Michael Smith Science Challenge 2022 Analysis

Chris Waltham, Theresa Liao, Willow Benitz and Nikita Bernier (translation)

Introduction

The Michael Smith Science Challenge is a national science contest written by students in grade 10/niveau 4 and below. It was first piloted in the province of British Columbia in April of 2002. Since then it has been run annually across Canada. The purpose of the contest is to challenge students' logical and creative thinking, with minimal memorization required. The Michael Smith Science Challenge is the only nationwide competition covering all science subjects taught up to grade 10/niveau 4.

Due to recent COVID regulations, the 2022 challenge was run entirely online; students completed the challenge at school or at home depending on local circumstances and at the discretion of the teacher. No teacher invigilation was required.

Participants were allowed access to the internet or books but were not allowed to seek assistance from anyone in person or online.

For security reasons, students were given the questions in a randomized order and could not go back to see a question they had already submitted. In addition, numerical values given in some questions were randomized.

The 2022 challenge had six multiple-choice questions, seven short answer calculation questions, one fill in the blank question, and one long answer question. The first question was an integrity test, which was included in the score; the last question required a longer answer which was only read in cases of ties of high scores in the multiple-choice part. The maximum numerical score was 15.

Michael Smith Science Challenge 2022 Analysis

Participation

A total of 1045 submissions were received this year, from nine provinces and 104 schools, including one international school (in Hong Kong).
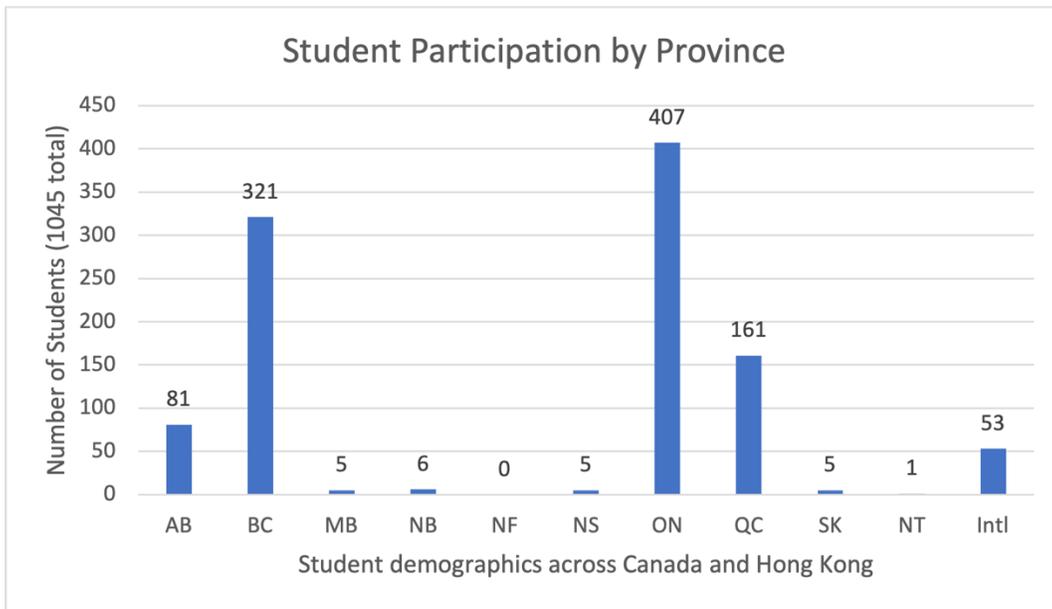
Figure 1: Student demographics across Canada and Hong Kong
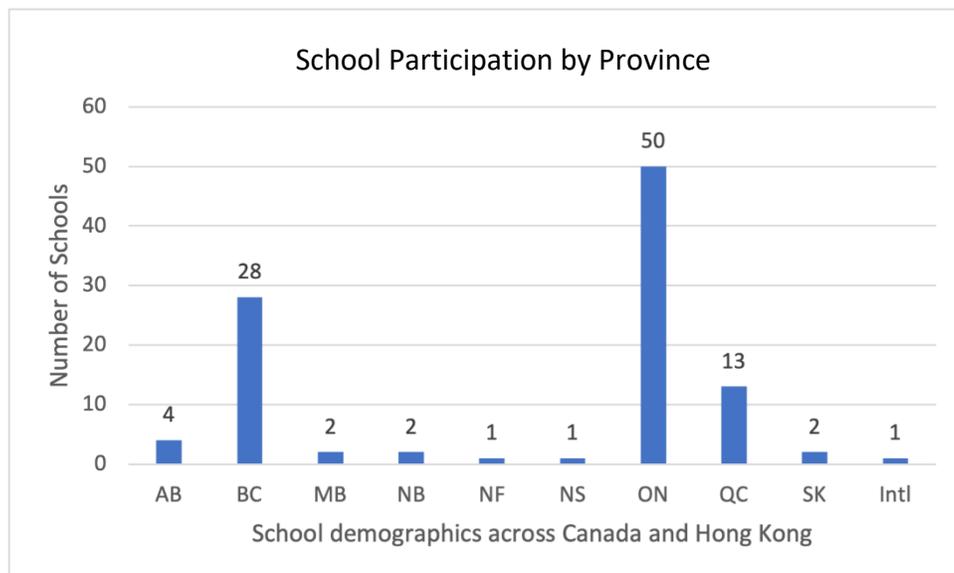
Figure 2: School demographics across Canada and Hong Kong

