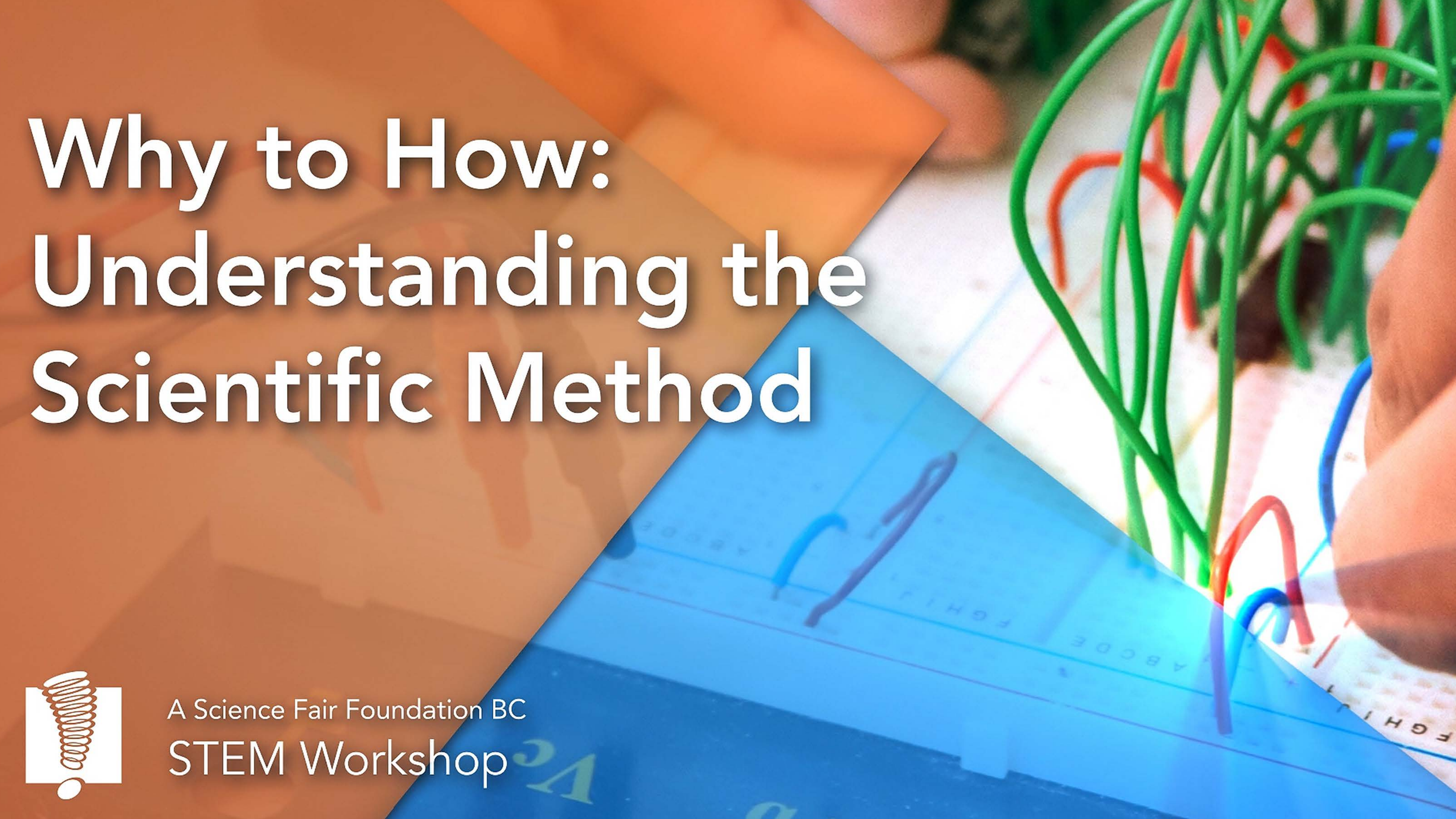
Why to How: Understanding the Scientific Method



A Science Fair Foundation BC
STEM Workshop

What is the Scientific Method?

