) and wishes for success.



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Relevance is a choice

© Charles Fadel Occupation (below)	Algebra	Applied Maths	Calculus	Discrete Mathematics	Foundations	Geometry	Numbers & Operations	Statistics & Probability	Topology & Recreational
Taxonomy & Ontology: Wolfram Research →	Matrices, Operations, Vectors etc	Complex systems, Control, Game theory, etc	Analysis, Transforms, Polynomials, etc	Automata, Graphs, Computational maths etc	Sets, Logic etc	Curves, Dimensions, Transformations, Trigonometry, etc	Arithmetic operations, Fractions, Sequences, etc	Distributions, Analysis, Estimation, etc	Knots, Figures, Folding, Spaces, etc
Agriculture						X	X	X	
Architecture		X				X	X	X	X
Astronomy/Cosmology	X	X	X	X		X	X	X	X
Biology, Botany, Zoology		X		X			X	X	
Biotechnology, Genetics	X	X	X	X		X	X	X	X
Business		X					X	X	
Cinematography/Photography						X	X		X
Civil engineering	X	X	X	X		X	X	X	X
Communication		X					X	X	
Computer science	X	X	X	X	X	X	X	X	X
Craftsmanship						X	X		X
Dance						X	X		X
Design						X	X		X
Drawing						X	X		X
Economics & Finance	X	X	X	X		X	X	X	
Education	X	X	X			X	X	X	
Electrical engineering	X	X	X	X		X	X	X	
Environmental science	X	X	X	X		X	X	X	
Ethics							X		
Geography/Geology	X	X	X	X		X	X	X	X
Health							X	X	
History/Archeology	X	X		X			X	X	
Journalism	X	X					X	X	
Languages/Linguistics	X	X		X			X	X	
Law		X					X	X	
Materials Science/Nanotechnology	X	X	X	X		X	X	X	X
Mechanical engineering, Robotics	X	X	X	X		X	X	X	X
Medicine/Pharmacy/Veterinary		X					X	X	
Music	X						X	X	
Painting						X	X		
Philosophy		X			X		X	X	
Physics	X	X	X	X	X	X	X	X	X
Poetry/Prose							X		
Psychology/Sociology/Anthropology	X	X		X			X	X	
Sculpture						X	X		X
Sewing/Knitting/Tapestry						X	X		X
Spirituality/Religions							X		
Theater/Acting							X		

Relevance is a choice

© Charles Fadel Occupation (below)									
Taxonomy & Ontology: Wolfram Research → Poetry: lyric, epic, dramatic Prose: novel, short story, science-fiction									
Agriculture						X	X	X	
Architecture		X				X	X	X	X
Astronomy/Cosmology	X	X	X	X		X	X	X	X
Biology, Botany, Zoology		X		X		X	X	X	
Biotechnology, Genetics	X	X	X	X		X	X	X	X
Business		X					X	X	
Cinematography/Photography						X	X		X
Civil engineering	X	X	X	X		X	X	X	X
Communication		X					X	X	
Computer science	X	X	X	X	X	X	X	X	X
Craftsmanship						X	X		X
Dance						X	X		X
Design						X	X		X
Drawing						X	X		X
Economics & Finance	X	X	X	X		X	X	X	
Education	X	X	X			X	X	X	
Electrical engineering	X	X	X	X		X	X	X	
Environmental science	X	X	X	X		X	X	X	
Ethics							X		
Geography/Geology	X	X	X	X		X	X	X	X
Health							X	X	
History/Archeology	X	X		X			X	X	
Journalism	X	X					X	X	
Languages/Linguistics	X	X		X			X	X	
Law		X					X	X	
Materials Science/Nanotechnology	X	X	X	X		X	X	X	X
Mechanical engineering, Robotics	X	X	X	X		X	X	X	X
Medicine/Pharmacy/Veterinary		X					X	X	
Music	X						X	X	
Painting						X	X		
Philosophy		X			X		X	X	
Physics	X	X	X	X	X	X	X	X	X
Poetry/Prose							X		
Psychology/Sociology/Anthropology	X	X		X			X	X	
Sculpture						X	X		X
Sewing/Knitting/Tapestry						X	X		X
Spirituality/Religions							X		
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Relevance is a choice

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Taxonomy & Ontology: Wolfram Research →								
Agriculture					X	X	X	
Architecture		X			X	X	X	X
Astronomy/Cosmology	X	X	X	X	X	X	X	X
Biology, Botany, Zoology		X		X		X	X	
Biotechnology, Genetics	X	X	X	X	X	X	X	X
Business		X				X	X	
C	<i>What literature do people really need?</i>							
C								
C								
C								
C								
D								
Design					X	X		X
Drawing					X	X		X
Economics & Finance	X	X	X	X	X	X	X	
Education	X	X	X	X	X	X	X	
Electrical engineering	X	X	X	X	X	X	X	
Environmental science	X	X	X	X	X	X	X	
Ethics						X		
Geography/Geology	X	X	X	X	X	X	X	X
Health						X	X	
History/Archeology	X	X		X		X	X	
Journalism	X	X				X	X	
Languages/Linguistics	X	X		X		X	X	
Law		X				X	X	
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Mechanical engineering, Robotics	X	X	X	X	X	X	X	X
Medicine/Pharmacy/Veterinary		X				X	X	
Music	X					X	X	
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Philosophy		X				X	X	
Physics	X	X	X	X	X	X	X	X
Poetry/Prose						X		
Psychology/Sociology/Anthropology	X	X		X		X	X	
Sculpture					X	X		X
Sewing/Knitting/Tapestry					X	X		X
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Architecture		X				X	X	X	X
Astronomy/Cosmology	X	X	X	X		X	X	X	X
Biology, Botany, Zoology		X					X	X	
Biotechnology, Genetics	X	X	X	X		X	X	X	X
Business		X					X	X	
C	<i>What literature do people really need?</i>								
C									
C									
C									
D									
Design						X	X		X
Drawing						X	X		X
Economics & Finance	X	X	X	X		X	X	X	
<i>What do we de-emphasize and remove?</i>									
Health							X	X	
History/Archeology	X	X		X			X	X	
Journalism	X	X					X	X	
Languages/Linguistics	X	X		X			X	X	
Law		X					X	X	
Materials Science/Nanotechnology	X	X	X	X		X	X	X	X
Mechanical engineering, Robotics	X	X	X	X		X	X	X	X
Medicine/Pharmacy/Veterinary		X					X	X	
Music	X						X	X	
Painting						X	X		
Philosophy		X			X		X	X	
Physics	X	X	X	X	X	X	X	X	X
Poetry/Prose							X		
Psychology/Sociology/Anthropology	X	X		X			X	X	
Sculpture						X	X		X
Sewing/Knitting/Tapestry						X	X		X
Spirituality/Religions							X		
Theater/Acting							X		