Results: **Total Mark Distribution**

The contest was marked out of a total of 15. The mean score was 5.1 points; the median score was 5 points.
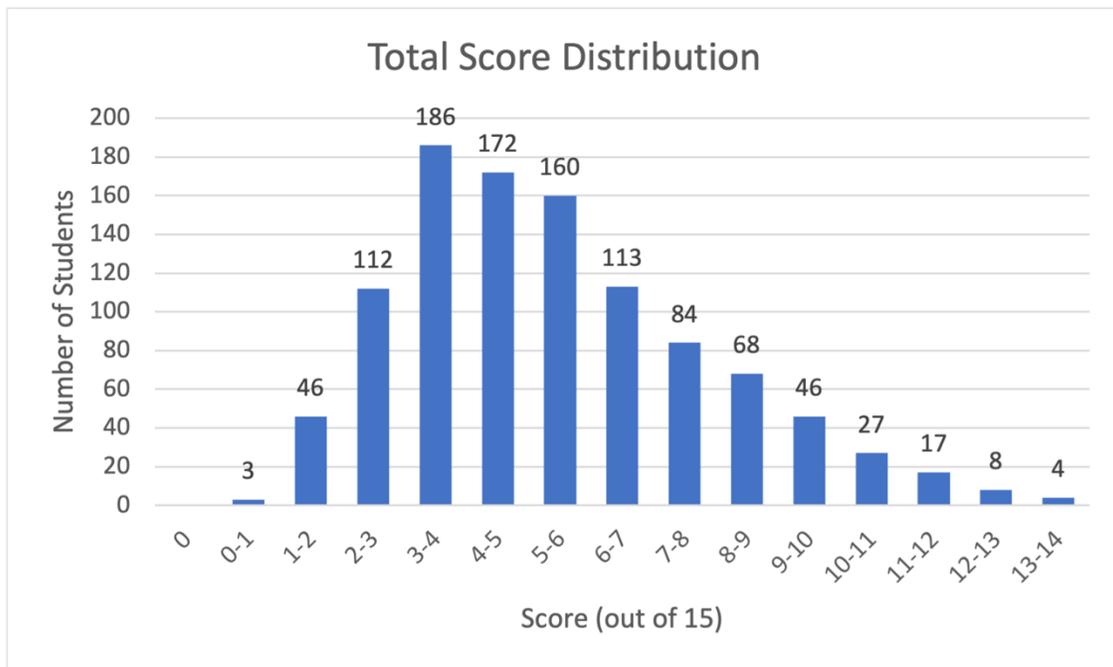
Figure 3: Total score distribution. Note: [a,b) means a < =score < b

The three students highest scoring students received 14 points, and 12 students received a score of 12 or higher.

