PISA 2012
Scientific Literacy

Performance of Hong Kong Students

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Outline

- Assessment framework of PISA 2012
- Findings of PISA 2012
- Sample questions
- Reflections

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Scientific Literacy Defined in PISA

- scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
- understanding of the characteristic features of science as a form of human knowledge and enquiry
- awareness of how science and technology shape our material, intellectual and cultural environments
- willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen

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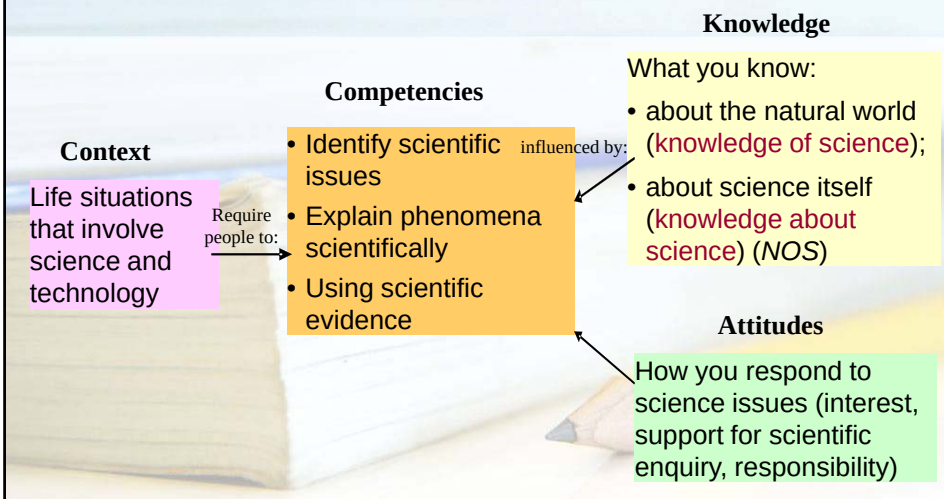
Framework



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Competencies

Explaining phenomena scientifically

- Applying knowledge of science in a given situation
- Describing or interpreting phenomena scientifically and predicting changes
- Identifying appropriate descriptions, explanations and predictions

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Competencies

Identifying scientific issues:

- Recognising issues that are possible to investigate scientifically
- Identifying keywords to search for scientific information
- Recognising the key features of a scientific investigation

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Competencies

Using scientific evidence

- Interpreting scientific evidence and making and communicating conclusions
- Identifying the assumptions, evidence and reasoning behind conclusions
- Reflecting on the societal implications of science and technological development

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Knowledge of/about science

Knowledge of science

- knowledge about the natural world
- understanding fundamental scientific concepts and theories

Knowledge about science

- knowledge about science itself
- understanding the nature of science as a human activity and the power and limitations of scientific knowledge

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Framework

Knowledge

What you know:

- about the natural world (knowledge of science);
- about science itself (knowledge about science) (*NOS*)

Competencies

- Identify scientific issues
- Explain phenomena scientifically
- Using scientific evidence

influenced by:

Context

Life situations that involve science and technology

Require people to:

Attitudes

How you respond to science issues (interest, support for scientific enquiry, responsibility)

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Distribution of science items by competency in PISA 2012

	Closed items	Open items	Total	% of items
Explaining phenomena scientifically	16	6	22	41.5
Identifying scientific issues	10	3	13	24.5
Using scientific evidence	10	8	18	34.0
Overall	36	17	53	100

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	Number of items	% of items
Nature of knowledge		
- Knowledge of science	26	49.1
- Knowledge about science	27	50.9
Knowledge systems		
- Earth and space systems	7	26.9
- Living systems	9	34.6
- Physical systems	6	23.1
- Technology systems	4	15.4

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酸雨

以下是超過2500年前、建造於雅典衛城名爲女像柱的雕像照片。這些雕像是用一種名爲大理石的岩石製造。大理石是由碳酸鈣組成。

在1980年，原始的雕像被遷移到衛城博物館內，並由複製品取代。原始的雕像受到酸雨的侵蝕。

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酸雨 – Qu(1)

正常的雨水略帶酸性，因爲它已經從空氣中吸收了一些二氧化碳。酸雨比正常的雨水更酸，因爲它已經同時吸收如硫氧化物和氮氧化物之類的氣體。

空氣中的硫氧化物和氮氧化物是從哪裡來的？

- Explaining Phenomena Scientifically
- Knowledge of science
- Physical systems

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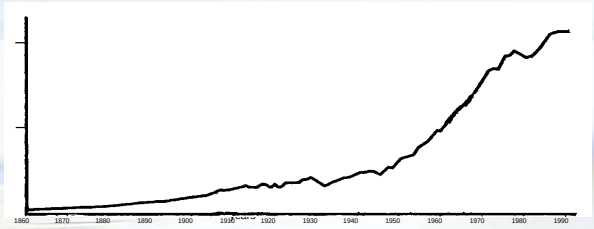
Answers

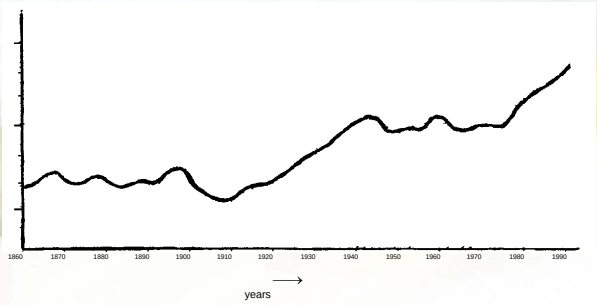
- 汽車廢氣、工廠排放、*燃燒*石油和煤等化石燃料、火山的氣體或其它類似的東西。
- 燃燒煤和天然氣。
- 空氣中的氧化物是從工業和工廠的污染而來的。
- 火山。
- 發電廠排放的廢氣（*「發電廠」一詞視爲包括了以化石燃料發電的發電廠*）。
- 它們來自燃燒含硫和氮的物料。

Greenhouse (Q1)

Carbon dioxide emission (thousand millions of tonnes per year)



Average temperature of the Earth's atmosphere (°C)



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André concludes from these two graphs that it is certain that the increase in the average temperature of the Earth's atmosphere is due to the increase in the carbon dioxide emission.