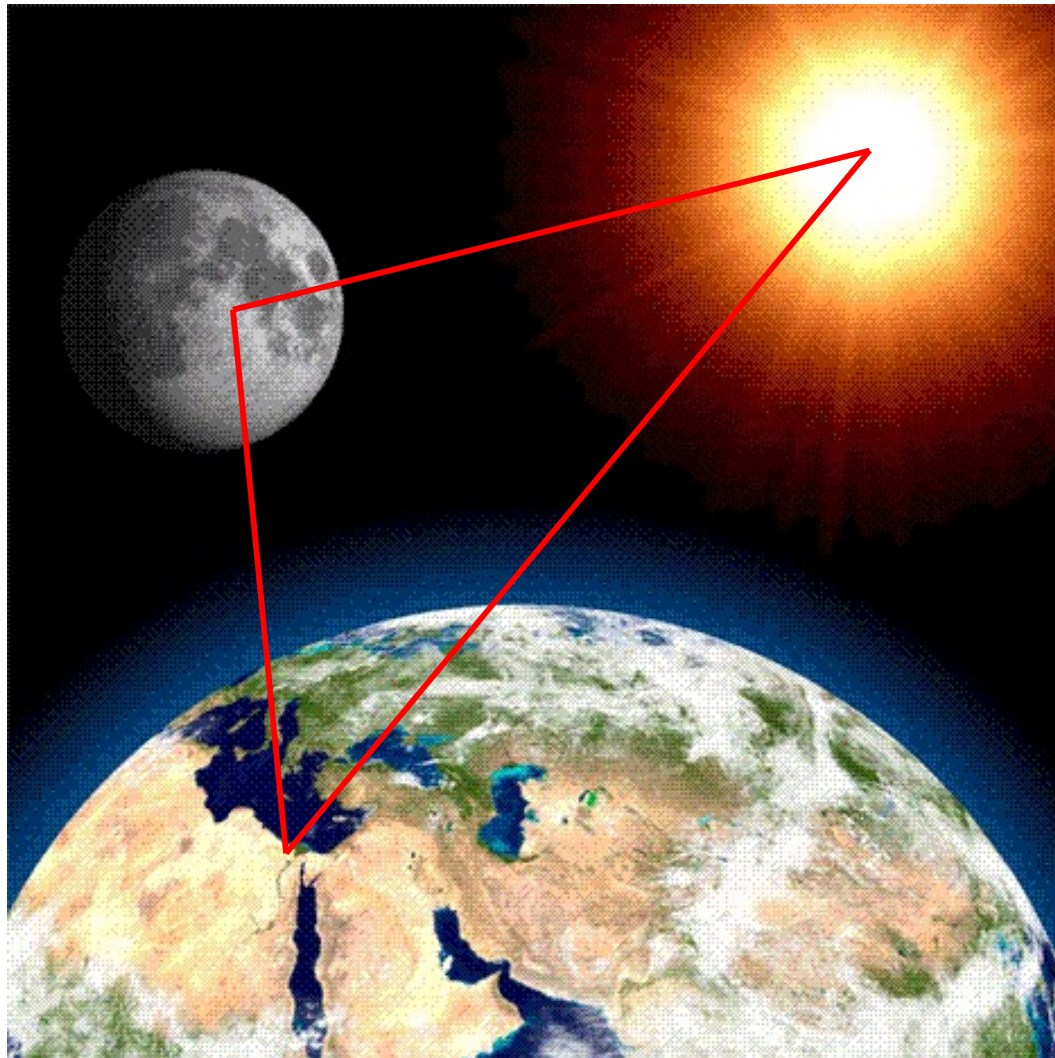
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Agriculture						X	X	X	
Architecture		X				X	X	X	X
Astronomy/Cosmology	X	X	X	X		X	X	X	X
Biology, Botany, Zoology		X		X			X	X	
Biotechnology, Genetics	X	X	X	X		X	X	X	X

Mathematics is, like literature and art, part of our cultural heritage

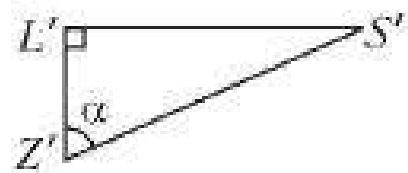
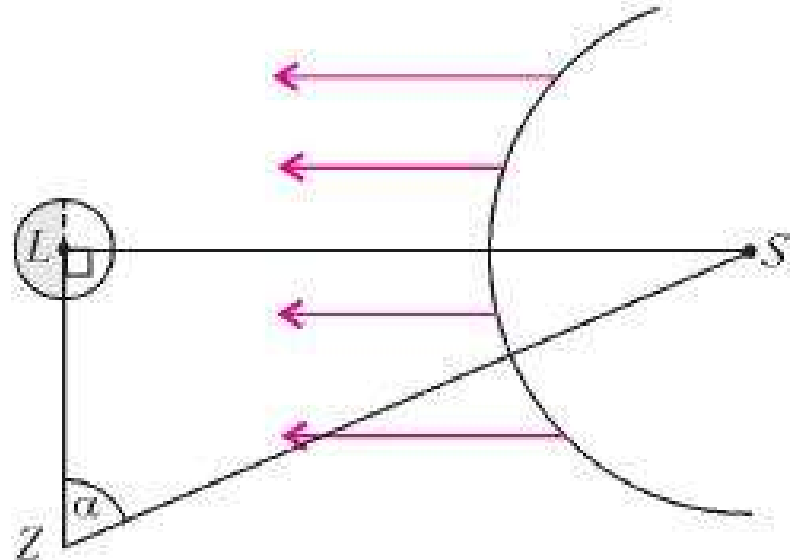
History/Archeology	X	X		X			X	X	
Journalism	X	X					X	X	
Languages/Linguistics	X	X		X			X	X	
Law		X					X	X	
Materials Science/Nanotechnology	X	X	X	X		X	X	X	X
Mechanical engineering, Robotics	X	X	X	X		X	X	X	X
Medicine/Pharmacy/Veterinary		X					X	X	
Music	X						X	X	
Painting						X	X		
Philosophy		X			X		X	X	
Physics	X	X	X	X	X	X	X	X	X
Poetry/Prose							X		
Psychology/Sociology/Anthropology	X	X		X			X	X	
Sculpture						X	X		X
Sewing/Knitting/Tapestry						X	X		X
Spirituality/Religions							X		
Theater/Acting							X		

How much further away from Earth is the Sun than the Moon?



=

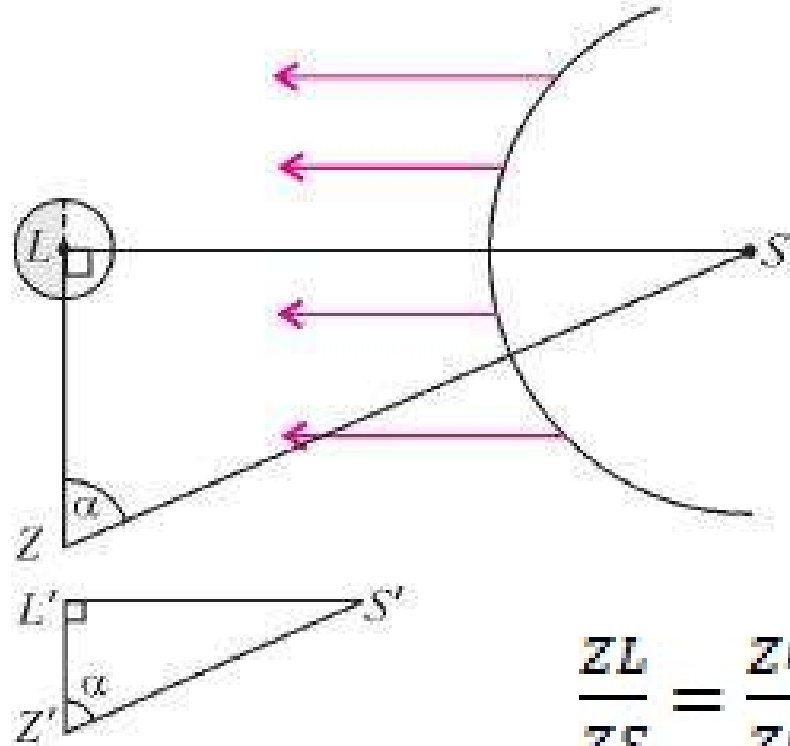
How much further away from Earth is the Sun than the Moon?



$$\frac{ZL}{ZS} = \frac{Z'L'}{Z'S'} = \frac{1}{400} = k$$

=

How much further away from Earth is the Sun than the Moon?

