# Inq-ITS Teacher Guide: Investigate Labs

## Overview

In each *Investigate Lab*, students conduct their own investigations to explore what causes scientific phenomena to occur. Each lab starts with a ***goal*** that orients the investigation. The goal states which relationships the student should investigate. For example, one Investigate Lab in our "Flower Growth" topic has students "Determine how the red dye in the water affects the redness of the petals."

Students conduct their own investigation using an interactive simulation of that phenomenon to explore the goal. Investigate Labs are structured into four stages:


- Hypothesis: Students form their own question and make an initial prediction about the relationship stated in the goal.
- Collect Data: Students collect data with a simulation that can be used to determine if their hypothesis is supported or not.
- Analyze Data: Students summarize their findings by examining the trends they found in their data. They then form a claim, choose which data they collected warrants their claim, and assert whether their initial hypothesis was supported or not.
- Explain Findings: Students use a "Claim-Evidence-Reasoning" format to describe their investigation in their own words. They write their claim, describe their evidence, describe how their evidence supports their claim, and describe the scientific principles behind the phenomena they observed.

Inq-ITS automatically scores how students conduct their investigation and write up their findings. Students' work products (e.g., the claims they make), processes (e.g., how they collect data), and lab write-ups are automatically scored against different criteria. Each stage and its respective scoring criteria are described below in more detail.

## Hypothesis

**Description.** Students create hypotheses by choosing independent variables, dependent variables, and a relationship between them. Investigate Labs use one of two different builders that help students do this:

1. Sentence pulldown (Fig. 1): create a hypothesis from a series of choices available by pressing on the arrow in each box.
2. Graphical (Fig. 2): choose variables and relationships graphically, clicking choices from each box.

Depending on the lab, the relationships between the variables may be simple causal relationships (changes / does not change), or directional (increases / decreases / stays the same).

Hypotheses are assessed based on whether they are testable and goal-aligned.

A testable hypothesis states an independent variable that can be changed (the cause), a dependent variable that can be measured (the effect), and a relationship between them. In Inq-ITS, independent variables are the inputs to the simulation students can change when they collect data. Dependent variables are the outputs of the simulation that they can observe or measure. They learn about the simulation, and consequently which variables are which, by reading the activity introduction that is automatically included when an Investigate Lab is assigned. It does not matter if the hypothesis is scientifically accurate since students will have the opportunity to debunk their initial thinking while conducting their investigation.

A goal-aligned hypothesis uses the variables stated in the goal. Goal-alignment helps ensure that the students are exploring the phenomenon intended by the investigation.


*Figure 1. Sentence pulldown hypothesis builder*


*Figure 2. Graphical hypothesis builder*

**Assessment Criteria.** All criteria must be met for students to receive full credit. Criteria are equally weighted.

| Criterion | Scoring |
|---|---|
| Independent variable in correct position? | Inq-ITS checks that the student chose an independent (manipulable) variable for the start of their hypothesis. If they do so, full credit is given. Otherwise, no credit is given. |
| Dependent variable in correct position? | Inq-ITS checks that the student chose a dependent (observable) variable for the end of their hypothesis. If they do so, full credit is given. Otherwise, no credit is given. |
| Independent variable matches Goal? | Inq-ITS checks that the student's hypothesis contains the independent variable stated in the goal.<br><br>Full credit is given in the following cases:<br>1. The student's hypothesis contains independent and dependent variables in the correct places, and the independent variable matches the goal's independent variable.<br>2. The student mixes the positions of the independent and dependent variables. If the independent variable matches the goal's independent variable, even if it is in the wrong position, full credit is given.<br>3. The student selects two independent variables and no dependent variable. If the independent variable at the start of the hypothesis matches the goal's independent variable, full credit is given.<br><br>If the student does not meet any of the above conditions, no credit is given. |
| Dependent variable matches Goal? | Inq-ITS checks that the student's hypothesis contains the dependent variable stated in the goal.<br><br>Full credit is given in the following cases:<br>1. The student's hypothesis contains independent and dependent variables in the correct places, and the dependent variable matches the goal's dependent variable.<br>2. The student mixes the positions of the independent and dependent variables. If the dependent variable matches the goal's dependent variable, even if it is in the wrong position, full credit is given.<br>3. The student's hypothesis contains two dependent variables and no independent variable. If the dependent variable at the end of the hypothesis matches the goal's dependent variable, full credit is given.<br><br>If the student does not meet any of the above conditions, no credit is given. |

**Examples.** We show how example hypotheses are scored from a "Flower Growth" Investigate Lab. In this lab, students use a flower simulation to determine how additives impact petal redness and petal loss over time. Students can manipulate three variables: "red dye in the water," "salt in the water," and "sugar in the water."

For these examples, assume the following:

- Goal: "determine how the red dye in the water affects the redness of the petals."

Student 1 Hypothesis Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| If I increase the redness of the petals, then the salt in the water will increase. | Independent variable in correct position? | ✘ | "redness of the petals" is not an independent variable (a cause) that students can manipulate with the simulation. |
| | Dependent variable in correct position? | ✘ | "salt" is not a dependent variable (an effect) that is an output generated by the simulation. |
| | Independent variable matches Goal? | ✘ | The independent variable does not match the goal's independent variable, the "red dye." |
| | Dependent variable matches Goal? | ✓ | The dependent variable matches the goal's dependent variable, even though it is not in the correct position in the sentence. |
| | Total Score: 25% | | |

Student 2 Hypothesis Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| If I decrease the salt in the water, then the redness of the petals will increase. | Independent variable in correct position? | ✓ | "salt in the water" is an independent variable for this simulation. |
| | Dependent variable in correct position? | ✓ | "redness of the petals" is a dependent variable for this simulation. |
| | Independent variable matches Goal? | ✘ | The independent variable does not match the goal's independent variable, the "red dye." |
| | Dependent variable matches Goal? | ✓ | The dependent variable matches the goal's dependent variable. |
| | Total Score: 75% | | |