What is it about the graphs that supports André's conclusion?

Using scientific evidence
Knowledge about science

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Which of the following is/are correct answers?

1. As the emissions increased, the temperature increased.
2. Both graphs are increasing.
3. Temperature is rising as CO2 is emitted.
4. The information lines on the graphs rise together.
5. Everything is increasing.
6. The more CO2 emission, the higher the temperature.
7. The amount of CO2 and average temperature of the Earth is directly proportional.
8. They have a similar shape indicating a relationship.

Why are they wrong?

- The temperature has gone up.
- CO_2 is increasing.
- It shows the dramatic change in the temperatures.

Reasoning of causality

Does X cause Y?

Does X change/ correlate/ covariate/ associate with Y?

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Other kind of wrong answers

- The carbon dioxide emission (graph 1) has an effect on the earth's rising temperature (graph 2).
- The carbon dioxide is the main cause of the increase in the earth's temperature.

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Evidence → Conclusion

- Evidence in science is empirical observations (經驗的觀察)
- A conclusion is an inference (推論) based on evidence (証據)

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Distinguish between...

Hypothesis		Evidence
Conclusion	support	Observations
Generalizations	←	Data
Theory		Results
Laws		(Empirical observations)
(Inferences)		

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How our students performed?

Code	Hong Kong (%)
12	8.4
11	67.5
02	12.1
01	6.9
99	5.0

mix up conclusion and evidence

lack concept of covariation to support causation

% Correct					
Hong Kong					OECD
F.4	F.1-F.3	Girls	Boys	Overall	
79.2	69.9	75.0	76.9	76.0	54.3

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Question 2: GREENHOUSE

Another student, Jeanne, disagrees with André's conclusion. She compares the two graphs and says that some parts of the graphs do not support his conclusion.

Give an example of a part of the graphs that does not support André's conclusion. Explain your answer.

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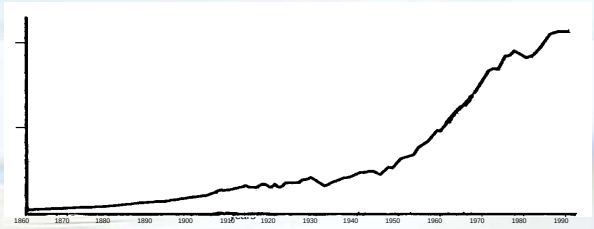
Greenhouse (Q1)

Carbon dioxide emission (thousand millions of tonnes per year)



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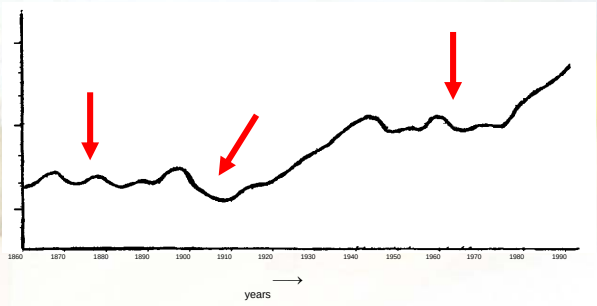

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Correct answers

- In 1900–1910 (about) CO2 was increasing, whilst the temperature was going down.
- In 1980–1983 carbon dioxide went down and the temperature rose.
- The temperature in the 1800's is much the same but the first graph keeps climbing.
- Between 1950 and 1980 the temperature didn't increase but the CO2 did.
- From 1940 until 1975 the temperature stays about the same but the carbon dioxide emission shows a sharp rise.
- In 1940 the temperature is a lot higher than in 1920 and they have similar carbon dioxide emissions.

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Wrong answers

- Most wrong answers are incomplete or not specific enough
- But some compare absolute values rather than changes in values – lack concept of covariation:

"Earlier there was little emission but nevertheless high temperature."

" Because at the start the temperature is still high where the carbon dioxide was very low."

- .

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How our students performed?

Code	Hong Kong (%)
2	40.3
1	26.3
0	22.8
9	10.6

% Correct					
Hong Kong					OECD
F.4	F.1-F.3	Girls	Boys	Overall	
59.7	42.0	52.2	54.8	53.5	34.9

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What is being assessed?

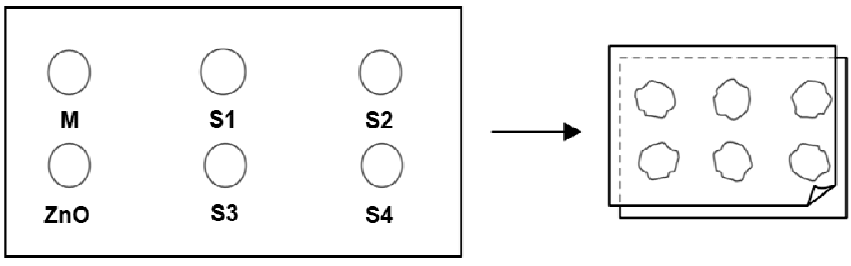
- Evidence vs Conclusion
- Correlation as a criterion for causation
- Evidence can support or not support a conclusion

→conclusion is not certain and straightforward

→science is tentative and involves judgment and arguments...

Sunscreens (Q9)

Dean placed a drop of each substance inside a circle marked on one sheet of plastic, then put the second plastic sheet over the top. He placed a large book on top of both sheets and pressed down.



