



Developing Scientific Explanations

Leadership Institute 2008

Five Essential Features of Inquiry in the Classroom

1. Learner engages in scientifically oriented questions
2. Learner gives priority to evidence in responding to questions
3. Learner formulates explanations from evidence
4. Learner connects explanations to scientific knowledge
5. Learner communicates and justifies explanations

Writing an Explanation

Example #1

	Mass	Density	Melting Point	Color
Liquid 1	38 g	0.93 g/cm ³	-98°C	no color
Liquid 2	38 g	0.79 g/cm ³	26°C	no color
Liquid 3	21 g	13.6 g/cm ³	-39°C	silver
Liquid 4	16 g	0.93 g/cm ³	-98°C	no color

Are any of the liquids the same substance?

Write a **scientific explanation** that answers the question:

How to Write a Scientific Explanation

Components

- Make a **claim** about the problem.
- Provide **evidence** for the claim.
- Provide **reasoning** that links the evidence to the claim.

Definitions

- **Claim:** An assertion or conclusion that answers the original question
- **Evidence:** Scientific data that supports the student's claim that must be appropriate and sufficient. Can come from an investigation or other source such as observations, reading material, archived data, or other
- **Reasoning:** Justification that links the claim and evidence. Shows why the data counts as evidence to support the claim, using appropriate scientific principles.

Qualities of Communication

- Use precise and accurate scientific language.
- Write clearly so that anyone interested in the explanation can understand it.

Rubric for Writing a Scientific Explanation

Component	Level 1	Level 2	Level 3
<p>Claim: A statement that responds to the questions asked or the problem posed.</p>	Does not make a claim, or makes an inaccurate claim	Makes an accurate, but incomplete claim	Makes an accurate and complete claim
<p>Evidence: Scientific data used to support the claim.</p>	Does not provide evidence, or only provides inappropriate evidence (that does not support the claim).	Provides appropriate, but insufficient evidence to support the claim. May include some inappropriate evidence.	Provides appropriate and sufficient evidence to support the claim.
<p>Reasoning: Using scientific principles to show why data count as evidence to support the claim</p>	Does not provide reasoning, or only provides reasoning that does not link evidence to the claim.	Provides reasoning that links the claim and evidence. Repeats the evidence and /or includes some scientific principles, but is not sufficient.	Provides reasoning that links evidence to the claim. Includes appropriate and sufficient scientific principles.

Developing a Scientific Explanation Tool

What is the question that you want to answer?
What did you do to collect evidence that will be used to support your explanations:

Support for your explanation

Claim that is based on the evidence	Evidence (observations)

Scientific Explanation = Claim + Evidence + Science Reasoning

My claim is _____ because _____ (evidence and science reasoning)

(Write a paragraph that includes all three parts to a scientific explanation)

Writing an Explanation

Example #2

Carlos has two liquids, butanic acid and butanol. He determines a number of measurements for the two liquids and then mixes them together. After heating and stirring the liquids, they form two separate layers, layer A and layer B. Carlos uses a dropper pipette to take a sample from each layer, and he determines a number of measurements for each (all measurements are displayed on the table below).

	Volume	Mass	Density	Solubility in Water	Melting Point
Butanic acid	10.18 cm ³	9.78 g	0.96 g/cm ³	Yes	-7.9° C
Butanol	10.15 cm ³	8.22 g	0.81 g/cm ³	Yes	-89.5° C
Layer A	2 cm ³	1.74 g	0.87 g/cm ³	No	-91.5° C
Layer B	2 cm ³	2.0 g	1.0 g/cm ³	Yes	0° C

Did a chemical reaction occur when Carlos mixed butanic acid and butanol?

Use the template to construct a **scientific explanation** that answers the question.

Specific Rubric for Substance and Property Scientific Explanation (Example #1) Rubric

Component	Level		
Claim – A statement or conclusion that answers the original question/problem	0	1	2
	Does not make a claim, or makes an inaccurate claim. ----- States none of the liquids are the same or specifies the wrong solids.	Makes an accurate but incomplete claim. ----- Vague statement, like “some of the liquids are the same.”	Makes an accurate and complete claim. ----- Explicitly states “Liquids 1 and 4 are the same substance.”
Evidence – Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	0	1 & 2	3
	Does not provide evidence, or only provides inappropriate evidence (Evidence that does not support claim). ----- Provides inappropriate data, like “the mass is the same” or provides vague evidence, like “the data table is my evidence.”	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence. ----- Provides 1 or 2 of the following pieces of evidence: the density, melting point, and colors of liquids 1 and 4 are the same. May also include inappropriate evidence, like mass.	Provides appropriate and sufficient evidence to support claim. ----- Provides all 3 of the following pieces of evidence: the density, melting point, and colors of liquids 1 and 4 are the same.
Reasoning – A justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	0	1, 2 & 3	4
	Does not provide reasoning, or only provides reasoning that does not link evidence to claim. ----- Provides an inappropriate reasoning statement like “they are like the fat and soap we used in class” or does not provide any reasoning.	Repeats evidence and links it to the claim. May include some scientific principles, but not sufficient. ----- Repeats the density, melting point, and colors are the same and states that this shows they are the same substance. Or provides an incomplete generalization about properties, like “mass is not a property so it does not count.”	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles. ----- Includes a complete generalization that density, melting point, and color are all properties. Different substances have different properties. Since liquids 1 and 4 have the same properties they are likely the same substance.