Student 3 Hypothesis Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| If I decrease the red dye in the water, then the redness of the petals will increase. | Independent variable in correct position? | ✓ | "red dye in the water" is an independent variable for this simulation. |
| | Dependent variable in correct position? | ✓ | "redness of the petals" is a dependent variable for this simulation. |
| | Independent variable matches Goal? | ✓ | The independent variable matches the goal's independent variable. |
| | Dependent variable matches Goal? | ✓ | The dependent variable matches the goal's dependent variable. |
| | Total Score: 100%<br><br>Note that full credit even though the hypothesis is scientifically inaccurate. Students can refute their hypothesis when they analyze their data. | | |

## Collect Data

**Description.** Students use a simulation to collect data they can use to determine if their hypothesis is sorted or not. The simulation has different inputs the students can manipulate (the independent variables), and outputs that it generates (the dependent variables). Controls for manipulating the inputs will either be buttons (Fig. 3) with a limited number of options, or sliders (Fig. 4) with more options. After setting the simulation inputs, they run a trial and watch the simulation execute. The inputs and outputs of running the simulation are captured in a trial and automatically added to the student's data table. Students may collect as many trials of data they think is necessary.

Data collection is assessed based *how* students collect their data. Students who are proficient:

1. Design controlled experiments, changing only one input variable at a time
2. Vary their independent variable, collecting data to determine if their hypothesis is supported or not.

Many factors are considered by Inq-ITS' proprietary algorithms to determine whether students' follow these data collection procedures. These include (but are not limited to): the number of times students change the simulation variables, the number of trials collected by the student, which pairs of trials are controlled, and which controlled trials target the independent variable in their hypothesis.

