

# Conference on Bioscience and Society: Organism as living systems

**Liv Sissel Grønmo**

**ILS, University of Oslo**

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Institutt for lærerutdanning og skoleutvikling UiO

# TIMSS Advanced 2008

## A research project

- An international comparative study in the final grade of upper secondary school:
  - mathematics (in Norway 3MX)
  - physics (in Norway 3FY)
- A trend study showing development over time
  - nationally
  - internationally

**Elaborate quality assurance of translation, implementation, and participation**

Institutt for lærerutdanning og skoleutvikling UiO

# TIMSS 2003 and 2007

## A research project

- An international comparative study in primary and lower secondary school:
  - mathematics in grade 4 and grade 8
  - science in grade 4 and grade 8
- A trend study showing development over time
  - nationally
  - internationally

**Elaborate quality assurance of translation, implementation, and participation**

# Three curriculum levels

**The intended curriculum**
**(system level)**

**- Documents and resources**

**The implemented curriculum**
**(school level)**

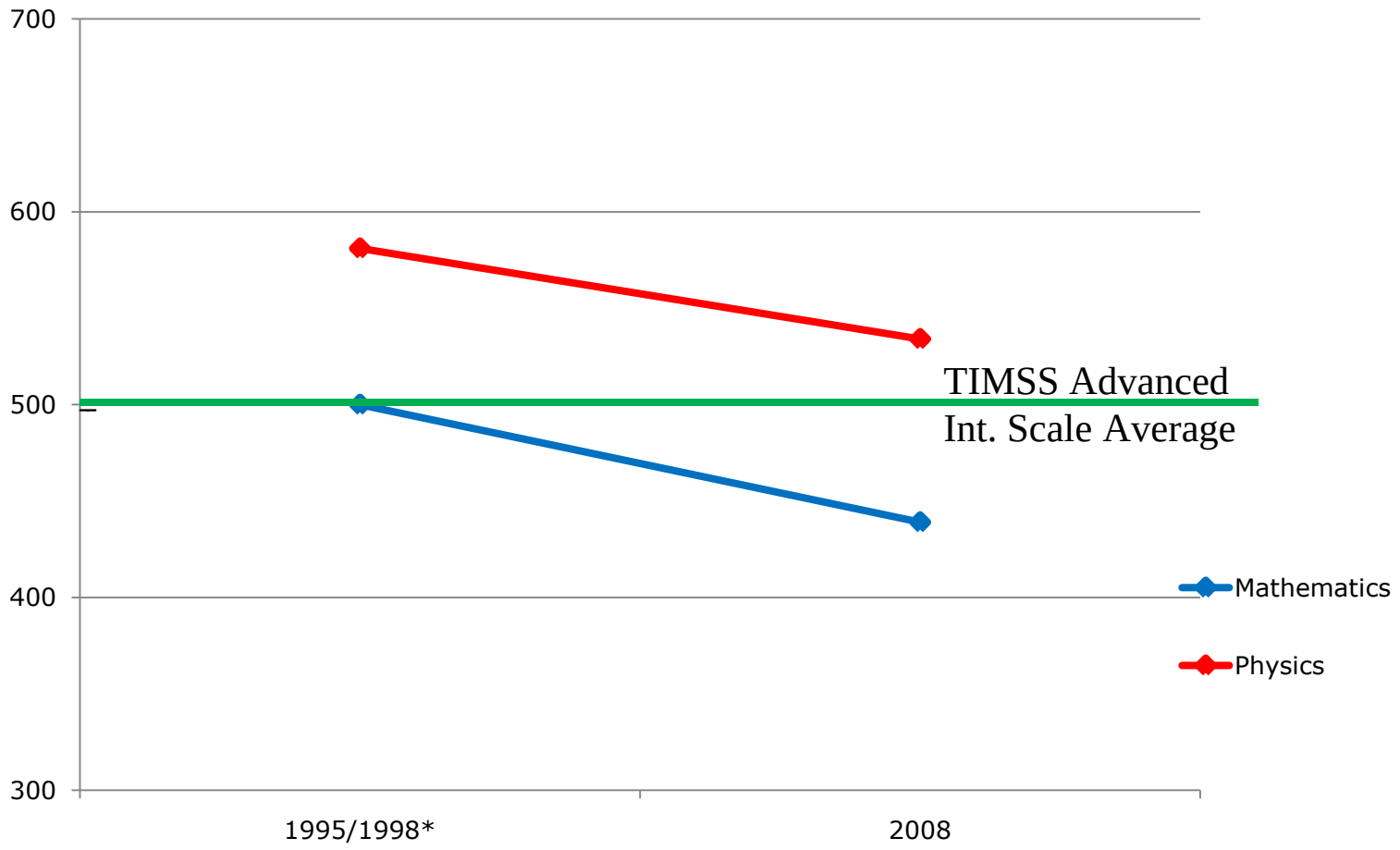
**- Instruction and teachers**

**The achieved curriculum**
**(student level)**

**- Knowledge and skills**

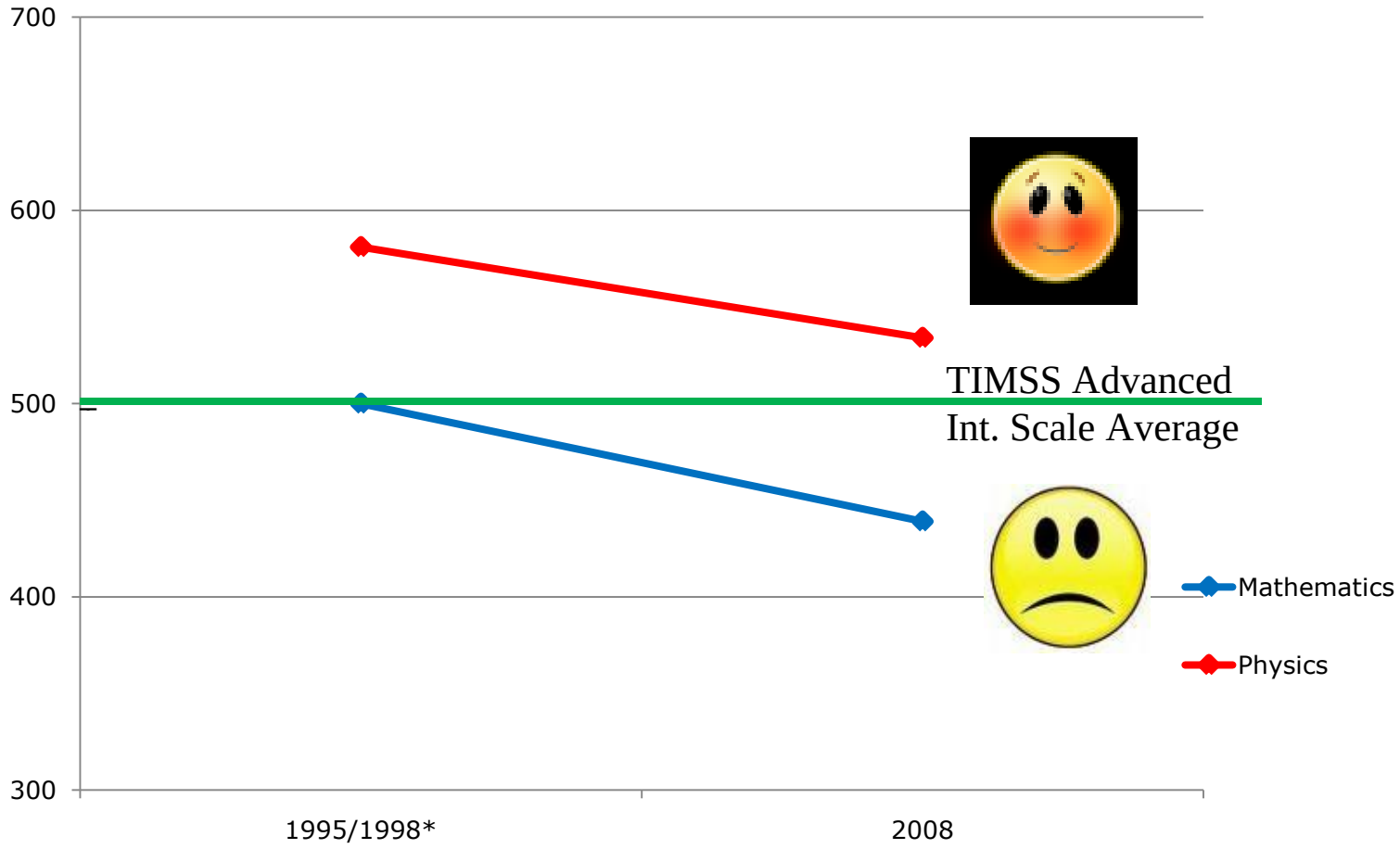
# One step back

## Advanced Mathematics and Physics



# One step back

## Advanced Mathematics and Physics





# Abridged report 9 Dec. 2009 in Norwegian and English

**Chapter 1** Main findings and trends in TIMSS Advanced 2008

**Chapter 2** Mathematics in TIMSS Advanced 2008
(Trends from 1998*)

