# Science education in HK through the lens of PISA 2022

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... Around 690 000 students took the PISA assessment in 2022, representing about 29 million 15-year-olds from schools in 81 participating countries and economies.

| Sample (n=6,037) | | Weighted % |
|---|---|---|
| Gender | | |
| Female | 2832 | 46.8 |
| Male | 3075 | 53.2 |
| Grade | | |
| 7 (S1) | 32 | 0.6 |
| 8 (S2) | 215 | 4.1 |
| 9 (S3) | **1796** | **32.6** |
| 10 (S4) | **3826** | **61.7** |
| 11 (S5) | 38 | 1.0 |
| Immigrant Status | | |
| Native (HK) | 3190 | 60.5 |
| Second Generation | 1627 | 31.3 |
| First-Generation | 382 | 8.2 |

Stratified sampling of schools :

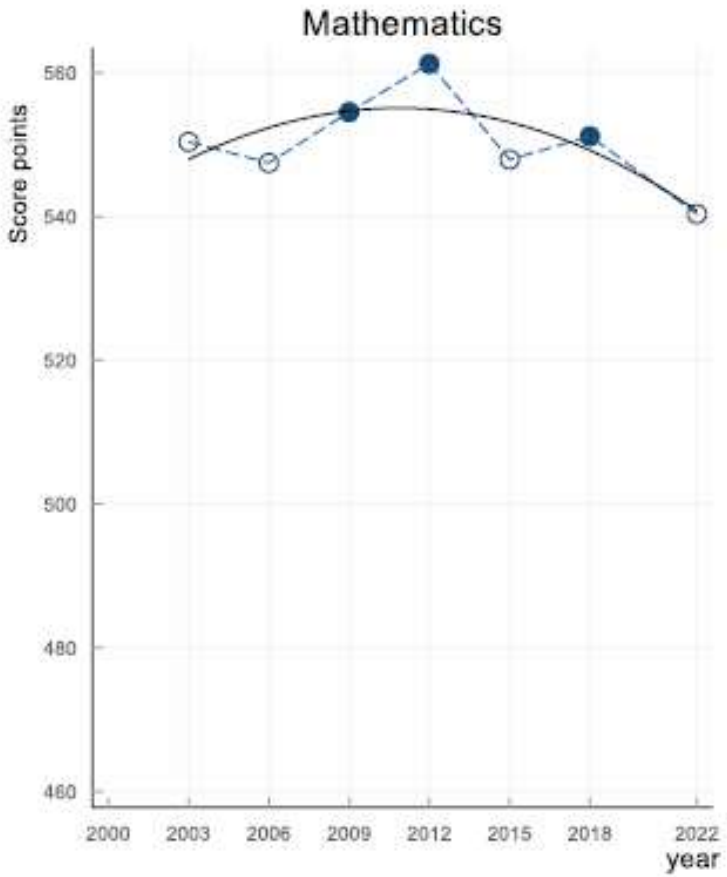
- Gender (Boys, Girls, Co-education)
- Academic Intake (High/medium/ low)
- Types of schools

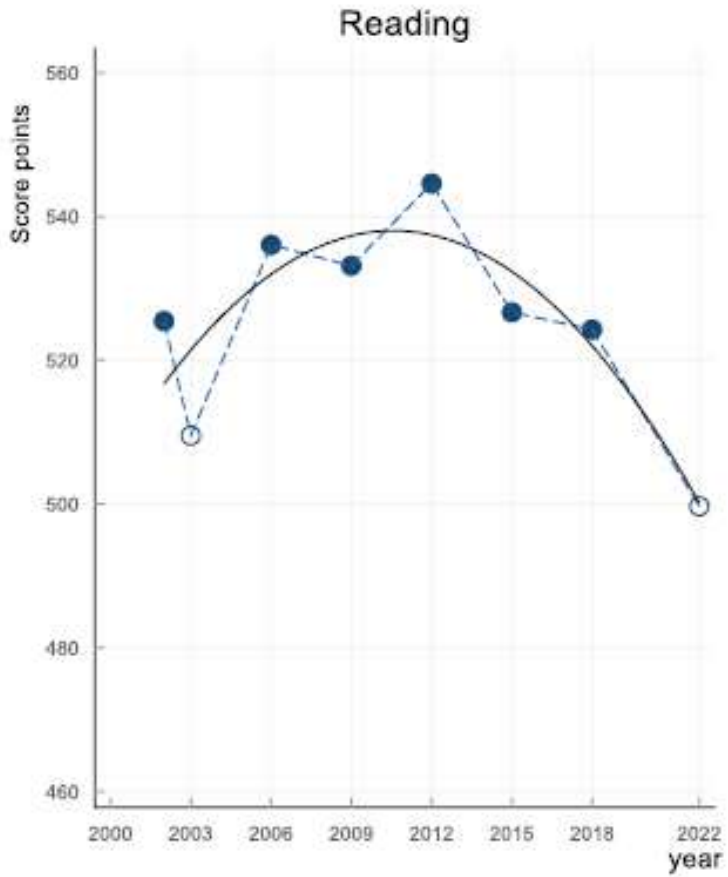
| Type | No of schools: |
|---|---|
| Government | 13 |
| Aided + CAPUT | 121 |
| DSS | 3 |
| Private and International | 26 |
| Total | 163 |

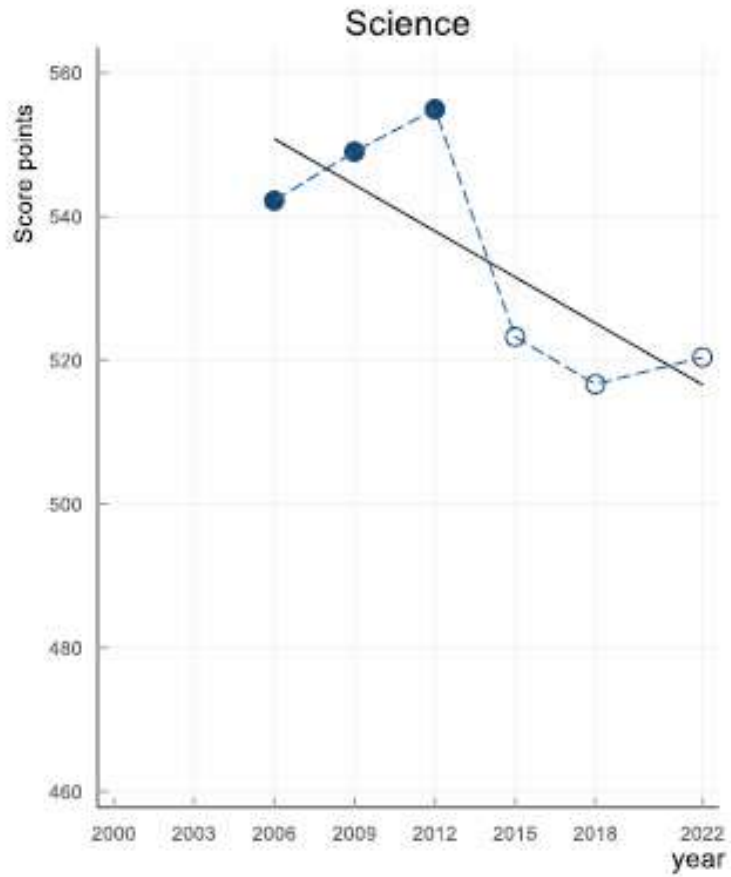
Sampling of 15-year-old students in the schools

| Mean score | Comparison country/economy | Countries and economies whose mean score is not statistically significantly different from the comparison country's/economy's score |
|---|---|---|
| 561 | Singapore | |
| 547 | Japan | *Macao (China)* |
| 543 | *Macao (China)* | Japan, *Chinese Taipei* |
| 537 | *Chinese Taipei* | *Macao (China)*, Korea |
| 528 | Korea | *Chinese Taipei*, Estonia, *Hong Kong (China)** |
| 526 | Estonia | Korea, *Hong Kong (China)** |
| 520 | *Hong Kong (China)** | Korea, Estonia, Canada* |
| 515 | Canada* | *Hong Kong (China)**, Finland |
| 511 | Finland | Canada*, Australia* |
| 507 | Australia* | Finland, New Zealand*, Ireland*, Switzerland, United States* |
| 504 | New Zealand* | Australia*, Ireland*, Switzerland, Slovenia, United Kingdom*, United States*, Poland |
| 504 | Ireland* | Australia*, New Zealand*, Switzerland, Slovenia, United Kingdom*, United States*, Poland, Czech Republic |
| 503 | Switzerland | Australia*, New Zealand*, Ireland*, Slovenia, United Kingdom*, United States*, Poland, Czech Republic |
| 500 | Slovenia | New Zealand*, Ireland*, Switzerland, United Kingdom*, United States*, Poland, Czech Republic |
| 500 | United Kingdom* | New Zealand*, Ireland*, Switzerland, Slovenia, United States*, Poland, Czech Republic, Latvia*, Denmark*, Sweden, Germany |
| 499 | United States* | Australia*, New Zealand*, Ireland*, Switzerland, Slovenia, United Kingdom*, Poland, Czech Republic, Latvia*, Denmark*, Sweden, Germany, Austria, Belgium, Netherlands* |
| 499 | Poland | New Zealand*, Ireland*, Switzerland, Slovenia, United Kingdom*, United States*, Czech Republic, Latvia*, Denmark*, Sweden, Germany |
| 498 | Czech Republic | Ireland*, Switzerland, Slovenia, United Kingdom*, United States*, Poland, Latvia*, Denmark*, Sweden, Germany, Austria |
| 494 | Latvia* | United Kingdom*, United States*, Poland, Czech Republic, Denmark*, Sweden, Germany, Austria, Belgium, Netherlands*, France |
| 494 | Denmark* | United Kingdom*, United States*, Poland, Czech Republic, Latvia*, Sweden, Germany, Austria, Belgium, Netherlands*, France |
| 494 | Sweden | United Kingdom*, United States*, Poland, Czech Republic, Latvia*, Denmark*, Germany, Austria, Belgium, Netherlands*, France |
| 492 | Germany | United Kingdom*, United States*, Poland, Czech Republic, Latvia*, Denmark*, Sweden, Austria, Belgium, Netherlands*, France, Hungary, Lithuania, Portugal |
| 491 | Austria | United States*, Czech Republic, Latvia*, Denmark*, Sweden, Germany, Belgium, Netherlands*, France, Hungary, Lithuania, Portugal |
| 491 | Belgium | United States*, Latvia*, Denmark*, Sweden, Germany, Austria, Netherlands*, France, Hungary, Lithuania, Portugal |