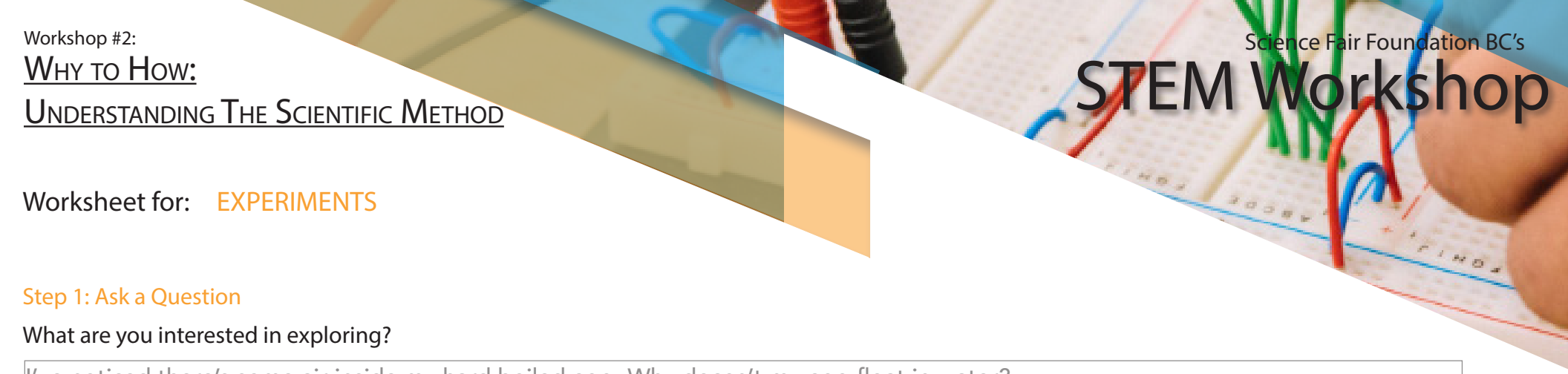
The Scientific Method is a series of steps used to guide research.

Why is it Important?

- Helps us answer questions based on evidence.
- Helps us look at evidence more objectively and limit our biases.
- Allows other people to replicate and validate our results.

The Scientific Method

1. **Ask a Question**
   - Base it on something you've seen or read, or on a problem you face during your day. Make sure the question is clear so others know what you're trying to solve.
2. **Do Some Research**
   - Learn more about your subject matter to gain a better understanding of it. This background knowledge will help you build an effective STEM project and see what others have already learned about your question.
3. **Make a Hypothesis / State Objective**
   - Based on your research, make an educated guess or goal related to your question. Predict an answer or end state.
4. **Test Your Hypothesis / Objective**
   - Build a way to test your hypothesis or meet your objective. Make sure it's as fair as possible. Make a list of the materials that you'll need and carefully record all the data you collect and your observations.
5. **Analyse Your Results & Form a Conclusion**
   - Look at the results of your test. Is your hypothesis supported? Did you meet your objective? It's okay if things didn't go as expected. We learn just as much from being wrong as we do from being right.
6. **Tell Others About it!**
   - Science is a community. We build on our shared knowledge to learn more than any single person could. So tell people what you learned!



Workshop #2:

Why to How:
Understanding The Scientific Method

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Worksheet for: EXPERIMENTS

Step 1: Ask a Question

What are you interested in exploring?

I've noticed there's some air inside my hard boiled egg. Why doesn't my egg float in water?

Need ideas? Watch Workshop 1: What's a STEM Project? at www.sciencefairs.ca/learn/workshops.

Step 2: Do Some Research

What things do you need to know more about?

What makes an object float in water?

What, if any, research has been done on this topic before? Summarize your findings.
Note: Use the pages at the end of this Worksheet to take detailed Research Notes.

