

Michael Smith Science Challenge 2018

Analysis of Results

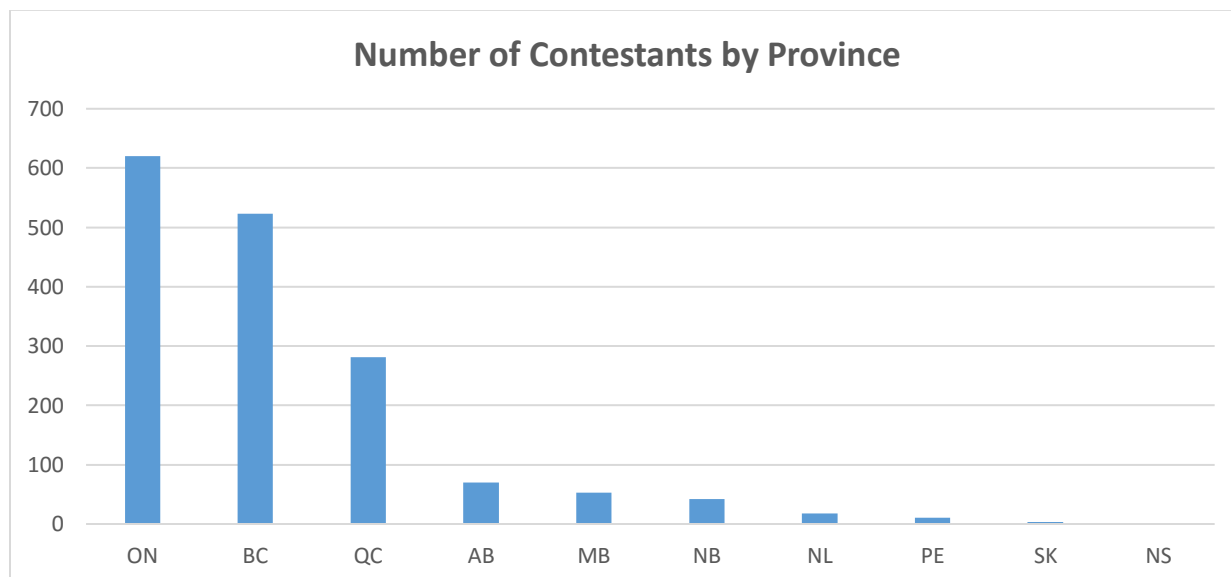
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Introduction

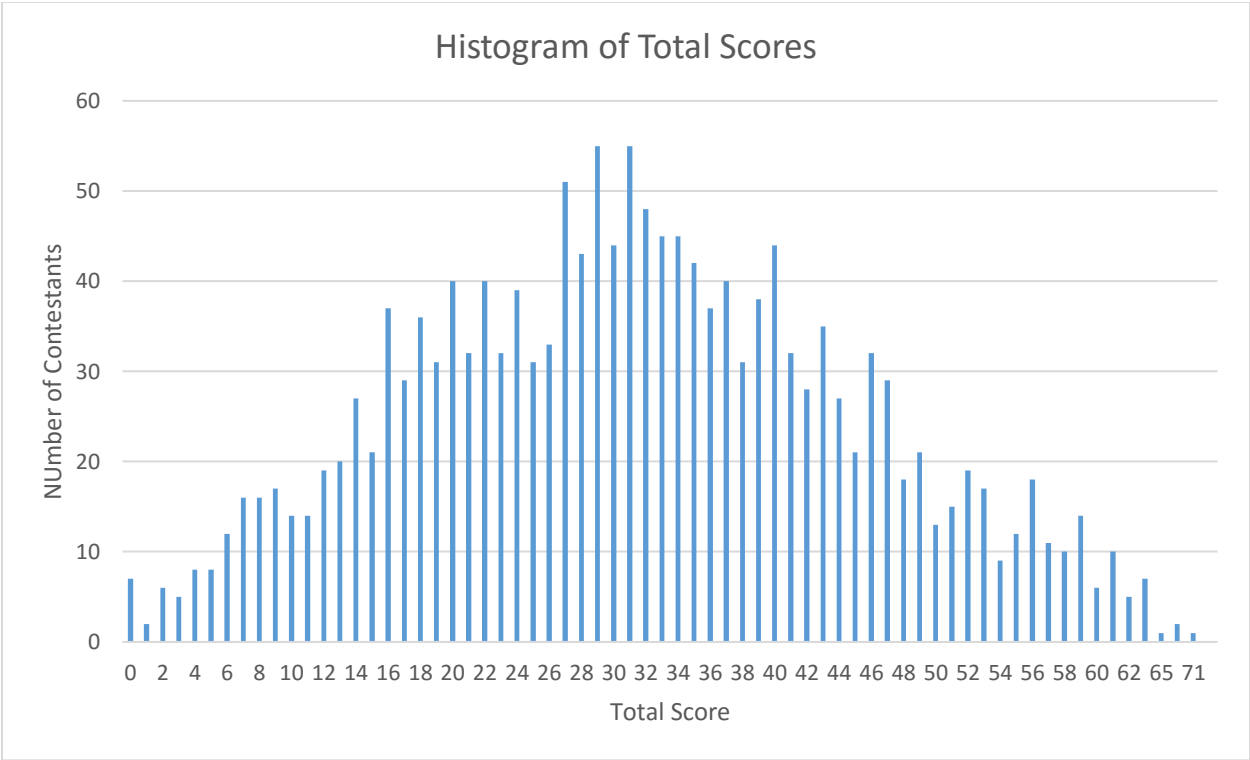
The Michael Smith Science Challenge is a national science contest written by students in grade 10/niveau 4 and below. It was first piloted in the Province of British Columbia in the April of 2002. Since then, it has been run annually across Canada. The purpose of the contest is to challenge students'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