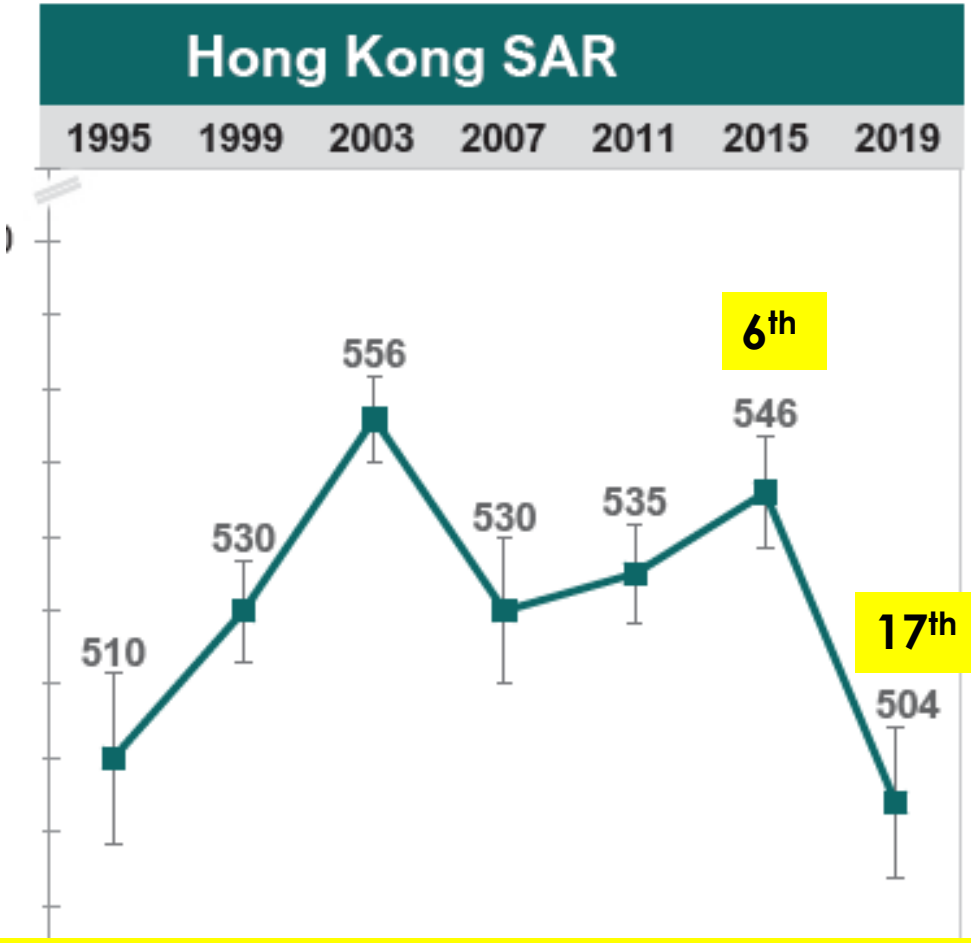
# Trends in mathematics, reading and science performance in Hong Kong (China)



# TIMSS 2019
# S2 Science




P4 science dropped from 5th to 15th

| | | | |
|---|---|---|---|
| 2 | Singapore | 608 (3.9) | ▲ |
| | Chinese Taipei | 574 (1.9) | ▲ |
| | Japan | 570 (2.1) | ▲ |
| | Korea, Rep. of | 561 (2.1) | ▲ |
| 2 | Russian Federation | 543 (4.2) | ▲ |
| | Finland | 543 (3.1) | ▲ |
| | Lithuania | 534 (3.0) | ▲ |
| | Hungary | 530 (2.6) | ▲ |
| | Australia | 528 (3.2) | ▲ |
| | Ireland | 523 (2.9) | ▲ |
| † | United States | 522 (4.7) | ▲ |
| 2 | Sweden | 521 (3.2) | ▲ |
| | Portugal | 519 (2.9) | ▲ |
| | England | 517 (4.8) | ▲ |
| | Turkey | 515 (3.7) | ▲ |
| 3 | Israel | 513 (4.2) | ▲ |
| † | Hong Kong SAR | 504 (5.2) | |
| | Italy | 500 (2.6) | |
| | **TIMSS Scale Centerpoint** | **500** | |
| † | New Zealand | 499 (3.5) | |
| † | Norway (9) | 495 (3.1) | |
| | France | 489 (2.7) | ▽ |
| | Bahrain | 486 (1.9) | ▽ |
| | Cyprus | 484 (1.9) | ▽ |
| 2 | Kazakhstan | 478 (3.1) | ▽ |
| | Qatar | 475 (4.4) | ▽ |
| | United Arab Emirates | 473 (2.2) | ▽ |
| | Romania | 470 (4.2) | ▽ |
| | Chile | 462 (2.9) | ▽ |
| | Malaysia | 460 (3.5) | ▽ |
| | Oman | 457 (2.9) | ▽ |
| | Jordan | 452 (4.7) | ▽ |

## Proportion of Hong Kong Students at Each Level of Science Proficiency from 2006 to 2022

| Proficiency Level | PISA 2006 | PISA 2009 | PISA 2012 | PISA 2015 | PISA 2018 | PISA 2022 |
|---|---|---|---|---|---|---|
| **1 or below** | 8.7 | 6.6 | 5.6 | 9.4 | 11.6 | 12.8 |
| **2** | 16.9 | 15.1 | 13.0 | 19.7 | 21.7 | 20.8 |
| **3** | 28.7 | 29.4 | 29.8 | 36.1 | 33.8 | 30.2 |
| **4** | 29.7 | 32.7 | 34.9 | 27.4 | 25.0 | 25.4 |
| **5** | 13.9 | 14.2 | 14.9 | 6.9 | 7.1 | 9.3 |
| **6** | 2.1 | 2.0 | 1.8 | 0.4 | 0.7 | 1.4 |

| | Math | reading | science |
|---|---|---|---|
| Proficiency levels: Change between 2012 and 2022 | | | |
| Percentage-point change in the share of top-performing students (Level 5 or 6) | -6.5* | -7.8* | -6.0* |
| Percentage-point change in the share of low-performing students (below Level 2) | +5.3* | +10.7* | +7.3* |
| Variation in performance: Change between 2018 and 2022 | | | |
| Average change among high-achieving students (90th percentile) | +5.5 | -23.8* | +13.2* |
| Average change among low-achieving students (10th percentile) | -27.2* | -23.9* | -6.4 |
| Gap in learning outcomes between high- and low-achieving students | widening gap | stable gap | widening gap |
| Trends by quarter of socio-economic status (ESCS): 2018-22 / average 10-year trend | | | |
| Performance among advantaged students (top quarter of ESCS) | -5.2 / -22.1* | -31.9* / -46.5* | +1.6 / -31.1* |
| Performance among disadvantaged students (bottom quarter of ESCS) | -12.6 / -19.8* | -19.4* / -42.3* | +3.9 / -31.3* |
| Performance gap (top – bottom quarter) | stable / stable | stable / stable | stable / stable |

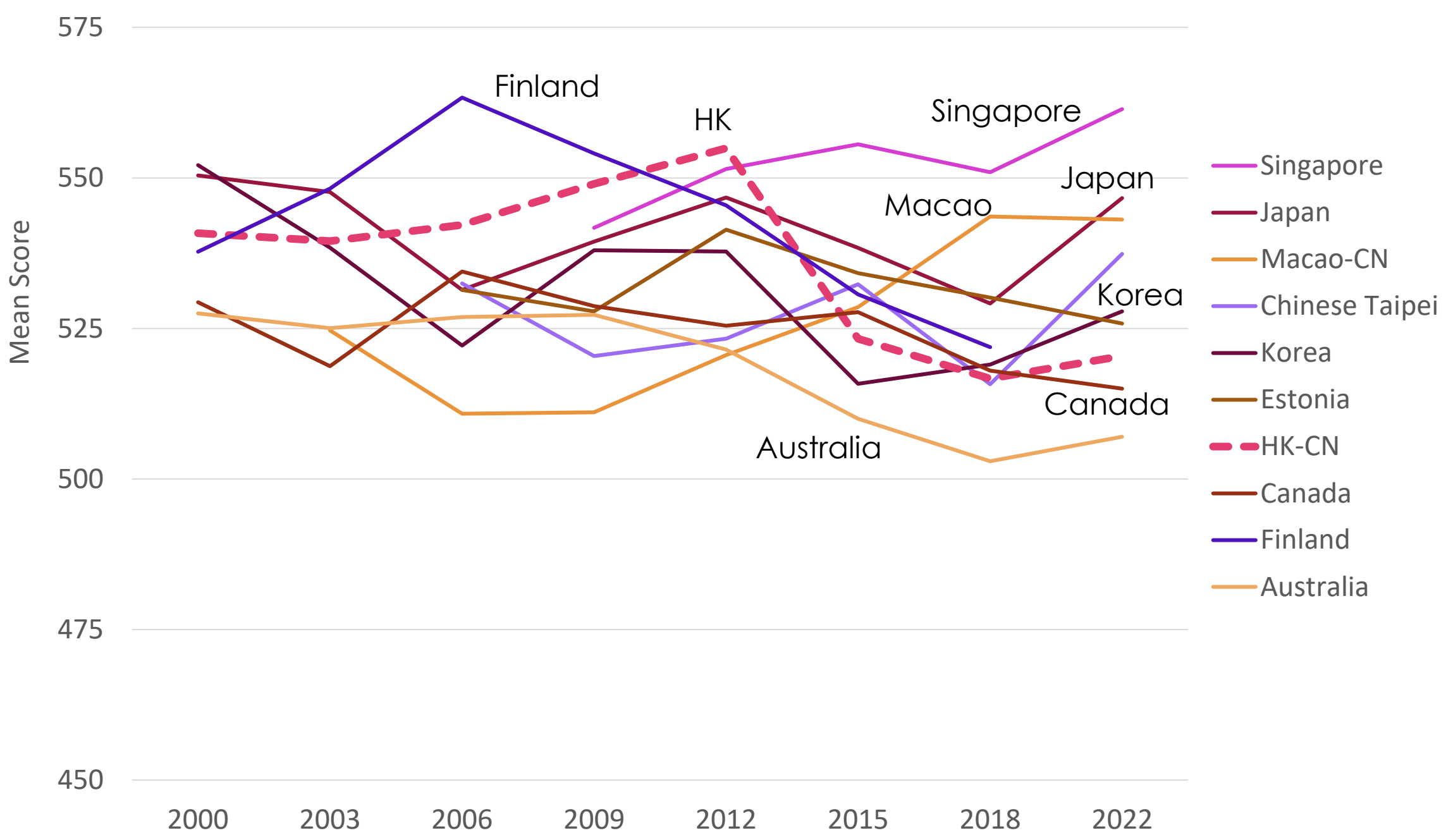
# Proportion of Students at Level 5 and Level 6 in Hong Kong and top-performing Countries/economies