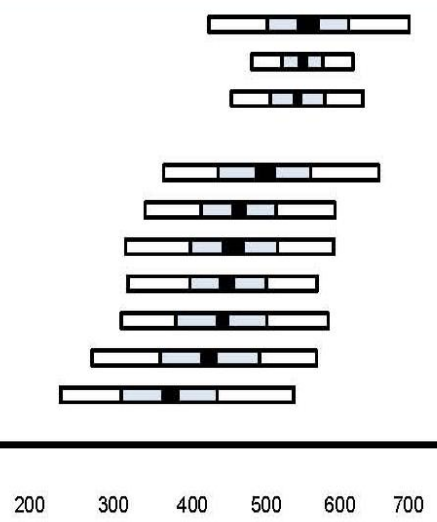
**Chapter 3** Physics in TIMSS Advanced 2008
(Trends from 1995)

# TIMSS Advanced 2008:

- ***A clear and pronounced decline in Norwegian students' performance in both Mathematics and Physics in the final grade of upper secondary school.***
- ***Performance is measured against a fixed international scale with average 500 and standard deviation 100, calculated on basis of results from 1995.***
- ***The decline in performance for the Norwegian students is about half a standard deviation in each subject. This pronounced decline coincides with the fact that the proportion of the age cohort choosing specialisation is decreasing in both subjects.***

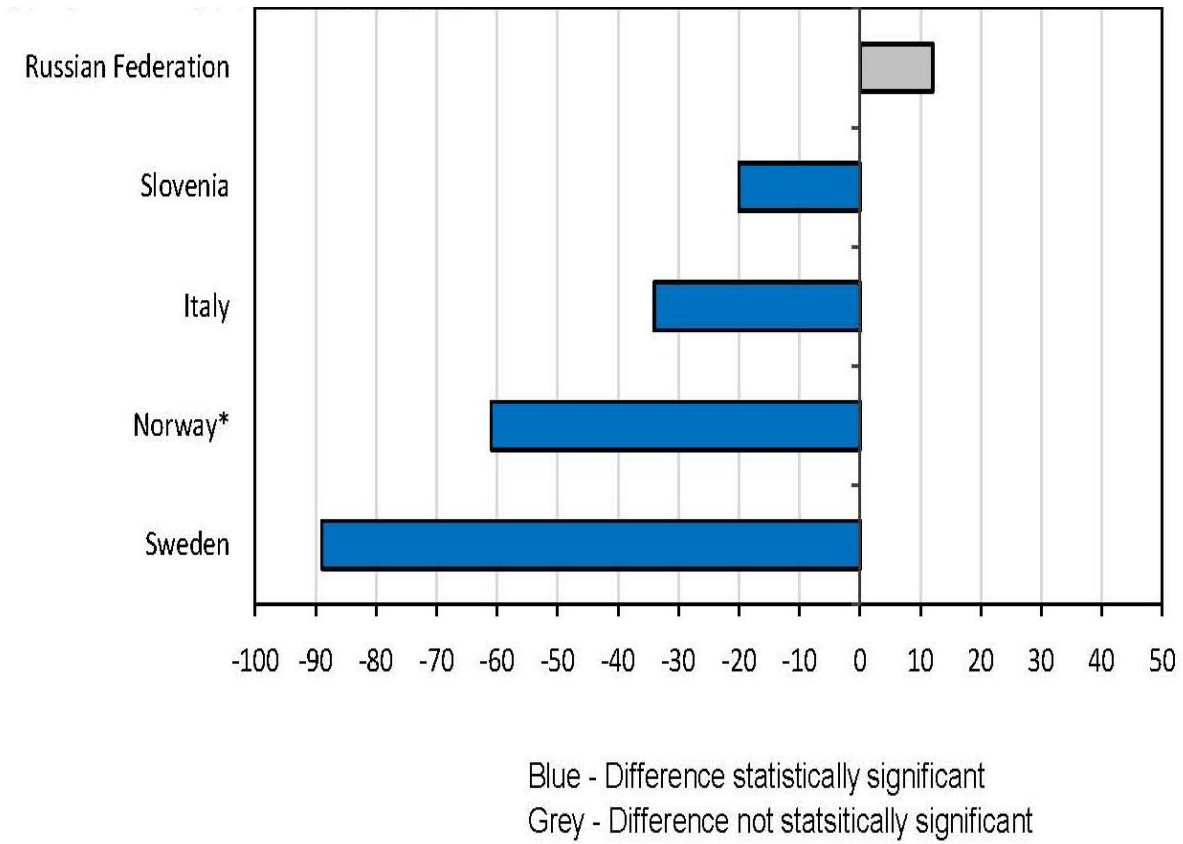
# Main results in mathematics end of upper secondary school

| Country | Coverage Index | Average Age | Years in School | Average Score | Achievement Distribution |
|---|---|---|---|---|---|
| Russian Federation | 1,4 | 17,0 | 10 el. 11 | 561 | |
| Netherlands | 3,5 | 18,0 | 12 | 552 | |
| Lebanon | 5,9 | 17,9 | 12 | 545 | |
| **TIMSS Adv. Scale Average** | | | | **500** | |
| Iran, Islamic Rep. of | 6,5 | 18,1 | 12 | 497 | |
| Slovenia | 40,5 | 18,8 | 12 | 457 | |
| Italy | 19,7 | 19,0 | 13 | 449 | |
| **Norway** | **10,9** | **18,8** | **12** | **439** | |
| Armenia | 4,3 | 17,7 | 10 | 433 | |
| Sweden | 12,8 | 18,8 | 12 | 412 | |
| Philippines | 0,7 | 16,4 | 10 | 355 | |




Are there more gifted students in Slovenia and Italy than in Norway and Sweden?