A total of 1622 exams was received this year, from all 10 provinces and 149 teachers. Of the students whose gender was given, 53% identified as female.



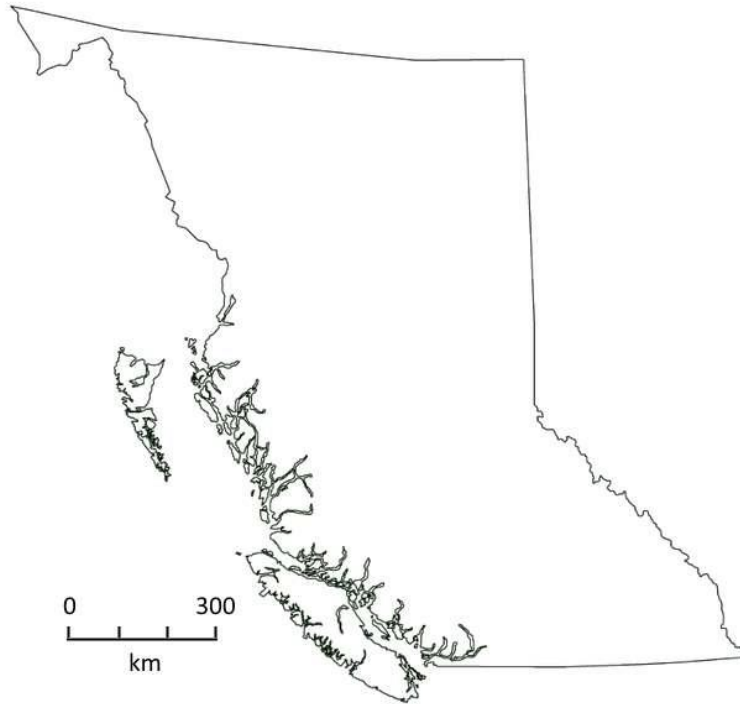
Results

The average score on the contest was 31/80.



The Contest

1. Last summer, fires burnt a million hectares in the heart of British Columbia. A square of side 100 m has an area of one hectare.
 - (a) Draw a square on the map below that is a million hectares in area. Use a ruler for accuracy.



- If a square of side 100 m has an area of one hectare, then a square that is a million hectares in area will have a side length of $(100 \text{ m})(10^6)^{\frac{1}{2}} = 100 \text{ km}$.