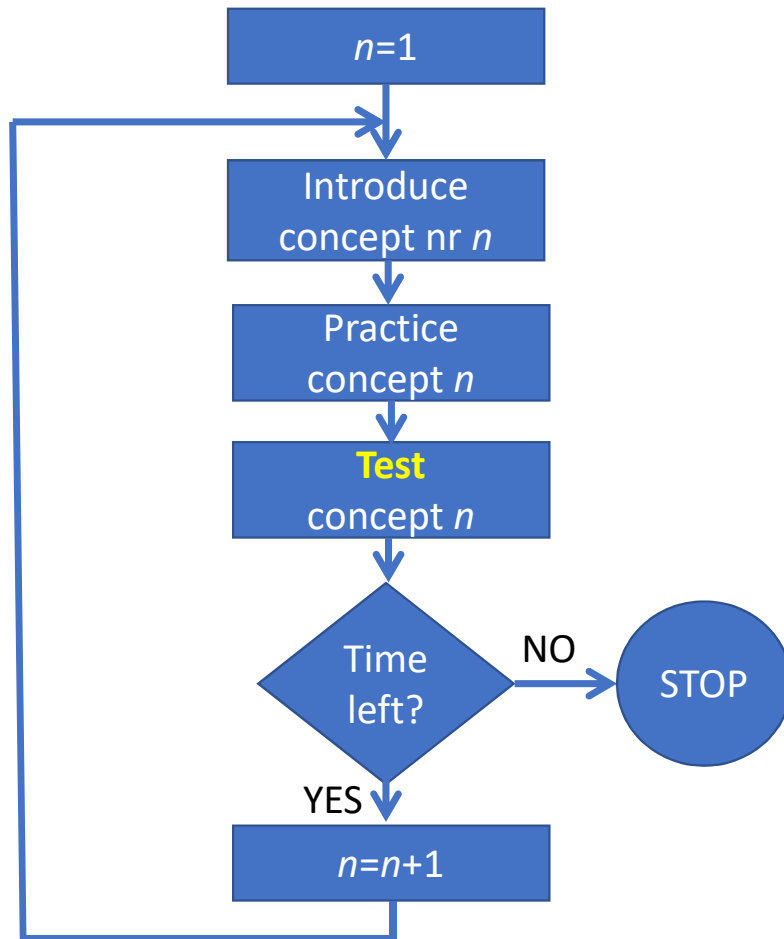


*Aristarchus
(-310 -230)*

$$\frac{ZL}{ZS} = \frac{Z'L'}{Z'S'} = \frac{1}{400} = k$$

Teaching

concept oriented:



process oriented:

Mathematical reasoning
and argumentation

Strategic thinking

Mathematical modeling

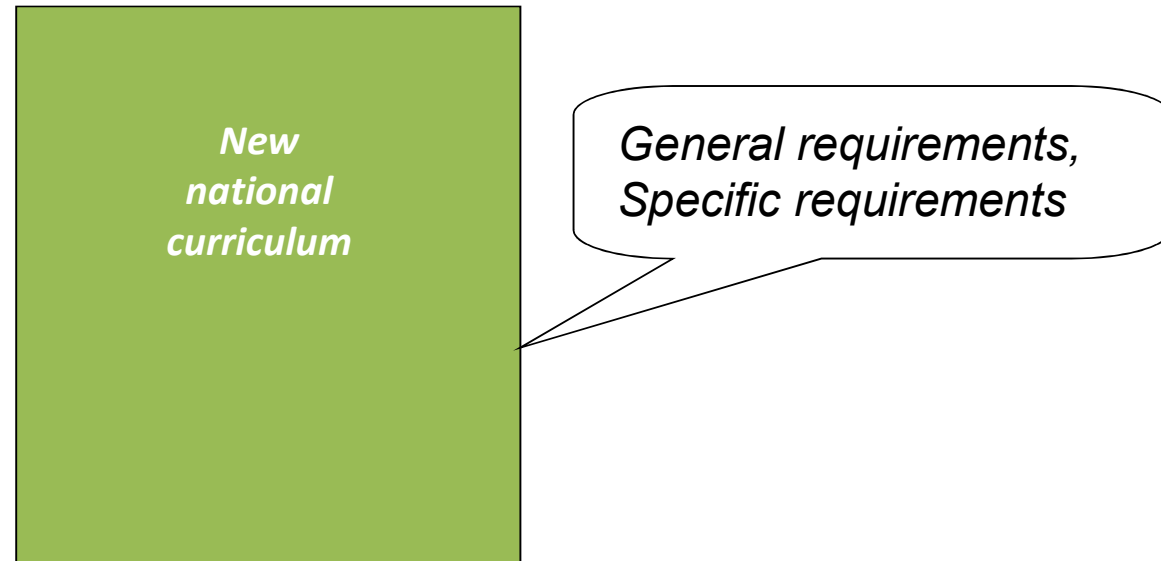
Prepare students to be ready to deal also with **non-routine tasks**

Strategic thinking

Prepare students to recognize and deal with **lies**

Mathematical reasoning
and argumentation

Polish national curriculum (2008)

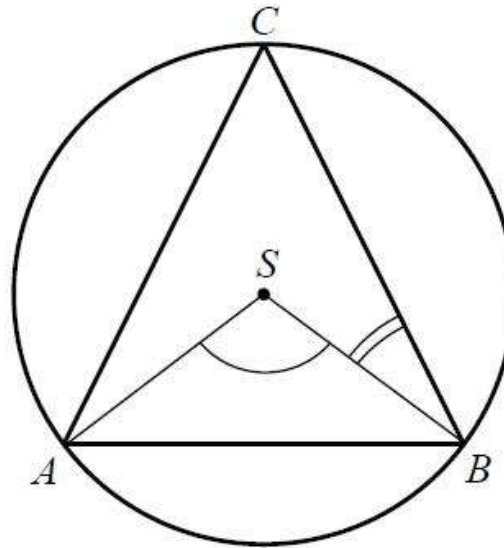


Matura 2014

Poziom podstawowy

Zadanie 31. (2 pkt)

Środek S okręgu opisanego na trójkącie równoramiennym ABC , o ramionach AC i BC , leży wewnątrz tego trójkąta (zobacz rysunek).



Prove
that...

Wykaż, że miara kąta wypukłego ASB jest cztery razy większa od miary kąta wypukłego SBC .

Matura 2014

Poziom podstawowy

Prove that...

Zadanie 28. (2 pkt)

Udowodnij, że każda liczba całkowita k , która przy dzieleniu przez 7 daje resztę 2, ma tę własność, że reszta z dzielenia liczby $3k^2$ przez 7 jest równa 5.

Prove that...

Zadanie 4. (2 pkt)

Udowodnij, że dla każdych dwóch liczb rzeczywistych dodatnich x, y prawdziwa jest nierówność $(x+1)\frac{x}{y} + (y+1)\frac{y}{x} > 2$.

Zadanie 6. (3 pkt)

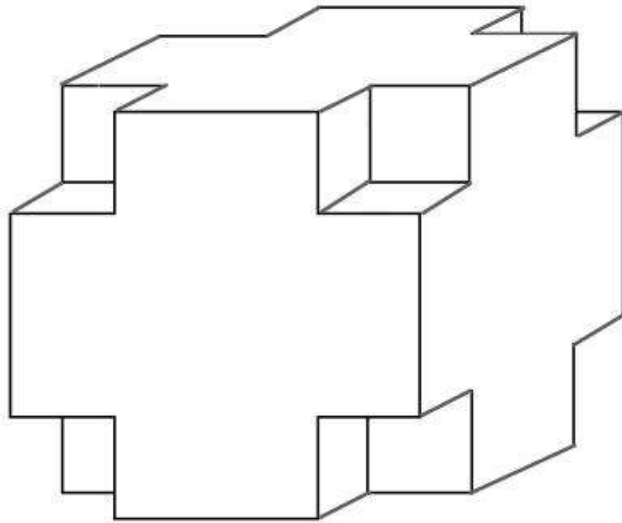
Trójkąt ABC jest wpisany w okrąg o środku S . Kąty wewnętrzne CAB , ABC i BCA tego trójkąta są równe, odpowiednio, α , 2α i 4α . Wykaż, że trójkąt ABC jest rozwartokątny, i udowodnij, że miary wypukłych kątów środkowych ASB , ASC i BSC tworzą w podanej kolejności ciąg arytmetyczny.

Prove that...