# Changes in mathematics scores during the period 1995/1998* – 2008

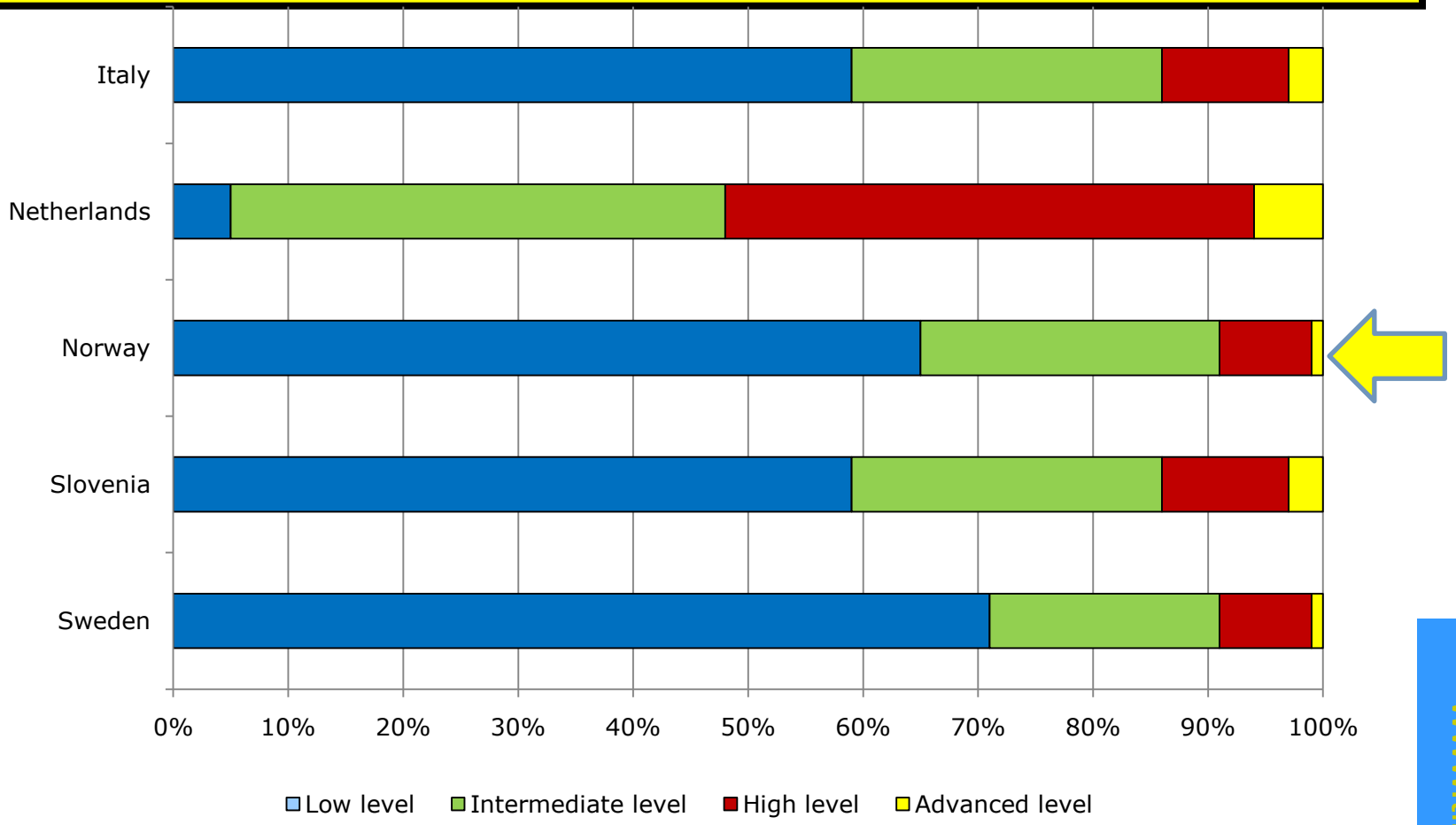



Agrees with TIMSS results in lower grades

Agrees with results in Physics in upper secondary school

# Distribution of students across benchmark levels in mathematics

Agrees with TIMSS results in lower grades. What about talented students? The future experts in technology, science, economy, mathematics?



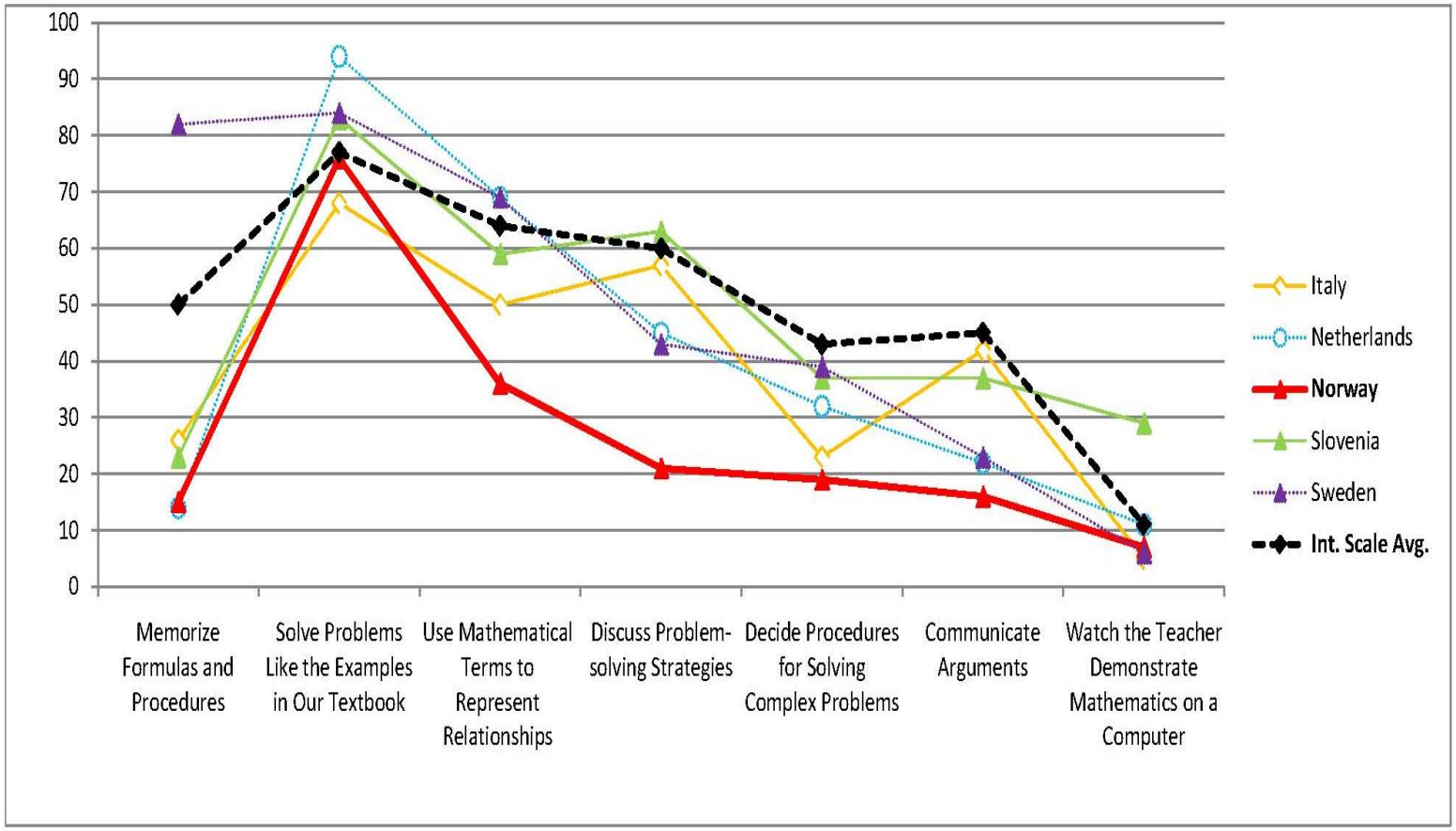


# School level

Instruction and teachers in

TIMSS Advanced

# Students reporting on how often various learning activities were used in mathematics lessons (half the lessons or more)