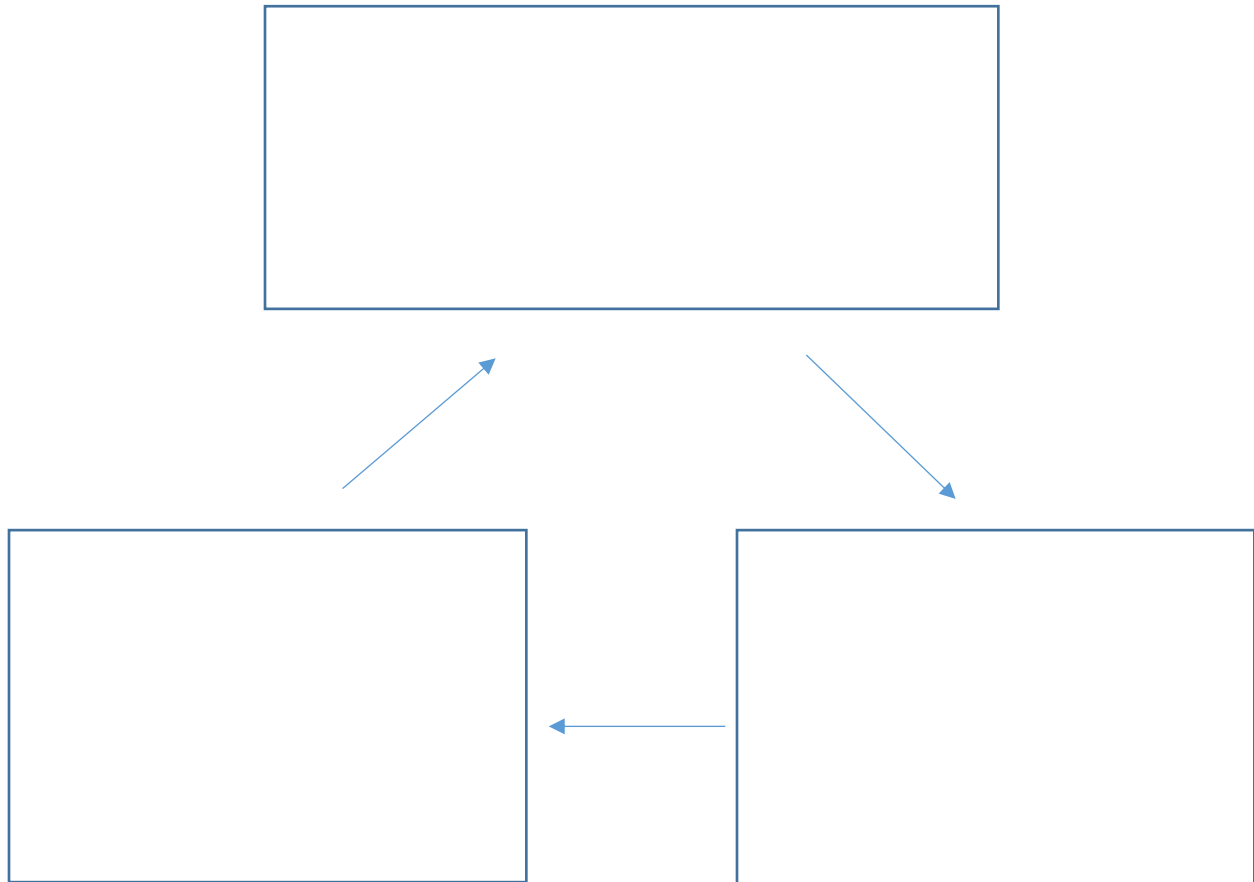
Grade Distribution:

- Full marks were given for squares drawn with side lengths within 10% of the 100 km as given by the scale on the map (otherwise no marks were given); around 35% of students did this.

Common Mistakes:

- A fifth of the students drew squares larger than the Province.

(b) Positive feedback is a process in which the effects of a disturbance on a system increase the magnitude of the original disturbance. That is, A produces more of B, which in turn produces more of A. Put some words in the boxes below to demonstrate that massive forest fires are an example of positive feedback.