Michael Smith Science Challenge 2022 Analysis

Questions and Solutions

1. Food

Identify these food products:

Calories 160	**% Daily Value*** / **% valeur quotidienne***
Fat / Lipides 0 g	0 %
Saturated / saturés 0 g + Trans / trans 0 g	0 %
Carbohydrate / Glucides 35 g	
Fibre / Fibres 0 g	0 %
Sugars / Sucres 0 g	0 %
Protein / Protéines 3 g	
Cholesterol / Cholestérol 0 mg	
Sodium 0 mg	0 %
Potassium 50 mg	1 %
Calcium 0 mg	0 %
Iron / Fer 0 mg	0 %

A

Calories 30	**% Daily Value*** / **% valeur quotidienne***
Fat / Lipides 2.5 g	3 %
Saturated / saturés 1.5 g + Trans / trans 0 g	8 %
Carbohydrate / Glucides 1 g	
Fibre / Fibres 0 g	0 %
Sugars / Sucres 1 g	1 %
Protein / Protéines 0.4 g	
Cholesterol / Cholestérol 10 mg	
Sodium 10 mg	1 %
Potassium 20 mg	1 %
Calcium 10 mg	1 %
Iron / Fer 0 mg	0 %

B

Calories 60	**% Daily Value*** / **% valeur quotidienne***
Fat / Lipides 0 g	0 %
Saturated / saturés 0 g + Trans / trans 0 g	0 %
Carbohydrate / Glucides 15 g	
Fibre / Fibres 0 g	0 %
Sugars / Sucres 15 g	15 %
Protein / Protéines 0 g	
Cholesterol / Cholestérol 0 mg	
Sodium 5 mg	1 %
Potassium 300 mg	6 %
Calcium 40 mg	3 %
Iron / Fer 1 mg	6 %

C

Calories 140	**% Daily Value*** / **% valeur quotidienne***
Fat / Lipides 1 g	1 %
Saturated / saturés 0.2 g + Trans / trans 0 g	1 %
Carbohydrate / Glucides 31 g	
Fibre / Fibres 3 g	11 %
Sugars / Sucres 0 g	0 %
Protein / Protéines 3 g	
Cholesterol / Cholestérol 0 mg	
Sodium 0 mg	0 %
Potassium 75 mg	2 %
Calcium 20 mg	2 %
Iron / Fer 0.4 mg	2 %

D

A. A - White rice; B - Cream; C - Molasses; D - Brown rice
B. A - Cream; B - White rice; C - Molasses; D - Brown rice
C. A - White rice; B - Molasses; C - Cream; D - Brown rice
D. A - White rice; B - Cream; C - Brown rice; D – Molasses
E. A - White rice; B - Molasses; C - Cream; D - Brown rice
F. A - Brown rice; B - Cream; C - Molasses; D - White rice

54% of respondents answered correctly, with 19% switching the two rice labels (the fibre, calcium and iron pointed to brown rice).

Michael Smith Science Challenge 2022 Analysis

2. The Sky

The moon sometimes takes on a crescent shape like this because:

A. it appears to be close to the sun in the sky
B. it is in Earth's shadow
C. it is in the opposite direction in the sky from the sun
D. it is very close to the horizon
E. it is the right time of year

20% of respondents gave the correct answer, with 39% choosing the Earth's shadow and 26% the opposite direction in the sky from the sun. The belief that the crescent moon is caused by the Earth's shadow is remarkably persistent, and extends to undergraduate science students and beyond.

3. Tree Rings

How old was this tree when it was cut down?
A. 85 y

B. 105 y
C. 125 y
D. 155 y

42% of all students answered this question correctly. There were three different versions of this question, all with the same correct answer of 85 years. The photographs were of good quality and could be expanded for an accurate count.