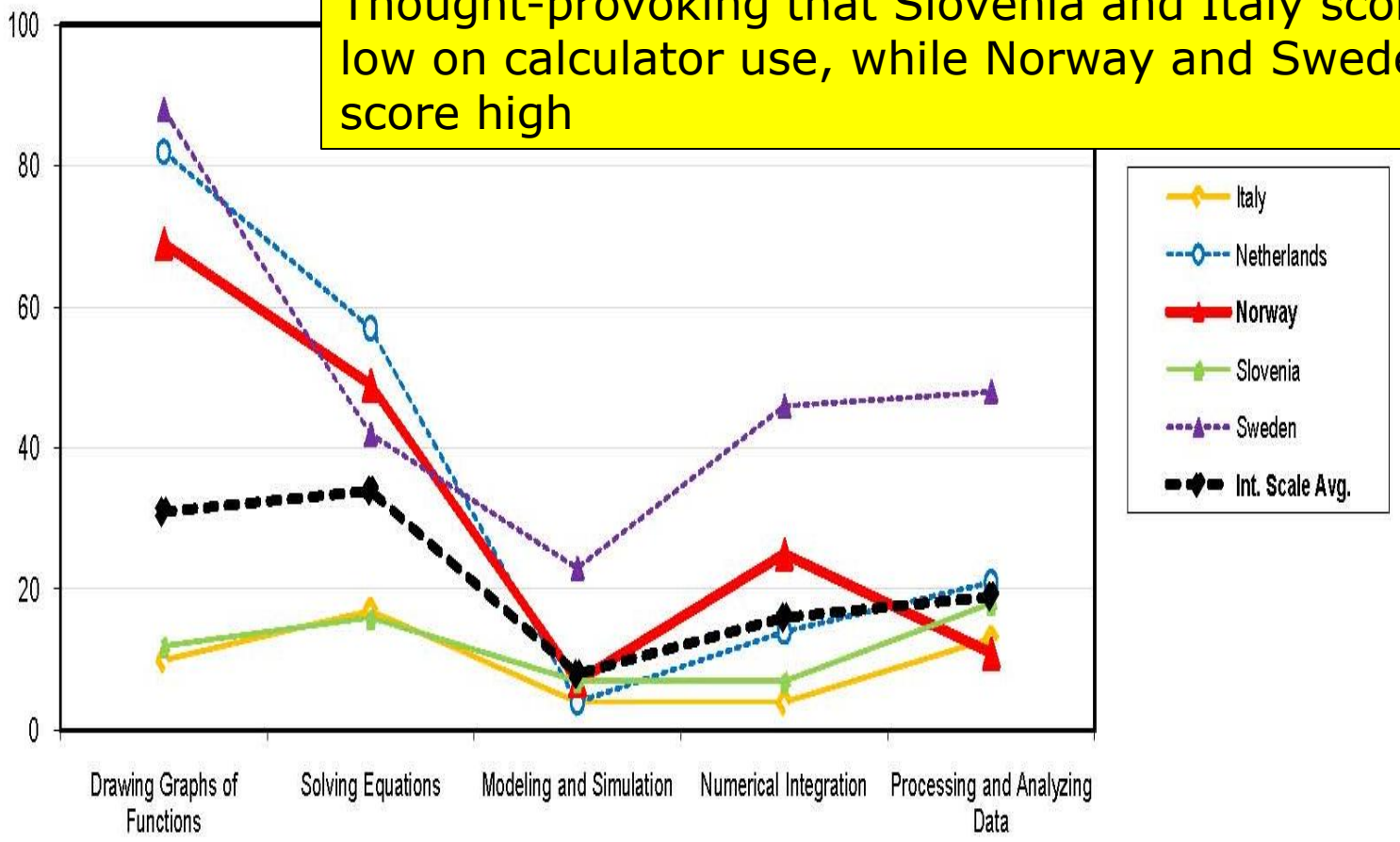



Agrees with TIMSS results in lower grades

Agrees with teachers' reports on learning activities

## *Teachers reporting on how often students use calculators in various ways in mathematics lessons (half the lessons or more)*

Thought-provoking that Slovenia and Italy score low on calculator use, while Norway and Sweden score high



# Factors related to instruction

- Results in TIMSS and TIMSS Advanced point out that practice and automation of skills in mathematics are less applied in Norway than in most countries.
- Learning activities like arguments and discussion of solutions and strategies seem to be less used in Norway than in other countries.
- **Norwegian students work much individually with problems.**
- Much calculator use in Norwegian schools.

This seems to be the case at all levels in Norwegian schools – conclusions are based on data from TIMSS and TIMSS Advanced

# National Norwegian perspective

Which instruction factors indicate better performance?

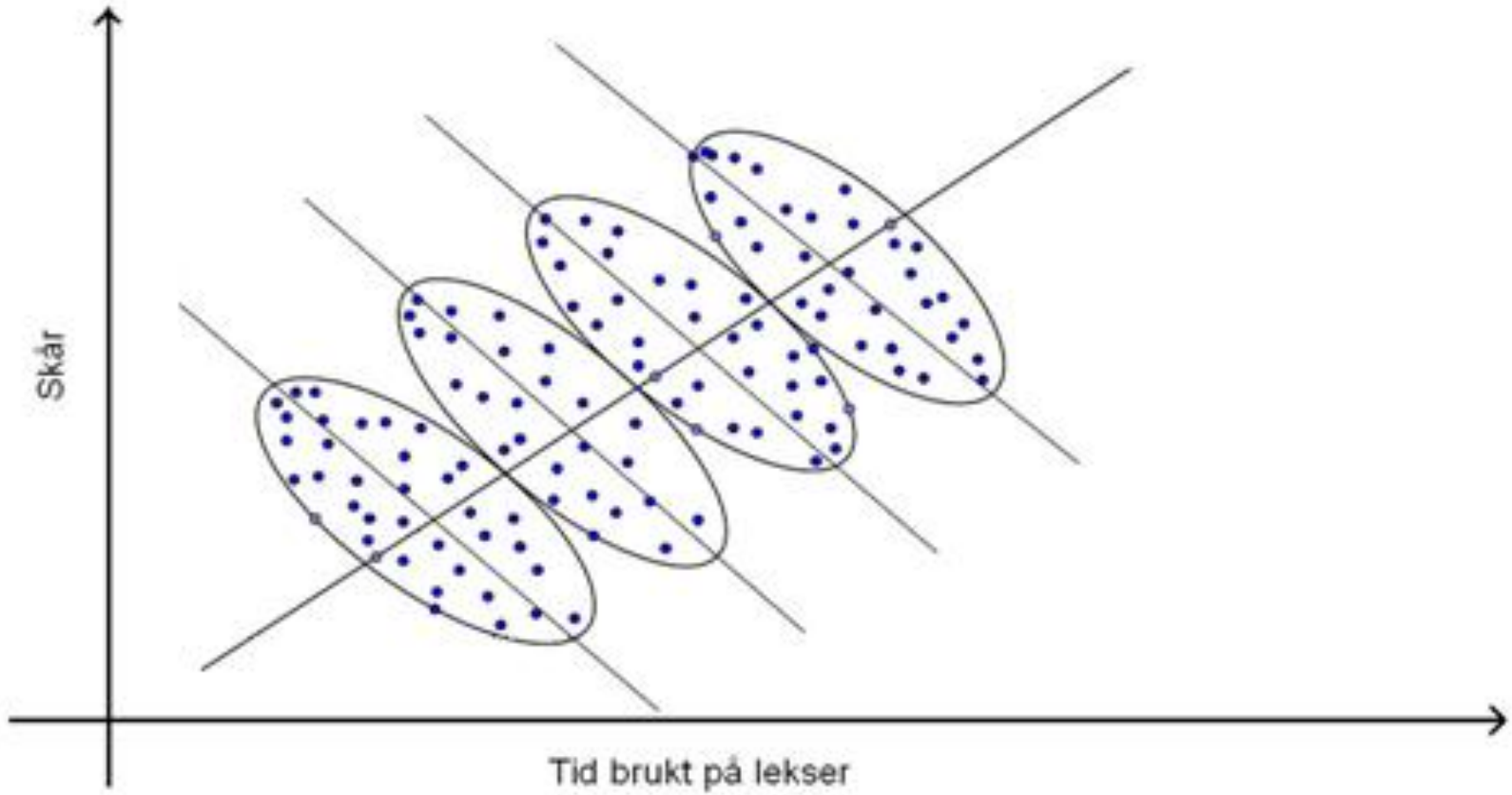
Student level?

Class level?

# Two-level analysis of Norwegian data
## TIMSS Advanced
## HOMEWORK

- Time used on homework is positively correlated with achievement at class level
- Time used on homework is negatively correlated with achievement at student level
- A series of recent studies by Trautwein and colleagues based on multi-level analysis show a negative relation between homework time and achievement at student level, and a positive relation between homework frequency and achievement at school/classroom levels

# *Homework TIMSS Advanced Norway*




- *Dots represent students – rings represent classes*
- *Lines indicate correlation*