| Country / Economy | Level 5 % | Level 6 % | Rank by overall mean score |
|---|---|---|---|
| **Singapore** | 18.9 | 5.6 | 1 |
| **Japan** | 15 | 3 | 2 |
| **Macao (China)** | 12.7 | 2 | 3 |
| **Chinese Taipei** | 14.2 | 3.6 | 4 |
| **Korea** | 12.7 | 3 | 5 |
| **Estonia** | 9.8 | 1.8 | 6 |
| **Hong Kong (China)** | 9.3 | 1.4 | **7** |
| **Canada** | 9.4 | 2.5 | 8 |
| **Finland** | 9.9 | 2.8 | 9 |
| **Australia** | 9.6 | 3 | 10 |

# Science performance of HK in PISA

| | PISA 2022 | | PISA 2018 | | PISA 2015** | | PISA 2012 | | PISA 2009 | | PISA 2006** | | PISA 2003 | | PISA 2000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rank/Mean | | Rank/Mean | | Rank/Mean | | Rank | Mean | Rank/Mean | | Rank/Mean | | Rank/Mean | | Rank/mean | |
| Singapore | 1 | 561 | 2 | 551 | 1 | 556 | 3 | 551 | 4 | 542 | - | - | - | - | - | - |
| Japan | 2 | 547 | 5 | 529 | 2 | 538 | 4 | 547 | 5 | 539 | 6 | 531 | 2 | 548 | 2 | 550 |
| Macao (China) | 3 | 543 | 3 | 544 | 6 | 529 | 17 | 521 | 18 | 511 | 17 | 511 | 7 | 525 | - | - |
| Chinese Taipei | 4 | 537 | 10 | 516 | 4 | 532 | 13 | 523 | 12 | 520 | 4 | 532 | - | - | - | - |
| Korea | 5 | 528 | 7 | 519 | 11 | 516 | 7 | 538 | 6 | 538 | 11 | 522 | 4 | 538 | 1 | 552 |
| Estonia | 6 | 526 | 4 | 530 | 3 | 534 | 6 | 541 | 9 | 528 | 5 | 531 | - | - | - | - |
| Hong Kong (China) | 7 | 520 | 9 | 517 | 9 | 523 | 2 | 555 | 3 | 549 | 2 | 542 | 3 | 539 | 3 | 541 |
| Canada | 8 | 515 | 8 | 518 | 7 | 528 | 10 | 525 | 8 | 529 | 3 | 534 | 11 | 519 | 6 | 529 |
| Finland | 9 | 511 | 6 | 522 | 5 | 531 | 5 | 545 | 2 | 554 | 1 | 563 | 1 | 548 | 4 | 538 |
| Australia | 10 | 507 | 17 | 503 | 14 | 510 | 16 | 521 | 10 | 527 | 8 | 527 | 6 | 525 | 9 | 528 |

** science as the major assessment


575
550
525
500
475
450
Mean Score
2000
2003
2006
2009
2012
2015
2018
2022
Finland
HK
Singapore
Japan
Macao
Korea
Canada
Australia
Singapore
Japan
Macao-CN
Chinese Taipei
Korea
Estonia
HK-CN
Canada
Finland
Australia

# Table I.6.2. Trajectories of average performance in science across PISA assessments

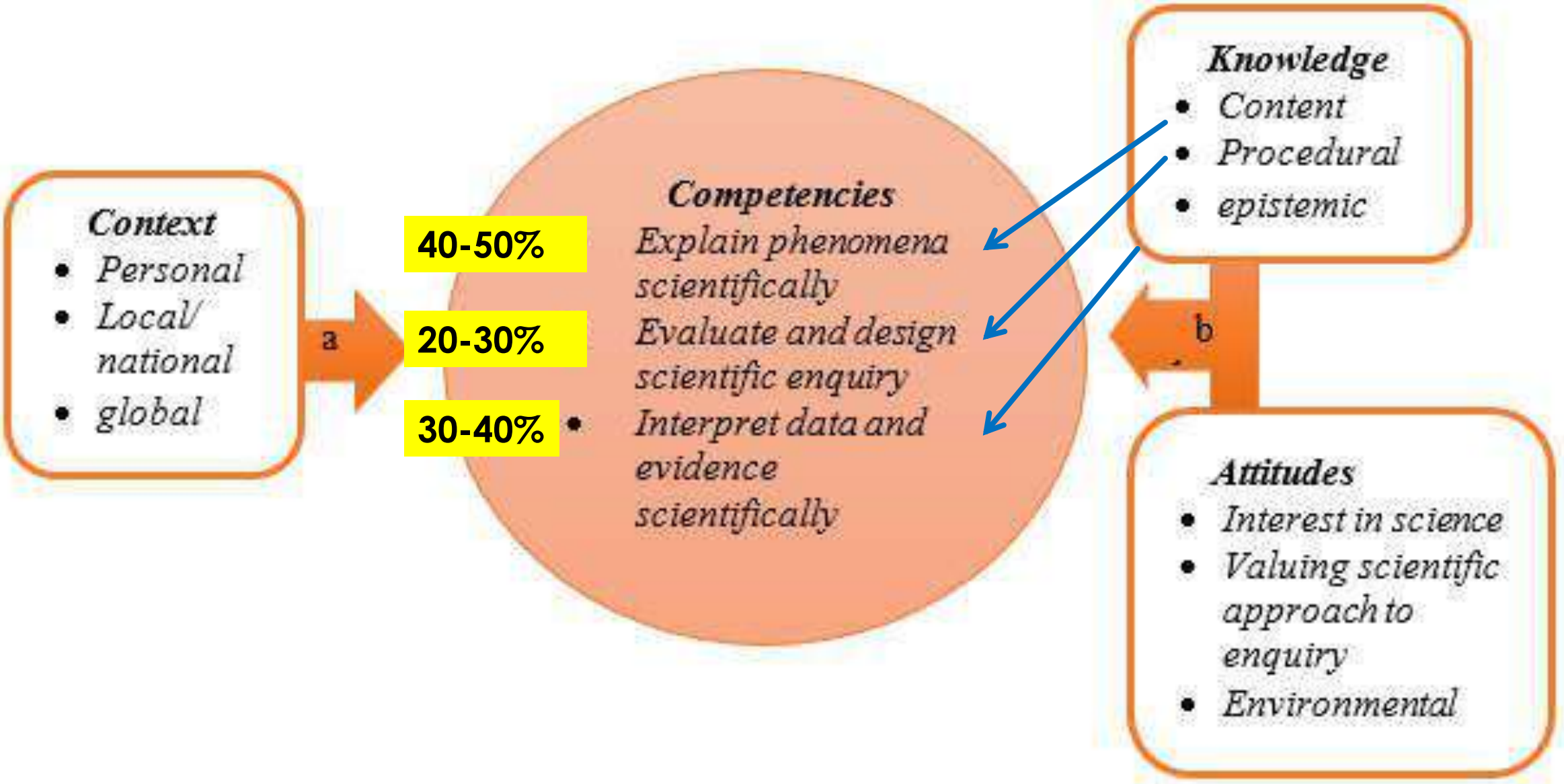
| | | | |
|---|---|---|---|
| **Countries/economies with a positive average trend** | **Increasingly positive** | **Steadily positive** | **Positive, but flattening** (less positive over more recent years) |
| | | Macao (China) (06), Peru (09), Singapore (09), Türkiye (06) | Colombia (06), Qatar (06) |
| **Countries/economies with no significant average trend** | **U-shaped** (more positive over more recent years) | **Flat** | **Hump-shaped** (more negative over more recent years) |
| | Sweden (06), Chinese Taipei (06) | Argentina (06), Chile (06), the Czech Republic (06), Denmark* (06), France (06), Indonesia (06), Ireland* (06), Israel (06), Japan (06), Korea (06), Latvia* (06), Lithuania (06), Montenegro (06), Serbia (06), the United Arab Emirates (09), the United States* (06), Uruguay (06) | Albania (09), Brazil (06), Bulgaria (06), Estonia (06), Italy (06), Mexico (06), Norway (06), Poland (06), Portugal (06), Romania (06), Spain (06), Thailand (06) |
| **Countries/economies with a negative average trend** | **Increasingly negative** | **Steadily negative** | **Negative, but flattening** (less negative over more recent years) |
| | Germany (06), Iceland (06), the Netherlands* (06) | Australia* (06), Austria (06), Belgium (06), Canada* (06), Costa Rica (10), Finland (06), Greece (06), Hong Kong (China)* (06), New Zealand* (06), Slovenia (06), Switzerland (06), the United Kingdom* (06) | Croatia (06), Hungary (06), the Slovak Republic (06) |

Dropped in high achievers

Since PISA 2015, scientific literacy is defined as:

"Scientific Literacy (**科學素養**) is the ability to engage with science-related issues, and with the ideas of science, as a **reflective citizen**.

