Authentic science investigation in the classroom: Tools for creating original testable questions and graphical hypotheses

**Supplementary Materials**
Page 1. Question strips
Page 2. Sorting activity worksheet
Page 3. Sorting activity key
Page 4. Testable question flowchart
Pages 5-10. Inquiry boards
<table>
<thead>
<tr>
<th>Question Strip</th>
<th>Question Strip</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>5.</td>
</tr>
<tr>
<td>Why does a plant grow?</td>
<td>Will my plant grow?</td>
</tr>
<tr>
<td>2.</td>
<td>6.</td>
</tr>
<tr>
<td>What type of soil is best for plants?</td>
<td>Will the amount of water increase plant height?</td>
</tr>
<tr>
<td>3.</td>
<td>7.</td>
</tr>
<tr>
<td>Will the type of fertilizer affect the number of fruits produced by the plant?</td>
<td>Will a plant grow taller in California or Alaska?</td>
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<tr>
<td>4.</td>
<td>8.</td>
</tr>
<tr>
<td>Does the size of the pot affect the number of plant roots?</td>
<td>What kind of seeds do I need to grow a plant?</td>
</tr>
</tbody>
</table>

Category labels: Cut these out so students can arrange questions under each category

<table>
<thead>
<tr>
<th>TESTABLE QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NON TESTABLE QUESTIONS</td>
</tr>
</tbody>
</table>
SORTING ACTIVITY WORKSHEET

Part 1: Use the checklist below to sort the questions in your envelope:

✔ Has variables you can measure or observe
✔ Can be answered with materials & time available
✔ Cannot be completely answered by a book or Internet search
✔ Does not contain opinion words (e.g. best, better)
✔ Can help you understand how or why something works

Part 2: Write down the questions you sorted under “NON TESTABLE QUESTIONS”. Draw a line(s) to match each question up to the reason(s) why it is not testable.

NON TESTABLE QUESTIONS:

<table>
<thead>
<tr>
<th>Question</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Does NOT contain variables that can be measured or observed.</td>
</tr>
<tr>
<td></td>
<td>Can NOT be answered with materials and time available.</td>
</tr>
<tr>
<td></td>
<td>Can be answered using a book or Internet search.</td>
</tr>
<tr>
<td></td>
<td>Contains opinion words (e.g. better, best).</td>
</tr>
<tr>
<td></td>
<td>Does not help understand how or why something works (e.g. can be answered with a yes or no).</td>
</tr>
</tbody>
</table>

Rewrite one of these non-testable questions to make it testable:
Sorting Activity Key

TESTABLE QUESTIONS (we can investigate now)
Variables that are observable/measurable are underlined.
3. Will the type of fertilizer affect the number of fruits produced by the plant?
4. Does the size of the pot affect the number of plant roots?
6. Will the amount of water increase plant height?

TESTABLE QUESTION (we can’t investigate right now)
7. Will a plant grow taller in California or Alaska?
This question is testable but it is not feasible for us to investigate right now because we are not able to go to these places to test plant growth. We could test plant growth at different temperatures (or some other variable that might be different between California and Alaska) instead of location to investigate this question.

NOT TESTABLE QUESTIONS
1. Why does a plant grow?
This is a how/why question rather than a testable question. It is also a question that could be answered using books or the internet rather than an investigation. How/why questions are often the questions that start us thinking about what we are interested in. Often doing research on these broad questions lead us to testable questions that can investigated.
2. What type of soil is best for plants?
This question is not specific enough. How will one measure what is the “best”? Students should avoid using words like “better” or “best” and replace them with specific ways to measure “better” or “best” (EX: What type of soil will make plants grow tallest?).
5. Will my plant grow?
This is a yes/no question rather than a testable question. Testable questions require more exploration than yes/no questions and generally result in learning something new about what we are investigating. For this to be a testable question, it should be reworded to include specific measurements. For example “Under what conditions will my plant grow?” or more specifically “Will my plant grow taller in Soil A or Soil B?”
8. What kind of seeds do I need to grow a plant?
This is a research question. It can be looked up online or in a book and does not require an investigation to answer.
Testable Question Flow Chart

Write your question here:

Start here

Does your question have variables that you can measure or observe?

No

Great start! Let’s revise that question to make it testable. Rewrite your question above and return to start.

Yes

My variables are:

1)

Yes

No

Can your question be answered with the materials and time available?

Yes

Can your question be answered with a book or internet search?

Yes

No

Does your question contain opinions (e.g. best, better)?

Yes

No

Great! You have your testable question.

Can answering your question help you understand how or why something works?

Yes

No

No
Step 1 - BRAINSTORM
Things I could change or vary

<table>
<thead>
<tr>
<th>Place yellow post-it note here</th>
<th>Place yellow post-it note here</th>
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</table>

Things I could measure or observe

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Step 2 - CHOOSE VARIABLES

I will change or vary (manipulated/independent variable)

I will measure (responding/dependent variable)

I will keep these constant (control variables)
Step 3 - ASK A QUESTION

When I change or vary
(manipulated/independent variable)

Place yellow post-it note here

what happens to
(responding/dependent variable)?

Place blue post-it note here

“When I change or vary __________, what happens to_______?”
Step 4 - GRAPHICAL HYPOTHESIS

This is how I expect the independent variable to change the response of the dependent variable

Explain what your graph predicts:

Why do you expect to see this pattern?:

Place blue post-it note here (dependent variable)

Place yellow post-it note here (independent variable)
## Step 5 - DATA TABLE

This is what I measured

<table>
<thead>
<tr>
<th>Date</th>
<th>Trials</th>
<th>Average</th>
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**Calculating the average**

\[
\text{Average} = \frac{\text{sum of measurements}}{\text{number of measurements}}
\]
Step 6 - RESULTS GRAPH
This is how the independent variable affected the dependent variable

This graph shows...

Place blue post-it note here
(dependent variable)

Place yellow post-it note here
(independent variable)