Two-level analysis of Norwegian data

**TIMSS Advanced**

# Instruction in the classroom

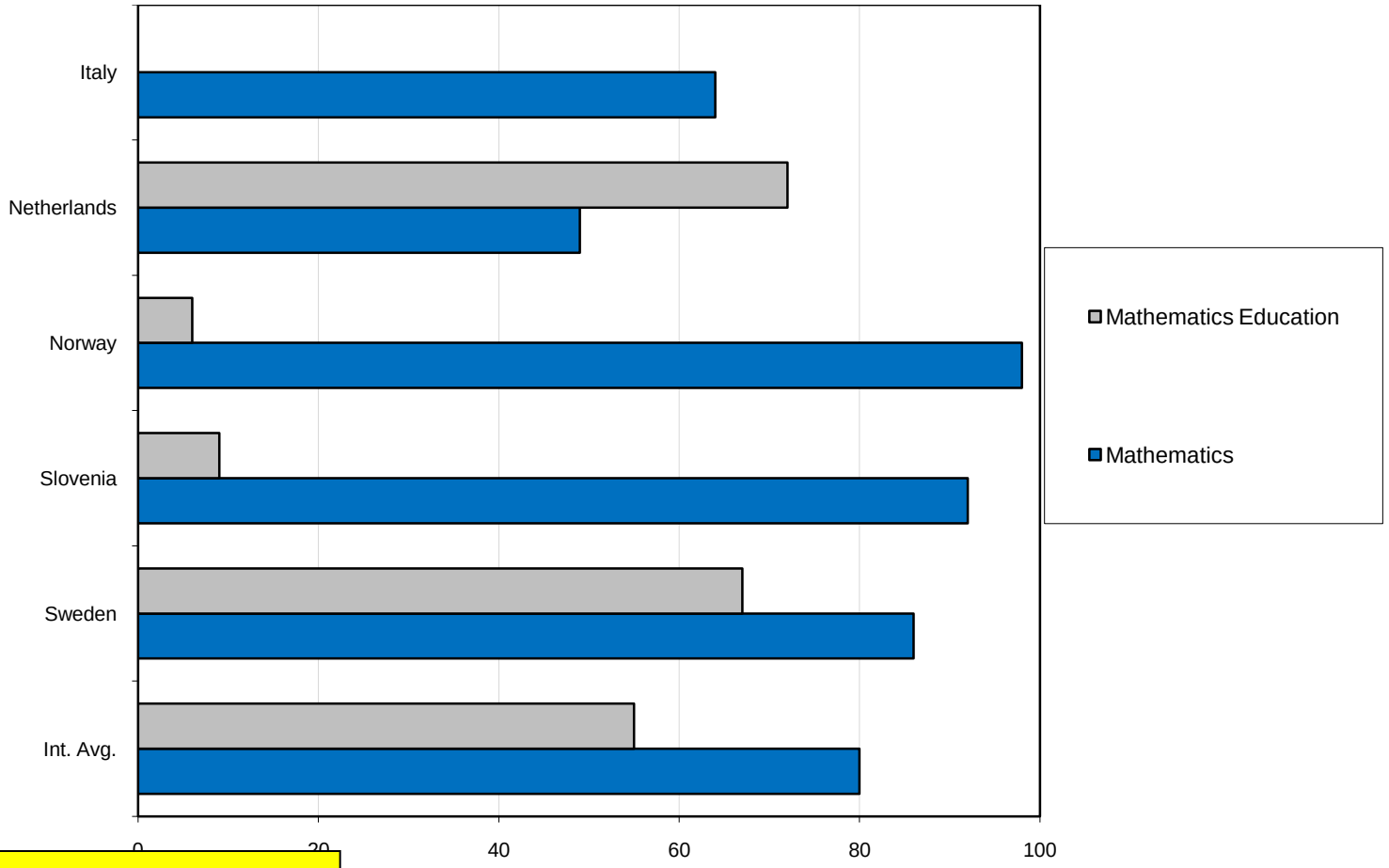
- Achievement correlates positively with use of discussions and arguing methods in the classroom at class level
- Amount – feedback - content of homework is important for students achievement in a class
- To much focus on individual work - an international as well as a national perspective indicates that in Norwegian school there should be more focus on learning as a social activity in the classroom
- The important role of the teacher need to be recognized

# Traditionally teaching versus New ways of teaching?

Teacher giving lectures in the classroom seen as outdated?

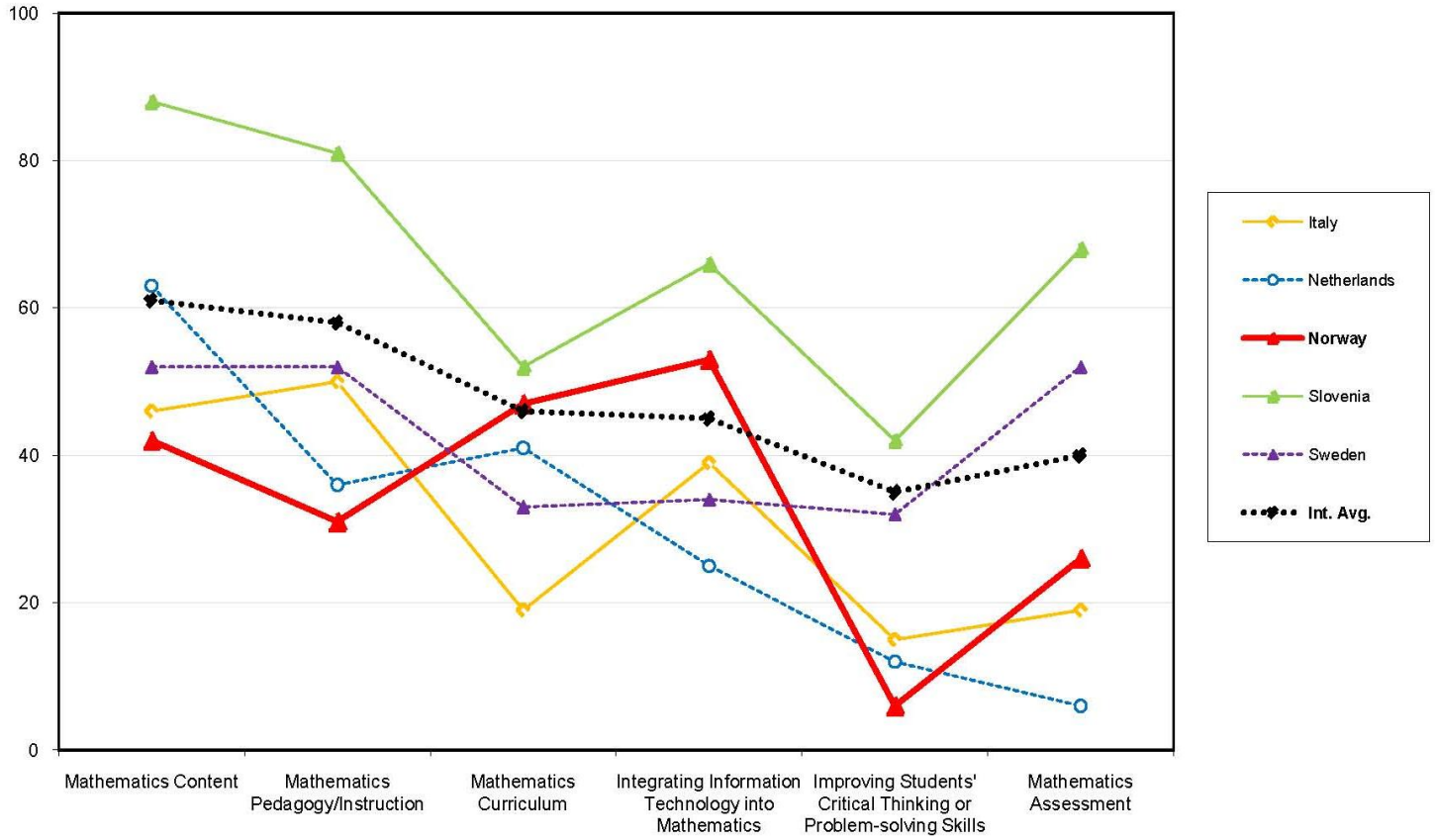
Activities and individual work seen as better ways of organising learning in principle?

# Percentage of the mathematics teachers reporting that they have specialisation in mathematics and/or mathematics education