Egzamin gimnazjalny 2014

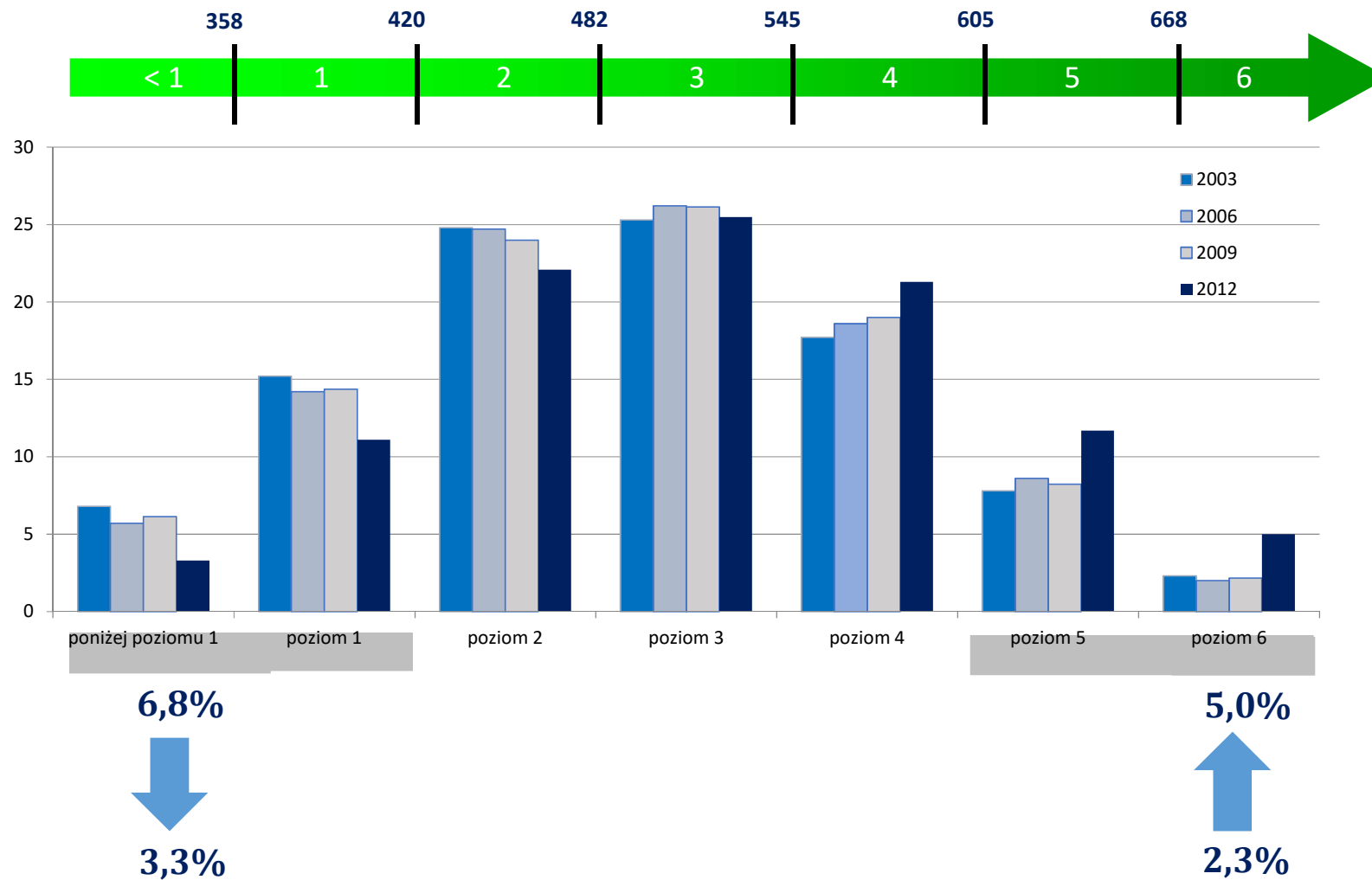
Zadanie 23. (0–3)

Z sześcianu zbudowanego z 64 małych sześcianów o krawędzi 1 cm usunięto z każdego narożnika po jednym małym sześcianie (patrz rysunek). Oblicz pole powierzchni powstałej bryły i porównaj je z polem powierzchni dużego sześcianu. Zapisz obliczenia.