- Following from part (a), the intent here was that students recognize that forest fires increase the CO₂ in the atmosphere that warms the planet, thus increasing the likelihood of forest fires.
- One possible correct approach to this problem was:

forest fire → carbon dioxide production → increasing Earth temperature → more forest fire

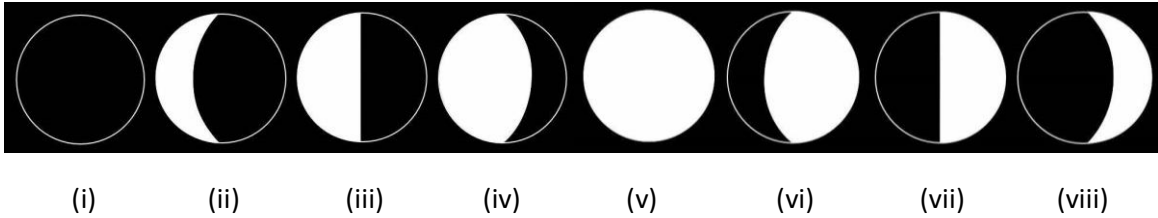
Grade Distribution:

- Around 20% of the students were awarded 10/10.
- About 18% cited the spread of a fire as an example of positive feedback. There are aspects of fires that show positive feedback, such as air rising due to the heat, causing

more air (and oxygen) to be drawn in to intensify the fire. For simply citing fires without giving details like this, we awarded 7 marks out of 10.

The average score for this question (both parts) was 7 points out of 20; 7% of students received the full score.

2. You are standing somewhere in Canada and the Moon appears like one of the images (i-viii) below:



(a) How would the Earth appear if you were standing near the North Pole of the Moon?

| Moon appears like this from Earth | Earth appears like this from Moon |
|-----------------------------------|-----------------------------------|
| (ii) | (vi) |
| (iv) | (viii) |
| (vii) | (iii) |

Grade Distribution:

- Around 50% of students got this question correct.

Common Mistakes:

- Students often drew ambiguous pictures rather than stating the Roman numeral identifiers; these were awarded zero marks.

(b) How would the Moon appear from Earth immediately before entering the Earth's shadow in a Lunar Eclipse event? (Please answer i-viii).

The answer is (v).

Common Mistakes:

- Unsurprisingly, many (~ 70%) students confused solar and lunar eclipses and answered (i). Clearly, many students had never seen a lunar eclipse, which is a pity, given the frequency of these events.

(c) The orbit of Mars lies outside that of Earth. In which of the configurations (i-viii) can Mars appear from Earth?

- This is a trickier question. The answer is (iv), (v) and (vi). Mars lies outside Earth's orbit and so can never appear as a crescent or even half full.

Grade Distribution:

- Very few students (~ 2%) were able to identify the three correct phases.

Common Mistakes:

- Students often stated all phases as the solution.

The average score for this question (all parts) was 8 points out of 20. Only three students received the full score (20/20).

3. The word “recyclable” should refer to an object that can be processed for reuse. However, the word has come to mean “can be put in the recycling bin”, which is not the same thing. Consider single-use coffee cups, which are a mix of plastic and paper that is hard to recycle:

(a) Estimate how many single-use coffee cups are thrown away every year in Canada. Show how you arrived at your answer. Marks will only be given for your reasoning.

- A reasonable ball-park estimate of coffee consumption is one single-use cup per person per day; the reality is very unlikely to be more than 10 cups a day or less than 0.1 cup per day. We allowed any number in between in this part of the calculation.
- We also allowed a Canadian population (36M) of between 10M and 50M, although many responses gave numbers far outside this range.
- Thus $(1)(36 \times 10^6)(365) = 13$ billion cups per year.

Grade Distribution:

- Around 40% of students gave a plausible answer to this question.

Common Mistakes:

- Students often used random values with no explanations.
- Some students used population values that were either very small (~ 1 million) or very big (largest used by a student being 700 billion).

