Drawing Conclusions

It takes many skills to design and carry out good scientific experiments. The scientific method involves asking a good question, making a hypothesis, conducting research, identifying and controlling variables, making observations during testing, collecting data, and drawing conclusions. Using data sheets, diagrams, and graphs helps you organize and present your results. These skills help make your experiments reliable, repeatable, and meaningful.

Purpose

To draw a conclusion that accurately and completely summarizes the results of a scientific experiment.

Process Skills

Observe, measure, collect data, interpret data, communicate, form a hypothesis, identify and control variables, draw conclusions

Background

When scientists conduct an **experiment**, they follow a set of steps known as the **scientific method**. Drawing a **conclusion** is always an essential last step. A conclusion contains a **summary** of the results of an experiment. It explains whether or not the results supported the original **hypothesis**. In a conclusion statement, scientists discuss any errors that were made in following **procedures** or keeping **variables** constant. A conclusion also makes recommendations for how to change or expand the experiment if it is going to be repeated. Finally, the conclusion statement suggests ideas for future experiments that could build upon current knowledge. In this experiment, you will practice drawing a conclusion based on a simple test.

Time – Preparation: 10 minutes; Part 1: 20 minutes; Part 2: 20 minutes

Grouping – Small groups

Materials
(per group)

- ❑ ice water
- ❑ very warm water
- ❑ 2 clear cups of the same size
- ❑ 2 bottles of blue food dye
- ❑ 2 bottles of yellow food dye
- ❑ a box of crayons or a set of colored pencils
- ❑ clock or timer
- ❑ Data Sheets 1 and 2 (one set per student)

Procedure

In this experiment, you should mainly focus on drawing a conclusion at the end of the activity. The information in the boxes will allow you to skip ahead in the scientific method so you can draw a conclusion more quickly. Read this information carefully.

Background Research:

- Particles are tiny bits of matter found in everything, including water.
- In hot water, particles have more heat and move more quickly.
- In cold water, particles have less heat and move more slowly.

Research Question:

Will the temperature of the water affect how quickly the yellow and blue food dyes mix?

Hypothesis:

If yellow and blue food dyes are added to hot water and to cold water, then the food dyes will mix just as quickly in each cup because there is nothing to keep them separated.

Part 1: Conduct the Experiment

1. Fill one cup with ice water and another cup with very warm water. Fill them to an equal height or measure an equal volume into each cup.
2. Have a group member add one drop of blue and one drop of yellow food dye to the cold water while another group member adds one drop of blue and one drop of yellow food dye to the warm water. Make sure to add all four drops of food dye at the same time. **TIP:** The experiment will work best if you hold the dropper close to the water without touching it as you add the drops of dye. Do not stir the water or move the cups.
3. Observe what happens inside the cups over a 30-second period. Discuss with your group what you are noticing and explain why you think this is happening.
4. On Data Sheet 1, use crayons or colored pencils to sketch what happened to the dye inside the cups.
5. As a group, discuss your observations. Be sure to identify any differences you observed between the two cups. Record these results on Data Sheet 1.
6. Clean up your work area. Keep Data Sheet 1 as a reference to use during *Part 2: Draw a Conclusion*. Return to your group with Data Sheet 2.

Part 2: Draw a Conclusion

1. Use Data Sheet 2 to complete each part of a conclusion for this experiment. Use the questions in the table as a guide.
2. On the back of Data Sheet 2 or on separate paper, use your answers from Data Sheet 2 to write a complete conclusion for this experiment. Combine all your responses into one paragraph.

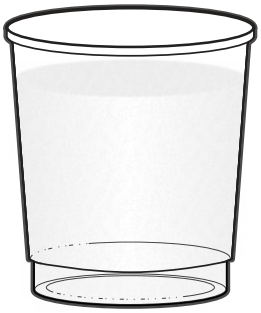
Name_____ Date_____

Part 1: Conduct the Experiment

Research Question: Will the temperature of the water affect how quickly the yellow and blue food dyes mix?

Hypothesis: If yellow and blue food dyes are added to hot water and to cold water, then the food dyes will mix just as quickly in each cup because there is nothing to keep them separated.

Results: Use crayons or colored pencils to draw what your group observed after the 30 seconds.