4. Environment

Version 1: Natural gas is a hydrocarbon with approximately four hydrogen atoms to each carbon atom. When burnt in a household furnace, a kg of natural gas produces –

A. more than a kg of CO_2 and more than a kg of water
B. a kg of CO_2, only
C. less than a kg of CO_2 and less than a kg of water
D. it depends on the engine's efficiency
E. less than a kg of CO_2, only

Version 2: Gasoline is a hydrocarbon with approximately two hydrogen atoms to each carbon atom. When burnt in an engine, a kg of gasoline produces –

A. more than a kg of CO_2 and more than a kg of water
B. a kg of CO_2, only
C. less than a kg of CO_2 and less than a kg of water
D. it depends on the engine's efficiency
E. less than a kg of CO_2, only
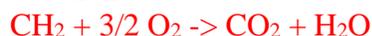
Solution:
$CH_2 + 3/2\ O_2 \rightarrow CO_2 + H_2O$
14 kg + 48 kg   -> 44 kg + 18 kg
$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$
16 kg + 64 kg   -> 44 kg + 36 kg

In both cases the masses of the CO_2 and the water individually are each greater than that of the hydrocarbon that is being burnt.

44% of all students answered this question correctly. There were two versions of this question, with C being the next most popular choice.

5. Solstice

On the day of the summer solstice at latitude [x] degrees, what is the maximum angle (in degrees) of the sun above the nearest horizon?

Solution: During the summer solstice the sun is directly overhead, at 90 deg. The declination of earth is 23.5 deg.
(90 + 23.5) – x = maximum angle
⇨ 113.5 – x = maximum angle
⇨ For example, if the latitude is 52 deg, the maximum angle is 113.5 – 52 = 61.5 deg above the horizon

18% of students answered this question within two degrees of the correct value. The latitude [x] was randomized.

6. Water Draining

The flat roof of your garage is 10 m by 10 m in area and drains into a 1 m^3 water butt which you use to water your garden when it its dry. If it is raining at a rate of [x] mm per hour, how long (in minutes) will it take to fill your water butt (from empty)?

Solution: x mm rain per hour refers to depth of rain caught in 1 m^2. We have an area that is 10 m by 10 m = 100 m^2. The volume of water is equal to the height x multiplied by the area of the square.

$$1 \text{ m}^3 \times \frac{60 \text{ min}}{x \text{ mm} \times 100 \text{ m}^2} \times \frac{1000 \text{ mm}}{1 \text{ m}}$$

i.e. 600/x.

So, for a rate of 18 mm/hour, 600/18 = 33.33 min.

22% of all students answered within one minute of the correct value. The rate of raining in mm per hour [x] was randomized.

Michael Smith Science Challenge 2022 Analysis

7. Dimensions

A cylindrical beverage can is made of aluminum, density 2700 kg/m^3 with a uniform thickness of [t] mm. The can has a diameter of [d] cm and a height of [h] cm. What is its mass (in grams)? Consider the can to be empty but unopened.

Solution: The mass can be found from the following formula and was typically around 20 g:

$$m = 0.27 * t * \pi * (d * h + \frac{d^2}{2})$$

11% of all students answered this question within one gram of the correct value.

8. Pandemic

A new, mild and non-fatal virus is known to produce and infection rate that doubles in the population of a city every three days. Starting off on day zero with one patient, how many days before [N] people are infected?

Solution: The number of days before N people are infected can be found from the following formula, which was typically several weeks:

$$days = \frac{3 \log N}{\log 2}$$

26% of all students answered correctly to the nearest day.

9. Floatation

A piece of maple wood, density 600 kg/m^3, measuring [x] mm x [y] mm x [z] mm, floats in water. How much of the wood (in mm) is above the water line?

Solution: The height of wood in mm above the water line can be found by multiplying x by 0.4:

$$height\ above\ water\ in\ mm = 0.4x$$

5% of all students answered this question to the nearest mm of the correct value (which was a few mm). Most failed to realize that the wood floats with its smallest dimension vertical.

Michael Smith Science Challenge 2022 Analysis

10. Environment II

Version 1: Consider a kilogram of sugar. Where did most of its component atoms come from?

