STEM Science Project Planning Guide

Middle & High School

Middle & High School Instruction and Assessment of Science Skills - Rubric

Open Inquiry Rubric - Instruction and Assessment of Science Skills

Science Skill	Exceeding - 4	Meeting - 3	Approaching - 2	Working Below - 1
PP1 - Testable Question		Testable and measurable/ observable **using specific language**	Testable and measurable/ observable from **but not specific to the parameters**	Any other answer

PP2 - Prediction and Hypothesis	- Makes a prediction or hypothesis statement which is testable; is specific details
	- Makes a hypothesis **using any format**:
	  - relevant to the question
	  - testable
	  - includes a plausible reason (refers to research)
	- Written in passive voice
		- Makes a prediction or hypothesis statement which is testable and specific
		- Makes a hypothesis using an "if,then, because" scaffold:
		- relevant to the question
		- testable
		- includes a plausible reason with some detail (may refer to readings or research)
		- Written in passive voice
			- Prediction or hypothesis is testable but is not specific
			- Makes a hypothesis using an "if, then, because" scaffold including a reason which may be relevant but lacks detail
			- Not written in passive voice
				Prediction or hypothesis is not clearly testable
				Makes a hypothesis, but the reason is not clearly expressed, missing, or irrelevant
				Any other answer

PP3 - Controlled Variables		Depending on the complexity of the investigation, most or all of the necessary variables are controlled **and described in detail**	Depending on the complexity of the investigation, **most or all of the necessary variables are controlled**	Only controls some of the relevant variables Control variables that are not relevant to the investigation Any other answer
PP3 - Independent Variable		Students identify one independent variable that fits the question	Students identify one independent variable **not relevant to the question**	Any other answer
PP3 - Dependent Variable		Students identify one dependent variable that fits the question	Students identify one dependent variable **not relevant to the question**	Any other answer

Science Skill	Exceeding - 4	Meeting - 3	Approaching - 2	Working Below - 1
PP4 - Planning an Investigation	Students can independently - procedures have a set of steps to test a single question - procedural design minimizing experimental bias - procedural design uses multiple trials to increase accuracy (if appropriate) - procedures are detailed enough to be repeated by someone else - procedure identifies needed equipment and materials - procedure identifies relevant measurements and/ or observations to be made - procedure has one independent and one dependent variable and is written in a way that controls other major variables - **procedures have an experimental group compared to a control group**	Students can independently - procedures have a set of steps to test a single question - **procedural design minimizing experimental bias** - **procedural design uses multiple trials to increase accuracy (if appropriate)** - procedures are detailed enough to be repeated by someone else - procedure identifies needed equipment and materials - procedure identifies relevant measurements and/ or observations to be made - procedure has one independent and one dependent variable and is written in a way that controls other major variables	Students can independently - procedures have a set of steps to test a single question - procedures are detailed enough to be repeated by someone else - procedure identifies needed equipment and materials - procedure identifies relevant measurements and/ or observations to be made - procedure has one independent and one dependent variable and is written in a way that controls other major variables	Students can independently perform **3-4** of the following: - procedures have a set of steps to test a single question - procedures are detailed enough to be repeated by someone else - procedure identifies needed equipment and materials - procedure identifies relevant measurements and/ or observations to be made - procedure has one independent and one dependent variable and is written in a way that controls other major variables
		Students may require support using experimental groups compared to a control group	Students may require support with: - procedural design minimizing experimental bias - procedural design uses multiple trials to increase accuracy (if appropriate)	Any other answer
PP5 - Collecting and Recording Data		Students are recording as many numbers as accurately as possible. They are detailed in their working and **accounting for every piece of relevant data possible**	Students are recording some numbers and are recording most relevant data	Students are not recording number data as a priority and are focussed on irrelevant observations
				Any other answer

Science Skill	Exceeding - 4	Meeting - 3	Approaching - 2	Working Below - 1
AE1 - Organizing and Displaying Data		Graphs have all appropriate titles and labels, plotted correctly with **proper x and y axis (convention in science is for IV on x axis and DV on the y axis**	Charts and graphs have all appropriate title and labels and information is plotted correctly	Data or information is plotted correctly but has minor error in labels Any other answer
AE2 - Pattern/ Trends/ Relationship	**Independently communicates additiona**l patterns/ trends/relationship	**Describes appropriate** patterns/ trends/relationship	Patterns/trends/ relationship is **unclear or over simplistic**	Any other answer
AE2 - Discrepancies	**Change to the experimental design is suggested to eliminate the occurrence of the source of error**	Identifies a discrepancy, **noting a possible source of error**	Identifies a discrepancy, **but is unable to explain the possible source of error**	Any other answer
AE2 - Interpolation and Extrapolation		Identifies reasonable values that are consistent with the pattern	Identifies values consistent with identified pattern **but value is unlikely**	Any other answer
AE2 - Identify and Quantify the Amount of Error from Design		Identifies a significant flaw in design **that leads to a quantifiable error with a reasonable suggestion for the amount of error**	Identifies a significant flaw in design. However, students are not able to quantify or their value is beyond the accepted range	Any other answer

