**GUIDING QUESTIONS**
**for a Comparative Study (4th and 5th grade)**

The following topics and questions are meant to guide student thinking before, during, and after the project for students who choose to do a comparative study and want to go further with their exploration of the scientific process. *This information is presented at a high level and designed for adults and students together.* We hope these questions will help lead students through some higher level thinking about the design of their project and how they make conclusions from the results. Students should not feel like they need a complete answer to each question before the Expo.

For a *comparative study*, the project should center on a comparison of two or more groups, as opposed to researching a topic or recording general observations on something of interest. Further information about some of the terms used in this document is provided at the end of this document and also feel free to contact us.

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## I. Problem, question statement, and background information:

*(1)* How or why did you choose the general topic for your project?

*(2)* What question or problem are you investigating? (Focus on a question rather than a hypothesis to avoid becoming attached to a particular outcome. Or, designing studies in an attempt to refute a hypothesis, rather than support it, is a good strategy!)

*(3)* What background research did you do before designing your investigation?

*(4)* Do you know if this investigation has been done before? If yes, do you know what the results or conclusions were?

## II. Study design:

-Note: A *study unit* (or experimental unit) is the animate or inanimate object that you will measure something on for your study. Each group in your study should be made up of a number of study units. Examples of study units include people, dogs, petri dishes, bottles, or possibly different "trials" using a person, animal, or object.

*(1) Are you designing an experiment or an observational study? Experiment:* Are you going to assign your study units to groups and then apply a treatment to each one (*e.g.,* assign different petri dishes to dog saliva vs. human saliva)? *Observational study:* Are you going to compare two or more groups that already exist (*e.g.,* compare 4th graders to 5th graders, dogs to cats, etc.)?

*(2) Deciding what to compare:* How did you decide the specific groups or treatments you compared?

If doing an experiment, did you include a "control" group? Why or why not?

*(3) Choosing subjects/study units to include in the study:* How did you select the subjects/study units you included in the study? Why did you do it this way?

*(4) Assigning subjects/study units to groups (for experiment only)* – How did you decide which subjects should be in which treatment group? Did you (or could you have) *randomly assigned* them? Why might you randomly assign them and how did/would you do it?

*(5) Deciding what to measure:* How did you decide what to measure on each study unit in order to compare the groups?

*(6) Thinking about possible lurking (or confounding) variables:* What things did you try to hold constant (or control for) while you compared the groups or treatments you were interested in?

*(7) Thinking about how many study units to use in the study:* How many study units did you have in each group? How did you choose this number?

*(8) Thinking about variability and randomness*: Think about your measurements from study units in the *same* group.

(a) What are some reasons they are different? Could you have controlled for any of the reasons in the design of the study by trying to keep it the same across groups?

(b) How different are they? If you have more study units per group does it make it easier to answer this question?

## III. What broad conclusions are appropriate? (What inferences are justified?)

*(1) Think about repeating the study:* Do you think your results might be different if you repeated the entire study with new study units? *Why* do you think the results would be different?

*(2) Think about making cause and effect statements in conclusions:* It is often tempting to conclude that the difference between the groups we created or identified is the cause of differences in the measurement. Can you identify other things that could have influenced the results you observed (other than the groups you were focused on)? (This relates to the earlier question about lurking variables).

*(3) Think about extending results beyond your study:* Do you think the results you got from your specific study units are similar to what you would have obtained if you had used other study units? Who (or what) do you think your results apply to beyond your study? (e.g. Do your results apply to all $4^{th}$ and $5^{th}$ graders? All dogs? Etc.)

## IV. Future research: (This is a really important part!)

(1) If you were to repeat your project, what would you change or improve? Why?

*(2)* What would you do as a follow-up study to this one? Why?
*(3)* What did you learn from doing this project?

## V. Presentation of project:

(1) Is your *research question* clearly stated on the poster board, and can you describe it briefly in words without reading from your poster?

(2) Are your *methods* (materials and procedures) written clearly so that someone else could repeat your study? Is it neat and easy to read? Did you use lists, charts, and/or pictures to help convey the information with fewer words? Can you describe it in words without reading from your poster?

(3) Are your *result*s clearly displayed? Do you make good use of tables, graphs, and/or charts? How did you summarize the measurements for each group to make the comparison easier? Can you summarize the results in words without reading from your poster?

(4) Do you include limitations of your study, things that went wrong, and things you would do differently in the future? A *Study Flaws* section is a wonderful inclusion to promote thinking through the whole process! Can you briefly describe your study limitations or flaws?

(5) Are your *conclusions* clearly displayed? Are the conclusions justified based on your investigation? Be sure to think about the questions in III when doing this. Are you prepared to answer questions about why you came to the conclusion(s) you did?

**DESCRIPTIONS of TERMS:** Here are some descriptions of terms used in this Guiding Questions document to help adults and students. We do not expect students to master these concept by completing a single project; the goal is simply exposure to and awareness of these ideas at a time when they are first being exposed to scientific research.

- **Comparative study:** A study meant to compare different groups with respect to some measurement of interest. It can be an experiment or an observational study (see below).
- **Experiment:** An experiment is a comparative study where study units are randomly assigned to groups according to the treatment they will receive, and then treatments are applied to the study units in each group. A control group that does not receive any treatment, or possibly receives a placebo, is usually included.
- **Observational Study**: An observational comparative study is designed to compare two or more groups when the groups already exist on their own before the study. For example, if a student wants to compare 4th graders to 5th graders, group membership is already known before the study and the researcher cannot control it.
- **Study unit:** The groups being compared are comprised of "study units." If students are using people in their study, then "subject" is the easiest example of a study unit. However, study units can be animate or inanimate objects. Examples of possible study units are petri dishes,

lizards, plants, or bottles. If the project involves measuring one thing repeatedly, then the study unit may be each "trial" where a measurement is taken. For example, if you are comparing how much your lizard eats at different times of the day, then each time you try to get your lizard to eat is called a "trial" and that is the study unit. Explicitly thinking about what the study unit actually is can be an important part of doing a study because it relates to thinking about replication and how generalizable the results of the study might be.

- **Variability:** A key concept in doing research is trying to get a handle on how much we expect measurements to differ for study units that are as similar as possible. This helps us understand how different we expect measurements to be just by chance, which helps us think about whether the differences we observe among our groups might just be due to chance or might be due to real underlying differences among the groups. This helps us understand how to word our results and our conclusions.
- **Cause and effects statements:** One of the most common mistakes in research is making cause and effect statements in conclusions that may not be justified. For example, suppose a study compares the amount of vegetables eaten by some kids who play videos to some kids who do not play video games. If the kids in the study who play video games ate more vegetables than the kids who did not, it might be tempting to conclude "video games cause kids to eat more vegetables!" We see such conclusions in the media nearly every day and it is important to start thinking critically about such statements at an early age. We hope to get students started asking "What else could explain the difference in the amount of vegetables eaten, other than the video game playing?" Using experiments is a way to help justify cause and effect statements. From observational studies, it is very difficult to justify cause and effect statements.
- **Inferring results beyond the study:** Another common mistake in research is assuming the results apply to subjects/study units beyond the study. For example, if you find a difference between 4th and 5th grades at Longfellow in 2016, does that imply you will find a similar difference at another elementary school or in a different year? Or, back to the video games and vegetables, based on the results of one study do you think all kids that play video games eat more vegetables than those who don't play video games? We hope to get students started thinking critically about how we should (or should not) generalize results of studies.