

Scientific Thinking for All: A Toolkit

Teach your students not to fool themselves

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STEM Learning

- UK's **leading provider** of STEM education programmes for teachers - working across the UK, reaching every primary school, secondary school and FE College – connecting with 270,000 teachers:
 - **Invest in teachers** to change the lives of young people
 - **Quality of teaching** has greatest influence on achievement and destination
 - **Impact** is magnified through teachers
 - Now - **delivering 78,000 days of teacher continuing professional development (CPD)** a year
- We **connect** schools with 37,000 volunteer STEM Ambassadors
- We **provide** enrichment and engagement opportunities for young people
- We **deliver** the Nuffield Research Placements programme
- We **host** the UK's largest collection of STEM resources





Online CPD and resources



Regional CPD



National STEM Learning Centre



Inspirational Programmes:



The Lawrence Hall of Science

A Center for Education and Research

For over 50 years, The Lawrence Hall of Science has been at the forefront of science education. As part of the University of California, Berkeley, we work with scientists, engineers, and educators to design the most effective learning experiences.

We strive to transform the world of STEM, infusing these fields with diverse perspectives and innovative minds.

lawrencehallofscience.org



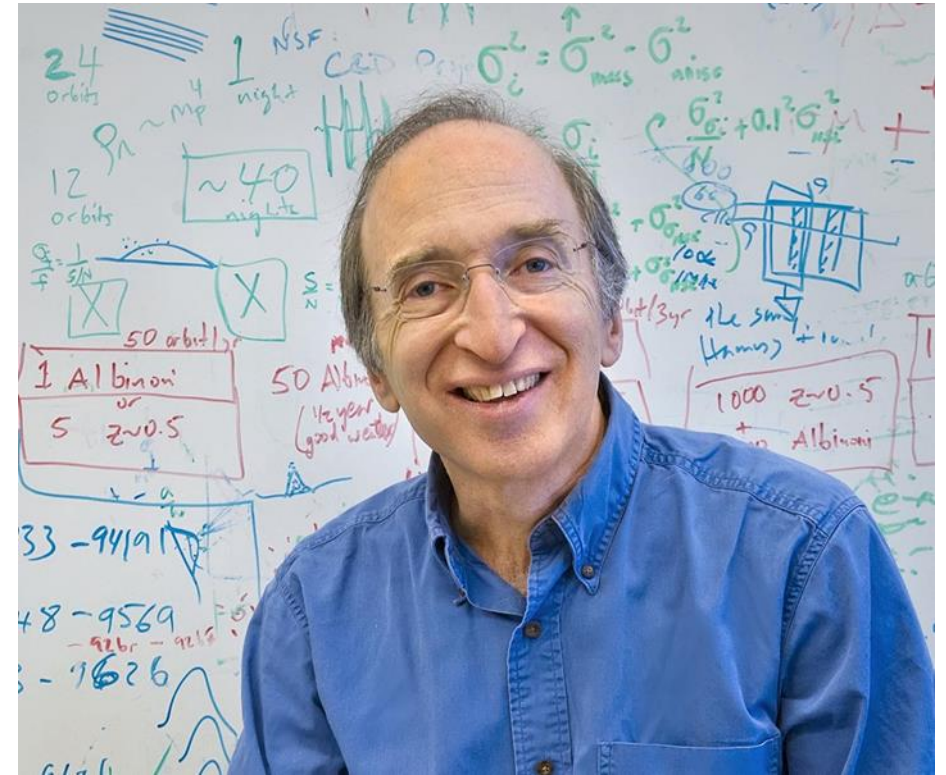
Background to project:

Sense & Sensibility & Science

Every day we make decisions as individuals, as voters, and as members of our various communities. We make decisions as students and parents and policy makers.

The problem is, we don't do it so well.

The focus in this course is on the errors humans tend to make, and the approaches science methodology has given us (and we are still developing) to prevent or at least minimize those errors.



Prof. Saul Perlmutter
Berkley California Physics

sensesensibilityscience.berkeley.edu/

Scientific Thinking for All: A Toolkit

Scientific Thinking for All: A Toolkit is designed to prepare high school students (14-18 years old) for the challenges and opportunities ahead. It teaches a toolkit of cognitive strategies for real-world issues.

By learning to view the world scientifically, students will develop skills in reasoning and collaborating, equipping them to deal with the challenges of the 21st century.