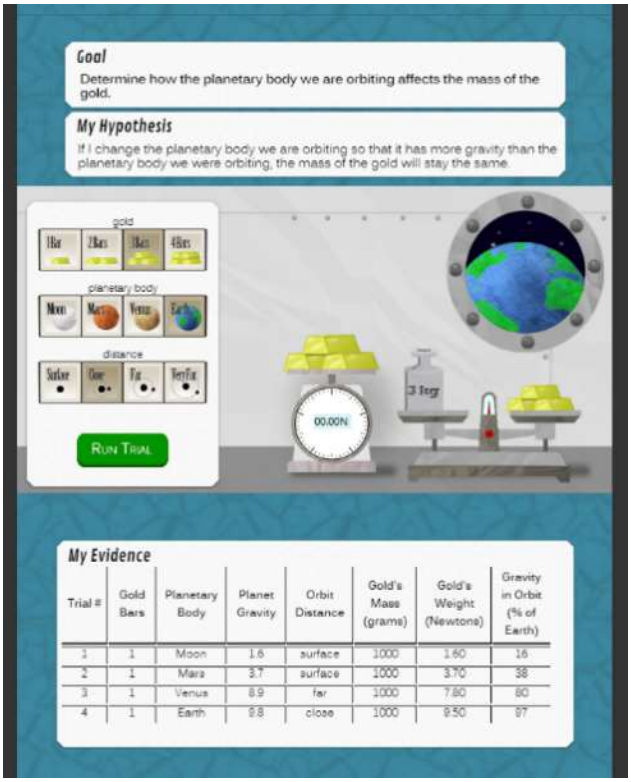


*Figure 3. Button style options for selecting the inputs to a simulation.*

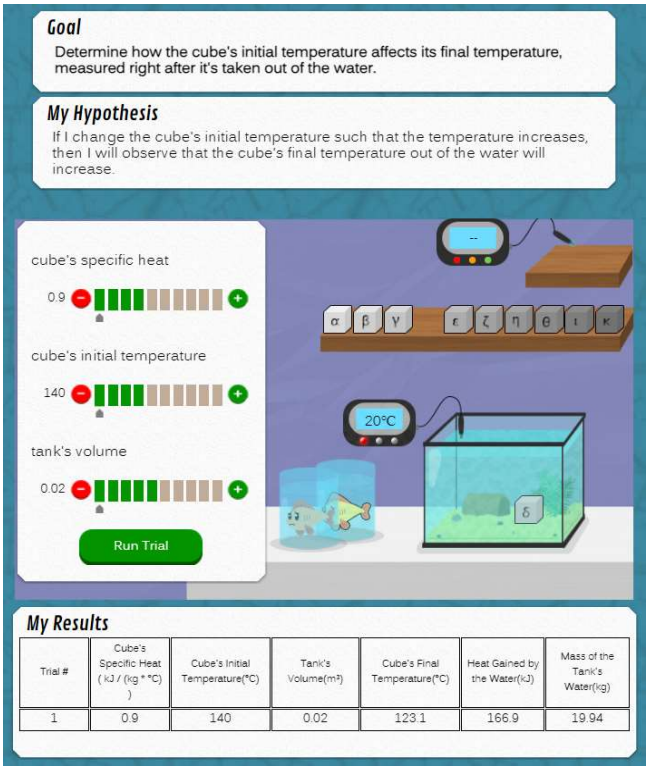


*Figure 4. Slider style options for selecting the inputs to a simulation.*

**Assessment Criteria.** All criteria must be met for students to receive full credit. Criteria are equally weighted.

| Criterion | Scoring |
|---|---|
| Varied independent variable? | As the student collects data, Inq-ITS keeps track of which simulation controls the student changes, which trials are collected, and other interactions. Based on these interactions, Inq-ITS determines if the student is collecting trials that will enable them to determine if their hypothesis is supported or not.<br><br>If Inq-ITS determines that the student is generating such trials, full credit is given. Otherwise, no credit is given.<br><br>This criterion depends upon the student's hypothesis. Inq-ITS tries to determine what the student's independent variable might be when they specify an untestable hypothesis as follows:<br>• If the student mixes the positions of the independent and dependent variables, the independent variable is still deemed to be the one for which the student is trying to collect data to support or refute<br>• If the student states two independent variables, the variable at the start of their hypothesis is deemed to be the one for which the student is trying to collect data to support or refute<br>• If the student specifies two dependent variables in their hypothesis, no credit is given because there is no independent variable to target. |
| Correct values for independent variable?<br><br>(Certain labs only) | Some hypotheses require collecting data with specific values for the independent variable stated in their hypothesis. In this situation, when the student completes their data collection, Inq-ITS checks that the student has collected controlled trials targeting those specific values of the independent variable. If the student has at least one pair of trials for which this occurs, full credit is given.<br><br>Otherwise, no credit is given. |
| Controlled Trials? | As the student collects data, Inq-ITS keeps track of which simulation controls the student changes, which trials are collected, and other interactions. Based on these interactions, Inq-ITS determines if the student is, on the whole, collecting controlled trials. Controlled trials are those for which only one independent (input) variable was changed between them.<br><br>If Inq-ITS determines that the student is generating controlled trials based on their actions, full credit is given. Full credit may be awarded even if not all trials in the data table are controlled.<br><br>Otherwise, no credit is given. |

*Note:* Inq-ITS allows students to collect data as many times as necessary, and will re-assess students' competencies should they try and collect additional data when navigating between Inq-ITS stages. The score reported for each criterion is the average percent of 'full credits' given across each data collection attempt. For example, if the student engages in two data collections and they receive one full credit for having varied their independent variable, it will be scored as 50%.

**Examples.** We show how data collections are scored from a "Phase Change" Investigate Lab. In this lab, students use a phase change simulation to determine how different factors affect the melting and boiling properties of ice. Students can manipulate three variables: "size of the container" holding the ice, "amount of heat" used to heat the ice, and "amount of ice." The simulation has four outputs: "melting point," "boiling point," "melting time," and "boiling time."

For these examples, assume the following:

- Goal: "determine how the size of the container affects the time the water takes to boil."
- Hypothesis: "If I increase the size of the container, the time the water takes to boil increases."
- Simulation variables:
  - Input - Size of the container: (Small, Medium, Large)
  - Input - Amount of heat: (Low, Medium, High)
  - Input - Amount of Ice: (100g, 200g, 300g)
  - Output – Boiling Time in seconds

Student 1 Data Collection Example

Sample of process factors:

- Changed inputs 10 times while collecting data
- Collected 4 trials of data

Data collected:

| Trial | Cont Sz | Heat | Ice Amt | Boil Time |
|---|---|---|---|---|
| 1 | Sm | Lo | 100 g | 129 s |
| 2 | Lg | Hi | 300 g | 305 s |
| 3 | Md | Lo | 100 g | 129 s |
| 4 | Md | Hi | 300 g | 305 s |

| Criterion | Score | Rationale |
|---|---|---|
| Varied independent variable? | ✓ | The independent variable in the hypothesis ("size of the container") was changed multiple times. Furthermore, that variable acted as a control. |
| Controlled Trials? | ✓ | Every trial is controlled. Trials 1 and 3 are controlled, changing only "size of the container". Trials 2 and 4 are controlled in the same way. |
| Total Score: 100% | | |

Student 2 Data Collection Example

Sample of process factors:

- Changed inputs 14 times while collecting data
- Collected 5 trials of data

Data collected:

| Trial | Cont Sz | Heat | Ice Amt | Boil Time |
|---|---|---|---|---|
| 1 | Sm | Lo | 100 g | 129 s |
| 2 | Sm | Lo | 100 g | 129 s |
| 3 | Md | Md | 200 g | 228 s |
| 4 | Lg | Hi | 300 g | 305 s |
| 5 | Sm | Md | 100g | 115 s |

| Criterion | Score | Rationale |
|---|---|---|
| Varied independent variable? | ✘ | The independent variable in the hypothesis ("size of the container") was changed multiple times by the student.<br><br>However, their overall process does not suggest that they tried to collect data for testing their hypothesis. They changed the inputs many times, and there are no controlled trials targeting the "size of the container." |
| Controlled Trials? | ✘ | The student changed the inputs many times, ran several trials, and several trials do not have controls (only Trials 1 and 5 are controlled, changing only the "amount of heat"). |
| Total Score: 0% | | |

Student 3 Data Collection Example

Sample of process factors:

- Changed inputs 5 times while collecting data
- Collected 5 trials of data

Data collected:

| Trial | Cont Sz | Heat | Ice Amt | Boil Time |
|---|---|---|---|---|
| 1 | Md | Md | 200 g | 228 s |
| 2 | Md | Md | 200 g | 228 s |
| 3 | Md | Md | 200 g | 228 s |
| 4 | Md | Hi | 200 g | 305 s |
| 5 | Md | Hi | 200 g | 115 s |

| Criterion | Score | Rationale |
|---|---|---|
| Varied independent variable? | ✘ | The independent variable in the hypothesis ("size of the container") was not changed between trials. |
| Controlled Trials? | ✓ | Though the student ran many repeated trials, every trial has a control with at least one other trial. For example, Trial 4 is controlled with Trials 1,2, and 3 (changing only the "amount of heat"). |
| Total Score: 50% | | |

## Analyze Data

**Description.** Students analyze their data by first looking at the trends between variables in the data they collected. Then, they form a claim summarizing their findings, also asserting whether their hypothesis was supported or not (refuted). Students also warrant their claim by selecting which trials in their data table count as evidence.

Like the Hypothesis Stage, Investigate Labs use one of two different builders that help students form their claim:

1. Sentence pulldown (Fig. 5): create a hypothesis from a series of choices available by pressing on the arrow in each box.
2. Graphical (Fig. 6): choose variables and relationships graphically, clicking choices from each box.

Analyses are assessed based on whether their claim is valid with respect to the data collected, and whether the evidence is valid, showing the relationship stated in their claim.