- An object floats if it is less dense than the liquid it is placed in.
- The density of water is 1 g/cm3. The density of air is 0.001225 g/cm3, so a large enough air pocket can make an object float. However, the density of an average egg is 1.031 g/cm3, even with its air pocket. An egg is denser than water and that's why it sinks.
- An egg can float in salt water. The density of table salt is 2.16 g/cm3. When mixed with water it increases the density of the solution.
- We wanted to see how adding substances with different densities to water would affect the buoyancy of an egg. We picked: baking soda, with a density of 2.20 g/cm3 and granulated sugar, with a density of 1.59 g/cm3.

Workshop #2:

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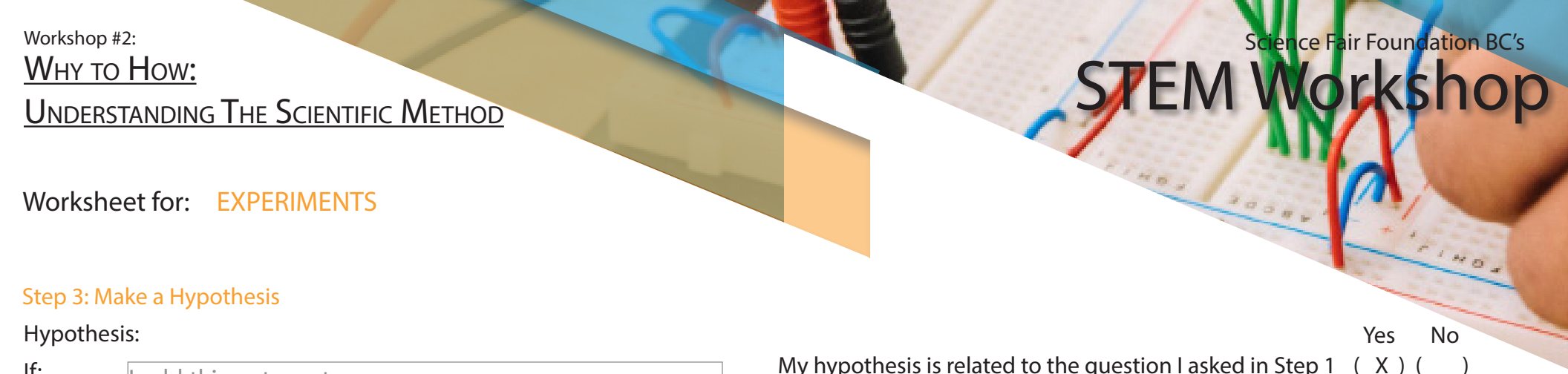
Worksheet for: EXPERIMENTS

Research Notes

Source #	Reference Details	Research Notes
1		
2		
3		
4		
5		
6		



Workshop #2:

WHY TO HOW:
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Worksheet for: EXPERIMENTS

Step 3: Make a Hypothesis

Hypothesis:

If: I add things to water,

then: I can make an egg float.

because: I know eggs float in salt water.

	Yes	No
My hypothesis is related to the question I asked in Step 1	(X)	( )
My hypothesis provides good direction for the project	( )	(X)

If you answered Yes to both questions, go to Step 4.
If you answered No to either question, try again.

Hypothesis:

If: I add baking soda, salt and sugar to different glasses of water

then: I will need the least amount of baking soda to make an egg float

because: baking soda is denser than salt and sugar.

What are your variables?