Science Skill	Exceeding - 4	Meeting - 3	Approaching - 2	Working Below - 1
AE3 - Conclusions	• Is relevant to initial question and prediction/ hypothesis • **Distinguishes if independent variable is actual cause to support/ refute the hypothesis** • States a relationship between variables and supporting evidence • **Reflects science understanding beyond that made available to students , indicating additional independent research** • Demonstrates analysis of data trends and relationships • May included suggestions to improve experimental design based on discrepant data • Compares finding of other similar investigations, if appropriate	• Is relevant to initial question and prediction/ hypothesis • States whether data supports or refutes initial prediction/ hypothesis • **States a relationship between variables and supporting evidence** • **Reflects science understanding and gives some reason for results based on evidence** • **Demonstrates analysis of data trends and relationships** • **May included suggestions to improve experimental design based on discrepant data** • **Compares finding of other similar investigations, if appropriate**	• Is relevant to initial question and prediction/ hypothesis • States whether data supports or refutes initial prediction/ hypothesis • Restates only the recorded results or is a result of flawed reasoning	Any other answer
AE4 - Applications of Learning	Students can draw relevancy of what they have learned to the real world **and** they can write a new question to test based on what they have learned in this project	Students can either draw relevancy of what they have learned to the real world **or** can write a new question to test based on what they have learned in this project	**Students have difficulty** to draw relevancy of what they have learned to the real world and to write a new question to test based on what they have learned in this project	Any other answer

Middle & High School Student Worksheets

My Science Project

Even though I am working in a group, I still need to show what I have learned...

1. The first thing you need to do is figure out what we are going to test. That does not mean that you need a title, we can get that at the end. **It does mean that you need to write a question that you plan to investigate.** (PP1)

_____

_____

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1. Now that you have an initial question, we need to set limits to what we plan to investigate. Its expected that science projects are fair, so need identify the variables. (PP3)

Independent Variable? _____

Dependent Variable? _____

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3. We now have a better understanding of the variables that we plan to test and measure, **rephrase your initial question in a testable form**. (PP1)

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_____

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4. A big part of being a scientist is using what you already know about your subject to predict what you think will happen in your project and to justify scientifically why you think so. **State a hypothesis based on research, background information or an observed pattern of events.** (PP2)

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_____

_____

_____

_____

5. Now its time to design how you are going to test your experiment.

A. List the Materials needed for this experiment (PP4)

B. Identify the Variables that need to be controlled for this experiment to be fair (PP3)

C. Design the Methods to test your hypothesis (PP4)

6. While you are carrying out procedures, it is each students responsibility to make and record relevant observations and measurements, and to organize data in a format that best fits the task. The goal should be to record as much detail as possible. Because, when you go to reflect on what you learned you will need all these notes and numbers. (PP5)

Try to record your observations with as many numbers (based on what you are trying to measure from section 2)

7. Once you have recorded all of your data and observations, you should try to make sense of what those numbers are telling you, by compiling and displaying data in a relevant way. The best way in science to do this is to create a bar or line graph, but in some cases diagrams, flow charts work well. (AE1)
The best thing to do is use the graph standard that you have use in Math class.

8. From what your data tells you, interpret patterns and trends in data to explain relationships among the variables.(AE2)

9. Identify and suggest explanation for any discrepancies in data. (AE2)

10. Please remember that nobody is perfect and you are not expected to do everything without fault. Sometimes, when we are doing science projects we get to the end and we realize that something is not right with my data or the way I recorded my data was not the same for each.
Do Not Worry About It! This is the sections you will identify and suggest explanations for sources of error and determine the amount of error in the measurement. (AE2)

11. Now that you have finished your project, you need to figure out what you learned (in terms of SCIENCE). State a conclusion, based on experimental data and explain how evidence gathered supports or refutes your hypothesis (section4). (AE3)

12. Finally, the last step is to figure out how what you have learned in your project relates to the real world. (AE4)

13. Also, you should be able to identify any new questions that you could now test about this subject. (AE4)

Middle & High School Teacher's Guide

My Science Project

Even though I am working in a group, I still need to show what I have learned...
The example of Diet Coke and Mentos Geysers will be used
1. The first thing you need to do is figure out what we are going to test. That does not mean that you need a title, we can get that at the end. **It does mean that you need to write a question that you plan to investigate.** (PP1)
How do Diet Coke and Mentos Geysers work?