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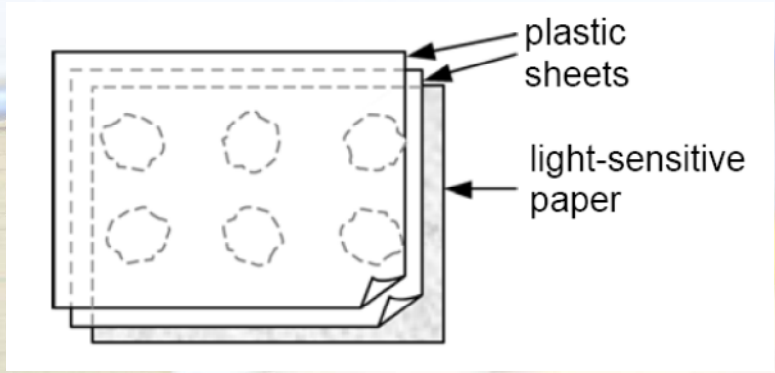
Mimi then put the plastic sheets on top of the sheet of light-sensitive paper. Light-sensitive paper changes from dark grey to white (or very light grey), depending on how long it is exposed to sunlight. Finally, Dean placed the sheets in a sunny place.



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Sunscreen (Q9)

Identifying scientific issues

Knowledge about science

Which one of these statements is a scientific description of the role of the mineral oil and the zinc oxide in comparing the effectiveness of the sunscreens?

A. Mineral oil and zinc oxide are both factors being tested. 15.7%

B. Mineral oil is a factor being tested and zinc oxide is a reference substance. 16.7%

C. Mineral oil is a reference substance and zinc oxide is a factor being tested. 19.9%

D. Mineral oil and zinc oxide are both reference substances. 46%

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Sunscreen (Q9)

% Correct					
Hong Kong					OECD
F.4	F.1-F.3	Girls	Boys	Overall	
52.0	35.2	48.5	43.3	46.0	40.4

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Concept of controlled experiment

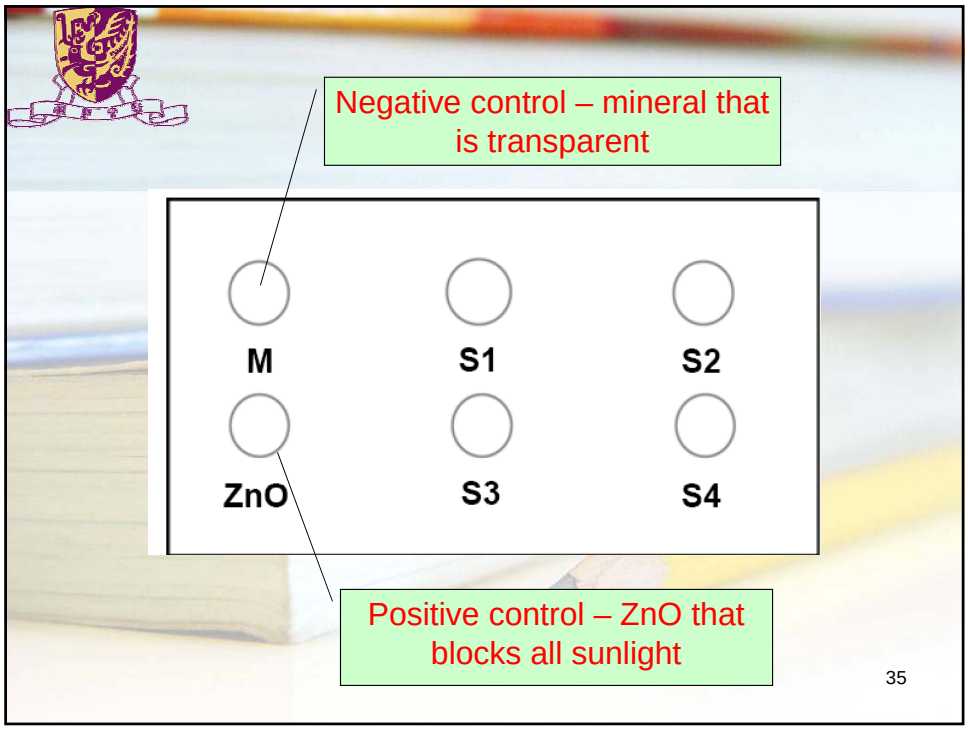
Experimental
Independent variable (IV) to be tested → results

Control
IV absent, everything else being the "same" → results

results → Effects of IV

IV → factor to be tested

Control → reference


Negative control – mineral that is transparent
M
S1
S2
ZnO
S3
S4
Positive control – ZnO that blocks all sunlight
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Our performances
in
PISA 2012

Mean Performance in scientific literacy of participating countries/regions in PISA 2012

Country/Region	Mean	S.E.	Significance
Shanghai-China	580	(3.0)	▲
Hong Kong-China	**555**	**(2.6)**	--
Singapore	551	(1.5)	O
Japan	547	(3.6)	O
Finland	545	(2.2)	▼
Estonia	541	(1.9)	▼
Korea	538	(3.7)	▼
Vietnam	528	(4.3)	▼
Poland	526	(3.1)	▼
Canada	525	(1.9)	▼
Liechtenstein	525	(3.5)	▼
Germany	524	(3.0)	▼
Chinese Taipei	523	(2.3)	▼

