

Scientific Investigation Worksheets

Western U.P. STEM Fair & Festival

2023-2024

This document includes a series of 8 worksheets that guide students through the scientific investigation process.

These worksheets should be used as the required progress log for science project submissions.

Western U.P. STEM Fair & Festival
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Memorial Union Building (MUB) @ Michigan Technological University

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If any support is needed from a teacher, student, or parent please do not hesitate to reach out to Emily Geiger, Western U.P. MiSTEM Network Director, at egeiger@copperisd.org or (906)482-4250 ext. 188

Overview of Student Worksheets

Worksheet 1: The Question

Ask a very specific question about the problem or phenomenon that you want to investigate. State your question in terms of independent and dependent variables.

Worksheet 2: Research and Bibliography

Gather information from at least three scientific resources such as magazines, books or websites and write a summary of what you found concerning the question. The bibliography should list all the resources you consulted in investigating the question. Items should be listed in alphabetical order in a standard format.

Worksheet 3: Hypothesis

Based on the findings of your research, write an if-then statement (hypothesis) of how you think the investigation will turn out. In your hypothesis, you should predict how changing the independent variable would affect the dependent variable. There should be an explanation how your hypothesis supports the background information that you gathered from reviewing scientific resources.

Worksheet 4: Design the Investigation

Design an investigation that looks at the effect of changing the independent variable on the dependent variable. It is important that only one independent variable be changed at a time and that only one dependent variable is measured at a time. Determine in what increment the independent variable will change and how to measure the result of the change on the dependent variable. The design of the investigation should include information about your control, materials used (including appropriate units and amounts), and a step-by-step list of steps. All parts should be clear enough for others to follow your investigation.

Worksheet 5: Data Table and Observations

Conduct the investigation. Record the data collected and what you observed during the investigation. Also, record any errors that may have occurred during the investigation.

Worksheet 6: Results

Analyze the data that you collected, looking for patterns to draw a conclusion based on the analysis of the data and evidence. The data gathered may not support the original hypothesis. This happens to scientists all the time and it is a normal part of the scientific process.

Worksheet 7: Conclusion

Write a summary of findings concerning whether the data and evidence supports the hypothesis or not. The conclusion represents what you actually learned by conducting the investigation.

Worksheet 8: Analysis of the Investigation

Write a discussion of the errors in the investigation procedure and what improvements could be made. Include any discoveries that were not originally planned and what unanswered questions you have concerning the investigation.

Worksheet 1: The Question

Explanation

Here you will formulate a very specific question about a problem or phenomenon you wish to investigate. Phenomena are things that happen in the real world that can be observed, such as adding salt to the ice on the roads melts the ice. This question should be written in the terms of independent and dependent variables.

Helpful Definitions

- **Variables:** Conditions of the investigation that are kept the same, changed or are the measure of the change.
- **Independent Variable:** The variable that is changed and tested in the investigation.
- **Dependent Variable:** The measure of change caused by changing the independent variable.
- **Constants (aka Controlled Variables):** Conditions of the investigation that are kept the same.

Example:

- **Phenomenon:** Recipes call for adding salt to cooking water, so pasta will cook faster.
- **Question:** Will the amount of table salt affect the boiling point temperature of water?
- **Independent Variable:** Amount of salt added to the solution
- **Dependent Variable:** Boiling point temperature (°C) of solution
- **Constants:** Amount and the purity of water; pot, thermometer and stove used in the experiment.

Your Turn

Problem or phenomenon you wish to investigate.

List some questions you have about the problem or phenomenon.

From the questions above, you will need to choose a question to investigate. This question should involve factors (variables) that can be easily measured using a number (quantitative) or a trait (qualitative) that can easily be identified such as change in color. The question should allow you to design an investigation where you change one factor (independent variable) and you can measure the effect of changing that factor (dependent variable).

What question would you like to investigate?

What is the independent variable for your question? (The variable you will change)

What is the dependent variable for your question? (The measure of the change)

State the question in terms of the independent and dependent variables.

[illegible]

Source 1 Bibliography:

Source 1 Information:

Source 2 Bibliography:

Source 2 Information:

Source 3 Bibliography:

Source 3 Information:

More than 3 sources may be used!

Bringing the Information Together ~ First Draft

On a separate sheet of paper, compile the background information from each resource and rewrite in your own words your first copy of a *Literature Review* of your topic. This is your first draft.