A valid claim has multiple components:

- It correctly specifies an independent variable as the cause and a dependent variable as the effect
- It correctly states the relationship between the independent and dependent variables which can be inferred from the data collected
- It correctly states whether the original hypothesis was supported or refuted (not supported).

Valid evidence consists of:

- *Only* sets of controlled trials that change only the independent variable stated in their claim. Every trial selected must have at least one other controlled trial also selected.
- Controlled trials that show the relationship stated in the claim.

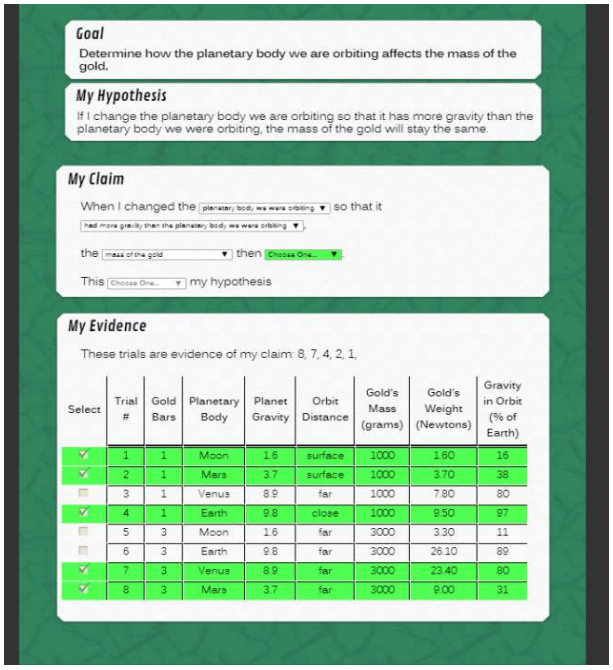


*Figure 5. Sentence pulldown claim builder and interface for selecting trials which count as evidence for the claim.*

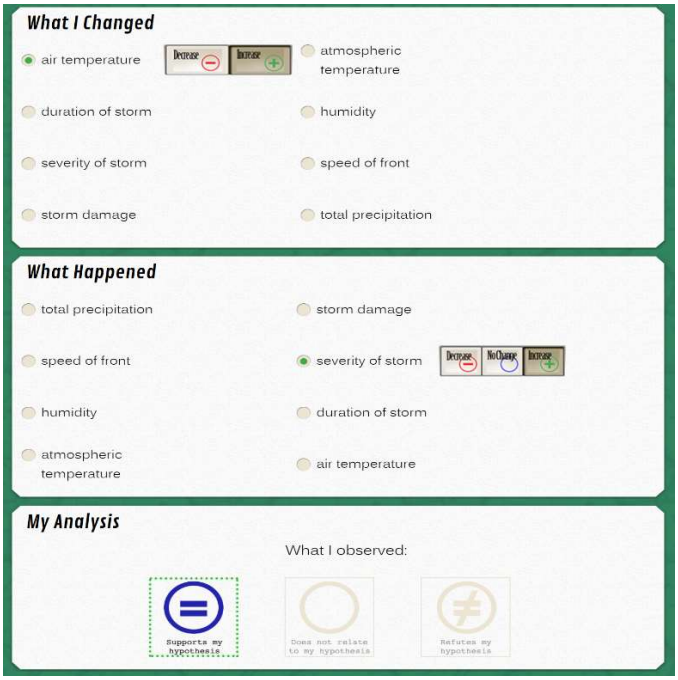


*Figure 6. Graphical claim builder. Interface for selecting trials not show, but is the same as in Figure 5.*

**Assessment Criteria.** All criteria must be met for students to receive full credit. Criteria are equally weighted.

## Claim

| Criterion | Scoring |
|---|---|
| Independent variable in correct position? | Inq-ITS checks that the student chose an independent (manipulable) variable for the start of their claim. If they do so, full credit is given. Otherwise, no credit is given. |
| Dependent variable in correct position? | Inq-ITS checks that the student chose a dependent (observable) variable for the end of their claim. If they do so, full credit is given. Otherwise, no credit is given. |
| Has trials where independent variable changed? | Inq-ITS looks at the student's claim and checks whether they have controlled trials in which only the independent variable specified in their claim is varied.<br><br>If they collected at least two controlled trials varying the independent variable, full credit is given. If not, no credit is given.<br><br>Note that Inq-ITS can still determine this even if the student's independent and dependent variables are in the wrong places within their claim.<br><br>If the student only collected one trial, no credit is given. |
| Relationship found in data? | Inq-ITS checks that the relationship between the independent variable and dependent variable stated in the student's claim can be found within their dataset, looking only at controlled trials. If the relationship is seen in the data, full credit is given. If not, no credit is given.<br><br>Note that Inq-ITS will still try to determine the student's independent and dependent variables even if they are in the wrong places within their claim.<br><br>If the student does not have at least one pair of controlled trials, no credit is given.<br><br>If the student specified two independent or two dependent variables in their claim, no credit is given. |
| Chose correct supports statement? | Inq-ITS looks at the student's claim, controlled trials, and their hypothesis. It then determines if their claim correctly supports or does not support their hypothesis. If the claim is correctly linked, full credit is given. If not, no credit is given.<br><br>Note that Inq-ITS can still determine this even if the student's independent and dependent variables are in the wrong places within their claim.<br><br>If the student does not have at least one pair of controlled trials, no credit is given.<br><br>If the student specified two independent or two dependent variables in their claim, no credit is given. |