# PISA assessment framework



# PISA compared with DSE

| | PISA 15 | HKDSE Bio 17 |
|---|---|---|
| Knowledge | | |
| Content | 53.3% | 86% |
| Procedural | 32.6% | 16% |
| Epistemic | 14.1 | 4% |
| Competency | | |
| Explain phenomena | 48% | 75% |
| Design enquiry | 21% | 6% |
| Interpret data | 30% | 19% |
| Problem complexity | | L:71%<br>M:25%<br>H:4% |

# Relative performance in competency in PISA 2015

| | Overall | Explain phenomena scientifically | Evaluate and design scientific enquiry | Interpret data and evidence scientifically |
|---|---|---|---|---|
| Singapore | 556 | 553 | **560** | 556 |
| Japan | 538 | 539 | 536 | 541 |
| Estonia | 534 | 533 | 535 | 537 |
| Chinese Taipei | 532 | 536 | **525** | 533 |
| Finland | 531 | 534 | 529 | 529 |
| Macao | 529 | 528 | 525 | **532** |
| Canada | 528 | 530 | 530 | 525 |
| Hong Kong | 523 | 524 | 524 | 521 |
| China | 518 | 520 | 517 | 516 |
| Korea | 516 | 510 | 515 | **523** |

PISA 2015 released items

https://www.oecd.org/pisa/test/PISA2015-Released-FT-Cognitive-Items.pdf

Interactive

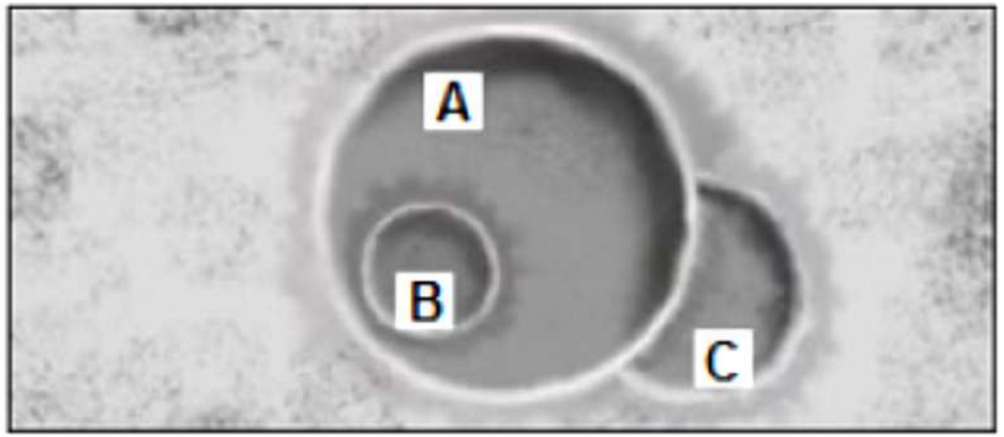
https://www.oecd.org/pisa/test/pisa2015/#d.en.537240

## Meteoroids and Craters

Question 3 / 3

*Refer to "Meteoroids and Craters" on the right. Use drag and drop to answer the question.*

Consider the following three craters.




Put the craters in order by the size of the meteoroids that caused them, from largest to smallest.

A B C

| Largest → | | Smallest |
|---|---|---|
| | | |

Put the craters in order by when they were formed, from oldest to newest.

A B C

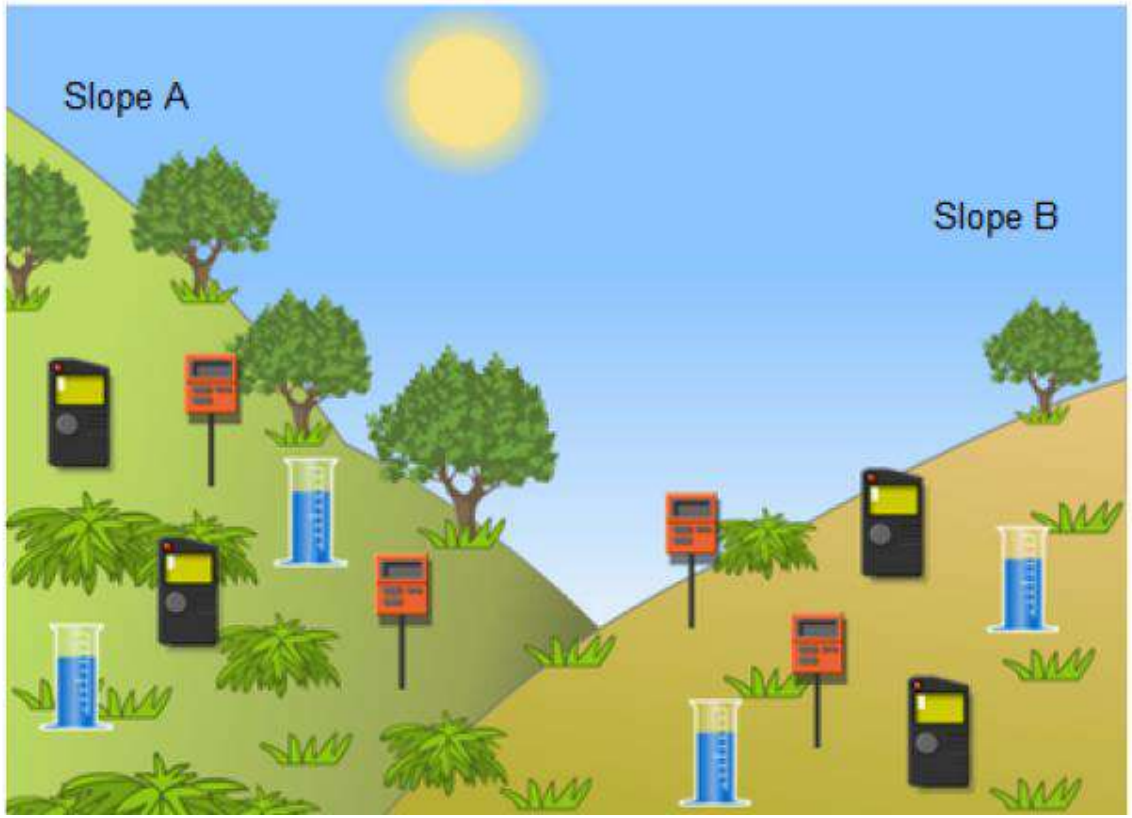
| Oldest → | | Newest |
|---|---|---|
| | | |

The students place two of each of the following three instruments on each slope, a
shown below.

**Solar radiation sensor:** measures the amount of sunlight, in megajoules per square metre ($MJ/m^2$)

**Soil moisture sensor:** measures the amount of water as a percentage of a volume of soil

**Rain gauge:** measures the amount of rainfall, in millimetres (mm)




A level 3 question assessing "design scientific enquiry"

## Why did the students place two of each instrument on each slope?

Full mark answers

1. Determine whether a difference between slopes is significant
2. There is likely to be variation within a slope
3. The data will be more accurate
4. In case one of the two cannot function
5. Compare different amounts of sun on a slope.

| | Answer to Q1 | 0/1 | Remarks |
|---|---|---|---|
| 1 | 減少數據出現誤差 | 1 | |
| 2 | To increase the reliability of the test | 1 | |
| 3 | 因為須要用兩個測試结果作比較. | 1 | |
| 4 | 因為這樣可以量度兩個斜率不同的斜坡在不同高度下各項數據,可加以比對。 | 0 | |
| 5 | 來集齊數據。 | 0 | |
| 6 | control experiment | 0 | |
| 7 | 因為要進行公平測試 | 0 | |
| 8 | 因為只是斜坡的其中一個部份，並不能夠完全代表整個斜坡，為了得到更確實的數據，所以需要放置兩套儀器。 | 1 | |
| 9 | 令結果更容觀 更準確因在同一個斜坡上的環境因素會有變化 | 1 | |
| 10 | it can have a more accurate result since both hills can act as the important part in experiment. Moreover, the two slopes are in different areas which receive different kind of sunlight and rain. This can lead to a more accurate result in that area | 1 | |

| | | | |
|---|---|---|---|
| 11 | 因為可以使數據更加準確和全面. | 1 | |
| 12 | Different position have different value of reading. By puting two sets of instruments and take the mean value, it can reflect the overall situation of the slope. | 1 | |
| 13 | 要用相同的仪器来测试才准确。 | 1 | |
| 14 | To get an average data from the slopes since the data maybe different since different parts of the slope in measured. | 1 | |
| 15 | 以保持實驗的公平性 | 0 | |
| 16 | 因为这是为了测试能公平的进行，而太阳辐射计是不可变数 | 0 | |
| 17 | 因為每邊的太陽幅射,泥土含水量和雨量都不同 | 0 | |
| 18 | 雙重儀器的放置將能有效提高實驗的準確性。因為一組的測試數據將未能完全反映其生長環境，也可能受到環境因素或人為因素導致結果有所不同，所以加多一組數據，將能大大提升其準確度。 | 1 | |
| 19 | 因為要在每邊的斜坡上均放置同樣數目的儀器才可以比較 | 0 | |
| 20 | 因為這樣才能同時收集兩組數據, 作準確以及公平的比較 | 1 | |

# Marking principles of PISA

1. The PISA science assessment is **not a test of written expression**
2. Every effort should be made to understand what the student means
3. **Spelling and gramma mistakes** should be ignored unless they make it impossible to determine what the student means (key words?)
4. They indicate the *level of response expected of a 15-year-old*
5. “Full Credit” responses may *not* necessarily be fully correct or **perfect responses.**
6. Don’t apply a “**deficit model**” (deduct if fall short of a perfect answer)
7. **Benefit of the doubt** (to the student). Should not assume students do not know

| | |
|---|---|
| **Competency** | **Evaluate and Design Scientific Enquiry** |
| **Knowledge System** | **Epistemic - Earth & Space** |
| **Context** | **Local/ National - Natural Resources** |
| **Difficulty** | **517 - Level 3** |

| PISA 2015 | Hong Kong | Macao | B-S-J-G (China) | Chinese Taipei | Singapore | Japan | Korea | Canada | Estonia | Finland | OECD average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % correct | **49.00** | 59.01 | 50.52 | **80.95** | 76.12 | 53.50 | **62.15** | **64.24** | **70.49** | 52.68 | 52.31 |

- Sampling error of measurement is seldom taught. Teachers often stress measuring errors and reduced them by repeated measurements.
- Students are seldom asked to explain the experimental design. They only need to state some 'standard' answers like 'fair test', or vague answers like 'make it more accurate'

**Slope-Face Investigation**
Question 2 / 2

*Refer to "Data Analysis" on the right. Click on a choice and then type an explanation to answer the question.*

Two students disagree about why there is a difference in soil moisture between the two slopes.