Review of Literature ~ Final Draft

Have someone proofread your first draft for spelling, punctuation, grammar, etc. On a separate sheet of paper, rewrite your first draft to be part of the final written report.

Standard Format for Bibliography (aka Reference List):

Book:

Author's last name, author's first name. (Copyright date). Title of book (pages read). Place of publication: Publisher

Example: Martin, Jacqueline. (1998). Snowflake Bentley (p. 3-12). New York, N: Houghton-Mifflin Company

Magazine:

Author's last name, author's first name. (Date of publication). Title of article. Title of magazine, volume number, page numbers of the article.

Example: Hembrock, Tony. (2003). Stay Out! Stay Alive!. Science Scope, v24, p. 30

Newspaper:

Author's last name, author's first name. (Date of publication). Title of article. Name of newspaper, Page numbers of the article.

Example: Buoniconti, Sergio. (2003, April 22). Superior Studies. The Daily Mining Gazette, p. 2A.

Encyclopedia

Title of article. Name of encyclopedia, volume number. Place of publication: publisher, year of publication, page number of the article.

CD-ROM Encyclopedia

Name of program, version or release number, name of supplier, address of supplier.

Internet Source

Author's last name, author's first name. Title of document. Name of organization that posted the document, Date published, Web site address.

Worksheet 3: Hypothesis/Prediction

Explanation:

Based on your research from worksheet 2, write an *if and then* statement of how changing the independent variable of your question will affect the dependent variable. Write a statement from your research to support your hypothesis.

Example:

Hypothesis/Prediction: If the amount of salt added to water is increased, the boiling point temperature (°C) of the solution will increase. This is because the addition of salt lowers the vapor pressure of the solution, requiring it to be heated to a higher temperature in order to come to a boil.

Your Turn

Write an *if and then* statement of how changing the independent variable of your question will affect the dependent variable. It should express what you believe the outcome of the experiment will be based on your research in step 2.

Write a “*This is because...*” statement of evidence from your research in step 2 to support your hypothesis.

Worksheet 4: Design the Investigation

Explanation

When you design an investigation, you are writing a step-by-step list of what you will do to test the hypothesis. It should be written clearly, and the steps should be clear so that someone else could take your paper and perform the investigation.

Keep Your Variables Simple

- Make sure you are only using one independent and one dependent variable in your investigation. If you are changing more than one variable, you will not be able to know for sure which variable was causing the results you recorded. All other factors involved in the investigation should not change. The factors that do not change are your controlled variables.
- Determine in what increment you are going to change the *independent variable*.
- Determine how you are going to measure the change in the *dependent variable*.
- Make sure that appropriate units are used in measurements and record keeping.
- This information should be highlighted in your progress log.

Example:

- **Independent Variable:** Amount of salt added to the solution will be increased by 1 Tablespoon.
- **Dependent Variable:** Boiling point temperature of solution will be measured in °C using a thermometer.
- **Controlled Variables** Amount of water, pot and stove used in the experiment, use of distilled water each time and the thermometer used.

Your Turn

In what increment will your independent variable change? Give units and the device to measure.

[illegible][illegible]

Each investigation needs a "control trial" for comparison so that you can see how changing the independent variable affects your results and observations. The control is a standard to test your experimental results against. The control trial will be set up the same as all the other trials, but the trial is not treated with independent variables.

Example:

The control trial is the measurement of the boiling point temperature in °C of the solution without any salt (independent variable) added to it. This solution should contain only water.

Your Turn

What will the control trial be for your experiment?

List of Materials

After the experiment has been theoretically designed, the next step is to list all materials and equipment you will need for this investigation. Make sure to specify the amount of each material that you will need.

Your Turn

Write out the materials list for your investigation.

Step-by-Step Procedure:

- Instructions should be written in clear, easy-to-follow steps, so that someone else could read your instructions and carry out the same experiment.
- Describe in detail how the independent variable will be changed and how the dependent variable will be measured.
- A control trial will be conducted using the procedure but not treated with the independent variable. Conduct at least three trials of the control trial.
- At least 3 trials of the procedure should be performed for each change in the independent variable. You should use the same procedure for all trials. These repeated procedures are called replicates and strengthen any measurements and/or observations that lead to your conclusion.
- It is a good idea to have someone else read your procedure to be sure it is easy to follow!