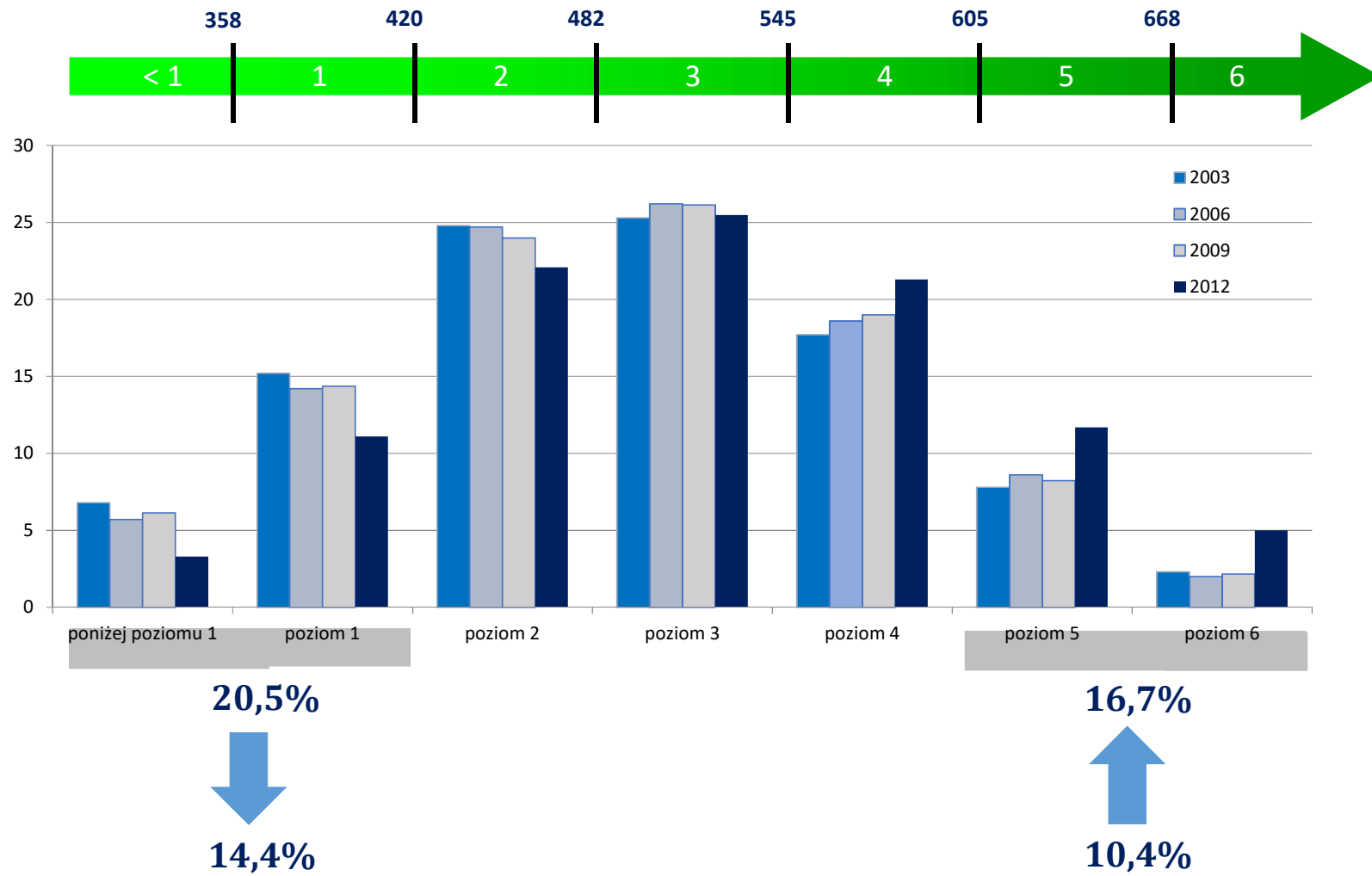


Internet: *I calculated like crazy, while it was enough to think!*

PISA – levels of math competences

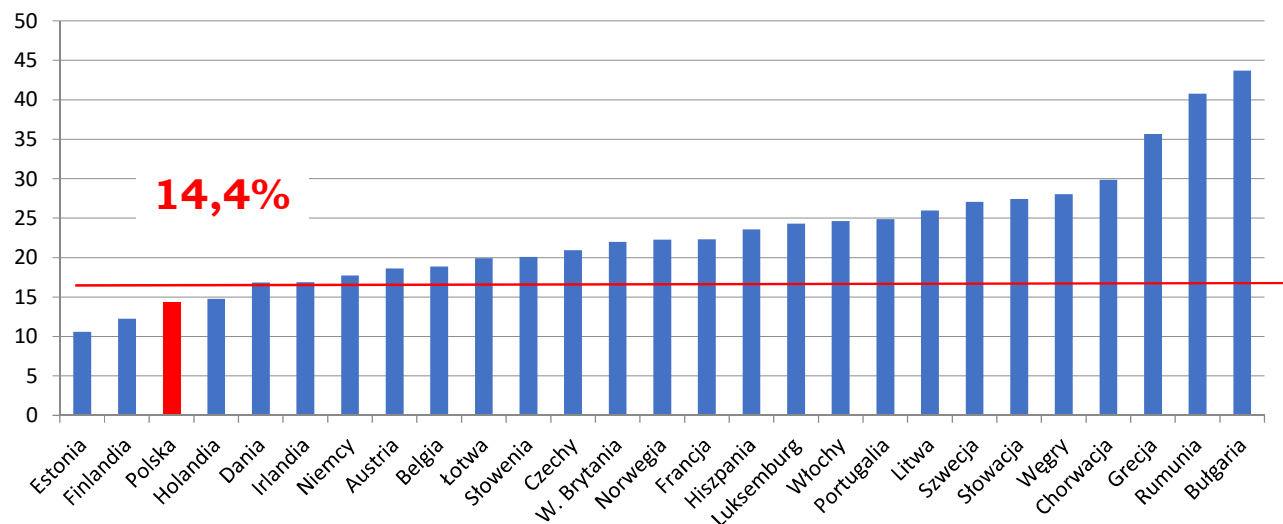


PISA – levels of math competences

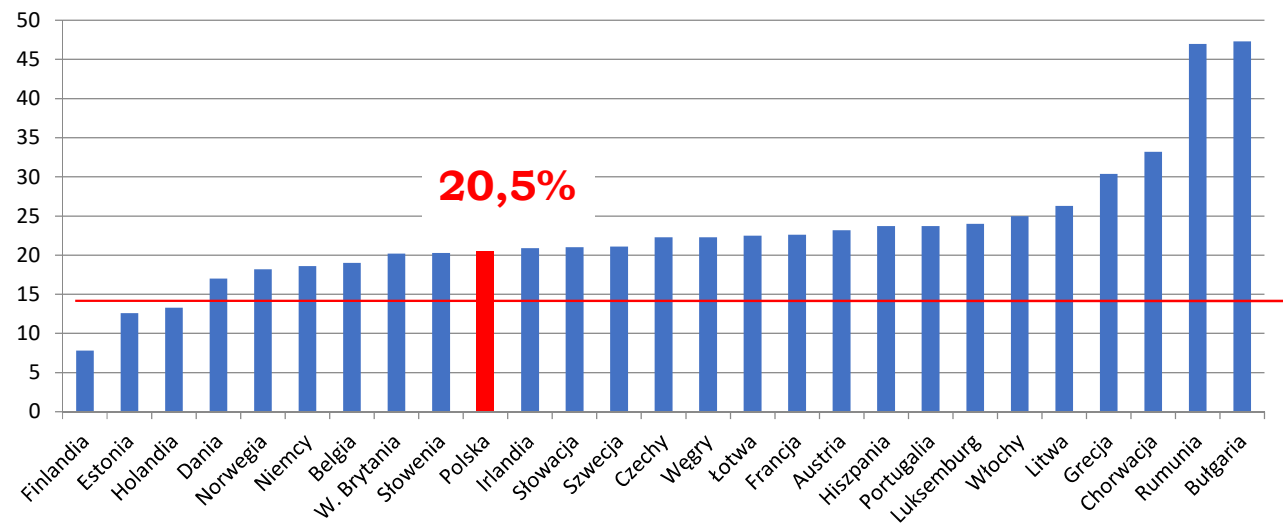


Students at level 1 or below in EU (math)

2012

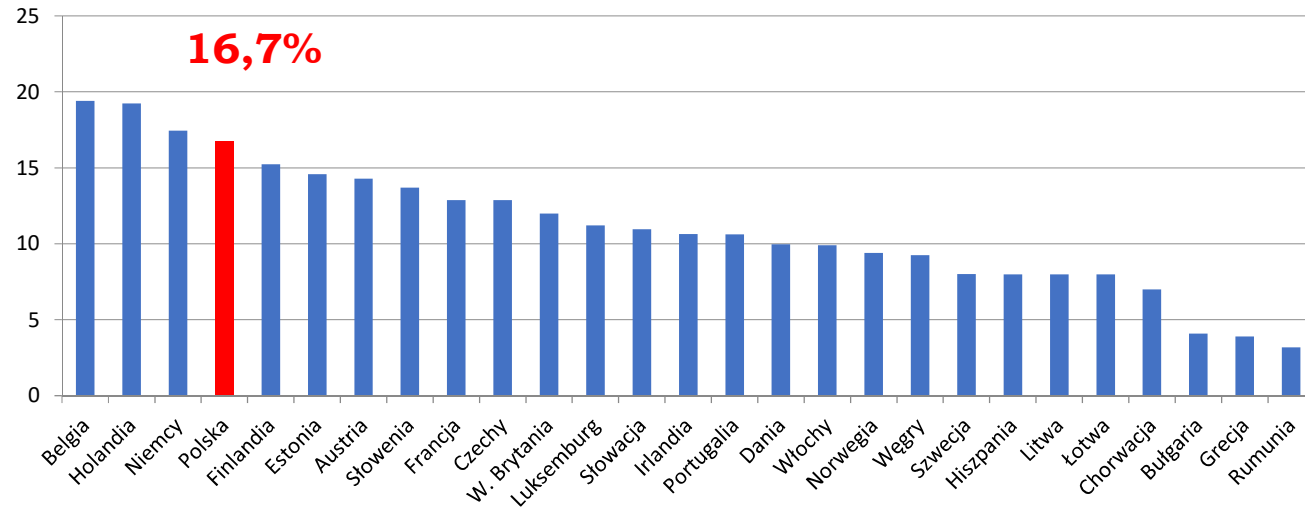


2009

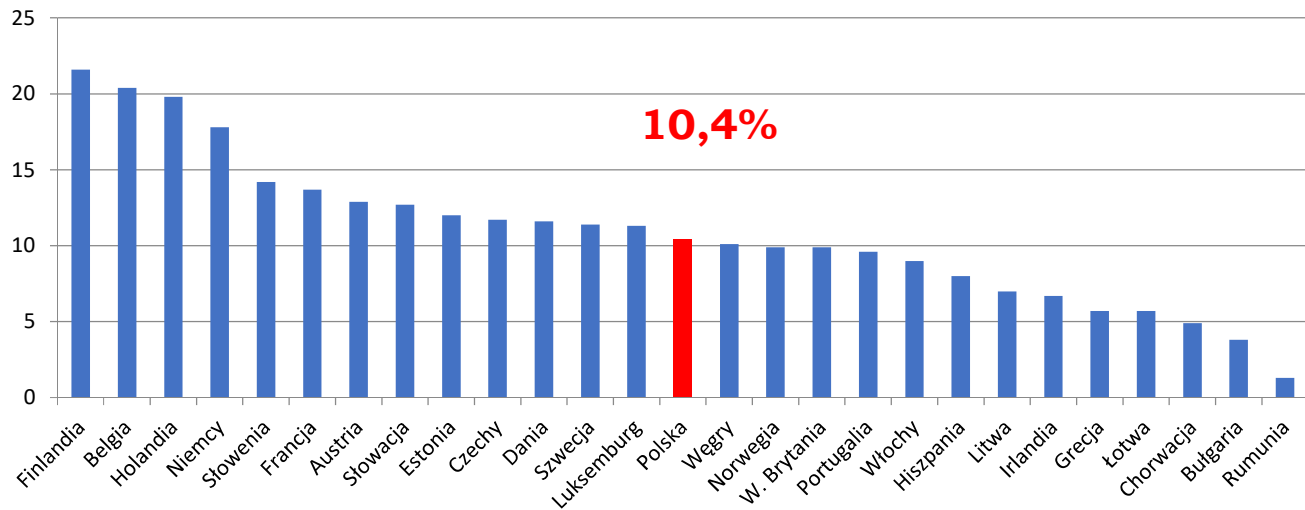


Students at levels 5 or 6 in EU (math)