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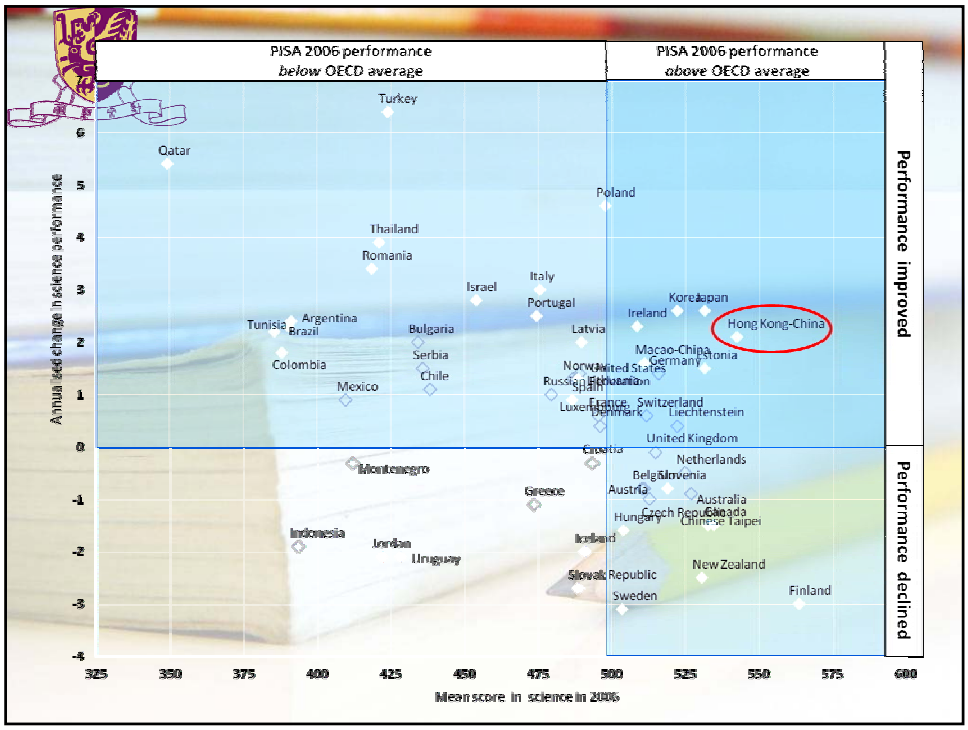
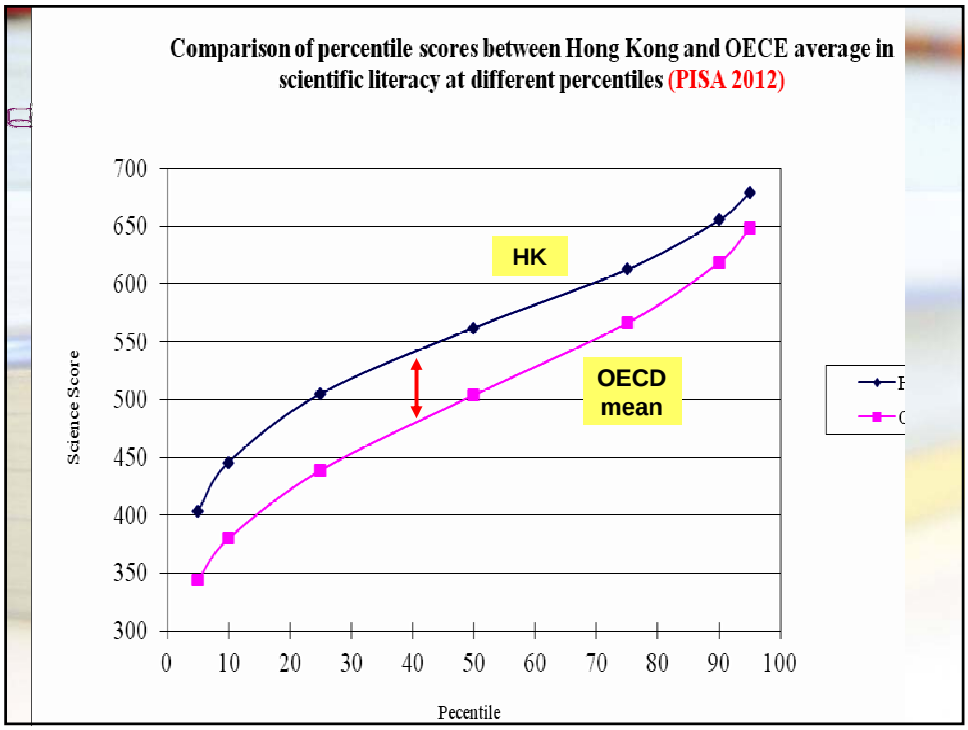
Ranks and Mean Scores in Scientific Literacy of Top Ranking Countries in the Five Cycles of PISA

Country/Region	PISA 2012	PISA 2009	PISA 2006	PISA 2003	PISA 2000+
Shanghai-China	1 (580)	1 (575)	-	-	-
Hong Kong	**2 (555)**	**3 (549)**	**2 (542)**	**3 (539)**	**3 (541)**
Singapore	3 (551)	4 (542)	-	-	-
Japan	4 (547)	5 (539)	6 (531)	2 (548)	2 (550)
Finland	5 (545)	2 (554)	1 (563)	1 (548)	4 (538)
Estonia	6 (541)	9 (528)	5 (531)	-	-
Korea	7 (538)	6 (538)	11 (522)	4 (538)	1 (552)
Vietnam	8 (528)	-	-	-	-
Poland	9 (526)	19 (508)	23 (498)	19 (498)	22 (483)
Canada	10 (525)	8 (529)	3 (534)	11 (519)	6 (529)
Chinese Taipei	13 (523)	12 (520)	4 (532)	-	-
Macao-China	17 (521)	18 (511)	17 (511)	7 (525)	-


PISA 2006 performance
below OECD average
PISA 2006 performance
above OECD average
Performance improved
Performance declined
Annual rate of change in science performance
Mean score in science in 2006
Turkey
Qatar
Poland
Thailand
Romania
Israel
Italy
Portugal
Korea
Japan
Ireland
Hong Kong-China
Tunisia
Argentina
Brazil
Bulgaria
Latvia
Macao-China
Germany
Colombia
Serbia
Chile
Mexico
Switzerland
Liechtenstein
United Kingdom
Netherlands
Montenegro
Greece
Austria
Australia
Canada
Indonesia
Uruguay
New Zealand
Slovak Republic
Sweden
Finland


Comparison of percentile scores between Hong Kong and OECE average in scientific literacy at different percentiles (PISA 2012)
HK
OECD mean
Science Score
Pecentile

Comparison of Proportion of Students at Each Proficiency Level between Hong Kong and OECD countries

Proficiency Level	Hong Kong (%)	OECD (%)	Difference (%) (HK - OECD)
6	1.8	1.2	0.7
5	14.9	7.2	7.6 ***
Levels 5 and 6	16.7	8.4	
4	34.9	20.5	14.4 ***
3	29.8	28.8	1.0
2	13.0	24.5	-11.5 ***
Levels 2 and above	94.4	82.2	
1	4.4	13.0	-8.6 ***
Below 1	1.2	4.8	-3.6 ***