## Evidence

| Criterion | Scoring |
|---|---|
| Chose trials where independent variable changed? | Inq-ITS looks at the trials the students selected to warrant their claim. If the trials they chose have different values associated with the independent variable stated in their claim, full credit is given. If not, no credit is given. Note that Inq-ITS can still determine this even if the student's independent and dependent variables are in the wrong places within their claim.<br><br>If the student only collected one trial, no credit is given. |
| All trials chosen are controlled? | Inq-ITS looks at the trials selected by the student to warrant their claim. If the trials they chose are all controlled for the independent variable in the claim, full credit is given. Otherwise, no credit is given. |
| Relationship found in data? | Inq-ITS checks that the relationship between the independent variable and dependent variable stated in their claim is found in the data they selected. They must select at least two controlled trials that demonstrate the relationship. If they do so, full credit is given. Otherwise, no credit is given.<br><br>Note that Inq-ITS will still try to determine the student's independent and dependent variables even if they are in the wrong places within their claim.<br><br>If the student specified two independent or two dependent variables in their claim, no credit is given. |
| Chose trials that support or refute hypothesis correctly? | Inq-ITS looks at the student's claim, the trials they selected to warrant their claim, and their hypothesis. It then determines if their claim correctly supports or does not support their hypothesis. If the link to the hypothesis is correct, full credit is given. Otherwise, no credit is given.<br><br>Note that Inq-ITS can still determine this even if the student's independent and dependent variables are in the wrong places within their claim.<br><br>If the student does not have at least one pair of controlled trials selected to warrant their claim, no credit is given.<br><br>If the student specified two independent or two dependent variables in their claim, no credit is given. |

**Examples.** We show how analyses are scored from a "Weather" Investigate Lab. In this lab, students use a weather simulation to determine what influences the severity of thunderstorms, how long they last, and how much damage they cause. Students can manipulate three variables: "air temperature," "atmospheric temperature," and "humidity."

For these examples, assume the following:

- Goal: "determine how the air temperature affects the severity of the storm."
- Simulation variables:
    - Input – Air temperature: (warm, hot, very hot)
    - Input – Atmospheric temperature: (extreme cold, very cold, cold)
    - Input – Humidity: (moderate, humid, very humid)
    - Output: Storm severity

Student 1 Analysis Example

Hypothesis: If I increase the air temperature, the storm severity will decrease

Claim: When I increased the storm severity, the air temperature increased. This does not support my hypothesis.

Data collected and selected evidence:

| | Trial | Air temp | Atmos temp | Humid | Sever |
|---|---|---|---|---|---|
| | 1 | warm | ex cold | mod | 6 |
| | 2 | hot | ex cold | mod | 8 |
| | 3 | v hot | ex cold | mod | 10 |
| ☑ | **4** | **v hot** | **v cold** | **very hum** | **55** |
| ☑ | **5** | **v hot** | **v cold** | **hum** | **24** |

| Claim | | |
|---|---|---|
| Criterion | Score | Rationale |
| Independent variable in correct position? | ✘ | "Storm severity" is a dependent variable. |
| Dependent variable in correct position? | ✘ | "Air temperature" is an independent variable. |
| Has trials where independent variable changed? | ✓ | "Air temperature" is inferred as the independent variable, and Trials 1,2, and 3 are controlled for this variable. |
| Relationship found in data? | ✓ | As "air temperature" increases, "storm severity" increases in Trials 1,2, and 3. |
| Chose correct supports statement? | ✓ | The hypothesis is not supported, because the data show the opposite relationship of what is stated in the hypothesis. |
| Evidence | | |
| Chose trials where independent variable changed? | ✘ | Trials 4 and 5 have the same value for "air temperature". |
| All trials chosen are controlled? | ✘ | Trials 4 and 5 are controlled for "humidity", not "air temperature". |
| Relationship found in data? | ✘ | Trials 4 and 5 have "storm severity" changing, but not because of any changes to "air temperature". |
| Chose trials that support or refute hypothesis correctly? | ✘ | Trials 4 and 5 control for "humidity" and therefore do not provide any evidence of whether the hypothesis was supported. |
| Total Score: 33% | | |

Student 2 Analysis Example

Hypothesis: If I increase the air temperature, the storm severity will increase

Claim: When I decreased the air temperature, the storm severity decreased. This does not support my hypothesis.

Data collected and selected evidence:

| | Trial | Air temp | Atmos temp | Humid | Sever |
|---|---|---|---|---|---|
| ☑ | **1** | **warm** | **ex cold** | **mod** | **6** |
| | 2 | hot | ex cold | mod | 8 |
| | 3 | v hot | ex cold | mod | 10 |
| | 4 | v hot | v cold | very hum | 55 |
| ☑ | **5** | **v hot** | **v cold** | **hum** | **24** |

| Claim | | |
|---|---|---|
| Criterion | Score | Rationale |
| Independent variable in correct position? | ✓ | "Air temperature" is an independent variable (the cause). |
| Dependent variable in correct position? | ✓ | "Storm severity" is a dependent variable (the effect). |
| Has trials where independent variable changed? | ✓ | "Air temperature" is controlled in Trials 1,2, and 3. |
| Relationship found in data? | ✓ | As "air temperature" decreases, "storm severity" decreases in Trials 3,2, and 1. |
| Chose correct supports statement? | ✗ | The hypothesis is, in fact, supported, because the data show the relationship of what is stated in the hypothesis. Stating a relationship as "increases-increases" between variables has the same meaning as "decreases-decreases." |
| Evidence | | |
| Chose trials where independent variable changed? | ✓ | Trials 1 and 5 have different values for "air temperature". |
| All trials chosen are controlled? | ✗ | Trials 1 and 5 are not controlled for "air temperature". This pair of trials has different values for "atmospheric temperature" and "humidity." |
| Relationship found in data? | ✗ | Trials 1 and 5 are not controlled, therefore the relationship stated in the claim cannot be determined with certainty using these trials as evidence. |
| Chose trials that support or refute hypothesis correctly? | ✗ | Trials 1 and 5 are not controlled and therefore do not provide any evidence of whether the hypothesis was supported. |
| Total Score: 56% | | |

Student 2 Analysis Example

Hypothesis: If I increase the storm severity temperature, the air temperature will decrease

Claim: When I decreased the air temperature, the storm severity decreased. This does not support my hypothesis.