(b) Re-usable (“Eco”) coffee cups, especially those made of plastic, may or may not be environmentally better than single-use cups. The appearance of plastics through the biosphere means it is crucial to figure out which is better. Government legislators have asked you, a scientist, to help them decide. What critical pieces of data would you collect? List up to six.

| |
|----|
| 1. |
| 2. |
| 3. |
| 4. |
| 5. |
| 6. |

- This question was marked holistically. If all the data cited would allow a comparison of the mass of plastic *consumed* per year (i.e. made or disposed of, not just in use at any one time) for each type of cup, then nine marks out of the twelve were awarded. In addition, any discussion of differing environmental effects, caused by differences between the two types of cup during manufacture, recycling or disposal, gained the remaining three marks.

Grade Distribution:

- Only six students were awarded full marks for this question.

Common Mistakes:

- Repetitious entries.
- Some students simply stated facts rather than listing critical pieces of data to be obtained.

The average score for this question (both parts) was 9 points out of 20. A single student received the full score for this question (20/20).

4. You are training for a marathon and need a lot of energy. On the other hand, you are trying to reduce the salt in your diet.

| Nutrition Facts Valeur nutritive | | Nutrition Facts Valeur nutritive | |
|---|---------------------------------------|---|---------------------------------------|
| Per 2 slices (71 g) / pour 2 tranches (71 g) | | Per 1 slice (50g) / pour 1 tranche (50 g) | |
| Amount Teneur | % Daily Value % valeur quotidienne | Amount Teneur | % Daily Value % valeur quotidienne |
| Calories / Calories 180 | | Calories / Calories 110 | |
| Fat / Lipides 2.5 g | 4 % | Fat / Lipides 1.5 g | 2 % |
| Saturated / saturés 1 g + Trans / trans 0 g | 5 % | Saturated / saturés 0.2 g + Trans / trans 0 g | 1 % |
| Cholesterol / Cholestérol 0 mg | | Cholesterol / Cholestérol 0 mg | |
| Sodium / Sodium 230 mg | 10 % | Sodium / Sodium 170 mg | 7 % |
| Carbohydrate / Glucides 32 g | 11 % | Carbohydrate / Glucides 20 g | 7 % |
| Fibre / Fibres 4 g | 16 % | Fibre / Fibres 2 g | 7 % |
| Sugars / Sucres 3 g | | Sugars / Sucres 1 g | |
| Protein / Protéines 6 g | | Protein / Protéines 4 g | |

Brand 1 Brand 2

(a) Which of these brands of bread would you choose? Marks will only be given for your reasoning.

- The obvious approach here is to take the ratio of energy (calories) to salt for each brand.

| Brand | Energy/Salt (cal/mg) |
|----------|----------------------|
| 1 | $(90/115) = 0.7826$ |
| 2 | $(110/170) = 0.6471$ |

- Alternatively, look at energy and salt per unit mass:

| Brand | Energy/gram (cal/mg) | Salt/gram (cal/mg) |
|----------|----------------------|--------------------|
| 1 | $180/71 = 2.535$ | $230/71 = 3.24$ |
| 2 | $110/50 = 2.2$ | $170/50 = 3.4$ |

- Either way, brand 1 looks to be the better choice.

Common Mistakes:

- Students often did not use ratios to support their answer and instead wrote long explanations that did not aid their argument. Around 60% of the students did this.
- Some students did not notice that the information given for the two brands was for different serving sizes.
- Some students mistook the amount of energy as the sum of calories, carbohydrates, and/or fats present.

(b) How many grams of salt (sodium chloride, NaCl) go into each 1 kg loaf of brand 1?

- Each 71 g of the bread contains 230 mg of sodium.
- Thus in 1 kg there is $(0.23 \text{ g})(1000/71) = 3.24 \text{ g}$ of sodium.
- Adding in the chlorine, NaCl is $(23+35.5)/23$ times more massive than Na alone, thus in 1 kg of bread, there is $(3.24)(58.5/23) = 8.24 \text{ g}$ of sodium chloride.

Grade Distribution:

- Around 20% of the students answered the whole question correctly.

Common Mistakes:

- A large number of students (~40%) confused the mass of sodium with the mass of salt.
- Rounding numbers too much and too early in the calculation and, although using the correct calculational approach, obtaining a significantly different answer from that given above.
- Confusing units (mg, g, kg).

The average score for this question (both parts) was 7 points out of 20. A total of 52 students received a full score for this question (20/20).