Does **NOT** agree with TIMSS results in lower grades

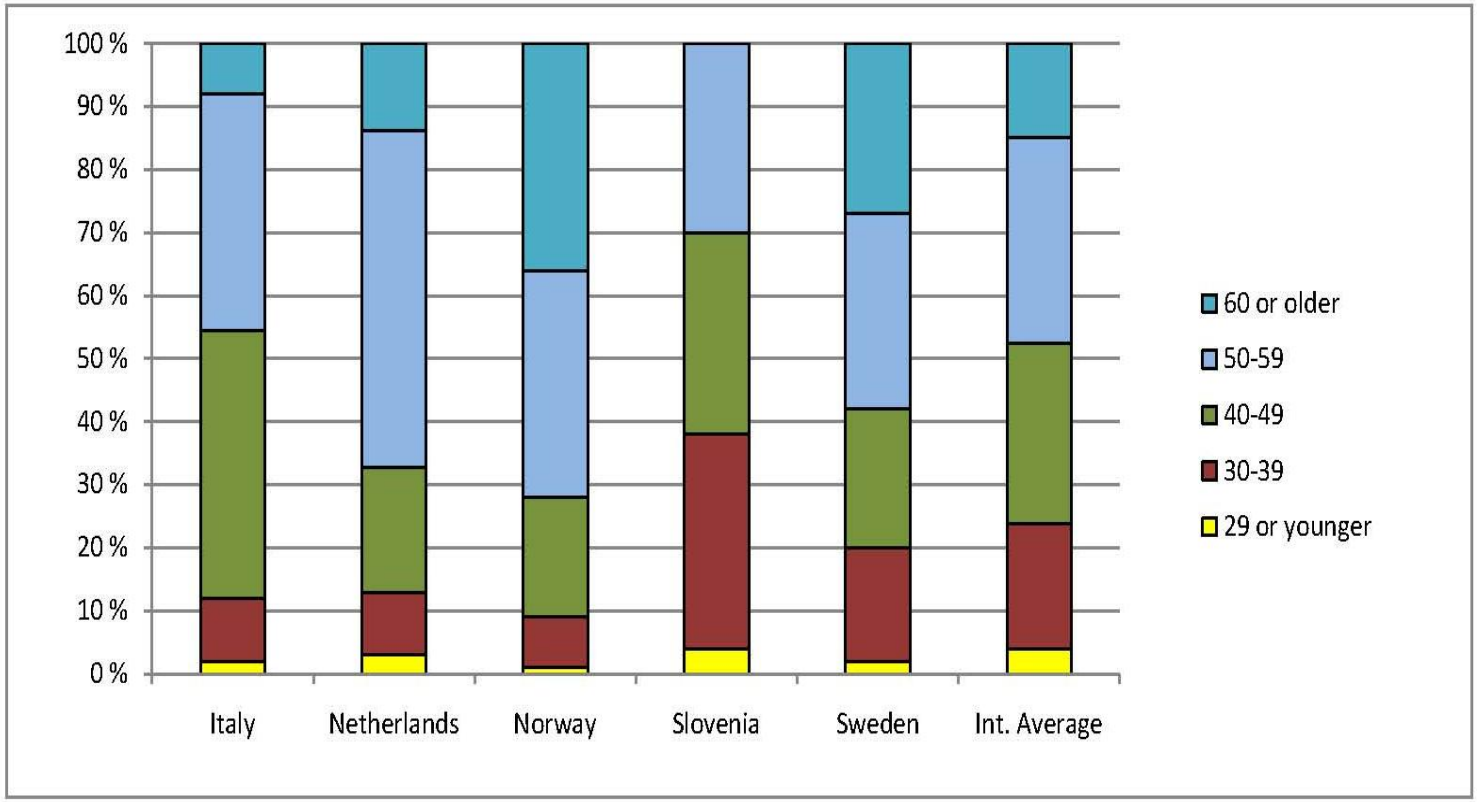
# Percentage of mathematics teachers reporting that they have participated in professional development in various areas during the last two years




Agrees with TIMSS results in lower grades

# Percentages of 3MX teachers distributed across age groups

**Recruitment to the teaching profession!!!**



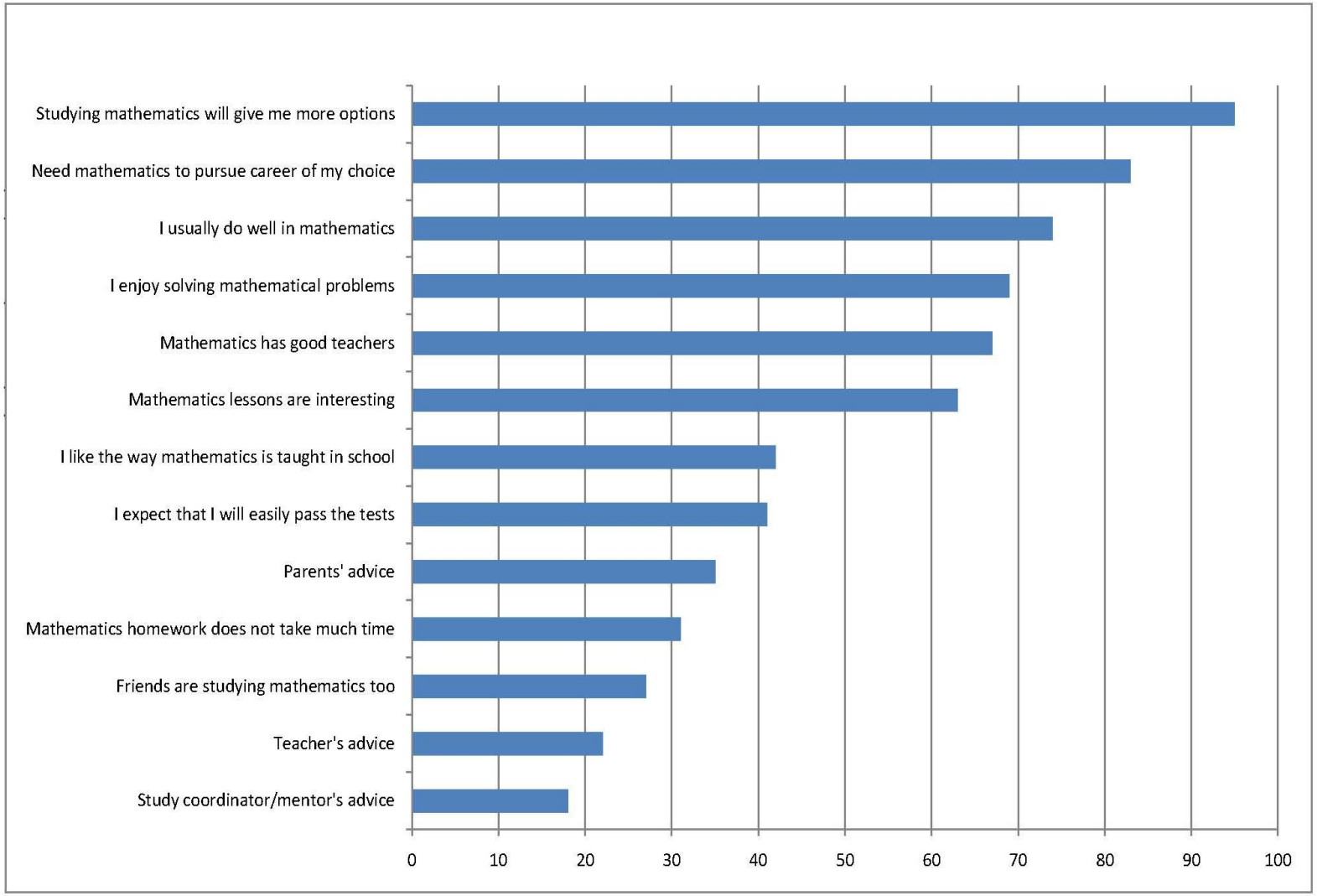

Well educated, experienced teachers, but with high age.
Applies to physics as well.