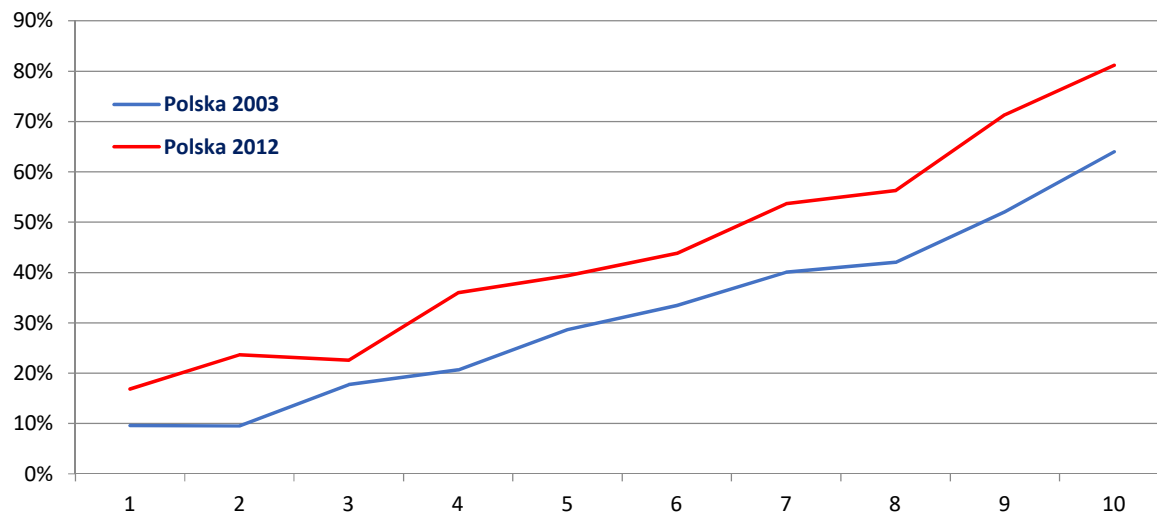
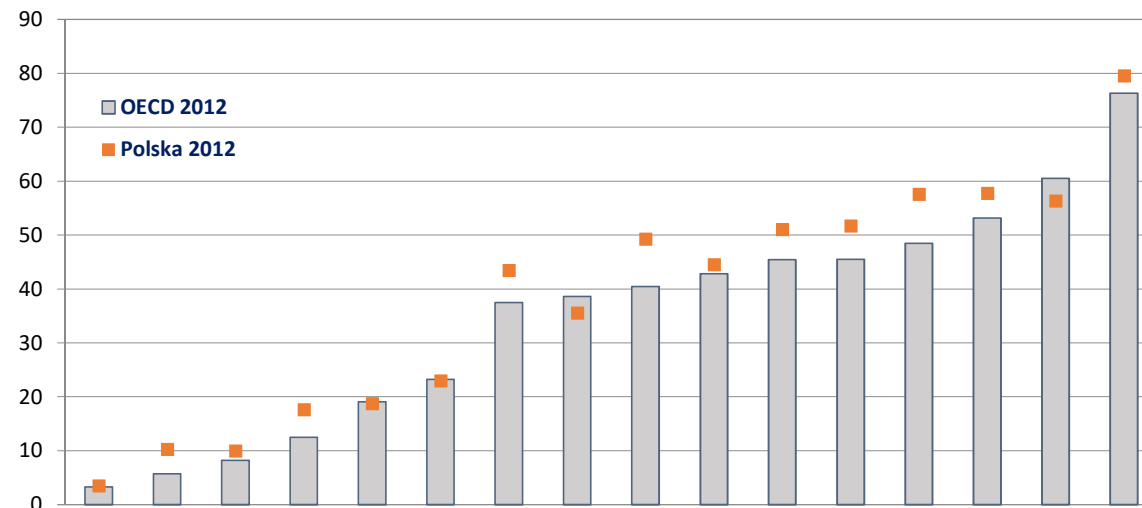
2012



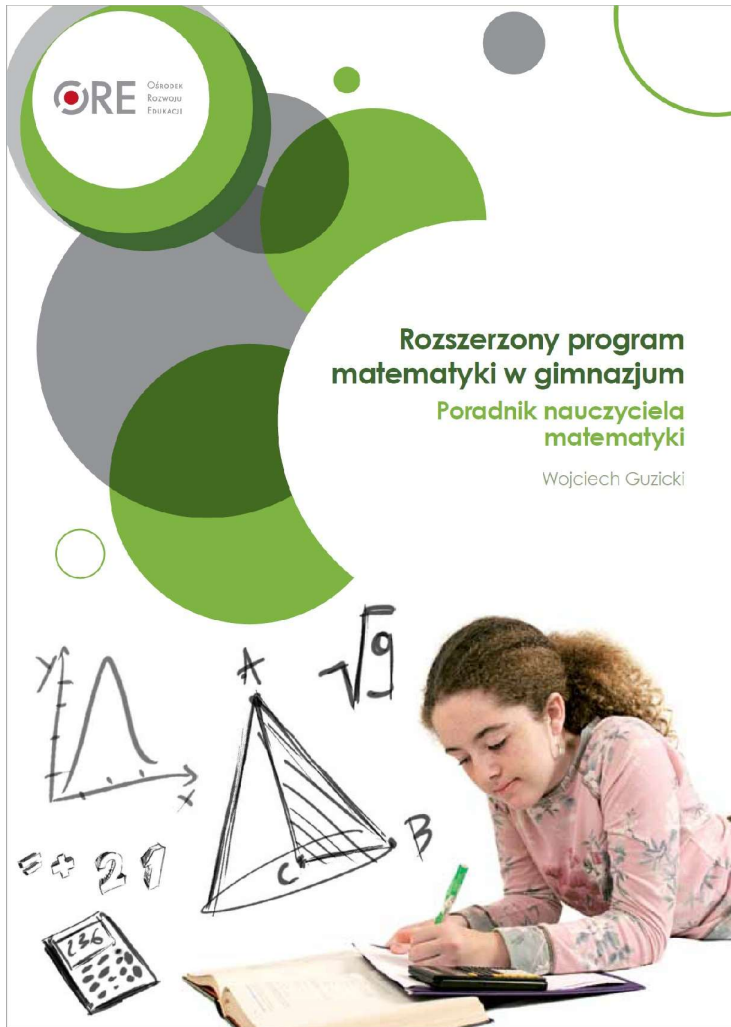
2009



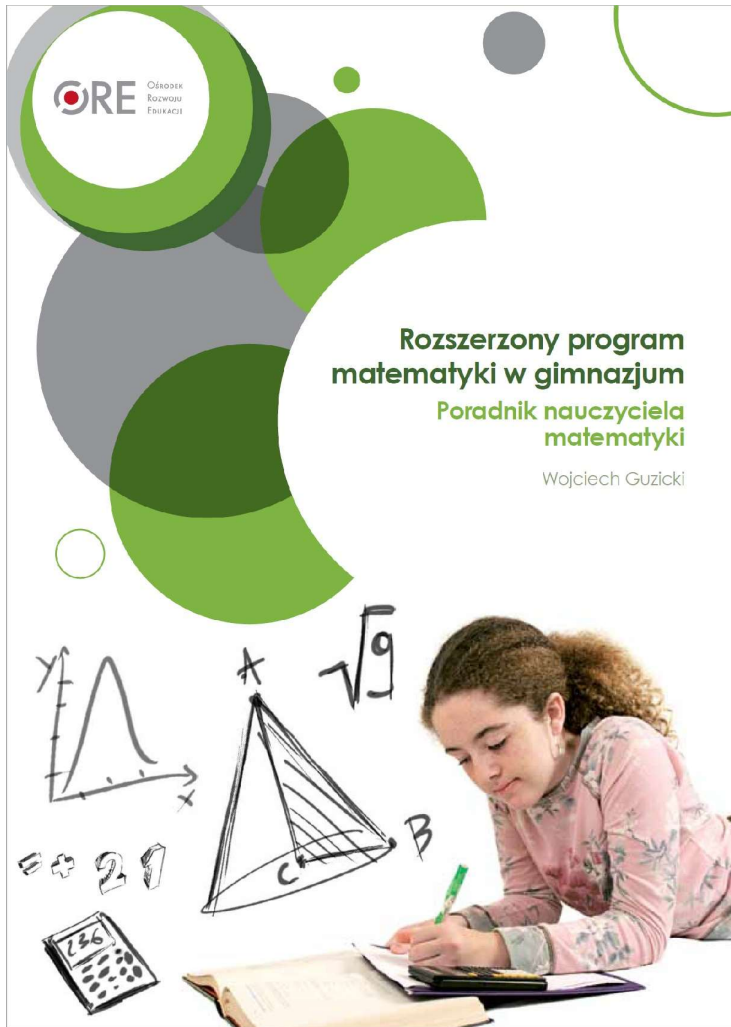
Mathematical reasoning – the weakest point in 2003



How to teach mathematical reasoning?