Both education partners are piloting course material and teacher training materials in US and UK

The Lawrence Hall of Science is adapting the UC Berkeley course into a high school version. The Lawrence develops such curricula with extensive feedback from teachers piloting the material and trainings.



STEM Learning is working closely with the Lawrence to ensure cross-cultural fit for the UK audiences and curriculum. STEM Learning works with an extensive network of teachers and students across the entire UK, and these will pilot the program there.



Planned content

Six Units of Content planned

Unit 1: Evidence and Iteration in Science

Unit 6: (Implementing energy solutions)





Unit 1: Evidence and iteration in science

How do people use evidence and iteration of ideas to construct scientific explanations that are relevant to everyday issues, such as water quality?



Multiple Lines of Evidence



Shared External Reality



Senses and Instrumentation



Scientific Advancement



Science as a Human Endeavor



Scientific Optimism



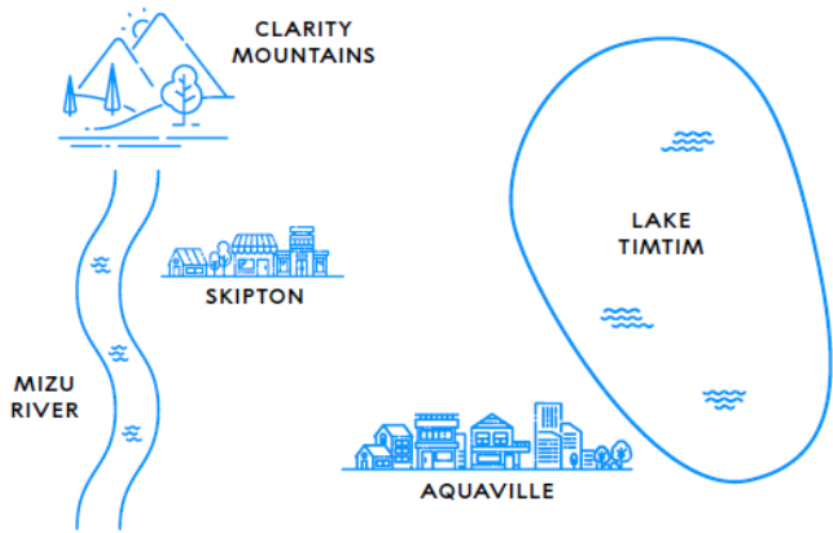
Credible Sources

Unit 1 content

1. Skipton's Water
2. Validating measurements
3. Scientific advancement
4. Testing local water
5. Iteration of ideas
6. Claims and evidence
7. Evidence and explanations
8. Science is a human endeavour
9. Water quality and design challenge
10. Solutions through scientific optimism

Card-based investigation
Laboratory based investigation
Card-based investigation
Field trip
Reading/literacy
Computer simulation
Card based investigation
Video-based
Laboratory investigation
Presentations

Skipton's Water



Skipton is a medium-sized town near the Mizu River. For many years, Skipton has piped in freshwater for residential use from the larger city of Aquaville.

Aquaville is near Lake Timtim, a huge freshwater lake from which Aquaville sources its water.

Piping water from Aquaville to Skipton costs the town of Skipton money, and it is money that the town no longer has.

Skipton is in debt and working on developing its own water supply directly from Lake Timtim to save money. This process will take a couple of years.

In the meantime, some members of the town have proposed a short-term solution: using water from the Mizu River. Although this will save the town \$3 million over 2 years, the river's flow is not large enough to provide a reliable long-term solution.

The main source of the river is snow melt from the Clarity Mountains about 100 miles upstream. The water is clear and has no odor. The results of pH tests—which determine if the water is too acidic or basic for residential use—show that the water falls within the recommended range of 6.5–9.

It has been routinely tested for microbial contaminants, and bacteria levels are low (within a normal range). The plan is to treat the water with chlorine, which kills most bacteria and viruses, before piping it into homes.



So, should Skipton save money by using water from the Mizu River?

Plan for Skipton's water:



	MY DECISION	EVIDENCE SUPPORTING MY DECISION	QUESTIONS I HAVE
INITIAL PROPOSAL			
AFTER DATA CARDS 1-8			
AFTER DATA CARDS 9-16			

The town of Skipton decided to move forward with using water from the Mizu River for residential use. Two months have passed.

Many residents report that their tap water looks and smells fine.

The pH tests of the water do not indicate any changes in water quality.

Repeated bacterial tests of the water do not indicate any changes in water quality.