*** Difference is significant at the 0.001 level.

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Top performers of HK as compared to other top performing countries in 2012

Country / Region	Level 5 & 6		Level 5		Level 6		
	%	S.E.	%	S.E.	%	S.E.	Rank
Shanghai-China	27.2	(1.3)	23.0	(1.1)	4.2	(0.6)	1
Singapore	22.7	(0.8)	16.9	(0.9)	5.8	(0.4)	3
Japan	18.2	(1.2)	14.8	(0.9)	3.4	(0.5)	4
Finland	17.1	(0.7)	13.9	(0.6)	3.2	(0.4)	5
Hong Kong-China	**16.7**	**(1.0)**	**14.9**	**(0.9)**	**1.8**	**(0.4)**	**2**
Australia	13.6	(0.5)	10.9	(0.5)	2.6	(0.3)	16
New Zealand	13.4	(0.7)	10.7	(0.6)	2.7	(0.3)	18
Estonia	12.8	(0.7)	11.1	(0.7)	1.7	(0.3)	6
Korea	11.7	(1.1)	10.6	(0.9)	1.1	(0.4)	7

As compared to other top performing countries, Hong Kong has less proportion of top performing students.

Trends of scientific literacy performance

- PISA 2006, 2009 and 2012 share the same science assessment framework
- A brief trend could be shown by comparing the performance in 2012 with that in 2009 and in 2006.
- When comparing the performance on the common items, Hong Kong students have seen a continued improvement of performance over the three cycles of assessment. This continued improvement has kept Hong Kong top in PISA.
- Low achievers improved significantly from 2006 to 2012.

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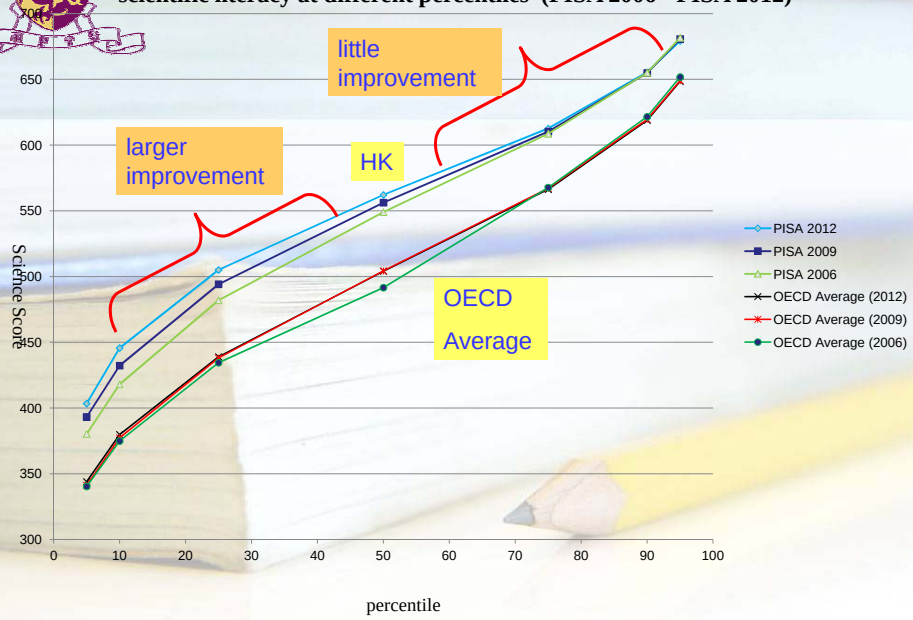
How the percentile scores changed from 2006 to 2012

Percentile	PISA 2012		PISA 2006		Difference in Scores (2012 - 2006)	
	Score	S.E.	Score	S.E.		
5	403	(7.1)	380	(6.2)	23	*
10	446	(5.1)	418	(6.1)	28	***
25	505	(3.8)	482	(3.6)	23	***
50	562	(2.8)	549	(2.8)	13	***
75	613	(3.0)	609	(2.8)	4	
90	655	(3.4)	655	(3.5)	0	
95	679	(3.4)	682	(3.1)	-2	

5th to 50th percentiles improved significantly from 2006 to 2012.

Comparison of percentile scores between Hong Kong and OECE average in scientific literacy at different percentiles (PISA 2006 - PISA 2012)



Proportion of Hong Kong students at each level of science proficiency in PISA 2006, PISA 2009 and PISA 2012

Proficiency Level	PISA 2012 (%)	PISA 2009 (%)	PISA 2006 (%)	Difference (2012 - 2009)		Difference (2012 - 2006)	
6	1.8	2.0	2.1	-0.2		-0.3	
5	14.9	14.2	13.9	0.7		1.0	
4	34.9	32.7	29.7	2.2		5.2	***
3	29.8	29.4	28.7	0.5		1.1	
2	13.0	15.1	16.9	-2.1	*	-3.9	***
1	4.4	5.2	7.0	-0.8		-2.6	**
Below 1	1.2	1.4	1.7	-0.2		-0.5	