Example ~ Procedure for the Investigation

Step 1: To measure the control, bring 4c of distilled water to a boil on the stove. Measure the temperature in °C of the boiling water. Record the highest temperature reading in the data table. Repeat this procedure two more times.

Step 2: Measure out 1T of table salt using the measuring spoon. Record the amount of salt with units in the data table.

Step 3: Add the measured salt to 4c of distilled water, stir, and bring to a boil. Measure the temperature in °C of the boiling water. Record the highest temperature reading with units in the data table.

Step 4: Repeat the procedure twice more for Trial 2 and Trial 3.

Step 5: Repeat the entire procedure using 2T, 3T, and 4T of salt.

Your Turn

Write out the step-by-step procedure to describe how the independent variable is changed and how the dependent variable is measured. Make sure that it is clear and easy to understand.

[illegible]

This image shows a single page of white paper with horizontal blue or grey ruling lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings present.

Worksheet 5: Data Table and Observations

Explanation

In this section, you will design a data table to help you to record the data you will measure in the investigation. You will also learn about making observations during your investigation. Collecting data and observations is very important. They will be valuable in helping you to draw a conclusion and locate any experimental errors. Below is a list of things to remember when conducting the experiment and collecting data and observations.

- Conduct at least 3 trials of your experimental procedure for the control trial and for each change in the independent variable.
- Record all measurements in a data table.
- Use the same units when recording data.
- Use the same materials and procedure for each trial.
- Use the same measuring device to record the changes.
- Record all observations during the investigation, things that happen, problems encountered, and errors made—these notes belong in your progress log.
- Tables should be numbered and have a descriptive caption above the table.

Example

Data Table 1. The effects of salt and boiling temperatures of solutions.

Independent Variable Amt. of salt (T)	Dependent Variable Boiling Temperature (°C) of Solution			Average Temperature (°C)
	Trial 1	Trial 2	Trial 3	
0 T (Control)	100.0	100.5	99.8	100.1
1T	100.4	101.6	100.8	100.9
2T	101.8	101.7	102.0	101.8
3T	102.5	102.8	102.6	102.6
4T	103.8	103.5	103.7	103.6

Observations

When the salt was added to distilled water it took longer for the water to reach a boil compared to the control. The water with salt in it also boiled more vigorously than the control. If the bulb of the thermometer rested on the bottom of the pot, it read at a higher temperature. Heat from the stove burner makes the thermometer read higher.

In trial 2, we spilled some of the 1T. of salt before adding it to the water.

Your Turn

Use the data sheet below to record your data. The calculation of the average will be done in Worksheet 6.

Data Table

Independent Variable: _____	Dependent Variable:			Average
	Trial 1	Trial 2	Trial 3	
Control				

Record your observations in the space below while you are conducting the trials. Make sure to include any problems you have or mistakes you make.

Observations

[illegible]

Worksheet 6: Results

Explanation

After all the data has been collected, it should be analyzed so that a pattern can be noticed, and a conclusion formulated. Using your data and observations from Worksheet 5, complete the following:

Averages

Using your data from Worksheet 5, calculate the average value for each dependent value. Record the averages in your data table. Show your work below or on a separate piece of paper:

Calculations

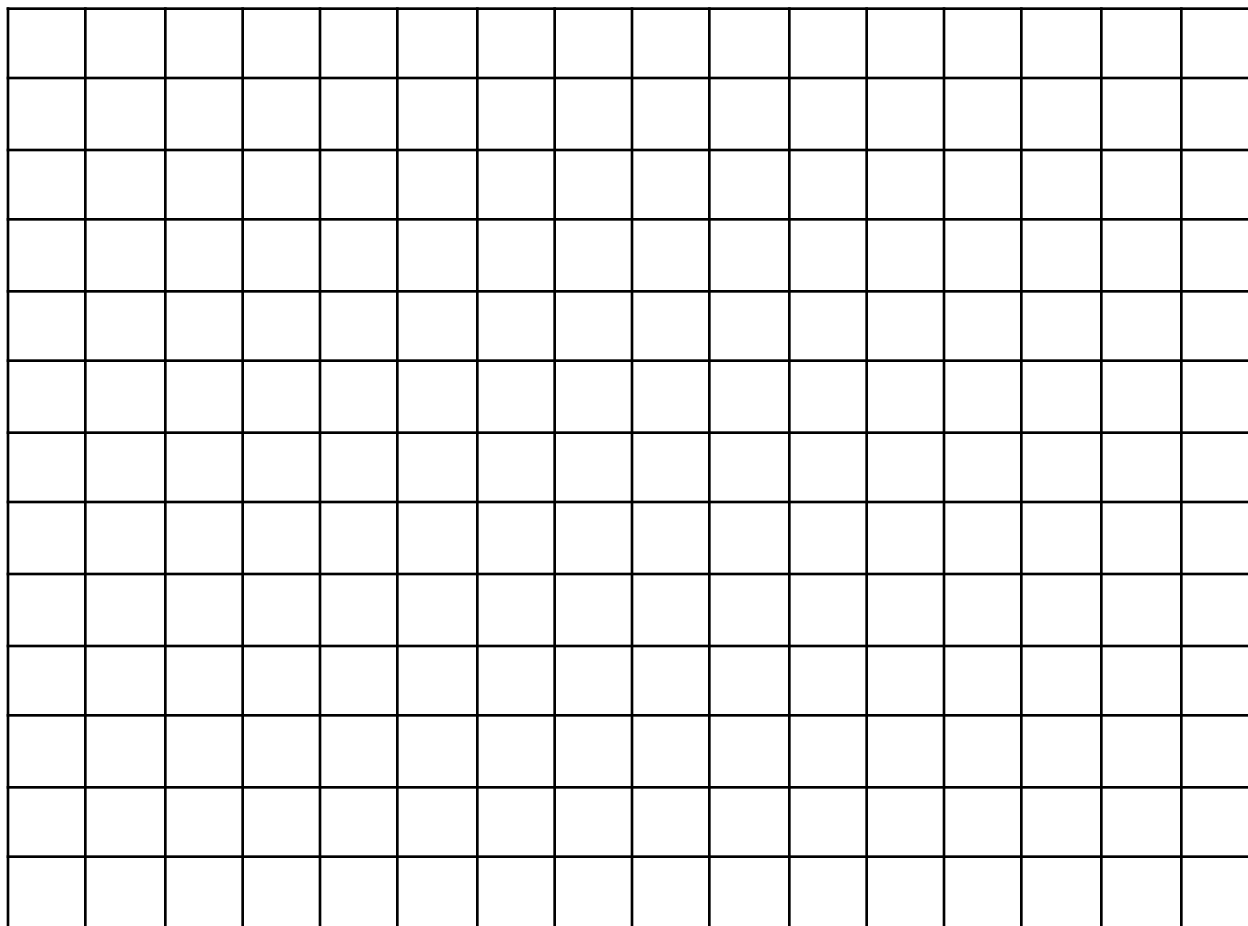
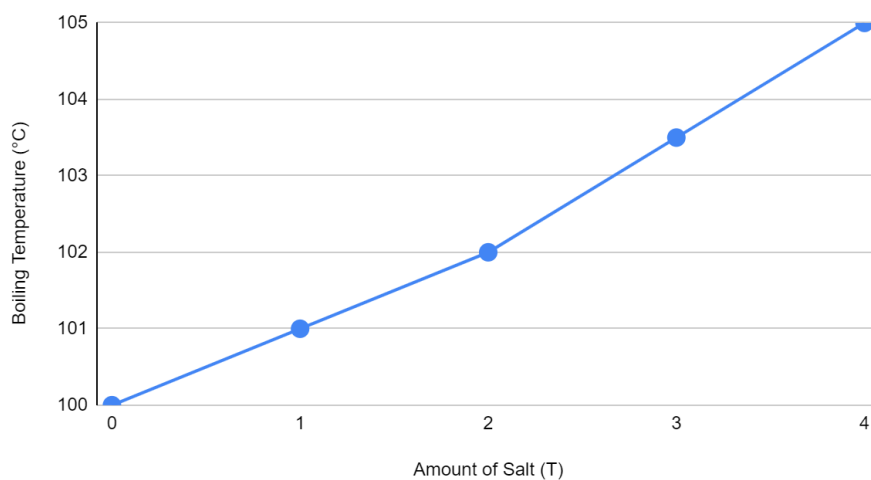
Perform any other mathematical calculations on your data using the average values that were calculated. Show your work on a separate piece of paper.

Graph

Design a graph(s) for your data on a separate sheet of graph paper, or the grid on the next page.. Remember to choose the correct type of graph to display your data! Some possibilities include: a bar graph, line graph, or pie chart. Make sure to label the horizontal (x) axis and vertical (y) axis. Don't forget units and a title for your graph! Here is an example graph.