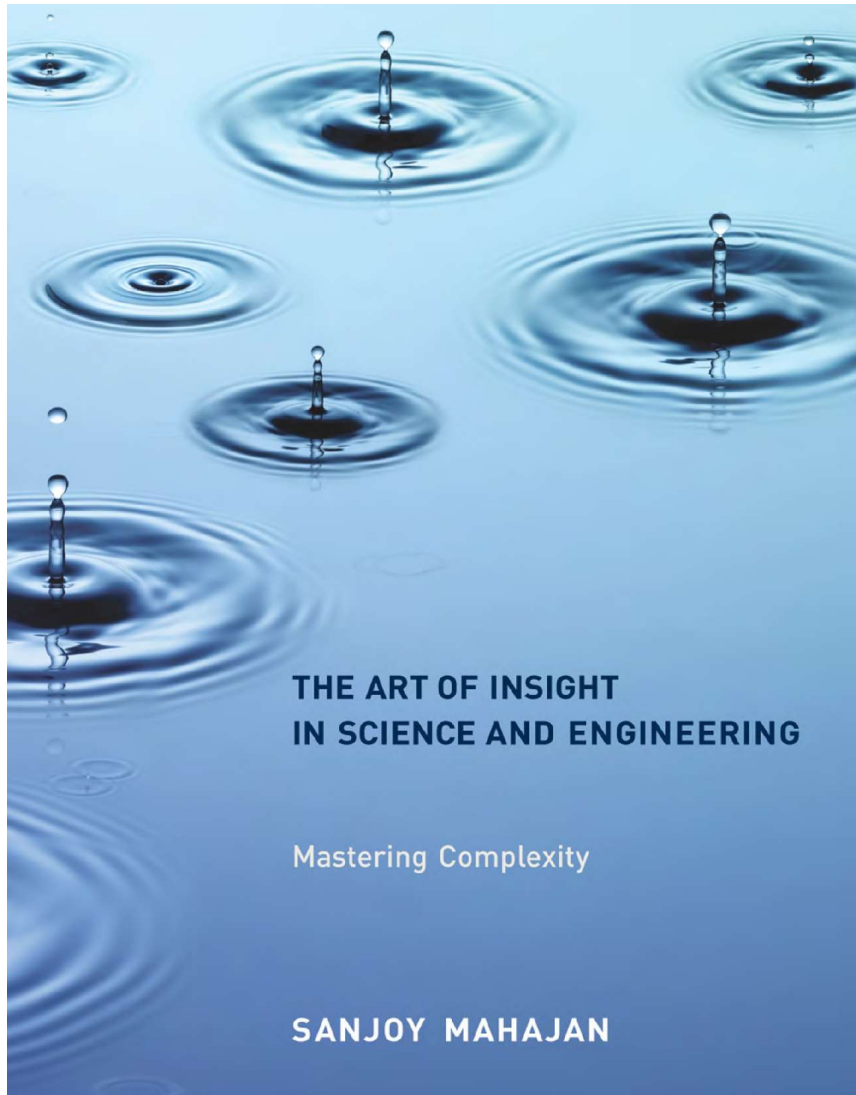
How to teach mathematical reasoning?



	5	8	*			6	2	
			9		7			
7	1			2			4	9
		3	2		5	8		
6								1
		9	6		4	5		
3	6			9			5	4
			4		1			
	8	4				9	1	

*Explain why you can start solving this Sudoku by writing 1 in position *.*

How to teach mathematical reasoning?



What is, roughly, the volume of a dollar bill?

Mathematical reasoning versus problem solving



OECD PISA test 2021
main domain: mathematics

**How the above winds of change
should influence this test?**

1 Conference + 2 Colloquia with OECD





Joan Ferrini-Mundy

Takura Baba



Zbigniew Marciniak

Jenni Ingram



Bill Schmidt

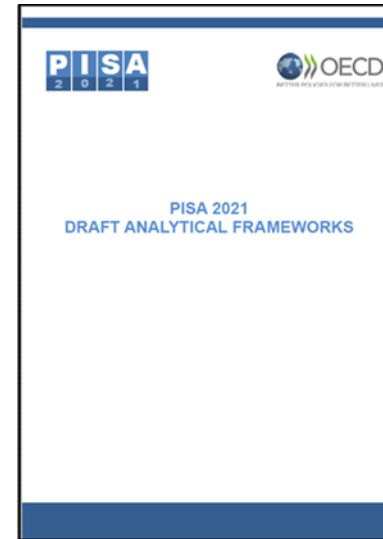
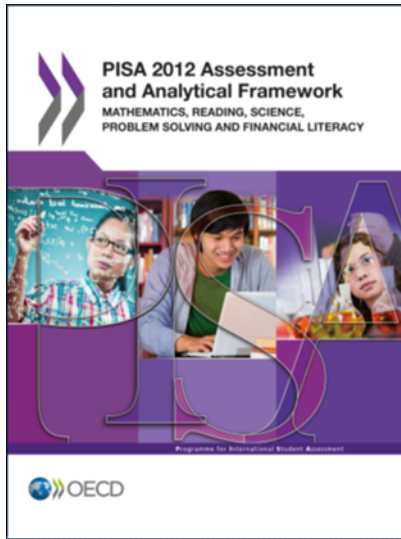
Julián Mariño

Core Experts Mathematics Expert Group (MEG)

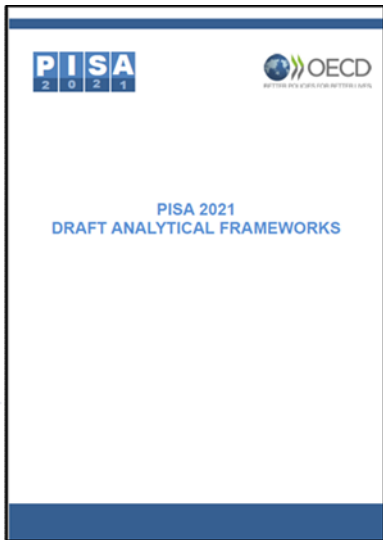
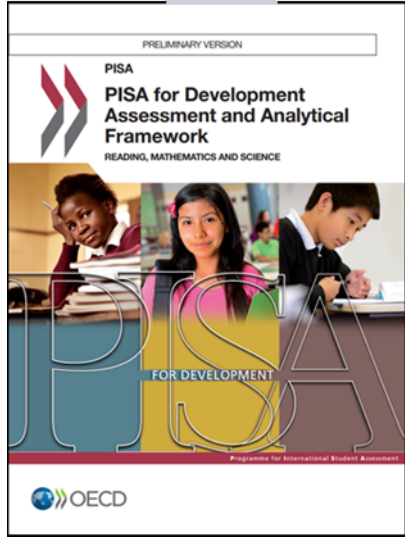
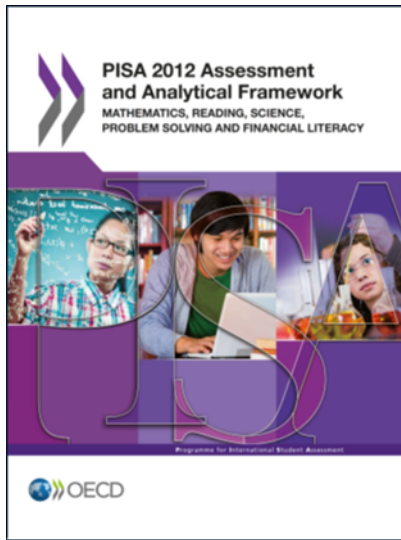
Stephania Bocconi