Hot Water

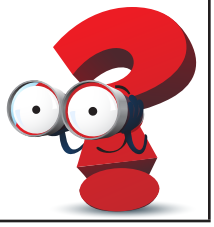
Cold Water

Observations: Write about what you observed in the cups, including any differences.

Name_____ Date_____

Part 2: Draw a Conclusion

The best science conclusions include *all* the parts in the table below. Using the information from Data Sheet 1, work with your group to complete each part of the conclusion.

Summary of experiment: What is the answer to the research question? 
Compare results to hypothesis: Did the results support the hypothesis? Explain why or why not. (Review the hypothesis and compare it to the results.)
Review procedures: How well did your group follow the procedures for the experiment? 
Suggest improvements: What would you change about the procedures or variables if you were going to do this experiment again?
New questions: List ideas for future experiments related to this one that you would like to try. They should add to what you learned during this experiment. 

Credits: (top, bottom): © iStockphoto.com/Mark Stay; (center): © Learning A-Z

Name_____ Date_____

Critical Thinking

1. What is a conclusion?

2. In your opinion, which is the most important part of drawing conclusions? Why do you think this part is the most important?

3. Why is it useful to know how to draw conclusions? Think about careers that require this skill.

Drawing Conclusions

TEACHING TIPS

This process activity will help students recognize and understand the components of a well-written conclusion statement. Students will learn how to draw a conclusion based on the results of a sample experiment. To practice drawing conclusions, student will summarize their results by answering the research question and explaining whether the results support the original hypothesis. They will reflect on the procedures and judge how well they followed them. Conclusions also include recommendations for how to change or expand the experiment if it were to be repeated. Finally, students will use what they have learned to suggest future related experiments. Drawing conclusions is an essential last step in following the scientific method.

SET-UP AND PROCEDURES

- Food dye will stain clothing and rugs. If available, students should wear smocks. The experiment should take place in an area where spills can be easily cleaned up.
- Explain to students that during the observation period, they should not stir, mix, move, or disturb the cups in any way. This will ensure that the results of the experiment are due to diffusion (the spreading of particles) rather than other factors. This is a good opportunity to teach students about controlling variables.
- Diffusion will occur more rapidly in warmer water, but hot water can be dangerous for students. Test the activity ahead of time to choose the best water temperature for your class.
- Consider assigning jobs for each student within a cooperative group prior to the activity. Examples include two helpers, a getter, a reporter, and a cleaner.
- To help make sure that students add the drops of food dye simultaneously, have them wait for your cue to begin. Instruct students to watch and discuss what happens for the entire 30-second observation period before they begin recording results and drawing conclusions.

MATERIALS

- For best results, keep the ice water and the hot water in thermoses until ready to use. Make sure there is no ice in the water that is poured into students' cups. Likewise, make sure the warm water poses no danger of burns.
- Have plenty of towels on hand in case of spills.
- If the classroom does not have a sink, have a large tub available for students to pour their water into during cleanup.

- Many districts have a science resource center to contact if supplies (blue and yellow food dyes, droppers, timers) are not readily available at the school. Otherwise, supplies can be purchased at local or online supply stores.
- Use clear plastic cups of the same type. To eliminate the need for each group to measure water, use a permanent marker to indicate a "fill line" on the cups before passing out materials.

EXTENSIONS AND VARIATIONS

- *Variation/Critical Thinking:* Have students try this experiment several more times. Ask them whether the results are always the same. Discuss why it is important to repeat an experiment in order to make sure that a conclusion is as accurate as possible. Discuss the fact that collecting more data affects the conclusion. For example, more data helps scientists become more certain of their results.
- *Variation:* Allow students to repeat the experiment, this time adding red and yellow food dyes to each cup of water. They might generate a new hypothesis, which will lead to a new conclusion. Have them compare their conclusions with those of the first experiment for similarities and differences.
- *Writing/Art:* Challenge students to create an acrostic poem using the word CONCLUSION. Their poem should describe the important components of a conclusion statement.
- *Writing:* Have students create a Venn diagram comparing the similarities and differences between drawing a conclusion in science and drawing a conclusion from reading a story.
- *Guest:* Invite a scientist to talk with students about some of the experiments he or she has done and the importance of drawing conclusions at the end of an experiment.
- *ELL/ESL:* Create a word wall. Include content vocabulary such as *experiment, scientific method, research question, hypothesis, observation, data, results, conclusion,* and *summary.* Also include vocabulary relevant to the lesson, such as *particles.* For more vocabulary resources, visit Vocabulary A–Z.com.