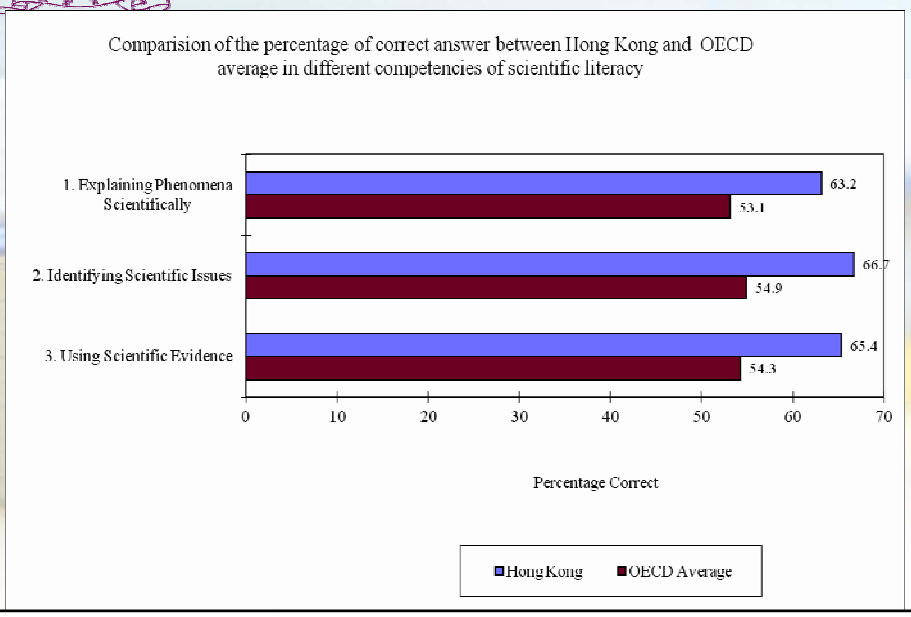
The improved performance of HK mainly comes from the the average and below average students

Comparison of Proportion of Students at Level 5 and Level 6 between Hong Kong and Other Countries/Regions across different cycles

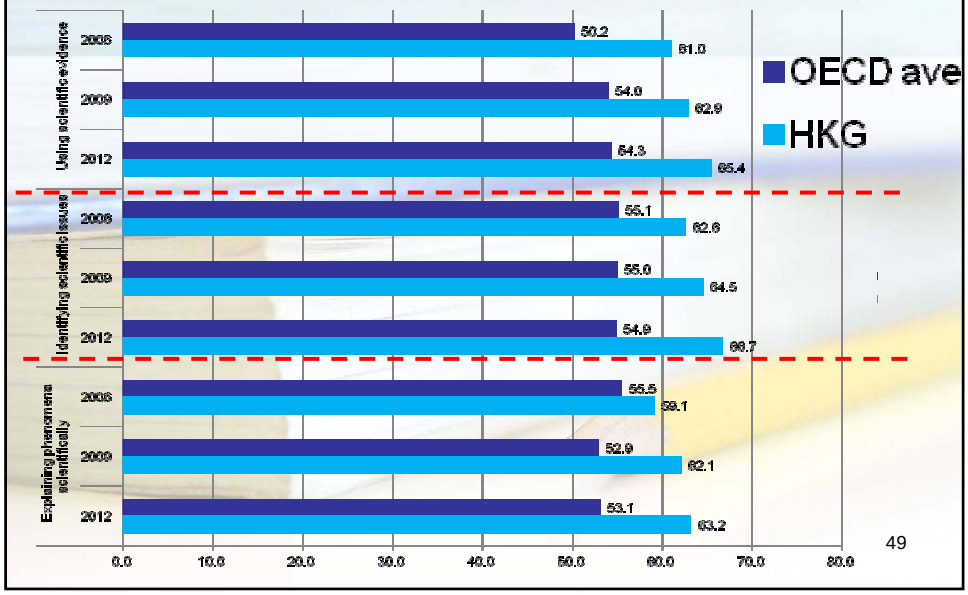
Country/Region	PISA 2006			PISA 2009			PISA 2012	
	Level 5 & 6		Diff. (2012 -2006)	Level 5 & 6		Diff. (2012 -2009)	Level 5 & 6	
	%	S.E.		%	S.E.		%	S.E.
Shanghai	-	-	- -	24.3	(1.2)	2.9	27.2	(1.3)
Singapore	-	-	- -	19.9	(0.6)	2.8 *	22.7	(0.8)
Japan	15.1	(0.8)	3.2	16.9	(0.9)	1.3	18.2	(1.2)
Finland	20.9	(0.8)	-3.9 **	18.7	(0.9)	-1.6	17.1	(0.7)
Hong Kong	15.9	(0.9)	0.8	16.2	(1.0)	0.5	16.7	(1.0)
Australia	14.6	(0.7)	-1.1	14.5	(0.8)	-1.0	13.6	(0.5)
New Zealand	17.6	(0.8)	-4.2 **	17.6	(0.8)	-4.3 ***	13.4	(0.7)
Estonia	11.5	(0.8)	1.3	10.4	(0.8)	2.4 *	12.8	(0.7)
Korea	10.3	(1.1)	1.4	11.6	(1.1)	0.1	11.7	(1.1)

Improvement in top performers is also possible in some top performing countries.

Performance in different competencies



Performance in different competencies over the 3 cycles



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Performance of different kinds of knowledge and competencies in the 3 cycles

Types of knowledge	PISA 2012		PISA 2009		PISA 2006	
	Hong Kong (%)	OECD Avg. (%)	Hong Kong (%)	OECD Avg. (%)	Hong Kong (%)	OECD Avg. (%)
Knowledge of science	64.7	54.8	63.2	54.5	59.9	52.1
Earth and space systems	61.9	55.8	61.1	55.9	55.6	51.4
Living systems	59.9	46.4	58.7	45.9	55.9	46.5
Physical systems	69.5	60.2	68.6	59.9	66.0	57.5
Technology systems	73.2	63.7	68.8	63.2	65.9	59.7
Knowledge about science	64.9	53.2	62.8	53.1	57.7	50.2
Scientific enquiry	64.2	53.1	62.1	53.1	57.0	51.9
Scientific explanations	65.6	53.3	63.5	53.1	58.4	48.1

Any Gender differences ?

No significant difference in overall scores between boys and girls.

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Percentile	Girls		Boys		Differences (Girls - Boys)
	Score	S.E.	Score	S.E.	
5th	409	(8.7)	398	(8.5)	11
10th	448	(5.8)	442	(6.8)	5
25th	505	(4.8)	505	(4.9)	-1
50th	558	(3.4)	567	(4.1)	-9
75th	605	(3.4)	619	(3.9)	-13 *
90th	647	(4.4)	662	(4.5)	-14 *
95th	669	(4.7)	688	(5.3)	-19 **
Whole Population	551	(3.1)	558	(3.6)	-7

* Score difference is significant at the 0.05 level.
** Score difference is significant at the 0.01 level.