Data collected and selected evidence:

| | Trial | Air temp | Atmos temp | Humid | Sever |
|---|---|---|---|---|---|
| ☑ | **1** | **warm** | **ex cold** | **mod** | **6** |
| ☑ | **2** | **hot** | **ex cold** | **mod** | **8** |
| | 3 | v hot | ex cold | mod | 10 |
| | 4 | v hot | v cold | very hum | 55 |
| | 5 | v hot | v cold | hum | 24 |

| Claim | | |
|---|---|---|
| Criterion | Score | Rationale |
| Independent variable in correct position? | ✓ | "Air temperature" is an independent variable (the cause). |
| Dependent variable in correct position? | ✓ | "Storm severity" is a dependent variable (the effect). |
| Has trials where independent variable changed? | ✓ | "Air temperature" is controlled in Trials 1,2, and 3. |
| Relationship found in data? | ✓ | As "air temperature" decreases, "storm severity" decreases in Trials 3,2, and 1. |
| Chose correct supports statement? | ✓ | The hypothesis is not supported, because the data show the opposite relationship of what is stated in the hypothesis. Note that Inq-ITS infers the independent and dependent variables in the hypothesis, even though they are in the wrong order. |
| Evidence | | |
| Chose trials where independent variable changed? | ✓ | Trials 1 and 2 have different values for "air temperature". |
| All trials chosen are controlled? | ✓ | Trials 1 and 2 are controlled for "air temperature". Note that full credit is given even though not all trials were chosen (Trial 3 also counts as valid evidence). |
| Relationship found in data? | ✓ | Trials 1 and 2 show the relationship stated in the claim. |
| Chose trials that support or refute hypothesis correctly? | ✓ | The hypothesis is not supported, because Trials 1 and 5 show the opposite relationship of what is stated in the hypothesis. Note that Inq-ITS infers the independent and dependent variables in the hypothesis, even though they are in the wrong order. |
| Total Score: 100% | | |

## Explain Findings

Description. Students complete Investigate Labs by writing up their findings in their own words. Inq-ITS uses a Claim-Evidence-Reasoning (C-E-R) framework to help structure students' writing. The *claim* is a statement that addresses the goal, succinctly summarizing the findings of the investigation. The *evidence* is a written description of the data used to support the claim. The *reasoning* describes how or why the claim is supported by the evidence; it connects the evidence to the claim. The reasoning also includes a *justification* that describes the underlying scientific principles that give rise to the phenomenon investigated.

Overall, students who are successful at explaining their findings use clear and concise language that someone of their age group could understand *without having run the simulation themselves*. In other words, students must complete their write-ups so that someone unfamiliar with the simulation could understand their findings.

More specifically, students who are proficient at writing a claim statement in the Investigate Lab:

1. Address the goal of the Investigate Lab
2. Describe the independent and dependent variables
3. Describe the causal relationship between the variables at a level of generality commensurate with the investigation. For example, if the Investigate Lab has students explore phenomena with directional relationships (increases / decreases / stays the same), the student's writeup should describe relationships at this level. If the Investigate Lab uses simple causal relationships (changes / does not change), the writeup should be at this level.

Students who are proficient at writing an evidence statement in the Investigate Lab:

1. Clearly describe the experimental setups and outcomes for each trial used as evidence. This entails describing the independent and dependent variables, and their values.
2. Describe at least two trials of controlled data, controlled for the independent variable defined in the goal, that were collected from running the simulation.

Students who are proficient at writing a reasoning statement in the Investigate Lab:

1. Reference the independent and dependent variables.
2. Explicitly describe why the evidence supports the claim. This can be done by explaining how trials were run making the evidence valid, or by asserting how the relationship stated in the claim is seen in the data used as evidence.
3. States the scientific concepts, theories, and/or laws of why the relationship described in the claim was observed. The specific concepts are different for every Investigate Lab. See the teacher guides for the specific topics and labs for more guidance.

Assessment Criteria. All criteria must be met for students to receive full credit. Criteria are equally weighted across all C-E-R components. For C-E-R activities that are automatically scored, the student *must* write to the goal, even if their investigation centered around different variables. Students will not receive full credit if their writeups are not goal-aligned.

Claim Writeup

| Criterion | Scoring |
|---|---|
| Stated independent variable in the goal? | When writing their claim, if the student references the independent variable stated in the goal, full credit is given.<br><br>Otherwise, no credit is given. |
| Described how independent variable was changed? | When writing their claim, the student must describe how they changed their independent variable.<br><br>If the student states a change at the appropriate level of generality (e.g., increases/decreases if the lab is designed to explore those relationships), or states two or more specific values of the independent variable they changed, full credit is given.<br><br>If the student just states that they changed the independent variable without providing any specifics about how they changed the variable, 80% credit is given.<br><br>If the student does not mention anything about changing the independent variable and only writes about one specific value of the independent variable, 50% credit is given.<br><br>Otherwise, no credit is given. |
| Stated the dependent variable in the goal? | When writing their claim, if the student references the dependent variable stated in the goal, full credit is given. Otherwise, no credit is given. |
| Correctly described how the dependent variable was affected? | When writing their claim, the student must also describe how they changed their dependent variable. The relationship between the independent and dependent variables must be scientifically accurate.<br><br>If the student states a change at the appropriate level of generality (e.g., increases/decreases if the lab is designed to explore those relationships), and it reflects the scientifically accurate relationship between the independent and dependent variables, full credit is given.<br><br>If the student states two or more specific values of the dependent variable they changed, full credit is given.<br><br>If the student just states that they changed the dependent variable without providing any specifics about how they changed the variable, 80% credit is given.<br><br>If the student does not mention anything about changing the dependent variable and only writes about one specific value of the dependent variable, 50% credit is given.<br><br>Otherwise, no credit is given. |