Controlled: Amount of water, egg size, equipment

Manipulated: Amount of each substance added to water

Responding: Buoyancy of the egg

Controlled Variable

a condition
you keep the same

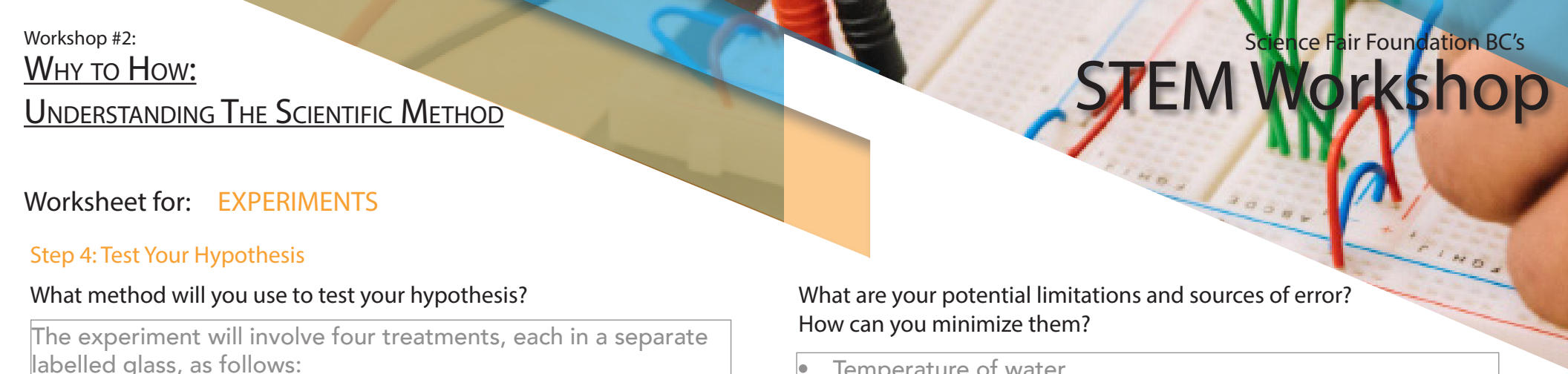
Manipulated Variable

also called an "independent variable"

a condition
you change

Responding Variable

a condition that
changes due to
your actions



Worksheet for: EXPERIMENTS

Step 4: Test Your Hypothesis

What method will you use to test your hypothesis?

The experiment will involve four treatments, each in a separate labelled glass, as follows:

- Treatment 1 - plain water (control)
- Treatment 2 - water + baking soda
- Treatment 3 - water + salt
- Treatment 4 - water + sugar

Begin by labelling your cups and spoons #1 to #4 using masking tape and a pen/marker. You will use spoon #1 with glass #1, spoon #2 with glass #2, etc.

Add 250 ml water to each glass. Add 1 tsp of solute to Treatments 2 to 4, as indicated above. Stir to dissolve the solute. Carefully lower an egg into each glass. Are any eggs floating after 30 seconds? If any eggs float, record the measurement as 1 tsp for that treatment.

Set aside the glasses with floating eggs. For the remaining glasses: Carefully remove any eggs that did not float. Add 1 tsp of the appropriate substance to each glass and stir until dissolved. Carefully replace each egg. Do any float? If so, record the measurement accordingly for that glass and set it aside. If not, repeat the above steps until all of the eggs float. This is Trial 1.

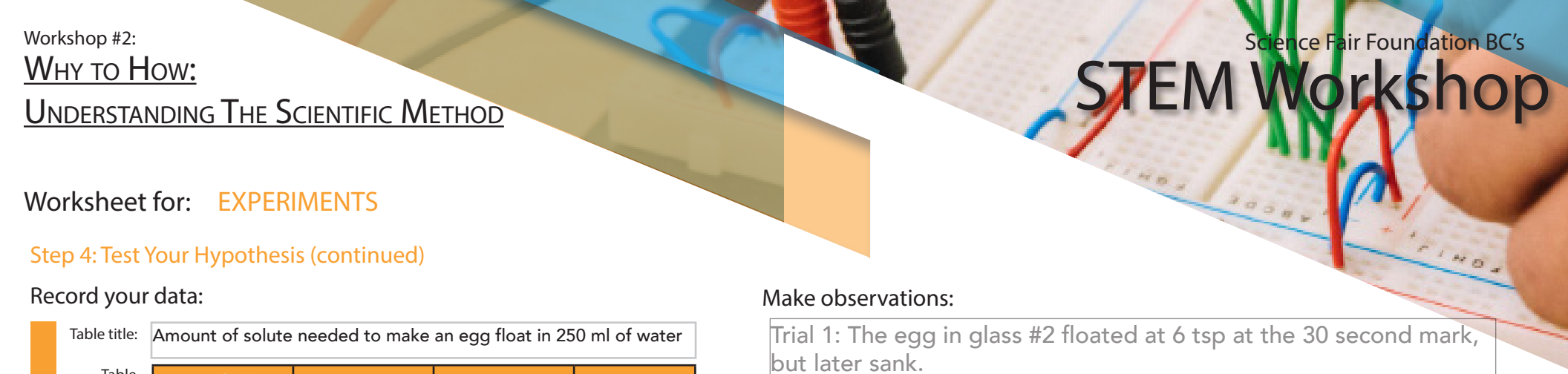
What are your potential limitations and sources of error? How can you minimize them?