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	Below Level 1		Level 1		Level 2		Level 3		Level 4		Level 5		Level 6	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
Boys	1.3	0.3	4.7	0.7	12.9	0.9	27.6	1.5	34.6	1.5	16.4	1.2	2.5	0.6
Girls	1.1	0.4	4.0	0.6	13.2	1.1	32.5	1.5	35.3	1.3	13.1	1.2	1.0	0.3

Among the top performers, there are more boys than girls.

Competency	Boys		Girls		Difference (Boys – Girls)	
	% Correct	S.E.	% Correct	S.E.		
1. Explaining phenomena scientifically	64.8%	(0.807)	61.3%	(0.732)	3.4%	**
2. Identifying scientific issues	65.0%	(0.804)	66.0%	(0.794)	-1.0%	
3. Using scientific evidence	64.4%	(0.838)	63.3%	(0.910)	1.1%	
Knowledge of science						
Earth and space systems	64.6%	(0.988)	57.6%	(0.970)	7.0%	***
Living systems	60.0%	(1.049)	59.4%	(0.932)	0.5%	
Physical systems	73.0%	(1.019)	67.6%	(0.925)	5.4%	***
Technology systems	72.3%	(1.032)	73.5%	(1.048)	-1.2%	

** Difference is significant at 0.01 level.

Why are boys better in some areas?

- Some items may have contexts *that are* more related to the life experiences and interests of boys e.g. dinosaurs, fossils, energy sources and burning
- Some items call upon abilities for map reading and quantitative reasoning
- Teaching and learning process in classroom may favour boys.

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Findings and "Implications"

1. Hong Kong shows consistently top performance since 2000, with steady improvement since 2006.
2. Our education system can take care of students across all ability levels.
3. But, when compared with some other top countries, Hong Kong still has room for developing the potential of high ability students.
4. Students showed equally well performances in the three competencies, reflecting that our science education can achieve a good balance between scientific knowledge, scientific inquiry and nature of science.

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Findings and "Implications"

5. Significant gender gaps in favour of boys at 75, 90 and 95 percentiles in PISA 2012, which were largely absent in PISA 2009 and 2006.

   Teachers should be sensitive about the gender differences in their teaching and assessment, such as languages, contexts, spatial and quantitative reasoning.

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Some reflections of our performance

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New senior secondary system?

- 60% DSE S4 students in PISA 2012
- Effects of the new science curricula in DSE?
- Effects of less students taking all three science subjects? (~40% → ~5%)
- Effects of more students taking at least one science subject? (~40% → ~50%)

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- No correlations can be seen between PISA performances and curriculum reforms in HK.
- But the curriculum reforms at least have not affected our good performance!

What correlates with scores?

Classroom activities	Explain phenomena scientifically	Identify scientific issues	Use scientific evidence
Students are given opportunities to explain their ideas	+++	+	++
Students are asked to draw conclusions from an experiment they have conducted	+	++	
The teacher explains how a science idea can be applied to a number of different phenomena	++		
Students are allowed to design their own experiments	- for overall scores + for interest in science		

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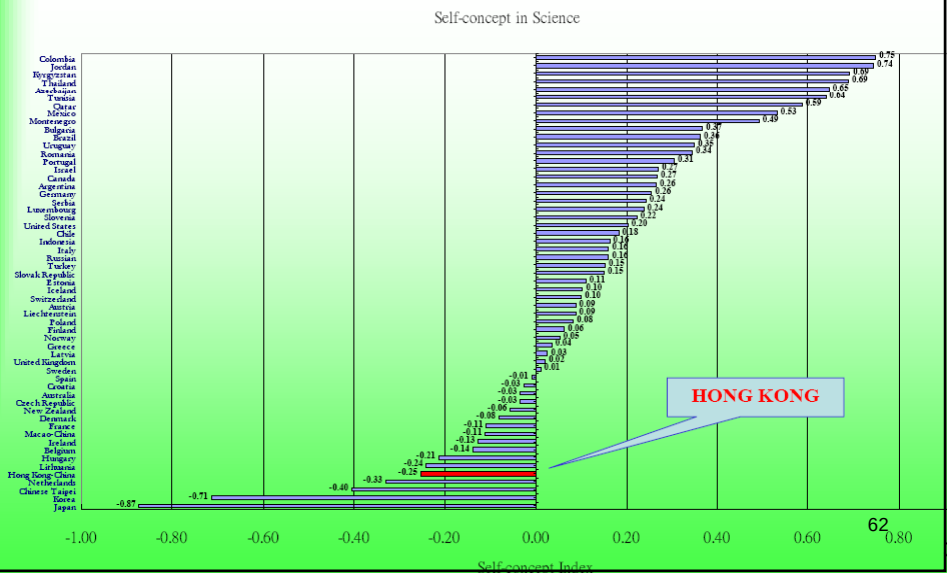
Possible Impact- Self-concept in Science