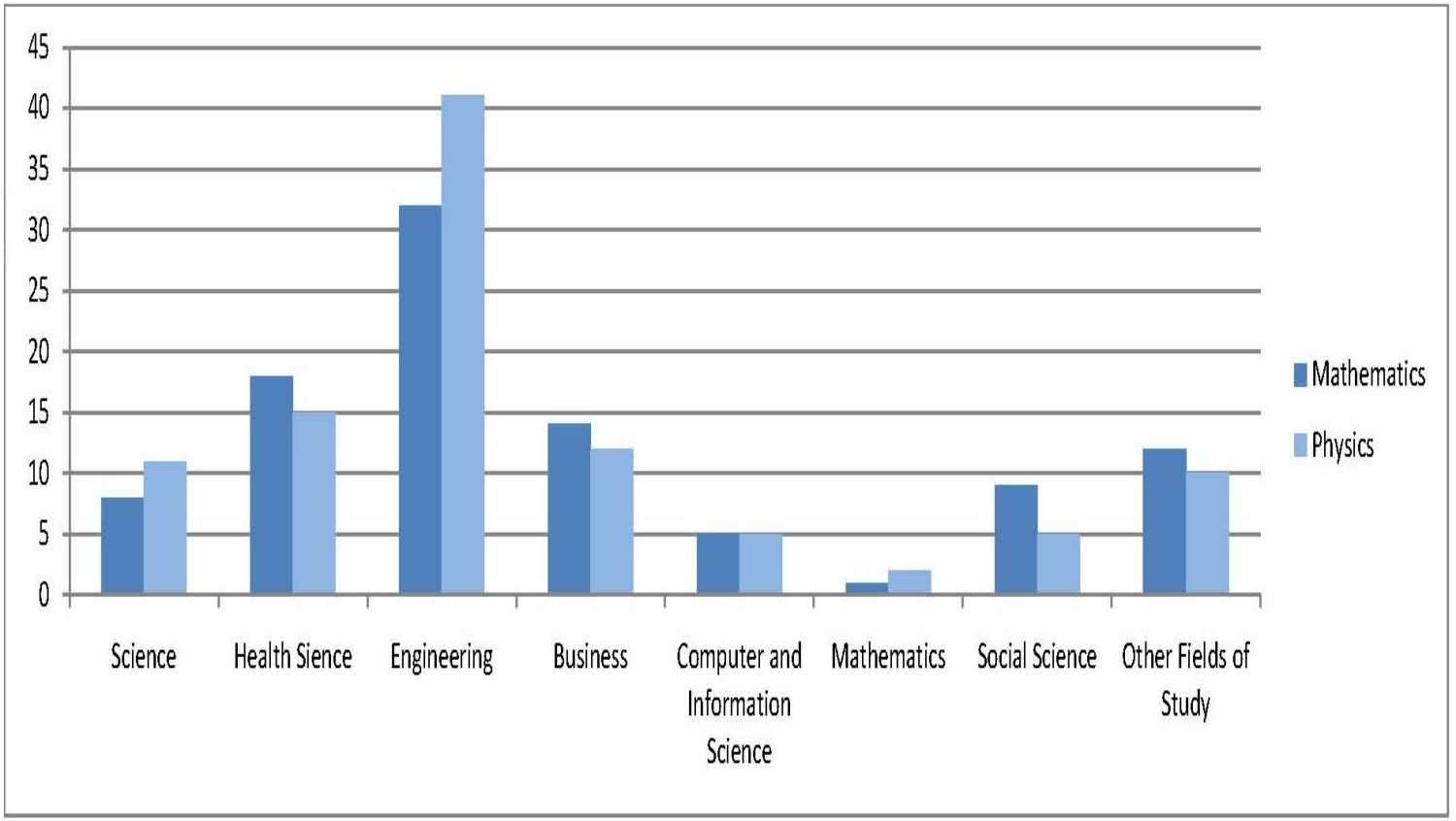
# Recruitment to mathematics (physics)

- reasons for choosing to specialise in mathematics and physics
- plans for further studies

# Percentages of students reporting that various reasons were "Very important" or "Important" for them in choosing 3MX

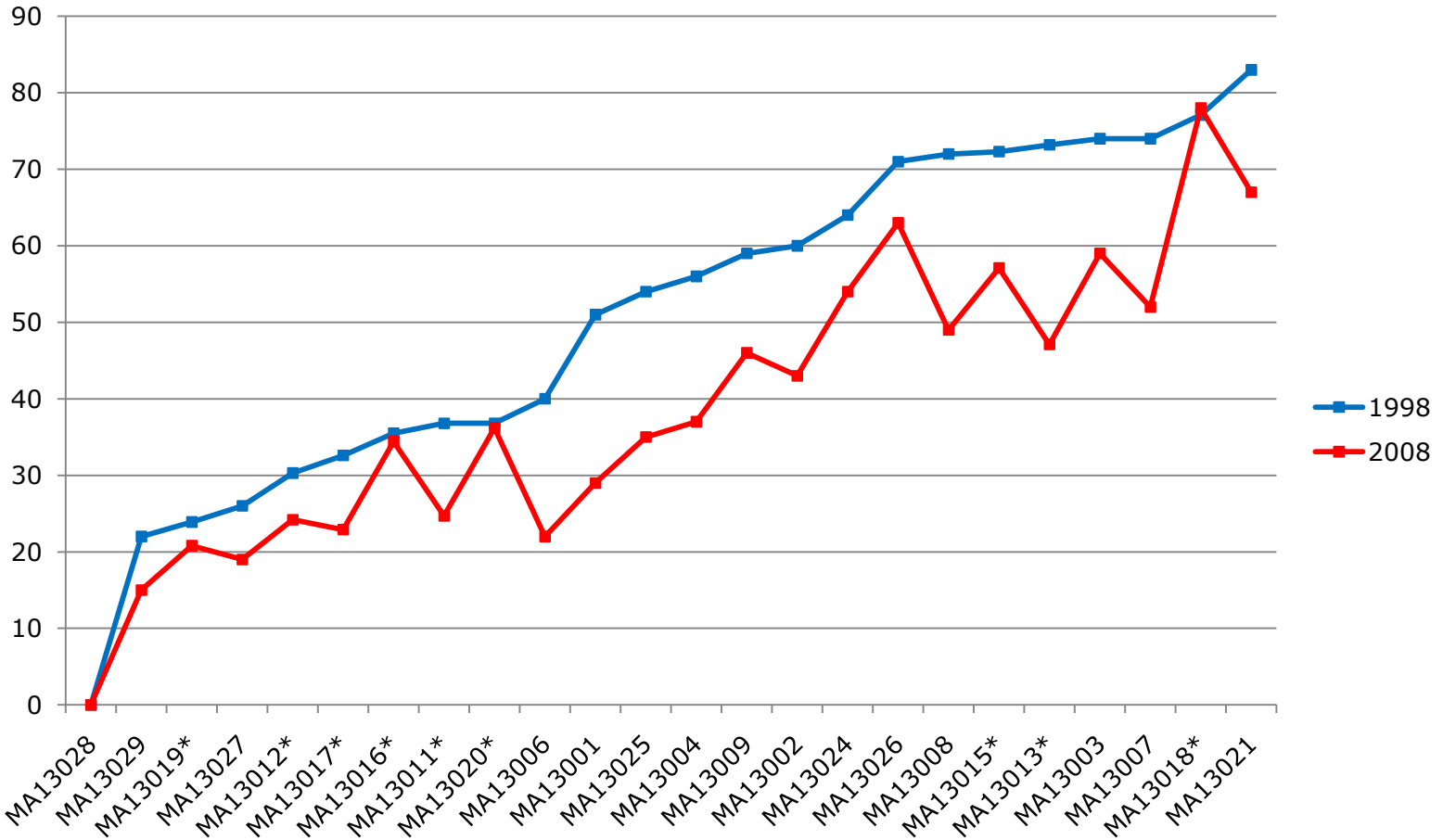


# *Percentages of students reporting on aspirations for further studies*




**Drop-out from studies is often caused by weak entrance knowledge in mathematics**

# Percentage of Norwegian 3MX students who answered correctly on identical problems in 1998 and 2008



# Item on differentiation

The derivative with respect to $x$ of $\frac{4}{\sqrt{3x-4}}$ is

Ⓐ $12\sqrt{3x-4}$

Ⓑ $\frac{4}{\sqrt{3}}$

Ⓒ $\frac{-2}{(3x-4)^{\frac{3}{2}}}$

Ⓓ $\frac{-6}{(3x-4)^{\frac{3}{2}}}$

Ⓔ $6\sqrt{3x-4}$

| | Norway | | Slovenia | Sweden | Netherlands | Italy | INT |
|---|---|---|---|---|---|---|---|
| | 1998 | 2008 | | | | | |
| A | 13 | 19 | 5 | 10 | 8 | 7 | 9 |
| B | 9 | 15 | 9 | 22 | 4 | 7 | 10 |
| C | 21 | 21 | 26 | 27 | 19 | 21 | 21 |
| D* | 40 | 22 | 36 | 27 | 55 | 42 | 44 |
| E | 9 | 10 | 13 | 8 | 10 | 9 | 8 |
| No response | 7 | 10 | 10 | 4 | 3 | 13 | 7 |



# Item in Algebra

Two mathematical models are proposed to predict the return $y$, in dollars, from the sale of $x$ thousand units of an article (where $0 < x < 5$). Each of these models, P and Q, is based on different marketing methods.

model P: $y = 6x - x^2$
model Q: $y = 2x$

For what values of $x$ does model Q predict a greater return than model P?