University of Michigan, 2006.

Looking at Student Work

Examine the following data table.

	Mass	Density	Melting Point	Color
Liquid 1	38 g	0.93 g/cm ³	-98 °C	no color
Liquid 2	38 g	0.79 g/cm ³	26 °C	no color
Liquid 3	21 g	13.6 g/cm ³	-39 °C	silver
Liquid 4	16 g	0.93 g/cm ³	-98 °C	no color

Student A

Write a **scientific explanation** that states whether any of the liquids are the same substance.

Liquid 1 and 4 are indeed the same substance. Looking at this data, the properties include Density, Color, and Melting Point. Mass is not a property. Density, color and M.P. are all the same for liquid 1 and 4. Since all of these properties are the same, 1 and 4 are the same substance.

Student B

Write a scientific explanation that states whether any of the liquids are the same substance.

no, the liquids are not the same substance because some are different and some are the same like liquid 1 and liquid 4 is just that liquid 4 has different mass than liquid 1 some has different color like

liquid 1, liquid 2, and liquid 4 they all has no color but liquid 3 the color is silver, and also liquid 2, and liquid 3 has different density than liquid 1 & 4. Liquids 2 & 3 has different melting point.

Student G

Write a scientific explanation that states whether any of the liquids are the same substance.

Liquid 1 and liquid 4 are of the same substance because all of their properties are the same, color, density, and melting point are the same. Mass is the same but it doesn't count.

Explanation about Chemical Reaction Problem (Example #2) Rubric

Component	Levels		
	0	1	2
Claim – A statement or conclusion that answers the original question/problem	Does not make a claim, or makes an inaccurate claim. ----- States a chemical reaction did not occur.	Makes an accurate but incomplete claim. ----- Vague statement, like “might have happened.”	Makes an accurate and complete claim. ----- Explicitly states “A chemical reaction occurred.”
Evidence – Scientific data that supports the claim. The data needs to be appropriate and sufficient to support the claim.	Does not provide evidence, or only provides inappropriate evidence (Evidence that does not support claim). ----- Provides inappropriate data, like “the volume is the same” or provides vague evidence, like “the data table is my evidence.”	Provides appropriate, but insufficient evidence to support claim. May include some inappropriate evidence. ----- Provides 1 or 2 of the following pieces of evidence: the densities and melting points of Layers A and B are different from the densities and melting points of either butanic acid or butanol. Layer A is insoluble in water while both butanol and butanic acid are soluble in water. May also include inappropriate evidence, like references to volume or mass.	Provides appropriate and sufficient evidence to support claim. ----- Provides all 3 of the following pieces of evidence: the densities and melting points of Layers A and B are different from the densities and melting points of either butanic acid or butanol. Layer A is insoluble in water while both butanol and butanic acid are soluble in water.
Reasoning – A justification that links the claim and evidence and includes appropriate and sufficient scientific principles to defend the claim and evidence.	Does not provide reasoning, or only provides reasoning that does not link evidence to claim. ----- Provides an inappropriate reasoning statement like “they are like the fat and soap we used in class” or does not provide any reasoning.	Repeats evidence and links it to the claim. May include some scientific principles, but not sufficient. ----- Repeats the evidence about densities, melting points, and/or solubility. Or provides an incomplete generalization about properties, like “volume is not a property so it does not count.”	Provides accurate and complete reasoning that links evidence to claim. Includes appropriate and sufficient scientific principles. ----- Includes a complete generalization that density, melting point, and solubility are all properties. Different substances have different properties. When a chemical reaction occurs, new substances are formed as products of the reaction. These new substances will have properties different from those of the original substances. Since layers A and B have properties different from either Layer A or Layer B, these layers must contain new substances indicating that a chemical reaction must have occurred.

Scientific Explanations in the Classroom

What should students know and be able to do in developing scientific explanations?

- Ask “How do you know?” in appropriate situations and attempt reasonable answers when others ask the same question (K-2)
- Offer reasons for findings and consider reasons suggested by others (3-5)
- Seek better reasons for believing something than “Everybody knows that...” or “I just know” and discount such reasons when given by others (3-5)
- Notice and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given (6-8)
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken – whether one’s own or that of others – can be judged (9-12)

AAAS Benchmarks, 1993.

What does research tell us?

In a study of scaffolding scientific explanations conducted by Katherine L. McNeill, David J. Lizotte, and Joseph Krajcik (University of Michigan) and Ronald W. Marx (University of Arizona), the following trends were synthesized:

- Explanations are rarely a part of classroom practice (Kuhn, 1993; Newton, Driver & Osborne 1999).
- Students have difficulty using appropriate evidence (Sandoval & Reiser, 1997) and including the backing for why they chose the evidence (Bell & Linn, 2000) in their written explanations.
- Students typically discount data if the data contradicts their current theory (Chinn & Brewer, 2001).
- During classroom discourse, discussions tend to be dominated by claims with little backing to support their claims (Jiménez-Aleixandre, Rodríguez & Duschl, 2000).