Evidence Writeup

| Criterion | Scoring |
|---|---|
| Referenced at least two trials of data? | For a student's claim to be supported, they must describe in their own words at least two trials controlled of data they collected that demonstrate the relationship they described in their claim.<br><br>Full credit is given if the student:<br>• states they collected at least two trials in which they changed their independent variable and stating how they changed it (e.g., increased, decreased, or changed, depending on what options were available when forming their hypothesis); OR<br>• states at least two data values of the independent variable.<br><br>If the student only states one trial, 50% credit is given.<br><br>If the student vaguely mentions tests or trials without stating anything specific, 25% credit is given.<br><br>Otherwise, no credit is given. |
| Detailed at least two trials where the independent variable was changed? | When writing their claim, the student must describe how they changed their independent variable.<br><br>If the student states a change at the appropriate level of generality (e.g., increases/decreases if the lab is designed to explore those relationships), or states two or more specific values of the independent variable they changed, full credit is given.<br><br>If the student just states that they changed the independent variable without providing any specifics about how they changed the variable, 80% credit is given.<br><br>If the student does not mention anything about changing the independent variable and only writes about one specific value of the independent variable, 50% credit is given.<br><br>Otherwise, no credit is given. |
| Detailed at least two trials stating the effects on the dependent variable? | The student must detail how their dependent variable changed in at least two trials of controlled data they collected.<br><br>Full credit is given if the student states all of the following:<br>• details of at least two trials,<br>• what dependent variable they changed,<br>• the exact values of the dependent variable in their data table, and<br>• an accurate relationship between the independent and dependent variable<br><br>80% credit is awarded if the student either:<br>• states a relative change (increase/decrease) that correctly reflects the relationship between independent and dependent variables, but does not state specific DV data values; OR<br>• states that they changed the dependent variable without providing specifics about how they changed that variable.<br><br>If only one trial of data is described in detail, 50% credit is given.<br><br>Otherwise, no credit is given. |

Reasoning Writeup

| Criterion | Scoring |
|---|---|
| Independent variable referenced? | Full credit is given if the student:<br>• describes the independent variable from the goal; OR<br>• describes at least two values of the independent variable they changed<br><br>If the student describes only one value of the independent variable, 50% credit is given.<br><br>Otherwise, no credit is given. |
| Dependent variable referenced? | Full credit is given if the student:<br>• describes the dependent variable from the goal; OR<br>• describes at least two values of the dependent variable they observed.<br><br>If the student describes only one value of the dependent variable, 50% credit is given.<br><br>Otherwise, no credit is given. |
| Linked evidence to claim? | The student must describe how their evidence and claim link together as part of their reasoning. In doing so, they should:<br>1. explicitly reference their claim by using the word "claim" or any synonyms in their description,<br>2. explicitly reference how their evidence links to their claim by using words like "support", "refute" or their synonyms, and<br>3. explicitly reference their evidence by using words like "data", "experiment", "evidence", or their synonyms<br><br>Full credit is given if the student has a writeup that:<br>• meets all three criteria listed above; OR<br>• first states their claim (or specifically uses the word "claim"), then uses the word support/refutes, and then finally describes their data (or uses the word "data").<br><br>80% credit is given if the student has a writeup that:<br>• meets two of the three criteria listed above; OR<br>• first states their claim and then specifically uses one of these words: support, refute, data; OR<br>• states their data values and specifically uses one of these words: support, refute, claim.<br><br>Otherwise, no credit is given. |
| Correct scientific principles? | The student must also describe the scientific principles that give rise to the phenomenon they described in their claim (a justification). The principles described will change depending on the content area investigated.<br><br>Broadly speaking, if the student states grade-level appropriate scientific principles, full credit is given.<br><br>If vague or inconsistent scientific principles are stated, 80% credit is given.<br><br>Otherwise, no credit is given. |

**Examples.** We show how example hypotheses are scored from a "Flower Growth" Investigate Lab. In this lab, students use a flower simulation to determine how additives impact petal redness and petal loss over time. Students can manipulate three variables: "red dye in the water," "salt in the water," and "sugar in the water."

For these examples, assume the following:

- Goal: "determine how the sugar in the water affects the petal loss."
- Simulation variables:
  - Input – Salt: (Yes, No)
  - Input – Sugar: (Yes, No)
  - Input – Dye: (Yes, No)
  - Output – Petals remaining
- Scientific principle for reasoning statement: Sugar can prevent the plant from receiving the amount of water that it needs in order to survive and it will begin to wilt. Therefore, increasing the amount of sugar would cause the petal loss to increase.

*Claim Scoring Examples*

Student 1 Claim Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| Petals fell down. | Stated independent variable in the goal? | ✘ | Independent variable not described. |
| | Described how independent variable was changed? | ✘ | No description provided on how the independent variable changed. |
| | Stated the dependent variable in the goal? | ✓ | "Petals falling down" implies that the goal-aligned dependent variable of "petal loss" was stated. |
| | Correctly described how the dependent variable was affected? | ✘ | No description provided on how the dependent variable changed as a result of the independent variable. |
| | Total Score for Claim Portion: 25% | | |

Student 2 Claim Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| I ran controlled experiments and saw that sugar had no effect. | Stated independent variable in the goal? | ✓ | Independent variable aligned to the goal mentioned. |
| | Described how independent variable was changed? | ✘ | No description provided on how the independent variable changed. |
| | Stated the dependent variable in the goal? | ✘ | Dependent variable not described. |
| | Correctly described how the dependent variable was affected? | 80% | A causal relationship was implied between the sugar and a dependent variable. However, the causal relationship is not correct (more petals fall when adding sugar). Therefore, partial credit is awarded. |
| | Total Score for Claim Portion: 45% | | |

Student 3 Claim Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| I know the sugar affected the petal loss because I ran controlled experiments and changed only the sugar. | Stated independent variable in the goal? | ✓ | Independent variable aligned to the goal mentioned. |
| | Described how independent variable was changed? | ✓ | Described that the independent variable was changed. |
| | Stated the dependent variable in the goal? | ✓ | Dependent variable aligned to the goal mentioned. |
| | Correctly described how the dependent variable was affected? | 80% | A causal relationship was stated between the sugar and petal loss. However, the causal relationship is vague, not stating how whether adding sugar caused more petals to fall. Therefore, partial credit is awarded. |
| | Total Score for Claim Portion: 95% | | |