- Student 1 thinks that the difference in soil moisture is due to a difference in solar radiation on the two slopes.
- Student 2 thinks that the difference in soil moisture is due to a difference in rainfall on the two slopes.

According to the data, which student is correct?

- Student 1
- Student 2

Explain your answer.

## SLOPE-FACE INVESTIGATION

### Data Analysis

The students take the average of the measurements collected over a given period of time from each pair of instruments on each slope and calculate the uncertainty in these averages. Their results are recorded in the following table. The uncertainty is given following the "±" sign.

| | Average Solar Radiation | Average Soil Moisture | Average Rainfall |
|---|---|---|---|
| Slope A | 3800 ± 300 MJ/m$^2$ | 28 ± 2% | 450 ± 40 mm |
| Slope B | 7200 ± 400 MJ/m$^2$ | 18 ± 3% | 440 ± 50 mm |

| | |
|---|---|
| **Competency** | **Interpret data and evidence scientifically** |
| **Knowledge System** | **Epistemic - Earth & Space** |
| **Context** | **Local/ National - Natural Resources** |
| **Difficulty** | **589 - Level 4** |

| PISA 2015 | Hong Kong | Macao | B-S-J-G (China) | Chinese Taipei | Singapore | Japan | Korea | Canada | Estonia | Finland | OECD average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % correct | **36.15** | 37.69 | 39.77 | 43.23 | 47.08 | 49.27 | 40.30 | 43.01 | **49.96** | 44.42 | 34.86 |

# Any explanations on HK students' performance on that item?

- Covariation/correlation to support causation
- HK students are not taught about the concept of statistically significant differences
- Confuse mechanisms with evidence/data in scientific explanation

| | Average Solar Radiation | Average Soil Moisture | Average Rainfall |
|---|---|---|---|
| Slope A | 3800 ± 300 $MJ/m^2$ | 28 ± 2% | 450 ± 40 mm |
| Slope B | 7200 ± 400 $MJ/m^2$ | 18 ± 3% | 440 ± 50 mm |

PISA2015

# PISA 15 - RUNNING IN HOT WEATHER


Air Temperature (°C) 20 25 30 35 40

Air Humidity (%) 20 40 60

Drinking Water ◉ Yes ○ No

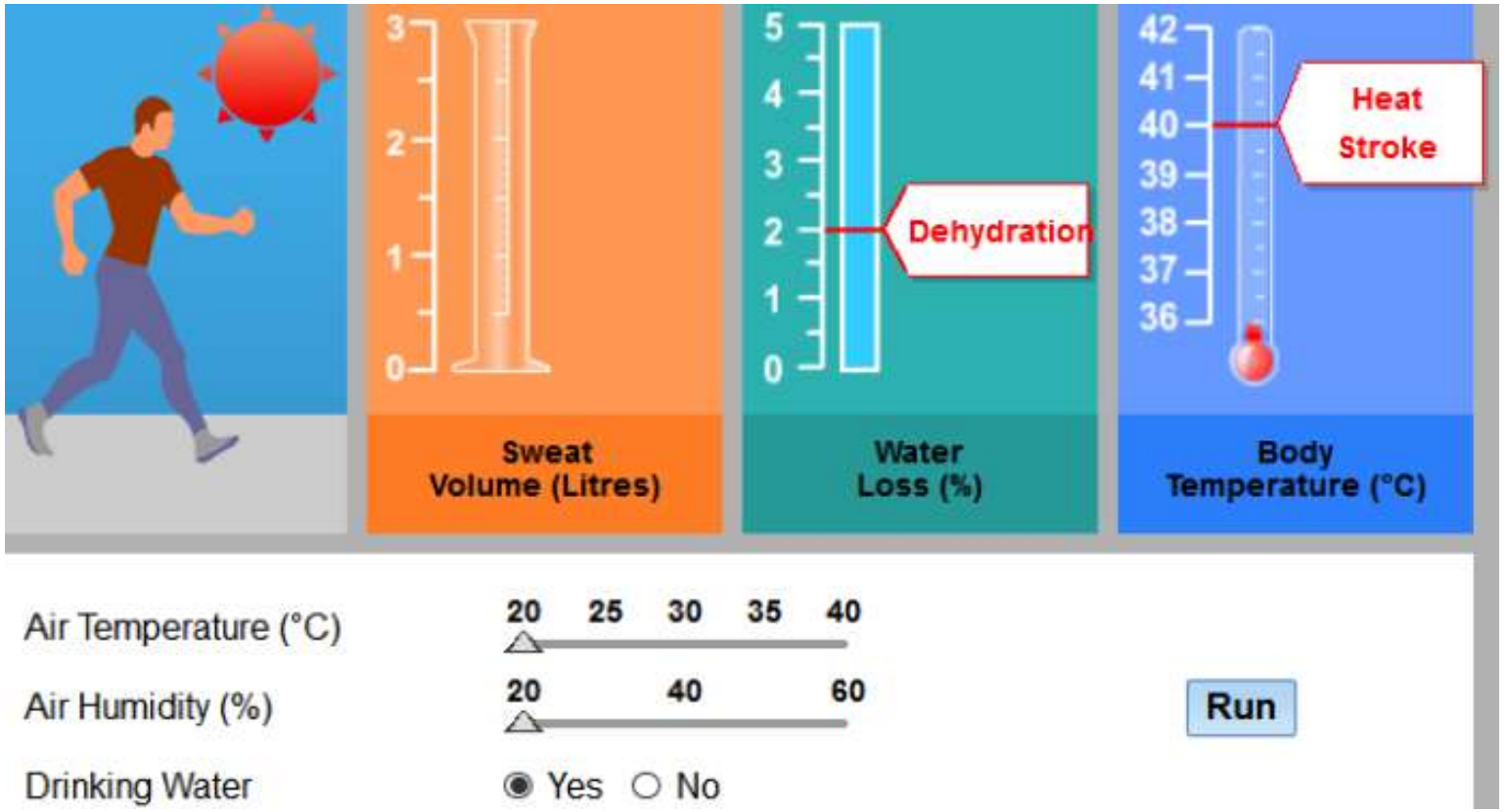
Run

| Air Temperature (°C) | Air Humidity (%) | Drinking Water | Sweat Volume (Litres) | Water Loss (%) | Body Temperature (°C) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

IV

DV

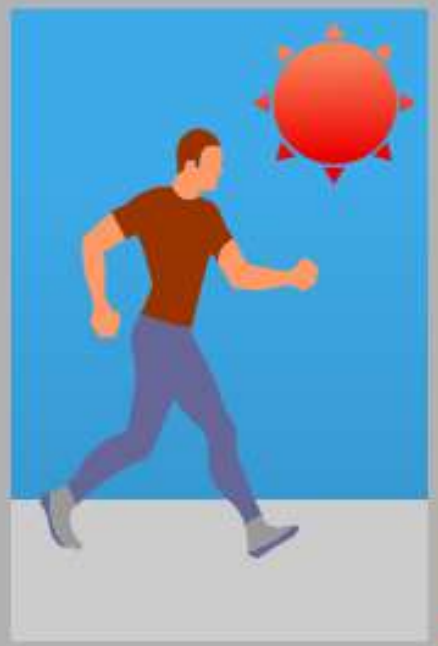
http://www.oecd.org/pisa/pisa-2015-science-test-questions.htm

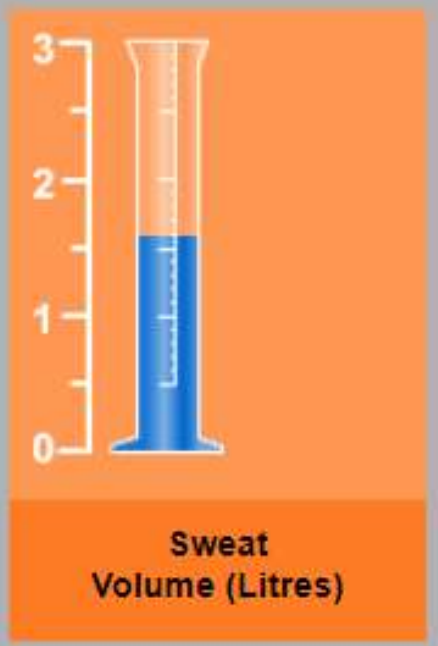


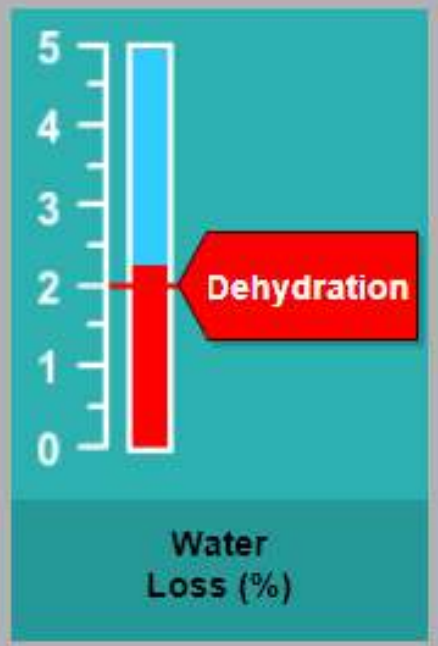

A runner runs for one hour on a hot, dry day (air temperature 40°C, air humidity of 20%). The runner does not drink any water.