- *Technology:* Have students take digital pictures during their experiment and then use these to create a digital slideshow of their conclusion.
- *Home Connection:* Challenge students to conduct their own complete experiment using food dyes at home. Examples include dyeing eggs or making cake frosting. Ask students to write a conclusion for their experiment to share with the class.

ANSWER KEY

EXPERIMENT Science Skills—Drawing Conclusions Data Sheet 1

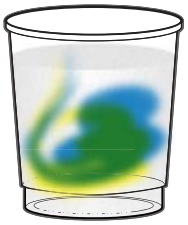
Name_____ Date_____

Part 1: Conduct the Experiment

Research Question: Will the temperature of the water affect how quickly the yellow and blue food dyes mix?

Hypothesis: If yellow and blue food dyes are added to hot water and to cold water, then the food dyes will mix just as quickly in each cup because there is nothing to keep them separated.

Results: Use crayons or colored pencils to draw what your group observed after the 30 seconds.



Hot Water

Cold Water

Observations: Write about what you observed in the cups, including any differences.

Responses will vary but should accurately reflect the observations made during the experiment. An example is provided below.

At first, there were no differences between the dyes in the two cups. After just a couple of seconds, the dyes started to spread out more in the warm water than in the cold water. Soon, the dyes in the warm water began to blend, creating a green color. After 30 seconds, the dyes in the warm water had mixed, and the water looked green. The cold water had some mixing but not as much. The two colors mostly stayed separated in the cold water.

ANSWER KEY

Answers will vary, depending on the results of the experiment and how well students followed the procedures. Examples are provided below.

EXPERIMENT Science Skills—Drawing Conclusions Data Sheet 2

Name_____ Date_____

Part 2: Draw a Conclusion

The best science conclusions include *all* the parts in the table below. Using the information from Data Sheet 1, work with your group to complete each part of the conclusion.

Summary of experiment: What is the answer to the research question?

The temperature of the water affected how quickly the yellow and blue food dyes mixed. In hot water, the yellow and blue dyes mixed, and the water turned green. In the cold water, the yellow and blue dye mostly stayed separate.

Compare results to hypothesis: Did the results support the hypothesis? Explain why or why not. (Review the hypothesis and compare it to the results.)

The results did not support the hypothesis. The food dyes mixed more quickly in the hot water. This is probably because particles move more quickly in hot water.

Review procedures: How well did your group follow the procedures for the experiment?

My group was careful to follow the procedures for this experiment. But we were not sure if the drops of dye were put in the water at exactly the same time.

Suggest improvements: What would you change about the procedures or variables if you were going to do this experiment again?

I would observe my cups for a longer period of time. I would use a thermometer to measure the temperature of the water before putting in the dyes. Also, I would try to make sure that the drops of dye were put in the water at exactly the same time.

New questions: List ideas for future experiments related to this one that you would like to try. They should add to what you learned during this experiment.

I would try adding food dyes to many different temperatures of water. I would also like to try gel food dyes and liquid food dyes to see if the results are the same.

Credits: (top, bottom): © iStockphoto.com/Mark Stay; (center): © Learning A-Z

ANSWER KEY AND EXPLANATIONS

Critical Thinking

1. What is a conclusion?

Answers will vary. Students should list the essential elements of a good conclusion statement. In science, a conclusion contains a summary of the results of an experiment. It answers a research question and states whether or not the hypothesis was supported by the results. Conclusions also describe any errors that were made while following procedures and recommends changes that would improve the experiment. Finally, the conclusion presents ideas for future research that add to what was learned during the experiment.

2. In your opinion, which is the most important part of drawing conclusions? Why do you think this part is the most important?

Answers will vary but should include a well thought-out rationale. Answers may focus on the ability to answer the research question using the results from an experiment.

3. Why is it useful to know how to draw conclusions? Think about careers that require this skill.

Conclusions are useful because they give answers to questions that are based on the results of research. Good conclusion statements synthesize the results of an experiment into a meaningful message. Most careers require the ability to create questions, formulate hypotheses, follow procedures, gather results, and draw conclusions. For example, teachers, nurses, and police investigators often follow these steps to solve problems. But careers in science, technology, and math require more rigorous adherence to the scientific method. Conclusions are particularly important for communicating research findings to the scientific community.