Student 4 Claim Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| In my experiment when I added sugar more petals fell off the flower. | Stated independent variable in the goal? | ✓ | Independent variable aligned to the goal mentioned. |
| | Described how independent variable was changed? | ✓ | Described that the independent variable was changed. |
| | Stated the dependent variable in the goal? | ✓ | Dependent variable aligned to the goal mentioned. |
| | Correctly described how the dependent variable was affected? | ✓ | A correct causal relationship was stated between the “sugar” and “petal loss” that was can be seen when running the simulation. |
| | Total Score for Claim Portion: 100% | | |

Student 1 Evidence Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| Look at my data in the table. | Referenced at least two trials of data? | ✘ | Though a student's data table may contain multiple trials of data, the student must explain their data here. |
| | Detailed at least two trials where the independent variable was changed? | ✘ | Same rationale as above. |
| | Detailed at least two trials stating the effects on the dependent variable? | ✘ | Same rationale as above. |
| | Total Score for Evidence Portion: 0% | | |

Student 2 Evidence Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| When I added sugar to the water at the end of the trial, there was only 3 petals left. | Referenced at least two trials of data? | 50% | Partial credit awarded, because only one trial of data referenced. |
| | Detailed at least two trials where the independent variable was changed? | 50% | Partial credit awarded, because:<br>(1) only one trial of data referenced;<br>(2) mentioned the independent variable aligned to the goal (sugar)<br>(3) mentioned a value change for that variable (adding). |
| | Detailed at least two trials stating the effects on the dependent variable? | 50% | Partial credit awarded, because:<br>(1) only one trial of data referenced<br>(2) mentioned the dependent variable aligned to the goal (petal loss)<br>(3) mentioned an explicit observation of that variable when the trial was run (3 petals remained). |
| | Total Score for Evidence Portion: 50% | | |

Student 3 Evidence Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| When there is no sugar, many petals stayed. When I added sugar, more petals fell down so less petals remained. | Referenced at least two trials of data? | ✓ | Two trials of data described. |
| | Detailed at least two trials where the independent variable was changed? | ✓ | Described two trials, one in which there was 'no sugar,' and one with 'sugar added.' |
| | Detailed at least two trials stating the effects on the dependent variable? | ✗ | Though the student mentioned petal loss, no exact values were described for each trials run. Therefore, no credit awarded. |
| | Total Score for Evidence Portion: 67% | | |

Student 4 Evidence Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| When I added sugar to the water at the end of the trial, there was only 3 petals left. When I tested the flower with no sugar in the water, 6 petals stayed on the flower. This proves that the sugar in the water increased petal loss. | Referenced at least two trials of data? | ✓ | Two trials of data described. |
| | Detailed at least two trials where the independent variable was changed? | ✓ | Described two trials, one in which there was 'no sugar,' and one with 'sugar added.' |
| | Detailed at least two trials stating the effects on the dependent variable? | ✓ | The student explicitly describes what they observed for the petal loss when running a trial with sugar, and without sugar. |
| | Total Score for Evidence Portion: 100% | | |

*Reasoning scoring examples*

Student 1 Reasoning Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| What I wrote in box 2 backs up what I wrote in box 1.<br><br>*Note: Box 1 refers to the 'claim' and Box 2 refers to the 'evidence' in the interface.* | Independent variable referenced? | ✗ | Independent variable not described. |
| | Dependent variable referenced? | ✗ | Dependent variable not described. |
| | Linked evidence to claim? | ✓ | Referring to "Box 1" and "Box 2" implies the student is linking the claim to their evidence. |
| | Correct scientific principles? | ✗ | No scientific principles described. |
| | Total Score for Reasoning Portion: 25% | | |

Student 2 Reasoning Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| I know the sugar affected the petal loss because I ran controlled experiments and changed only the sugar. So my evidence supports my claim. | Independent variable referenced? | ✓ | Independent variable aligned to the goal described. |
| | Dependent variable referenced? | ✓ | Dependent variable aligned to the goal described. |
| | Linked evidence to claim? | ✓ | Described running controlled experiments and explicitly linked evidence and claim in their writing. |
| | Correct scientific principles? | ✗ | No scientific principles described. |
| | Total Score for Reasoning Portion: 75% | | |

Student 3 Reasoning Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| My claim is supported. The sugar stops the flower from getting the right nutrients. | Independent variable referenced? | ✓ | Described independent variable aligned to the goal. |
| | Dependent variable referenced? | ✗ | Did not describe dependent variable aligned to the goal. |
| | Linked evidence to claim? | 80% | Mentioned their claim, but does not fully link the claim to the evidence, or provide rationale why the claim is supported. Therefore, partial credit awarded. |
| | Correct scientific principles? | ✓ | Described correct scientific principle at the right level of complexity. |
| | Total Score for Reasoning Portion: 70% | | |

Student 4 Reasoning Example

| | Criterion | Score | Rationale |
|---|---|---|---|
| My evidence shows that the flower that was effected by the sugar. The one with no sugar had more petals attached to it at the end of a week than the flower with sugar. I think this happened because the flower was not used to the extra glucose in the water it was receiving, it caused it to lose petals. | Independent variable referenced? | ✓ | Described independent variable aligned to the goal. |
| | Dependent variable referenced? | ✓ | Described dependent variable aligned to the goal. |
| | Linked evidence to claim? | ✓ | Used observations in evidence to make an inference. The inference is a restatement of their claim. Full credit is awarded even though the word “claim” is not written explicitly. |
| | Correct scientific principles? | ✓ | Described correct scientific principle at the right level of complexity. |
| | Total Score for Reasoning Portion: 100% | | |