This section does not require a testable question. Students may have had exposure to striving for a testable question from previous work so allow them, just understand that rephrasing to testable comes later. This section is looking for the students to lay out a general statement of what they want to work on.

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2. Now that you have an initial question, we need to set limits to what we plan to investigate. Its expected that science projects are fair, so need identify the variables. (PP3)

Independent Variable? The reaction of 3 mentos in diet coke vs coca-cola
Independent variable - diet coke vs coca-cola (only material that will be different)

Dependent Variable? How high (cm) the geyser reaches at its highest point
Dependent variable - how you are going to measure (number data)

At the Middle level, students should have had enough exposure to be able to identify variables. In the design, students will identify the controls. This section is intended to offer the variables necessary to correctly rephrase a question to be testable.

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3. We now have a better understanding of the variables that we plan to test and measure, **rephrase your initial question in a testable form**. (PP1)
Does the type of soda, diet coke or coca-cola, reacting to three mentos make a higher (cm) geyser stream at the highest point?
Teachers should be using the same format for writing a question in science as they do in language arts. Be mindful that the noun and verb are replaced by the independent and dependent variables.
Students should be writing the questions with the variable to test and how they are specifically going to measure it?

4. A big part of being a scientist is using what you already know about your subject to predict what you think will happen in your project and to justify scientifically why you think so. **State a hypothesis based on research, background information or an observed pattern of events.** (PP2)

If 3 mentos are added to both diet coke and coca-cola, then it's expect the diet coke geyser to shoot higher. Because, most youtube video uses diet coke so it must have chemical that makes it react more with mentos.

The scaffold of if...then...because should be followed
If variable to test (independent), then variable to measure (dependent) because scientific justification

Students should be able to identify their prediction of which product in this example will give a higher (cm) geyser
Also, it is crucial to the skill that students can justify based on science they know as to why they think this will happen. In Middle level research should be introduced, especially for science fair.

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5. Now its time to design how you are going to test your experiment.
This outcome (208-6) requires students to perform all three sections in order to appropriately complete it.

A. List the Materials needed for this experiment (PP4)
2L of Coca Cola (x5)
2L of Diet Coke (x5)
20 Mint Mentos
3 Meter Stick
Camera
Table Cloth
Container
This section requires students to list all materials and quantities needed to perform their steps below.

B. Identify the Variables that need to be controlled for this experiment to be fair (PP3)
Each Soda needs to be unopened
Each Soda must be done using the same design:
Same starting height
Same room
Same measuring set up
Each trial requires 3 mint mentos
Each trial requires the same reletive amount of time to add mentos to soda
Each trial has to be recorded with camera facing meter sticks
This area is intended for students to list any and all items that need to be controlled to be a fair test. Generally, students do not realize how many things need to be controlled, but as a part of the planning phase it is necessary they do this before starting to plan step.

I. Design the Methods to test your hypothesis (PP40

Science curriculum has not set standard for the style of writing of a procedure. The requirement is that procedure are replicable. It would be up to the individual teacher if they would want to have Steps or written procedural paragrphs. It would be suggested to consult with the Language Arts teacher to understand the expected level and standard.

Steps
1. Set up a table, cover with at table cloth to reduce the mess.
2. Strap 3 meter stick to wall so they are extended to measure 3m
3. Adjust the camera so that it records the area in which the geyser will shoot.
4. Place a bottle of soda in a container, to contain the overflow, on top of the table
5. Uncap a soda, add 3 mentos....
6....

Procedural Paragraph
Set up the table and cover it with a table cloth to reduce the mess. Next, strap 3 meter stick to the wall so they are extended to measure a total of 3 meters. Adjust your digital camera so that it records the ara in which the geyser will shoot. Choose one type of soda to start with and place the bottle in a plastic container, the container is used to decrease the overflow on the table and floor.
Uncap the soda, add 3 mentos....

6. While you are carrying out procedures, it is each students responsibility to make and record relevant observations and measurements, and to organize data in a format that best fits the task. The goal should be to record as much detail as possible. Because, when you go to reflect on what you learned you will need all these notes and numbers. (PP5)

Try to record your observations with as many numbers (based on what you are trying to measure from section 2)

Trial	Diet Coke	Coca Cola
1	352cm	292cm
2	341cm	302cm
3	102cm	305cm
4	338cm	288cm
5	344cm	299cm

During the conducting phase, students should be recording all relevant information that they may need in the future to respond to their learning.