(A) $0 < x < 4$

(B) $0 < x < 5$

(C) $3 < x < 5$

(D) $3 < x < 4$

(E) $4 < x < 5$

# Algebra item – results

| | Norway | | Slovenia | Sweden | Netherlands | Italy | INT |
|---|---|---|---|---|---|---|---|
| | 1998 | 2008 | | | | | |
| A | 14 | 11 | 19 | 8 | 15 | 17 | 15 |
| B | 4 | 7 | 5 | 8 | 2 | 9 | 7 |
| C | 3 | 10 | 8 | 12 | 2 | 10 | 10 |
| D | 2 | 6 | 6 | 7 | 1 | 6 | 6 |
| E* | 74 | 59 | 53 | 55 | 78 | 40 | 51 |
| No response | 1 | 7 | 8 | 9 | 2 | 19 | 11 |

# Item in Geometry

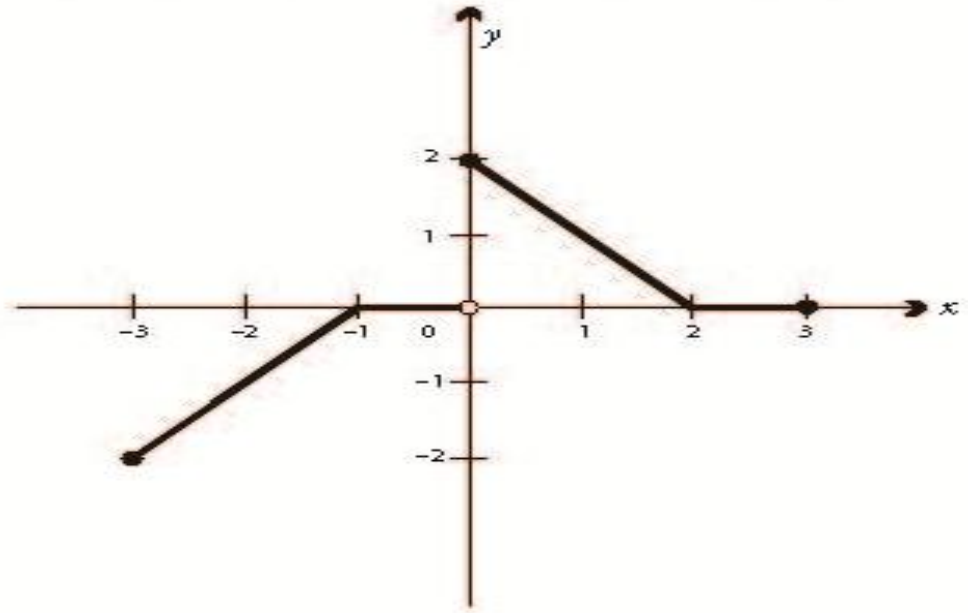
How many solutions does the equation $\sin x + \cos x = 2$ have in the interval 0 to $8\pi$?

(A) 0
(B) 2
(C) 4
(D) 8

| | **Norway** | Slovenia | Sweden | Netherlands | Italy | INT |
|---|---|---|---|---|---|---|
| A* | 33 | 28 | 45 | 87 | 44 | 46 |
| B | 7 | 17 | 12 | 2 | 13 | 11 |
| C | 34 | 35 | 28 | 7 | 21 | 24 |
| D | 23 | 11 | 12 | 4 | 10 | 12 |
| No response | 4 | 10 | 3 | 1 | 13 | 8 |

# Item in Calculus

The function $y = f(x), -3 \le x \le 3$, is defined in the following graph




A. For what value(s) of $x$ in the interval $-3 < x < 3$ is the function $f$ NOT continuous?

| A) | Norway | | Slovenia | Sweden | Netherlands | Italy | INT |
|---|---|---|---|---|---|---|---|
| | 1998 | 2008 | | | | | |
| Correct answer: only for $x = 0$ | 54 | 35 | 58 | 23 | 37 | 52 | 46 |
| Wrong answer | 27 | 36 | 27 | 52 | 56 | 20 | 34 |
| No response | 19 | 29 | 15 | 26 | 7 | 28 | 20 |

# Algebra Grade 8

Joe knows that a pen costs 1 zed more than a pencil.
His friend bought 2 pens and 3 pencils for 17 zeds.
How many zeds will Joe need to buy 1 pen and 2 pencils?

Show your work.

| | |
|---|---|
| **Australia** | **36** |
| **Italy** | **19** |
| **Japan** | **42** |
| **Norway** | **18** |
| **Slovenia** | **30** |
| **Int. Avg.** | **18** |

May be solved without formal knowledge in algebra –
Advanced benchmark level

# Algebra Grade 8

In Zedland, total shipping charges to ship an item are given by the equation $y = 4x + 30$, where $x$ is the weight in grams and $y$ is the cost in zeds. If you have 150 zeds, how many grams can you ship?

(A) 630

(B) 150

(C) 120

(D) 30

| | |
|---|---|
| **Australia** | **26** |
| **Italy** | **24** |
| **Japan** | **65** |
| **Norway** | **10** |
| **Slovenia** | **37** |
| **Int. Avg.** | **34** |

Requires some formal competence in algebra – High benchmark level

# Number Grade 4

Multiply:

$53 \times 26$

Answer: _____

| | |
|---|---|
| **Australia** | **9** |
| **Italy** | **64** |
| **Japan** | **67** |
| **Norway** | **2** |
| **Slovenia** | **12** |
| **Int. Avg.** | **41** |

Numerical skill: algorithm for multiplication

# Number Grade 4

$$\begin{array}{r} 942 \\ -5\blacksquare7 \\ \hline 415 \end{array}$$

Mano did the subtraction problem above for homework but spilled some of his drink on it. One digit could not be read. His answer of 415 was correct. What is the missing digit?

Answer: _____

| | |
|---|---|
| **Australia** | **22** |
| **Italy** | **49** |
| **Japan** | **80** |
| **Norway** | **18** |
| **Slovenia** | **32** |
| **Int. Avg.** | **42** |

Requires algorithm for subtraction – reasoning

# Number Grade 4

Al wanted to find how much his cat weighed. He weighed himself and noted that the scale read 57 kg. He then stepped on the scale holding his cat and found that it read 62 kg.

What was the weight of the cat in kilograms?

Answer: _____ kilograms

| | |
|---|---|
| Australia | 61 |
| Italy | 69 |
| Japan | 83 |
| Norway | 67 |
| Slovenia | 69 |
| Int. Avg. | 60 |

Requires no formal algorithm –
can be solved by reasoning and counting

# Possible reasons for the decline?

- The decline in performance in both mathematics and physics seems to be related to lack of basic skills in mathematics.
- This regards skills in arithmetic, in algebra, and in the basics of calculus.
- Mathematics is both a subject in its own right, and a tool for other subjects.

# Mathematics as an important tool in ...

- Mathematics is an important tool in daily life – YES

  AND

- Mathematics is an important tool in subjects and professions as physics, biology, economy, computer science, engineering...

# Basic mathematical skills (a concept with progression)

- In primary school, the multiplication table and basic number calculations
- In lower se[illegible]y school, also skills in algebra, like manipulat[illegible]h symbols and equations
- In upper secondary sc[illegible]lso skills in differentiation, limits and [illegible]ulation with more complex algebraic expressio[illegible]
- In university, also calculations with complex numbers and matrices

Maintenance of skills

# Measures taken at system level: curriculum, exams, frames

- New national curriculum (K06)
- Exams
  - Two parts (with/without aids)
  - Testing topics from lower levels?
- Testing
  - Basic arithmetical skills
  - What about basic mathematical skills (algebra, differentiation, …)??

# What other measures/initiatives are needed?

It is all about educating our future experts:

- with sufficient competence
- in sufficient numbers

**We turned the trend of decline in TIMSS in lower grades from 2003 to 2007.**

**Now we must turn the trend in upper secondary and work for an increase in achievement in mathematics at all levels in school!**

# Look to Scandinavia?

Yes –

**BUT the importance of teachers giving lectures – summarising and focusing on learning goals has been underestimated in countries like Norway and Sweden**

**SO PLEASE DO NOT COPY THAT!**



# Look to Scandinavia?

Yes –

**BUT the importance of pure mathematics has been underestimated in countries like Norway and Sweden**

**SO PLEASE DO NOT COPY THAT!**



# Look to Scandinavia?

Yes –

**BUT the importance of students background seem to be more important in the latest TIMSS studies than it was in the mid 1990ties.**

**When to much responsibility has been taken from the teachers and given to the students – it is the students with little support at home who suffer the most!**



# Thank you for your attention!