- Temperature of water
- Contamination between treatments
- Measuring errors
- Size of eggs

Tip: Adjust your method now if you need to!

What materials do you need for your method?

- 4 glasses and 4 spoons
- Masking tape and a pen or marker
- Water
- A measuring cup and a teaspoon
- Table salt, baking soda, and sugar
- 4 eggs
- A timing device (e.g., clock, phone, timer)



Worksheet for: EXPERIMENTS

Step 4: Test Your Hypothesis (continued)

Record your data:

TRIAL #1

Table title: Amount of solute needed to make an egg float in 250 ml of water

Table labels:

Type of solute	# tsp solute added		
None	N/A, Control		
Baking Soda	6		
Table Salt	4		
Sugar	11		

TRIAL #2

Table title: Amount of solute needed to make an egg float in 250 ml of water

Table labels:

Type of solute	# tsp solute added		
None	N/A, Control		
Baking Soda	8		
Table Salt	4		
Sugar	11		

TRIAL #3

Table title: Amount of solute needed to make an egg float in 250 ml of water

Table labels:

Type of solute	# tsp solute added		
None	N/A, Control		
Baking Soda	6		
Table Salt	3		
Sugar	10		

Make observations:

Trial 1: The egg in glass #2 floated at 6 tsp at the 30 second mark, but later sank.

Trial 2: The egg in glass #2 floated briefly at 6 and 7 tsp, but then sank before the 30 second mark.

Trial 3: The egg in glass #2 floated at 6 tsp at the 30 second mark, but later sank.

All trials: Some of the baking soda settled at the bottom of the glass no matter how much I stirred.

Have more observations? Use the pages at the end of this Worksheet to add Other Notes, or start your own logbook.

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Worksheet for: EXPERIMENTS

Step 5: Analyze Your Results and Form a Conclusion

Perform calculations:

For each treatment:

(Trial 1 Measurement + Trial 2 Measurement + Trial 3 Measurement) / 3 Trials
= Average Measurement Across Trials

Treatment #1: No calculation, it's our control

Treatment #2: (6 tsp + 8 tsp + 6 tsp) / 3 trials = 6.67 tsp

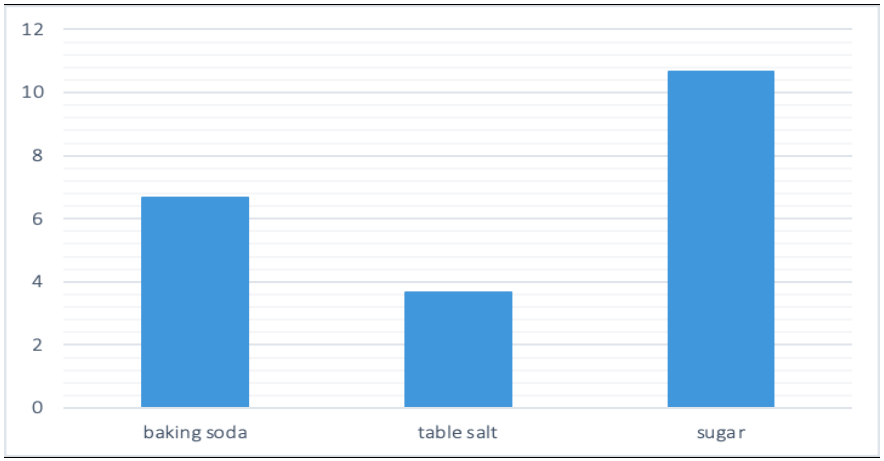
Treatment #3: (4 tsp + 4 tsp + 3 tsp) / 3 trials = 3.67 tsp