Many residents enjoy drinking fresh orange juice at breakfast.

Some residents have recently complained that their tap water is cloudy, not clear.

A few residents are worried about the quality of their drinking water.

Sales of bottled water have increased.

The city has already saved \$500,000.

Should Skipton use the Mizu River?

Another month passes...

Numerous tests of the water do not indicate any changes in water quality.

Residents of one area of Skipton have observed increased water cloudiness over a period of two weeks.

The water has undergone multiple additional measurements of cloudiness beyond those required by law, and the water meets national treatment standards.

Thousands of town residents have experienced stomach upset and diarrhea over a period of several weeks.

A stool sample of a sick patient contains *Cryptosporidium*. *Cryptosporidium* is a microscopic parasite that causes watery diarrhea. It can be found in water, food, soil, or on surfaces that have been contaminated with the feces of humans or animals infected with the parasite

Cryptosporidium cannot be detected by most standard tests of water quality.

Reusable water bottles are on sale at local stores.

Cryptosporidium cannot be killed with chlorine at the concentrations used in routine water treatment.

Did anyone change their mind?



	MY DECISION	EVIDENCE SUPPORTING MY DECISION	QUESTIONS I HAVE
INITIAL PROPOSAL	Yes, use water from Mizu River for 2 years.	<p>Saves money.</p> <p>Water is clear and has no odor.</p> <p>The pH is in the right range.</p> <p>Low level of microbes.</p> <p>Water will be treated with chlorine.</p>	<p>Will there be enough water for the 2 years?</p> <p>Will the water be tested for other factors?</p> <p>Is the water from Lake Timtim clean?</p>
AFTER DATA CARDS 1-8	Yes, keep using water from Mizu River.	<p>Tap water looks and smells fine.</p> <p>Bacterial and pH tests of water show no change.</p> <p>City saved \$500,000.</p>	<p>Who is deciding that the water looks and smells fine?</p> <p>Exactly how is this being determined?</p>
AFTER DATA CARDS 9-16	Yes, keep using water from Mizu River.	<p>No other tests indicate any change in water quality.</p> <p>Water meets national treatment standards.</p> <p>Conducting more water quality tests for cloudiness than required by law.</p>	<p>What else could be making people sick?</p> <p>Why is the water cloudy?</p>

Many residents enjoy drinking fresh orange juice at breakfast

DATA	IS THE DATA RELEVANT?		DOES IT PROVIDE EVIDENCE THAT SUPPORTS OR REFUTES USING WATER FROM MIZU RIVER?	
	YES	NO	SUPPORTS	REFUTES
1				
2				

Residents of one area of Skipton have observed increased water cloudiness over a period of two weeks.

Typical levels of response

LEVEL 1 RESPONSE

I agree with Skipton's decision to get water from the river because river water is clean and good for you.

Typical levels of response

LEVEL 2 RESPONSE

I agree with Skipton's decision to get water from the river. The water quality tests are okay, but people might get sick.

Typical levels of response

LEVEL 3 RESPONSE

I agree with Skipton's decision to get water from the river. The town has saved money, the water quality tests haven't changed, and the cloudiness levels meet standards. The trade-off of my decision is that there might be Cryptosporidium in the water.

Typical levels of response

LEVEL 4 RESPONSE

I agree with Skipton's decision to get water from the river. The town has already saved a lot of money.

Water quality tests do not show any change, and cloudiness levels meet standards for water quality.

While some residents have gotten sick, there is no evidence that it is from the drinking water. The trade-off of my decision is that if the *Cryptosporidium* is in the water, more people may get sick.

Some people might not think saving money is worth the risk.

Unit 1 content

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- 2. Validating measurements**
- 3. Scientific advancement**
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What is up next... Unit 6

Students will begin to consider the future of energy in a fictional town, and, in turn, their own use.

Students will use FERMI estimates, and engage in the FACTS and VALUES held by different stakeholders. As part of this process they, they learn and apply DECISION ANALYSIS procedures and tools, which can integrate facts and values into group decision making.

Finally, they research current issues around energy supply and apply their knowledge and tools to support their recommendations for the future.



How you can engage:

Keep updated on the Nobel site:

www.nobelprize.org/scientific-thinking-for-all/

Sign up to the mailing list on the Lawrence Hall of Science site:

berkeley.qualtrics.com/jfe/form/SV_dgVqaSuFzb8dRHg



Thank you and any questions?

Please do not hesitate to contact me directly:

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