A. Atmospheric carbon dioxide and water
B. Nutrients in the soil
C. Atmospheric nitrogen and oxygen
D. Atmospheric oxygen and carbon dioxide
E. Fertilizer

Version 2: Consider a kilogram of dry wood. Where did most of its component atoms come from?

A. Atmospheric carbon dioxide and water
B. Nutrients in the soil
C. Atmospheric nitrogen and oxygen
D. Atmospheric oxygen and carbon dioxide
E. Fertilizer

43% of all students answered this question correctly, with a similar number choosing atmospheric oxygen and CO_2. There were 2 versions of this question.

11. Greenhouse Gas (Fill in the blank)

A greenhouse gas is described physically as one that is mostly transparent to [1] and absorbs [2].

Possible answers are:
- heat
- light
- visible light
- infrared light
- ozone
- pollution
- warming

Most correct answer: A greenhouse gas is described physically as one that is mostly transparent to **visible light** and absorbs **infrared light**.

The correct answer was worth 1 point, with each correct word choice being worth 0.5 marks. About 21% of all students answered this question correctly, and about 41% of students got 0.5 marks.

12. Sound Tube

The lowest resonant frequency of a sound tube is approximately the frequency with which sound can travel from one end of the tube to the other *and back again*. If the sound tube is [x] cm long, what is this frequency (in Hertz, which means cycles per second).

Solution: The frequency can be found from the following formula:

$$f = 343 * \frac{50}{x}$$

9% of all students answered this question to within 2% of the correct value. This is notably lower than the performance on other questions. The length of the sound tube [x] was randomized.

13. Area

A hectare is an area of $(100 \text{ m})^2$. In one particular year, [x] million hectares of forest burned in BC; this area is equivalent to a square with a side how many km long?

Solution: The length of the square (typically ~ 100 km) can be found from the following formula:

$$side\ length\ of\ square = \sqrt{x} * 100$$

The correct answer was worth 1 point. About 24% of all students answered this question within 1 km of the correct value. The number [x] of million hectares was randomized.

Michael Smith Science Challenge 2022 Analysis

14. Contour Map

This is a contour map with the lines connecting places of equal altitude. The lines are spaced every 50 m. Local peaks are marked A-E.
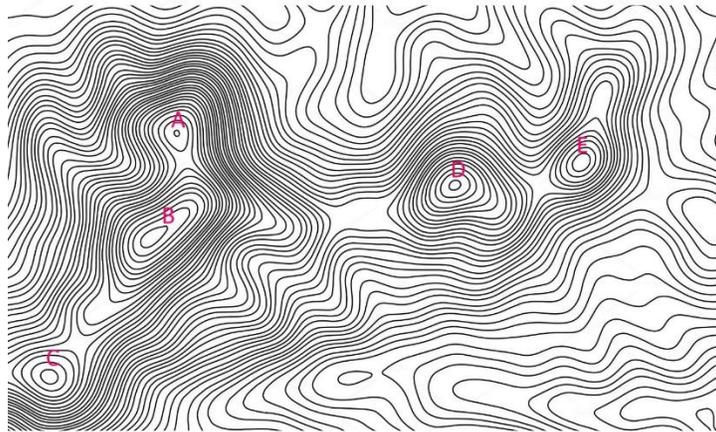
Which of the peaks A-E is the second highest?
A   B   C   D   E
Which of the peaks A-E is the lowest?
A   B   C   D   E

42% of all students answered this question correctly. There were 2 versions of this question.

Michael Smith Science Challenge 2022 Analysis

<u>Long Answer</u>

1. Below is a photograph of a Seaspan barge being towed by a tug, several km away, on a cold morning in late winter. Inset is a close up photograph of a similar tug and barge. Explain in a few brief sentences why the distant image looks the way it does.

The long answer question was used only as a potential tie breaker for top scoring students.

Solution:

On a winter's day the sea water is warmer than the bulk of the air, so there is a layer of warmer (and therefore less dense) air just above the water. The speed of light in this layer is slightly greater than that further above leading to the possibility of total internal reflection just above the water surface. It is this reflection that produces an inverted image of the word "Seaspan" just visible above the water on the side of the barge.