Treatment #4: (11 tsp + 11 tsp + 10 tsp) / 3 trials = 10.67 tsp

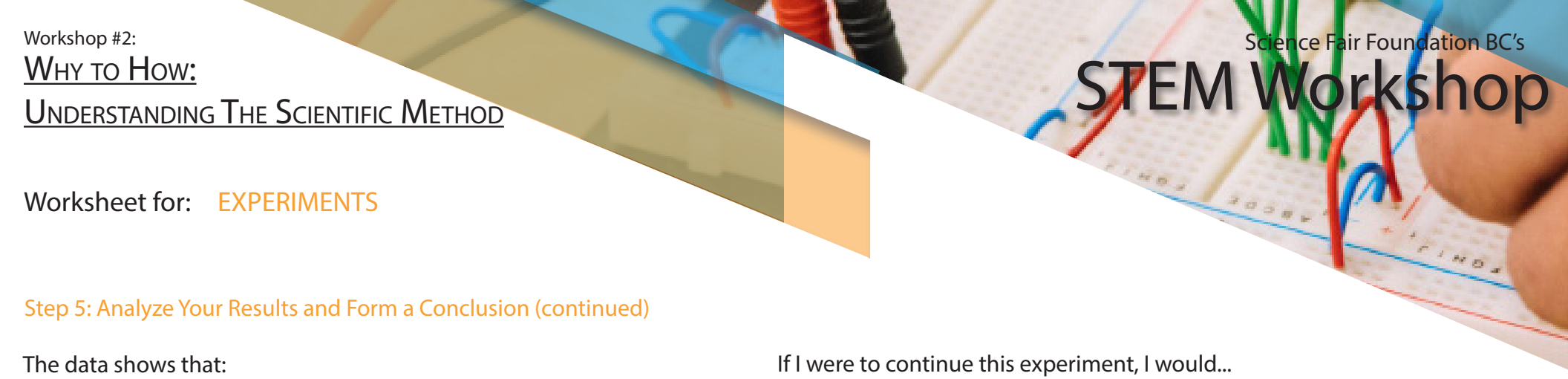
Graph your results:

Title of graph: Average amount of solute added (in tsp) to make an egg float in 250 ml of water

Axis label: tsp



Axis label: type of solute



Worksheet for: EXPERIMENTS

Step 5: Analyze Your Results and Form a Conclusion (continued)

The data shows that:

- An egg does not float in 250 ml of plain water.
- An egg floats in 250 ml of plain water with 6.67 tsp of baking soda mixed in.
- An egg floats in 250 ml of plain water with 3.67 tsp of salt mixed in.
- An egg floats in 250 ml of plain water with 10.67 tsp of sugar mixed in.

Are the results what you expected? Do they match existing research?

Based on our research about the density of the solutes, we expected that baking soda would make an egg float first, but it didn't, the salt did.

What might have affected your results?

The baking soda didn't fully dissolve into the water. The salt did, making the water denser faster. It's also possible that small variations in measurements or the size of our eggs could have made a difference in our results.

If I were to continue this experiment, I would...

Try more solutes, with a wider range of densities. I would also do some research into the solubility of the substances I'm using in water.

If I started over, I would...