Example ~ Graph of Experimental Data

The Effect of Table Salt on the Boiling Temperature of Water



Worksheet 7: Developing a Conclusion

Explanation

Using your evidence gathered (data, graph(s), and observations) you will develop a conclusion on whether your evidence supports or does support your hypothesis. The conclusion should include statements of how the evidence supports or does not support the hypothesis. Statements made in the conclusion should refer to the evidence gathered from your investigation that supports those statements. The conclusion represents what you actually learned by conducting the investigation. It should include a statement describing the importance of the investigation.

Example

The data shows that the boiling point temperatures of the water increased as more salt was added. When no salt was added to the water it boiled at 100.1°C, while the addition of 1T of salt increased the boiling temperature to 100.9°C. Salt was added one tablespoon at a time and the boiling point temperature was measured until when 4T of salt was added, a boiling point temperature of 103.6°C was observed. The data collected in this experiment supports my hypothesis, “As the amount of table salt added to water increases, the boiling temperature of the water increases.” I also observed that the water with salt added takes longer to reach a boil and boiled more vigorously than water without salt in it.

This experiment is important because it relates to why we add salt to water while cooking. Many recipes ask for salt to be added to water before bringing it to a boil so the water will boil at a higher temperature and the food will cook faster.

I am wondering if adding salt to water will affect the freezing point also. I know that salt is used in the winter on the roads to melt ice. It would be interesting to see how the amount of salt affects the freezing point. This could be useful to know the minimum amount of salt needed to make sure ice does not form on the roads at a particular temperature.

Your Turn

Complete the following questions to help you organize your information and develop a conclusion.

Using your evidence gathered (experimental data, graph(s), and observations), was your hypothesis correct?

If yes, what evidence supports your hypothesis?

If no, explain how the evidence shows that your hypothesis is incorrect?

What did you learn from this investigation and why is it important in the real world?

On a separate sheet of paper, re-write your conclusion in paragraph form. Look at the example if you need help. After you are finished with your first draft, have someone else read it and help you proofread it.

Worksheet 8: Analysis of the Investigation

Explanation

Scientists critically analyze their investigations to further their exploration of the phenomenon. They look at errors in the procedure, observations they made and consult additional scientific resources to improve their investigation. During and after the investigation, they record questions that come up and design further investigations to explore the phenomenon.

What problems did you encounter? What mistakes did you make?

How would you improve your investigation?

As the result of the investigation, what other questions would you like to explore?

On a separate sheet of paper (or below), re-write your analysis in paragraph form. Look at the example if you need help. After you are finished with your first draft, have someone else read it and help you proofread it.

Written Report

It is important to follow the scientific process when you design your science project. The **scientific process** includes designing and conducting an investigation to explore a question. You will be gathering evidence to answer the question and then communicating your findings to others through your science project report.

The 8 worksheets will help you with each component of the written report. Make sure that your written report has all of the components below. Use the information from the completed worksheets to write your written report. The report should be a minimum of 4-6 pages long including the title page.

- **Title Page:** include the question to investigate (Worksheet 1), first name and grade of the student(s) only.
- **Purpose:** The problem stated in the form of a question. (This is also the **title** of your project.)
- **Hypothesis:** A prediction of how the investigation will turn out, worded in terms of the independent and dependent variables. The hypothesis is developed based on findings of the research on a problem or question.
- **Investigation & Materials List:** A summary of the procedure that was followed to conduct the investigation, including summary of materials used.
- **Results:** The data collected, as part of the experiment, should be displayed in tables, charts, and/or graphs. photographs, diagrams, and drawings that describe what was done and what was learned may be included.
- **Conclusion:** A summary of the findings of the investigation, concerning whether the data and evidence supports the hypothesis.

Display Board

1. **Display board:** This forms the background for the project. A standard-size display board is 36" (height) by 48" (width). It is usually three-sided and sturdy enough to stand on its own for several days.
2. **Models, materials, devices and samples (not a required component):** These should relate to the science project experiment and may be shown in front of the display unit. **Safety First!** These items should present no hazards to observers who may be viewing the display. No breakable or dangerous items should be included. Avoid using open containers of liquids or smelly items, as they may be a hazard to observers and neighboring displays.
3. **Information from the written report:** This information should be on the display unit in a NEAT, CONCISE, and EASY TO READ manner. You should include the following:
 - **First name (only)** of student(s) and their grade
 - **Purpose:** The problem stated in the form of a question. (This is also the **title** of your project.)