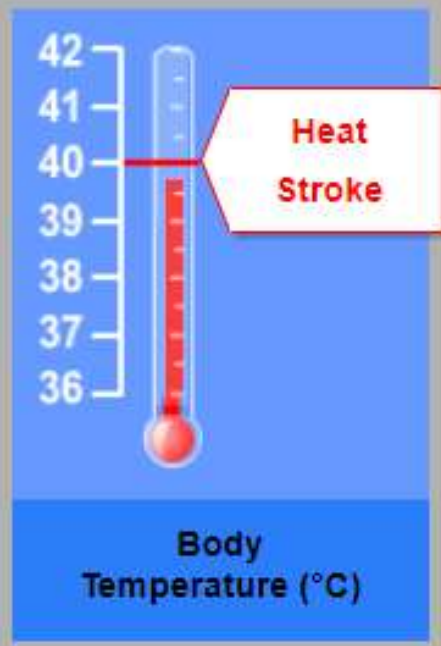
What health danger does the runner encounter by running under these conditions?

| | |
|---|---|
| Competency | **Interpret data** |
| Knowledge | **Procedural knowledge** |
| Cognitive demand | **medium** |
| Complexity | **Medium (difficulty 3)** |






Air Temperature (°C) 20 25 30 35 40

Air Humidity (%) 20 40 60

Drinking Water ○ Yes ◉ No

Run

| Air Temperature (°C) | Air Humidity (%) | Drinking Water | Sweat Volume (Litres) | Water Loss (%) | Body Temperature (°C) |
|---|---|---|---|---|---|
| 40 | 20 | No | 1.6 | 2.3 | 39.8 |
| | | | | | |

S623Q03

CV

When the air humidity is 60%, what is the effect of an increase in air temperature on sweat volume after a one-hour run?

IV

DV

- Sweat volume increases
- Sweat volume decreases

Water

Select two rows of data in the table to support your answer.

S623Q04

What is the biological reason for this effects?

| Competency | **Design Scientific Enquiry (+ID)** |
|---|---|
| Knowledge | **Procedural knowledge** |
| Cognitive demand | **medium** |
| Complexity | **Medium (difficulty 3)** |

IV

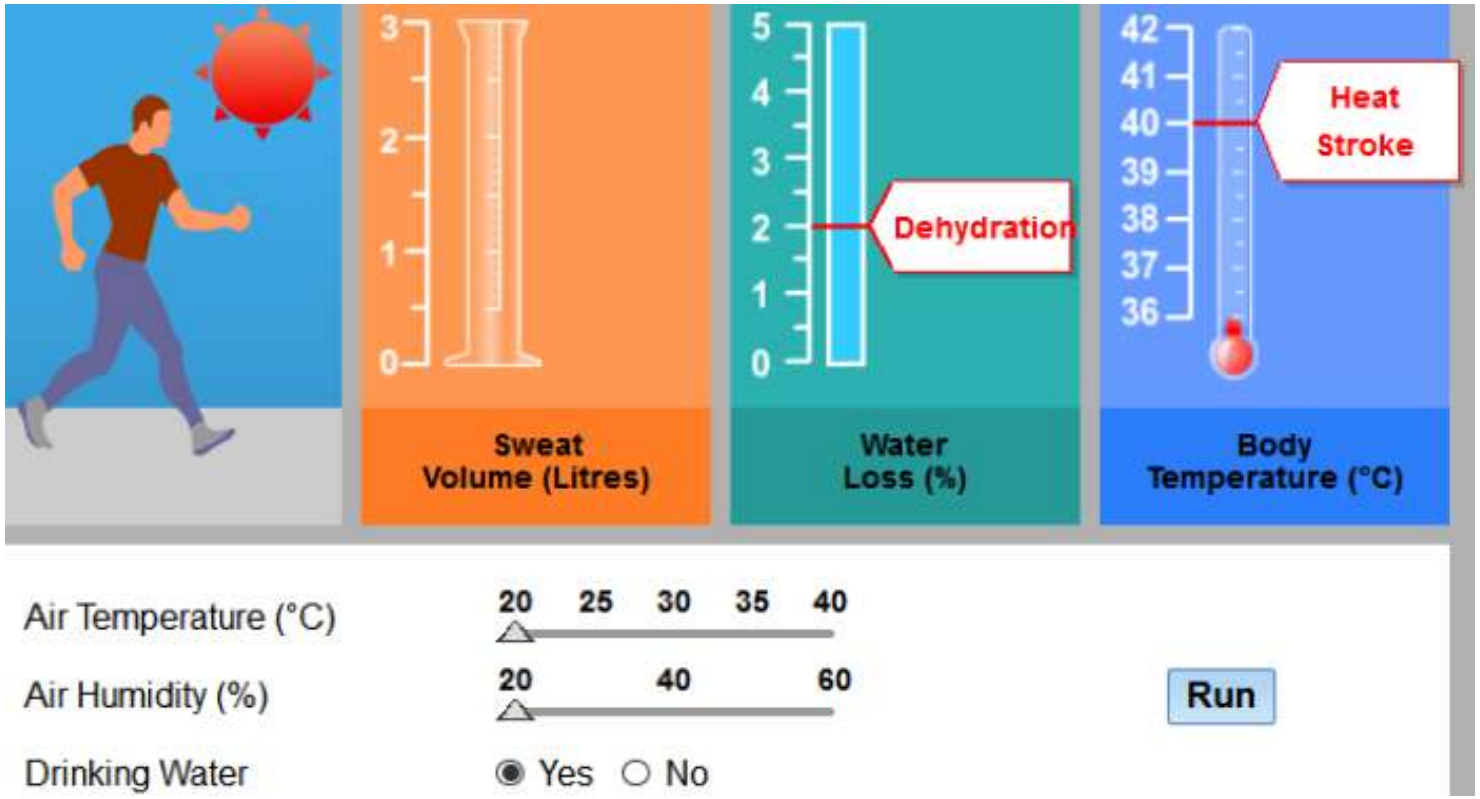
CV

DV

| Air Temperature (°C) | Air Humidity (%) | Drinking Water | Sweat Volume (Litres) | Water Loss (%) | Body Temperature (°C) |
|---|---|---|---|---|---|
| 20 | 60 | Yes | 0.8 | 0.0 | 38.9 |
| 25 | 60 | Yes | 1.1 | 0.0 | 39.1 |
| 20 | 60 | No | 0.8 | 1.2 | 38.9 |
| 25 | 60 | No | 1.1 | 1.6 | 39.1 |
| | | | | | |

| | % correct (in PISA 2015 FT) | |
|---|---|---|
| | Hong Kong | International (53 countries) |
| S623Q03 | 47.1% | 44.4% |
| S623Q04 | 12.2% | 17.7% |

- For S623Q03, HK students, on average, outperformed international students from 53 countries
- For S623Q04, it requires students to draw on their knowledge of biology (content knowledge) to explain that sweating cools the body at higher temperatures
- The cognitive demand: medium, but the mean score of 53 countries is only 18%.
- The performance of Hong Kong students : very poor (% correct: 12 %). 15-year-old HK students did not learn this topic in school.




Do you expect that it would be safe or unsafe to run while drinking water with the air humidity at 50% and air temperature of 40°C?

**Explain how the data support your conclusion.**

| | |
|---|---|
| Competency | **Design scientific enquiry** |
| Knowledge | **Procedural knowledge** |
| Cognitive demand | **High/medium** |
| Complexity | **Medium (difficulty -4)** |

CV IV CV DV

| Air Temperature (°C) | Air Humidity (%) | Drinking Water | Sweat Volume (Litres) | Water Loss (%) | Body Temperature (°C) |
|---|---|---|---|---|---|
| 40 | 40 | Yes | 1.9 | 0.0 | 40.7 |
| 40 | 60 | Yes | 2.5 | 0.0 | 41.2 |

50%?

| | % correct (in PISA 2015 FT) | |
|---|---|---|
| | Hong Kong | International (53 countries) |
| S623Q06 | 57.3% | 37.6% |

- This item uses a simulation to assess scientific enquiry processes not assessed in the paper-based booklets.
- % correct: the mean score of 53 countries (38%) vs Hong Kong (57%).
- Reasons for Hong Kong's good performance ?