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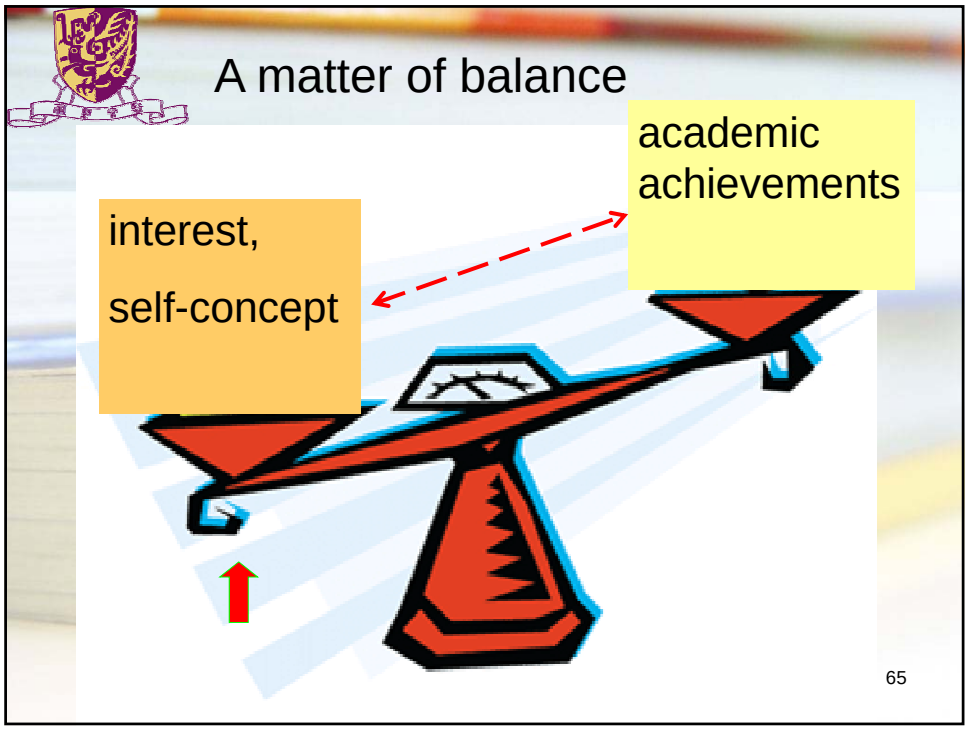
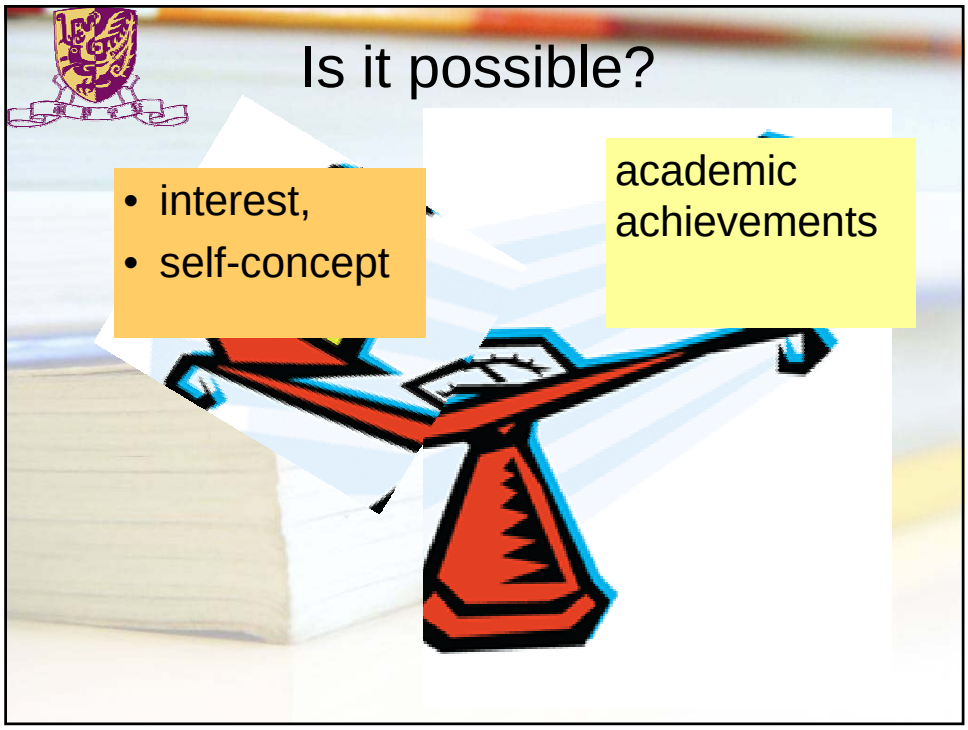
Self concept in science

- I can usually give good answers to test questions on school science topics. 38 (65)
- Learning advanced school science topics would be easy for me. 35 (47)
- School science topics are easy for me. 37(47)
- I learn school science topics quickly. 48 (56)
- I can easily understand new ideas in school science. 52 (55)

滿招損，謙受益!

小小苦楚等於激勵!

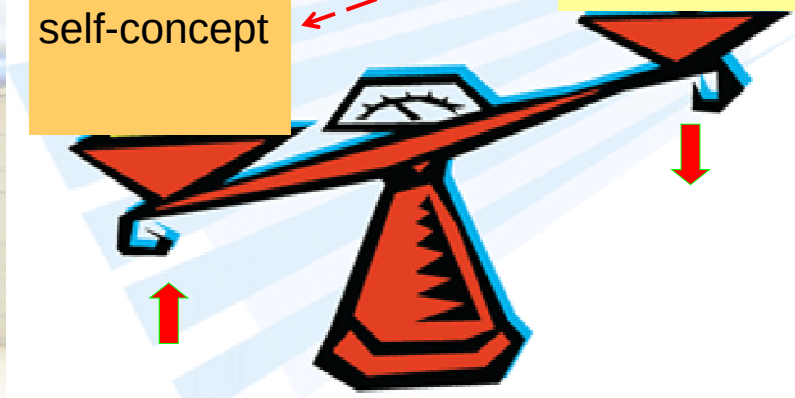

A matter of balance
academic achievements
interest,
self-concept
65


Is it possible?
• interest,
• self-concept
academic achievements

A matter of values

academic achievements

interest, self-concept



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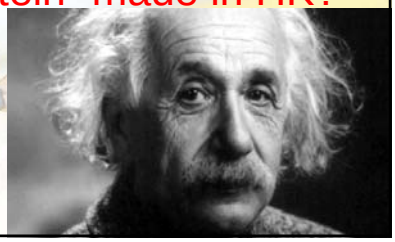
We are having the best 15-year-olds

Are we going to have the best 25-year-olds?

Are we going to have the best 35-year-olds?

Are we going to have “Einstein” made in HK?




Thank you!
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