- **Hypothesis:** A prediction of how the investigation will turn out, worded in terms of the independent and dependent variables. The hypothesis is developed based on findings of the research on a problem or question.
- **Investigation & Materials List:** A summary of the procedure that was followed to conduct the investigation, including summary of materials used.
- **Results:** The data collected, as part of the experiment, should be displayed in tables, charts, and/or graphs. photographs, diagrams, and drawings that describe what was done and what was learned may be included.
- **Conclusion:** A summary of the findings of the investigation, concerning whether the data and evidence supports the hypothesis.

Judging Criteria

Scientific Thought

- Does the project meet all requirements given in the Student Planning Guide?
- Does the project have a title, question to be investigated, and hypothesis clearly stated?
- Does the project represent sincere study and effort?
- Does the project form conclusions based on the data or information gathered?
- Does the project show that the student is familiar with the topic?
- Is the investigation designed to test the stated hypothesis?
- Does the project illustrate controlled experimentation?

Originality

- Does the project demonstrate ideas arrived at by the student?
- Does the project show a high degree of accomplishment? Is the degree of accomplishment consistent with the student's age level?
- Is the project primarily the work of the student?

Thoroughness

- Does the project tell a complete story?
- Are all the parts of the project well done, including the visual display and the interview with the judges?

Technical Skill and Neatness

- Does the project show effort and creativity by the student?
- Are the display unit and written report clear, neat and easy to read?

Student Project Checklist

Progress Log

_____ Are the 8 worksheets complete?

Display (includes the exhibit materials)

_____ Is the question neat and easy to read?

_____ Is the hypothesis neat and easy to read?

_____ Is the procedure and materials summarized and easy to read?

_____ Are the results and conclusions clearly stated and easy to read?

_____ Are there photographs, charts, graphs or drawings that support the information in the project? Are they neat and attractive?

_____ Does the display show original and creative work of the student?

_____ Is the display of the project clear and logical?

Typed Report

_____ Is there a title page that includes the question, first name of student(s) and grade only.

_____ Is the independent variable correctly stated and related to the phenomenon?

_____ Is the dependent variable correctly stated and measure the change of the independent variable?

_____ Are the controlled variables defined and relate to the phenomenon?

_____ Is the problem written in the form of a question using the independent and dependent variables?

_____ Is the hypothesis written as an *if-then statement* using the independent and dependent variables?

_____ Does the hypothesis include a "*this is because*" statement from the research that supports the hypothesis?

_____ Does the background research relate to the question and hypothesis?

_____ Does the research represent a diversity of sources, at least 3 sources cited in a bibliography using the standard format?

_____ Are all the materials used in the investigation listed clearly?

_____ Are specific amounts of each material given with appropriate units in the procedure of investigation?

_____ Are the steps in the procedure of the investigation listed in logical order & easy to follow?

_____ Was a control trial used in the investigation?

_____ Is the investigation designed to test the hypothesis?

_____ Were three trials of the procedure conducted for each change in the independent variable?

_____ Were the observations and data recorded with appropriate units in a clear and concise manner?

- _____ Are graphs, charts or pictures used to present the evidence gathered (data and observations)?
- _____ Does the conclusion address the hypothesis and is it supported by the evidence gathered?
- _____ Does the conclusion address what was learned by conducting the investigation and a statement describing the importance of the investigation
- _____ Are experimental errors, problems encountered and areas of improvement in the procedure addressed in the analysis?
- _____ Is there a discussion of questions that came up during the investigation and what further investigations would like to be done to address those questions
- _____ Overall, is the written report clear, neat and easy to read?

STUDENT INTERVIEW

- _____ Can the student explain why he/she chose the topic or phenomenon to research and did the student gain new knowledge from the project?
- _____ Can the student describe how he/she formulated the hypothesis from the research of the question?
- _____ Can the student explain why he/she chose the procedure to test the hypothesis?
- _____ Can the student explain why he/she chose the particular graphs, pictures, etc. in their report to represent the evidence gathered?
- _____ Can the student explain how he/she formulated the conclusion?
- _____ Can the student explain what he learned from the investigation and why it is important?
- _____ Does the student see where improvements or changes can be made?
- _____ Can the student share questions that came up during the investigation?