TIME FOR A
BREAK

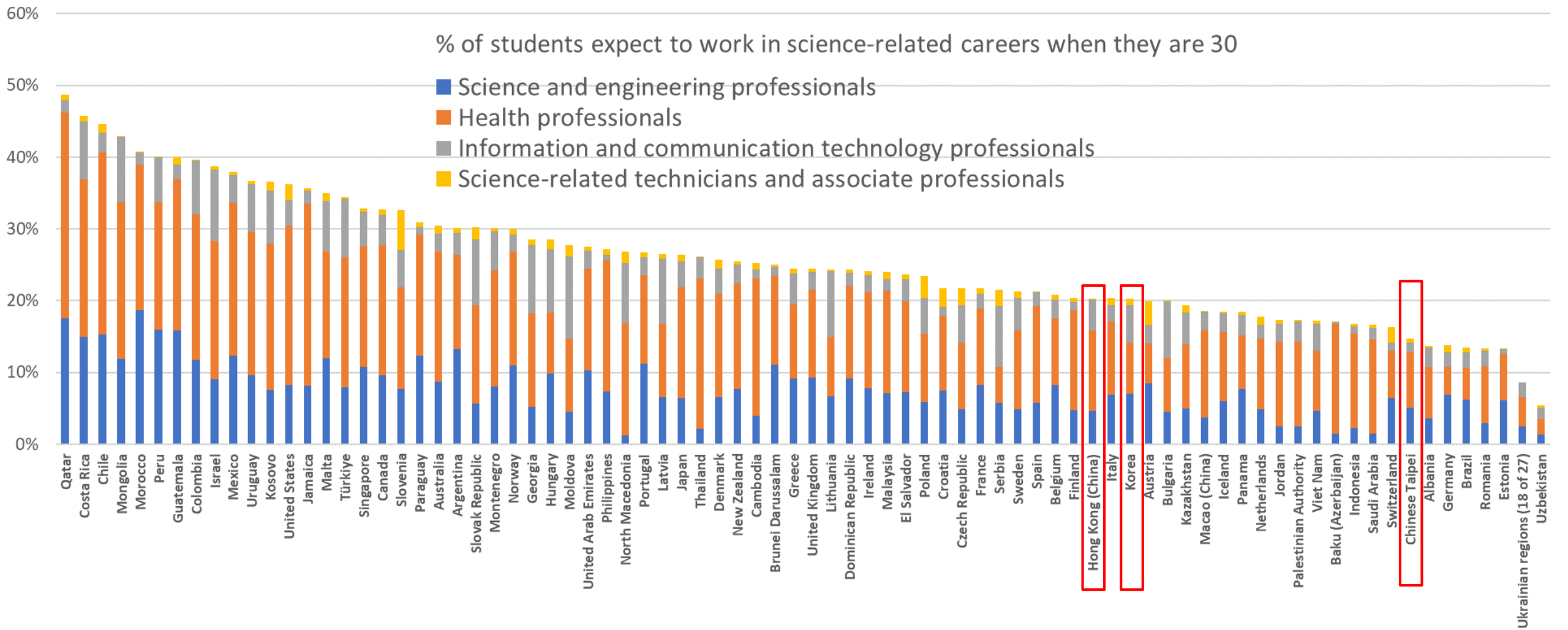
# ATTITUDES TOWARDS SCIENCE LEARNING

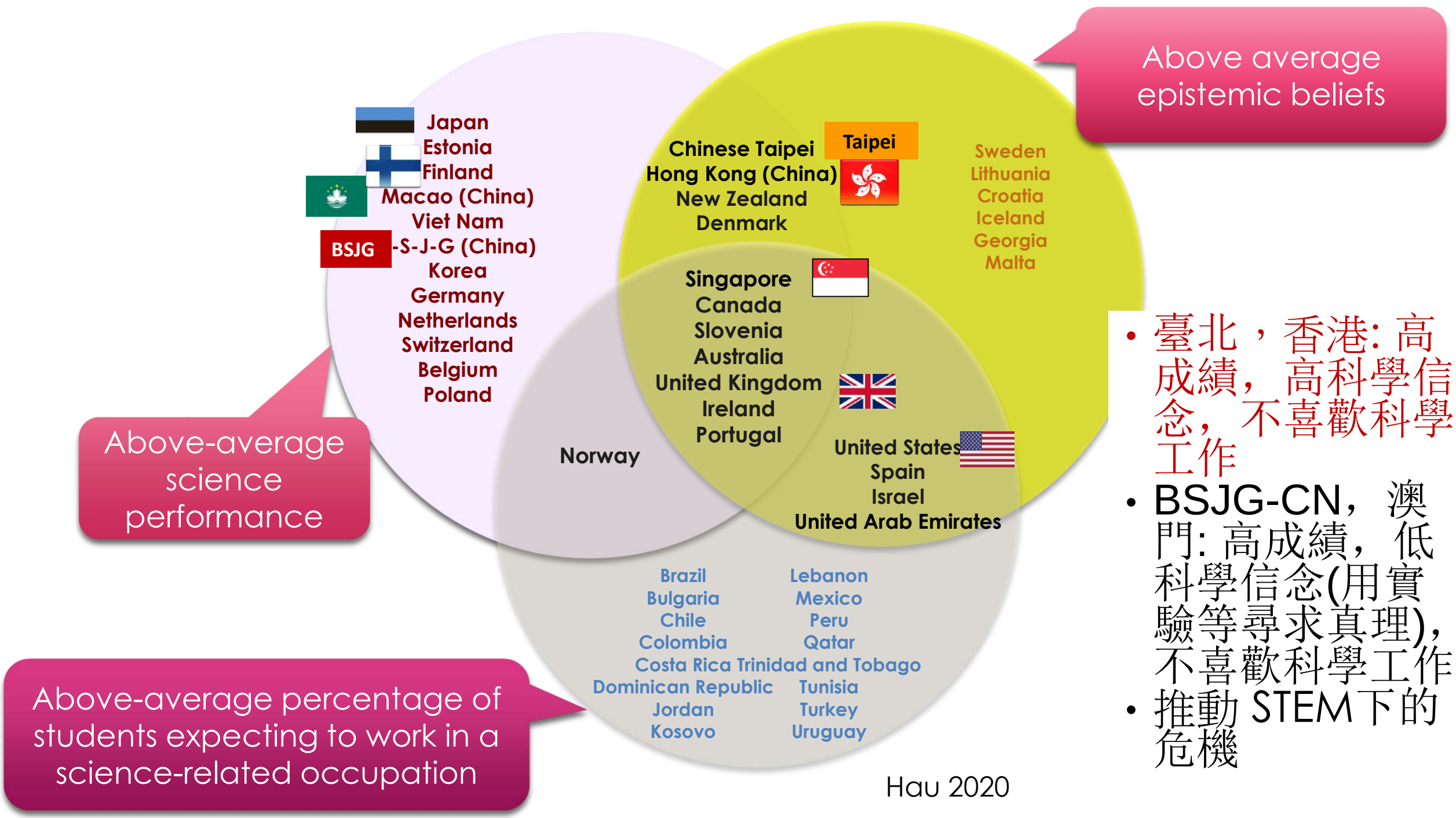
**Lau, Kwok-chi**, Ho, S. (2020). Attitudes towards science, teaching practices, and science performance in PISA 2015: Multilevel Analysis of the Chinese and Western top performers. *Research in Science Education*.

| Constructs of attitudes toward science in PISA 2015 with sample items | |
|---|---|
| **Interest in Science** | To what extent are you **interested** in the following <broad science> topics?<br>a) Biosphere (e.g. ecosystem services, sustainability)<br>b) Energy and its transformation |
| **Enjoyment of Science learning** | How much do you agree with the statements below?<br>a) I generally **have fun** when I am learning science topics.<br>b) **I like** reading about science. |
| **Instrumental Motivation for learning Science** | How much do you agree with the statements below?<br>a) Making an effort in my science subject(s) is worth it because this will **help me in the work** I want to do later on.<br>b) What I learn in my science subject(s) is important for me because I need this for what I want to **study later** on.<br>c) I study science because I know it is **useful** for me. |
| **Science career expectation** | What kind of **job** do you expect to have when you are about **30 years old**?<br>(open answer) |
| **Science Self-Efficacy** | How **easy do you** think it would be for you to perform the following tasks on your own?<br>a) Recognise the science question that underlies a newspaper report on a health issue.<br>b) Explain why earthquakes occur more frequently in some areas than in others.<br>c) Describe the role of antibiotics in the treatment of diseases. |
| **Science Activities** | How **often** do you do these things?<br>a) Watch **TV programmes** about science.<br>b) Borrow or buy **books** on science topics.<br>c) Visit **web sites** about science topics. |

# ATTITUDES TOWARD SCIENCE LEARNING (2015)

| | Enjoyment of science | | Instrumental motivation | | Science self-efficacy | | Science Activities | |
|---|---|---|---|---|---|---|---|---|
| | | G-B (Sig) | | G-B (Sig) | | G-B (Sig) | | G-B (Sig) |
| **Hong Kong** | **.273** | **-.279 (***)** | **.233** | **-.148 (***)** | **-.071** | **-.174 (***)** | **.272** | **-.404 (***)** |
| **China (BSJG)** | .407 | -.130 (***) | .517 | -.002 (ns) | .065 | -.090 (***) | .546 | -.222 (***) |
| **Canada** | .352 | -.113 (***) | .468 | .089 (***) | .272 | -.268 (***) | -.046 | -.392 (***) |
| **Finland** | -.071 | -.040 (ns) | .157 | .040 (ns) | -.041 | -.260 (***) | -.502 | -.304 (***) |


% of students expect to work in science-related careers when they are 30
Science and engineering professionals
Health professionals
Information and communication technology professionals
Science-related technicians and associate professionals
60%
50%
40%
30%
20%
10%
0%
Qatar
Costa Rica
Chile
Mongolia
Morocco
Peru
Guatemala
Colombia
Israel
Mexico
Uruguay
Kosovo
United States
Jamaica
Malta
Türkiye
Singapore
Canada
Slovenia
Paraguay
Australia
Argentina
Slovak Republic
Montenegro
Norway
Georgia
Hungary
Moldova
United Arab Emirates
Philippines
North Macedonia
Portugal
Latvia
Japan
Thailand
Denmark
New Zealand
Cambodia
Brunei Darussalam
Greece
United Kingdom
Lithuania
Dominican Republic
Ireland
Malaysia
El Salvador
Poland
Croatia
Czech Republic
France
Serbia
Sweden
Spain
Belgium
Finland
Hong Kong (China)
Italy
Korea
Austria
Bulgaria
Kazakhstan
Macao (China)
Iceland
Panama
Netherlands
Jordan
Palestinian Authority
Viet Nam
Baku (Azerbaijan)
Indonesia
Saudi Arabia
Switzerland
Chinese Taipei
Albania
Germany
Brazil
Romania
Estonia
Ukrainian regions (18 of 27)
Uzbekistan




- 臺北，香港: 高成績，高科學信念，不喜歡科學工作
- BSJG-CN，澳門: 高成績，低科學信念(用實驗等尋求真理)，不喜歡科學工作
- 推動 STEM下的危機

Hau 2020

# ATTITUDES AND PERFORMANCE (2015)

| | HK | BSJG | Canada | Finland |
|---|---|---|---|---|
| **Enjoyment of science learning** | 17.00*** | 15.67*** | 19.47*** | 19.61*** |
| **Instrumental motivation** | 2.72 | -1.56 | 0.56 | 2.32 |
| **Science self-efficacy** | 5.29*** | 6.42*** | 11.27*** | 15.45*** |
| **Science Activities** | -.80 | -10.87*** | -3.50*** | -5.04** |

HLM analysis of the effects of the teaching practice and attitudes towards science on science performance after controlling for the student and school background variables of the four regions in PISA 2015.