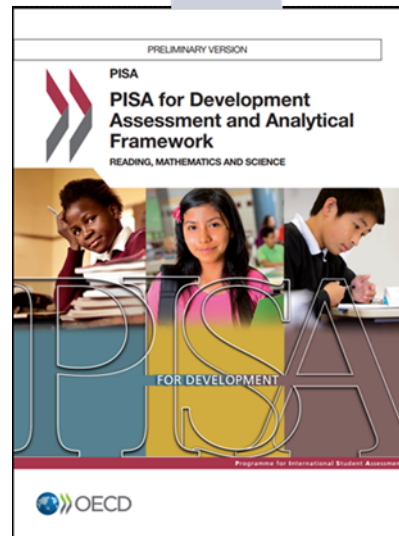
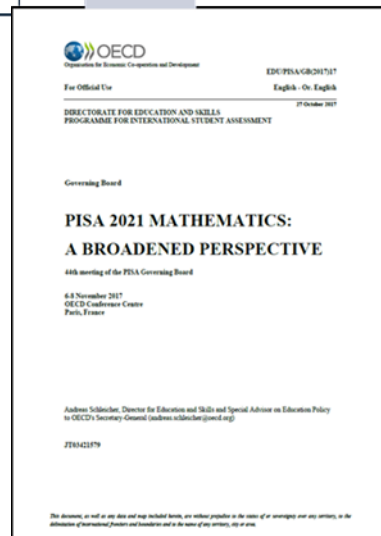
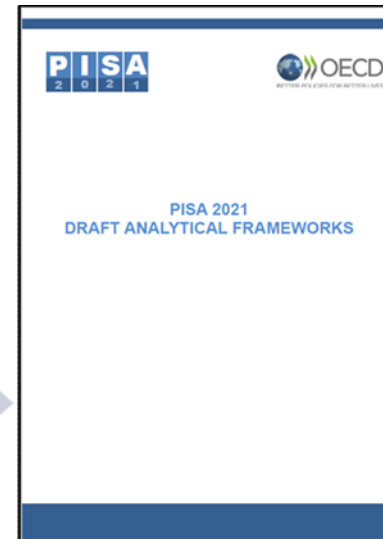
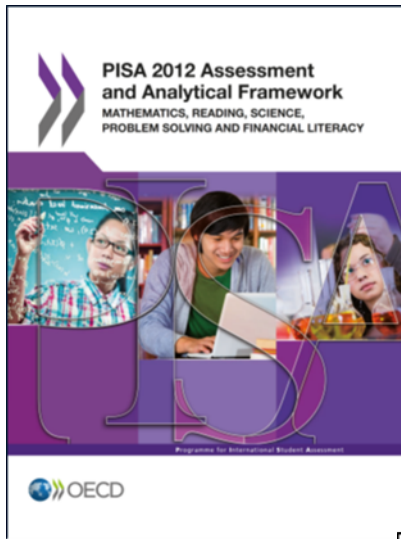
Development of the PISA 2021 Mathematics Framework



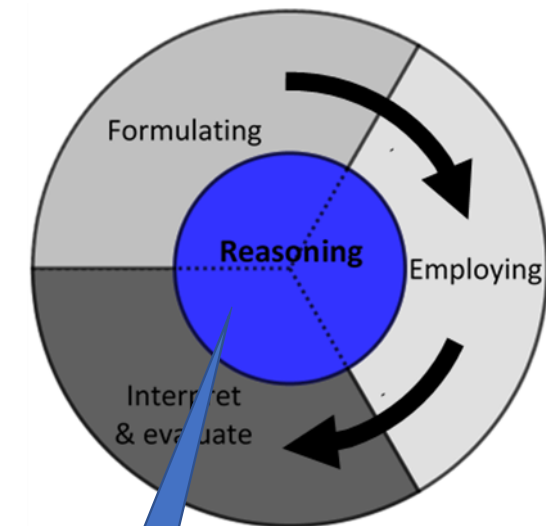
Development of the PISA 2021 Mathematics Framework



Development of the PISA 2021 Mathematics Framework



Development of the PISA 2021 Mathematics Framework



25% of items

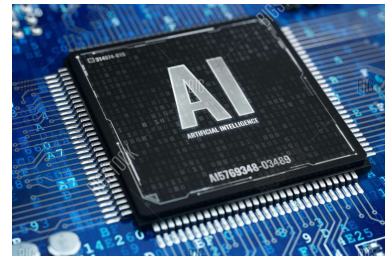
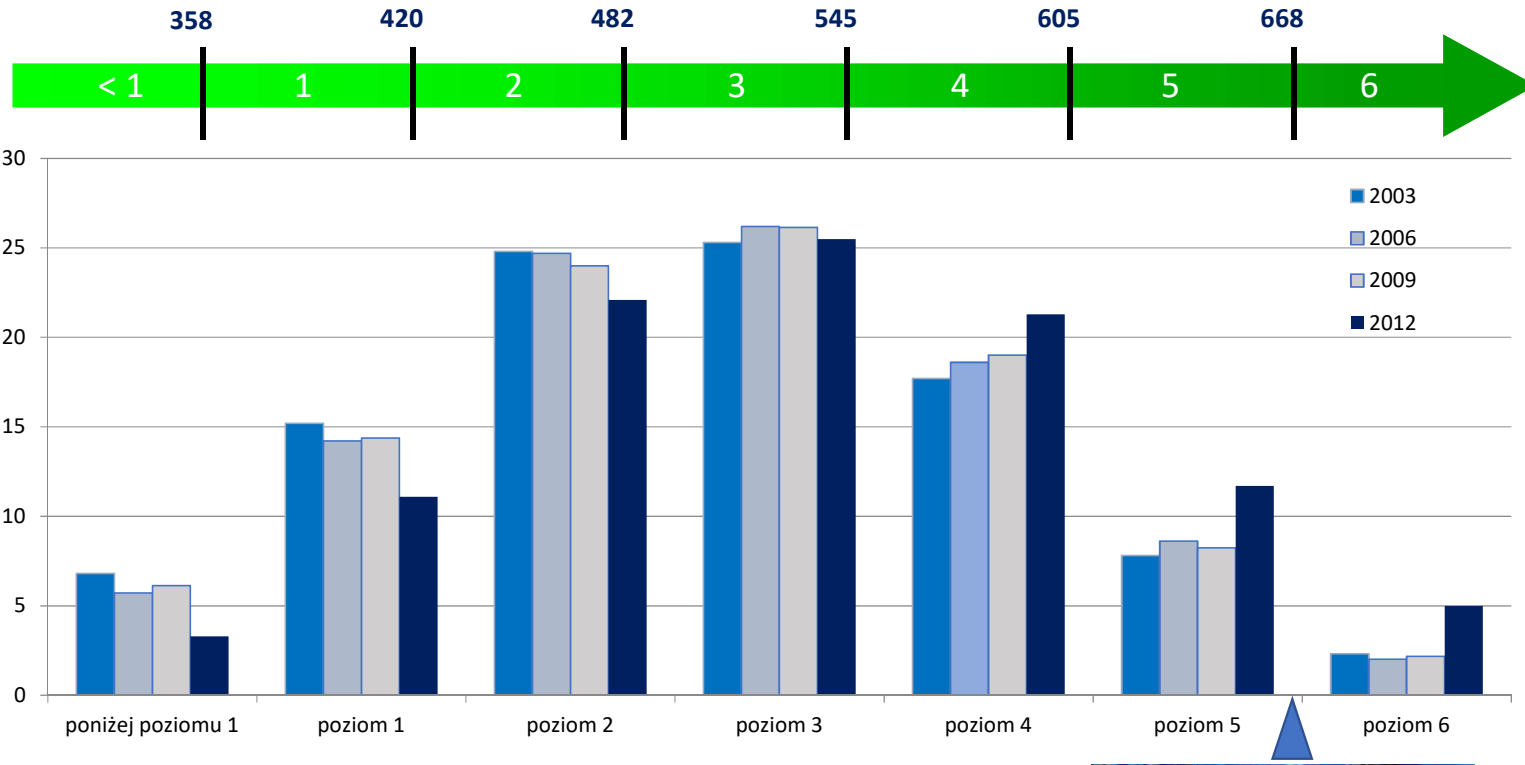
A new subscale reporting the ability to reason mathematically

*Mathematical literacy is an individual's capacity to **reason mathematically** and to **formulate, employ, and interpret mathematics** to solve problems in a variety of real-world contexts.*

It includes concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to know the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective 21st century citizens.

More distant future?

More distant future?



Summary

Mathematics is much more than a toolbox.

Concept oriented teaching does not fit the present challenges.
Teach the method of mathematics.

As it has always been, mathematics will then be the best answer
to problems we face today.

It is so, because mathematics is one of the best parts
of the cultural heritage of humanity.

Thank you!