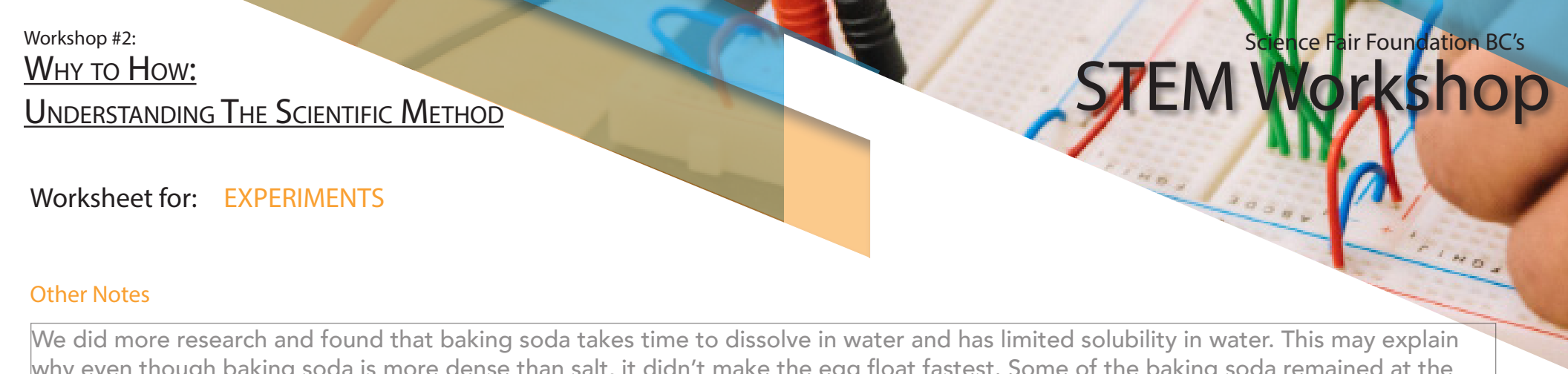
I used a measuring cup and a tsp to measure my water and additives. A scale might have been more accurate and allowed me to measure smaller increments / make my results more accurate.

Conclusion:

We expected that baking soda would make an egg float first, but it didn't, the salt did. We think this is because the baking soda didn't fully dissolve in the water. The salt did, making the water denser faster. Therefore, we can conclude that the egg floated when the solution became denser than the egg itself. If I were to continue this experiment I'd factor in the solubility of baking soda in water and also test other solutes with a wider range of densities.

Step 6: Tell People!

Reports, Presentations, Interviews.



Worksheet for: EXPERIMENTS

Other Notes

We did more research and found that baking soda takes time to dissolve in water and has limited solubility in water. This may explain why even though baking soda is more dense than salt, it didn't make the egg float fastest. Some of the baking soda remained at the bottom of the glass no matter how much we stirred and so wasn't increasing the density of the water as quickly as the salt, which more fully dissolved into the water.

More notes? Consider starting your own logbook.

Upcoming Programs

From Science Fair Foundation BC

Science Fair Foundation BC's

STEM Workshop

STEM Workshops

"What's a STEM Project"
October 12th, 2021

"Why to How:
Understanding the Scientific Method"
November 9th, 2021

"Understanding Ethics & Safety"
December 7th, 2021

"What Does an Awesome STEM Project Look Like?"
January 18th, 2022

"Analyzing Your Results"
February 15th, 2022

"Communication:
Reports, Presentations, Interviews"
March 15th, 2022

Mentorship Program

Have a question about your STEM project? Not sure what your results mean? Looking for expert advice on your specific STEM topic? Our Mentorship Program connects students across BC and the Yukon with science fair organizers, science fair alumni, scientists and industry experts to help in the development of their STEM projects. Send in your question using the webform on our website and get an answer from a mentor whose background best fits your subject matter.

- Available from December 1st, 2021, until mid-April, 2022, for students in grades 4 to 12

- Email access to experts in your area of interest

- Get help during any phase of your project

Discovery Foundation STEM Project Grant

Have a great idea for a STEM project, but don't have the resources to make it a reality? The Discovery Foundation STEM Project Grant awards project funding to Grade 4 to 12 students in BC and the Yukon who plan to participate in a science fair or the Youth Innovation Showcase in 2022.

- Apply between November 1st and December 15th, 2021

- Funding up to $200 for STEM projects

- Will cover costs for project supplies, access to academic journals, access to lab space or lab equipment, and registration fees for science fairs or the Youth Innovation Showcase

Find out more at www.sciencefairs.ca, following us on social, or subscribing to our newsletter.