# Conclusions

1. Enjoyment of science learning is the strongest factor related to performance. Instrumental motivation, however, is not significantly related to performance. Science learning needs intrinsic rather than extrinsic motivation.
2. Chinese students have relatively low self-efficacy as compared to Canada - the paradox of Chinese learners (Chan & Rao, 2009). It may be caused by the Confucian Heritage Culture (CHC) that emphasizes modesty, diligence and education as route of success.
3. Girls are found having less positive attitudes towards science than boys. Chinese girls suffer mainly from less enjoyment of science learning and instrumental motivation, while girls in Canada and Finland are having lower self-efficacy. Both Finland and Canada education systems have lesser gender gaps.

# INSTRUCTIONAL PRACTICES

**Lau, K. C**. & Lam, Y. P. T. (2017). Instructional practices and science performance of 10 top-performing regions in PISA 2015. *International Journal of Science Education, 15*.

# Instructional practices Lau & Lam 2017

**Table 7.** Mean scores of the selected items of the constructs of teaching practices of the 10 regions in PISA 2015.

| Items | Hong Kong | Macao | China | Taipei | Singapore | Japan | Korea | Canada | Finland | Estonia | OECD mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. The teacher explains scientific ideas. | 2.90 | 2.74 | 2.75 | 2.77 | 2.92 | 2.51 | 2.12 | 3.01 | 2.90 | 2.53 | 2.67 |
| 2. A whole-class discussion takes place with the teacher. | 2.42 | 2.34 | 2.55 | 2.54 | 2.45 | 1.69 | 1.67 | 2.57 | 2.46 | 2.50 | 2.32 |
| 3. Students are given opportunities to explain their ideas. | 2.69 | 2.61 | 2.97 | 2.73 | 2.89 | 2.47 | 2.36 | 3.08 | 2.97 | 2.93 | 2.94 |
| 4. The teacher clearly explains the relevance of <broad science> concepts to our lives. | 2.54 | 2.41 | 2.33 | 2.32 | 2.48 | 2.15 | 2.38 | 2.76 | 2.47 | 2.65 | 2.54 |
| 5. Students spend time in the laboratory doing practical experiments | 2.35 | 2.06 | 1.88 | 1.83 | 2.15 | 1.81 | 1.58 | 2.19 | 1.94 | 1.75 | 1.94 |
| 6. Students are allowed to design their own experiments. | 1.83 | 1.57 | 1.79 | 1.55 | 1.61 | 1.46 | 1.54 | 1.84 | 1.28 | 1.56 | 1.63 |

Note; Students are asked how often these things happen in their lessons. The responses of *In all lessons/In most lessons/In some lessons/Never or hardly ever* are given scores of 4 to 1, respectively.

# Teaching practices and performance (PISA 2015)

Lau & Lam 2017

| Teaching practices | Association with science scores |
|---|---|
| Application | 15.57 |
| Teacher-directed instruction | 8.02 |
| Adaptive instruction | 4.53 |
| Feedback | -5.85 |
| Investigation | -20.6 |

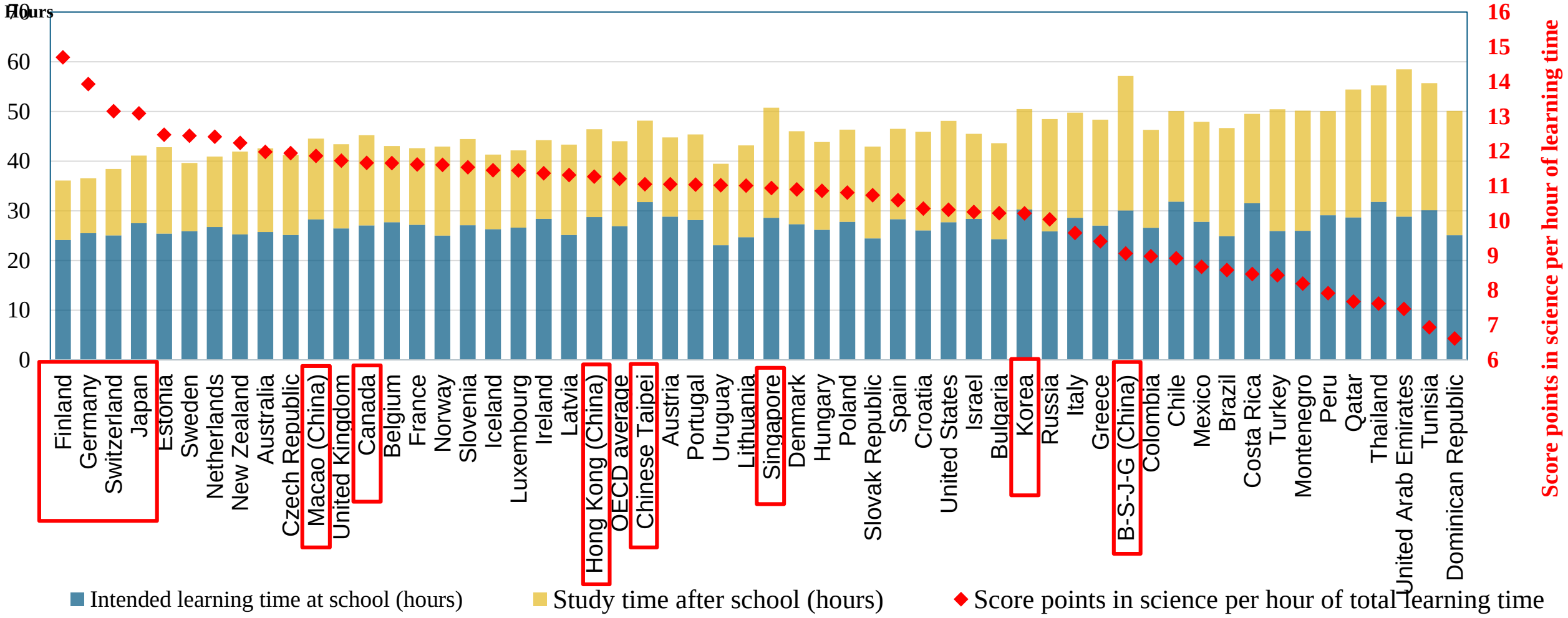
**Application**

- Students are given opportunities to explain their ideas.
- The teacher explains how a science idea can be applied.
- The teacher clearly explains relevance of concepts to our lives.

# Conclusions

- There are no great differences in teaching practices between western and eastern classrooms
- In general, **Canada and Singapore** tend to be more student-centred and enquiry-oriented, while **Japan and Korea** are more traditional and didactic.
- Practical work does not improve science performances, or even detrimental.
- Good science performance is a result of the teaching that is highly **content-focused**. The TIMSS 1999 Video Study found that the classrooms of some low-performing regions such as the United States are **filled with activities with no or very limited content learning** (Roth et al., 2006).
- Effective science teaching is a balance between the student-centred **constructivist pedagogy** under the Western **progressive educational philosophy** and the **teacher-controlled, didactic pedagogy** under the **Confucian Hertiage culture** of diligence, high expectation and conformism.

# Learning efficiency (PISA 2015)



# Educational equity

## Correlation between science performance and ESCS

| | 2022 | 2018 | 2015 | 2012 | 2009 | 2006 | 2003 |
|---|---|---|---|---|---|---|---|
| Singapore | 0.41 | 0.38 | 0.41 | 0.41 | 0.40 | - | - |
| Japan | 0.30 | 0.28 | 0.32 | 0.27 | 0.27 | 0.27 | 0.33 |
| Macao (China) | 0.15 | 0.12 | 0.13 | 0.14 | 0.11 | 0.15 | 0.10 |
| Chinese Taipei | 0.37 | 0.33 | 0.38 | 0.41 | 0.36 | 0.35 | - |
| Korea | 0.31 | 0.28 | 0.32 | 0.26 | 0.32 | 0.29 | 0.33 |
| Estonia | 0.33 | 0.27 | 0.28 | 0.27 | 0.27 | 0.31 | - |
| Hong Kong (China) | **0.21** | **0.24** | **0.22** | **0.25** | **0.22** | **0.26** | **0.26** |
| Canada | 0.28 | 0.25 | 0.30 | 0.28 | 0.30 | 0.29 | 0.34 |
| Finland | **0.32** | **0.32** | **0.32** | **0.28** | **0.27** | **0.29** | **0.31** |
| Australia | 0.36 | 0.32 | 0.34 | 0.35 | 0.37 | 0.34 | 0.38 |

# School environment and other findings

- The disciplinary climate is one of the best compared to other countries and economies. (0.33 PISA Index, rank 10/80 , 2022)
- a lower level of school safety risks. (-0.29 PISA Index, rank 64/69 , 2022)
- Mostly group students by ability for some subjects.
- The time spent on homework is long (2 Hours, rank 6/80 , 2022)
- sense of belonging was one of the lowest. (-0.39 PISA Index, rank 76/78 , 2022)
- students in Hong Kong (China) have a relatively weak perseverance in COVID periods. (-0.22 PISA Index, rank 48/50 , 2022)

# What are challenges of science education in HK?

It is unequivocal that HK is seeing a drop in science performance as evidenced by PISA and TIMSS results, which is likely a result of many factors:

- Less students taking DSE science subjects (60% of PISA candidates are S4!)
- Class time in S1-S2 IS may be reduced due to emphasis on languages and LS. S3 IS is increasingly used for preparation of DSE.
- In NSS, there is greater diversity of students in both academic ability and MOI.
- Teachers need to take up more and more non-teaching duties?
- DSE exams focus too much on content, memorization and 'exam skills'?
- STEM education?

# Is STEM a rescue?

To what extent are the existing STEM activities help students

- learn the science concepts in the curricula?
- develop the scientific inquiry abilities?
- develop interest in science and science careers?
- develop creativity and entrepreneurship?

"I'm not saying that the STEM programs are a failure, but we have to better integrate them into the traditional curriculum,“
Leung Koon Shing.
https://www.thestandard.com.hk/section-news/section/11/225527/Cold-hard-facts-of-science-learning-decline

# Outlook

- Primary science
- LS no longer exists
- More science related careers in HK
- University admission e.g. M1/M2 as elective

# Thank you!!

PISA 2022 reports

- https://www.oecd.org/publication/pisa-2022-results/