The primary struggle for students is that they do not know what is relevant and that they do not record what measurements they were supposed to get.

At the middle level, students should have a focus on quantitative (numbers) data and based on their identified variables, this is the info they should be collecting. Also students should record qualitative (word) data that explains what they observed in each trial. This anecdotal evidence provides justification as to what each number is telling them.

Students would also have all video of the trial in this example so they could extract single images.

As the teachers, regularly conference with students to ensure that they are recording the number (in this example the centimeters of geyser stream) each time they perform a trial or at a regularly scheduled time.

Next, encourage students to record everything, get as much detail as possible. As a learning activity, you can have each of them narrow down and eliminate irrelevant info. They need to get as much in order to narrow things down.

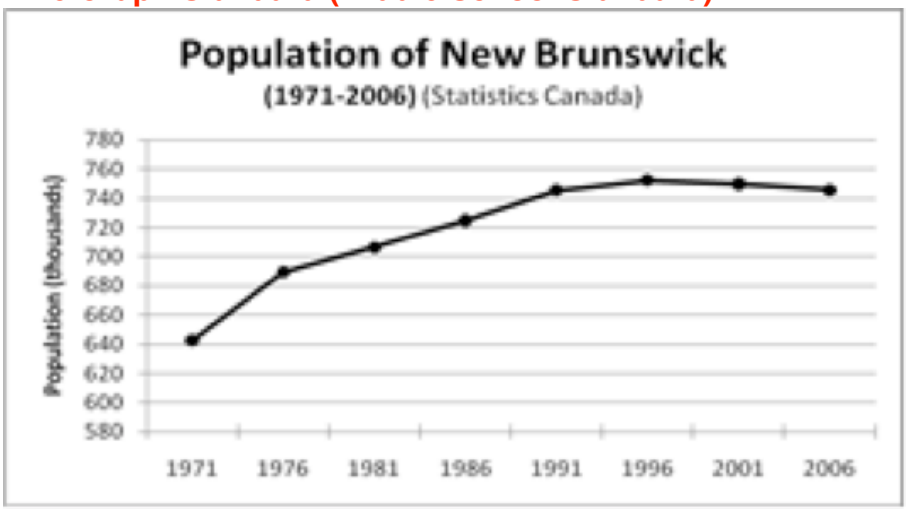
This section is dedicated to only raw numbers....graphing will come in the next section.

7. Once you have recorded all of your data and observations, you should try to make sense of what those numbers are telling you, by compiling and displaying data in a relevant way. The best way in science to do this is to create a bar or line graph, but in some cases diagrams, flow charts work well. (AE1)
The best thing to do is use the graph standard that you have use in Math class.

Students are expected to be able to take the raw data they have recorded and graph those units.

At the Middle School Math students are expected to be able to correctly use Bar and Line Graphs.

Line Graph Standard (Middle School Standard)



Single Bar Graph (Standard Grade 3)

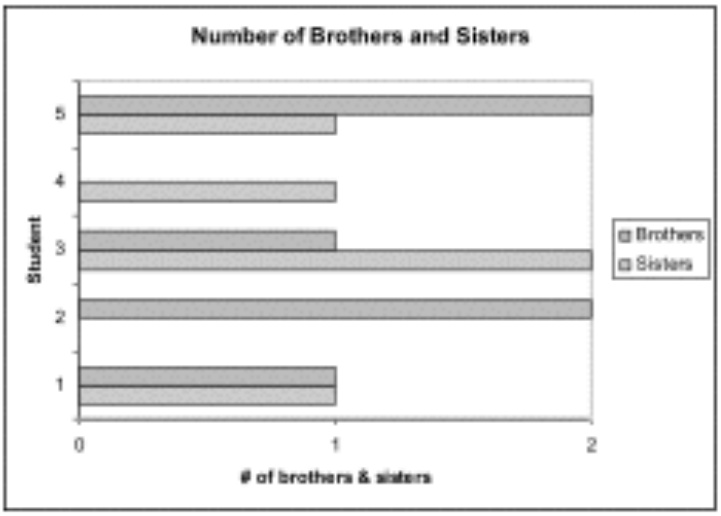
Sample bar graph:

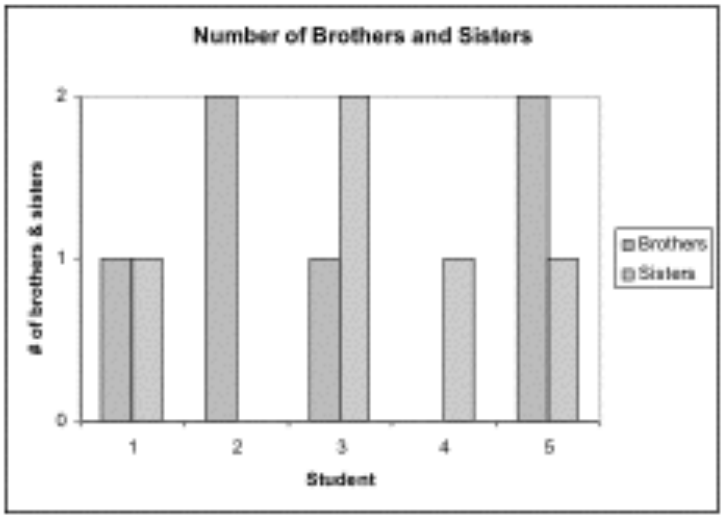
From the Grade 5 Mathematics Curriculum Document
Outcome SP2: Construct and interpret double bar graphs to draw conclusion
Page 94

Students should be aware that sometimes when two pieces of data are collected about a certain population, it is desirable to display both sets of data side by side, using the same scale. For example, census data often shows male and female data separately for different years. This is usually done using a **double bar graph**. A **legend** is used to help the reader interpret a double bar graph. An example is presented below. Five students in the class have been asked how many brothers and sisters they have.

This type of graph allows students to be compared not only in terms of how many brothers they have, or how many sisters they have, but also to compare the number of brothers versus the number of sisters.

It is essential that students include **titles**, **horizontal** and **vertical axis** headings and **scale**, **legends** and **category labels** in the **legend**. The pairs of bars should be separated and the order of the colours must remain the same in the graph.
A common mistake made by students is to place the numbers on the scale in the space between lines rather than on the place where the line for the limit of that number would be (e.g., 1, 2, etc.).





8. From what your data tells you, interpret patterns and trends in data to explain relationships among the variables.(AE2)

The mean of 4* trials of Diet Coke gave 343.75 cm. The mean for Coca Cola over 5 trials gave 297.20 cm. **The trend is that Diet Coke yields a higher geyser.**

This is the area for mean (average) calculations and other trend calculations

9. Identify and suggest explanation for any discrepancies in data. (AE2)

A data trial for diet coke gave a reading of 102cm, this discrepancy in data is not a reliable piece of evidence and is thus discarded.

Students should be able to look at raw data and justify major discrepancies in data being discarded.

10. Please remember that nobody is perfect and you are not expected to do everything without fault. Sometimes, when we are doing science projects we get to the end and we realize that something is not right with my data or the way I recorded my data was not the same for each.

Do Not Worry About It! This is the sections you will identify and suggest explanations for sources of error and determine the amount of error in the measurement. (AE2)

During Trial 3 of Diet Coke a hole was noticed in the bottle and thus the reading is thrown out because it was a source of error.

Students in Middle School SHOULD have several sources of error. This section is intended for students to state these errors and omission and predict how they affected the results.

Based on the procedures and the recorded observations these errors should be evident to the teacher and thus each should be stated.

11. Now that you have finished your project, you need to figure out what you learned (in terms of SCIENCE). State a conclusion, based on experimental data and explain how evidence gathered supports or refutes your hypothesis (section4). (AE3)

Does the type of soda, diet coke or coca-cola, reacting to three mentos make a higher (cm) geyser stream at the highest point?
Yes, the type of soda does make a higher geyser stream. Diet Coke had the higher geyser stream. This supports (or refutes) my hypothesis because the Diet Coke has an average geyser of 343.755cm and Coca-Cola was only 297.20cm.
Based on the Language Arts standards of the class in terms of writing standards. For science purposes, students should answer a restated version of the question. A simple conclusion mentions how their prediction was affect (support or refutes) and give evidence from data that was gathered.
There is no set standard that students MUST do analytical research, so their is not set need to mention the research that was required.
However, students should be encouraged to do research (3 credible sources) and their research should be mentioned in their conclusion as well.

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12. Finally, the last step is to figure out how what you have learned in your project relates to the real world. (AE4)
Students should be able to identify how the experiment that they have done applied to the real world.
As a measure of higher level blooms (evaluation) students should be encouraged to explain the relationship of what their evidence tells them to real world

In the case of Diet Coke and Mentos they could apply this learning to reactions in their stomach that make them feel bloated (for example)

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13. Also, you should be able to identify any new questions that you could now test about this subject. (AE4)
Students should then be able to write the next questions that they would want to study based on what they learned in this experiment.

Does adding more than three mentos to diet coke make a higher geyser stream?