McNeill, Lizotte, Krajcik, & Marx, (in press).

Cell Model Investigation 1

Title: *The Effects of different solutions on the movement through a dialysis bag acting as a cell model*

Question: *Which solutions (glucose and starch) can pass through the membrane of a dialysis bag?*

Hypothesis: 1) *If a dialysis bag containing glucose solution is placed in distilled water, then some of the glucose solution will pass through the membrane into the surrounding container.*
 2) *If a dialysis bag containing starch solution is placed in distilled water, then some of the starch solution will pass through the membrane into the surrounding container.*

IV: <i>type of solution inside dialysis bag</i>				
(control group) <i>Distilled water</i>	<i>Glucose solution</i>	<i>Starch solution</i>		
<i>5 trials</i>	<i>5 trials</i>	<i>5 trials</i>		

DV: *presence of glucose solution using glucose test strips and presence of starch using Lugol's iodine solution as indicators*

Constants: *distilled water outside dialysis bags, amount of distilled water in a container, amount of time, amount of indicator used, amount of solution inside dialysis bag, how tight dialysis bags are tied*

Cell Model Investigations 1 & 2

Materials

- 250 mL beakers
- Dialysis tubing cut into 3 inch strips
- String to tie ends of tubing
- 10 mL graduated cylinder
- funnel
- Glucose solution
- Starch solution
- Distilled water
- Clock
- scissors
- Indicators: glucose test strips and Lugol's iodine solution
- Electronic balance

Procedure

1. See protocol on page 161 in text and the background information on page 162
2. Determine the amount of solution inside the dialysis tubing and the amount of distilled water in the beaker
3. Review techniques for using indicators or determining the mass of the dialysis bags using an electronic balance

Evidence (observations/data)

Initial and final tests of solutions	Trial 1		Trial 2		Trial 3		Trial 4		Trial 5		Claims	
	Inside bag	Outside bag	Inside bag	Outside bag	Inside bag	Outside bag	Inside bag	Outside bag	Inside bag	Outside bag		
Water	-	-	-	-	-	-	-	-	-	-	-	no solutions
Glucose	+	+	-	+	+	+	-	+	+	+	+	Glucose moved out
Starch	+	+	-	-	+	+	-	-	+	+	-	Starch stayed in

	Trial 1		Trial 2		Trial 3		Trial 4		Trial 5		Average
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	
Water	24g	24g	23g	22g	25g	24g	24g	25g	23g	24g	
% change											
Glucose	31g	27g	32g	27g	30g	28g	29g	26g	30g	27g	
% change											
Starch	27g	35g	28g	34g	30g	36g	29g	33g	30g	35g	
% change											

Developing a Scientific Explanation Tool

<p>What is the question that you want to answer?</p> <p><i>What solutions (glucose and starch) can pass through the membrane of a dialysis bag?</i></p>
<p>What did you do to collect evidence that will be used to support your explanations:</p> <p><i>See Experimental Design Diagram for Cell Model Investigation 1</i></p>

Support for your explanation

Claim that is based on the evidence	Evidence (observations)
<p><i>Glucose moved out of dialysis bag</i></p> <p><i>Starch stayed inside dialysis bag</i></p>	<p><i>Final Glucose test strips were positive both inside and outside the dialysis bags</i></p> <p><i>Final Lugol's iodine test was negative outside the dialysis bags and positive inside the dialysis bags</i></p>

Scientific Explanation = Claim + Evidence + Science Reasoning

My claim is _____ because _____ (evidence and science reasoning)

My claim is that glucose was able to move through the membrane of the dialysis bag and that starch was not able to move through the membrane of the dialysis bag. This is because glucose was found to be present both inside and outside the dialysis bags after 30 minutes and starch was found to be present only side the dialysis bag. The membrane of the dialysis bag is a semi-permeable membrane that allows smaller substances to pass through it and larger substances not to pass through. Since glucose is a smaller molecule than starch, the membrane allowed glucose to pass through it. Starch molecules were too large to fit through the membrane pores.

Supporting Students' Construction of Scientific Explanations
By Fading Scaffolds in Instructional Materials

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McNeill, K. L. Lizotte, D.J., Krajcik, J., & Marx, R.W. (in press). Supporting Students' Construction of Scientific Explanations By Fading Scaffolds in Instructional Materials. *The Journal of the Learning Sciences*.

Scaffolding Student Learning

In order to help middle school students learn how to construct scientific explanations, we incorporated our instructional model into an 8-week project-based chemistry unit. Research on scaffolding informed both our design of the curriculum materials and this research study where we investigated the effect of fading written instructional supports (scaffolds) for scientific explanation.

Wood, Bruner and Ross (1976) originally introduced the term “scaffolding” in the context of adult-child interactions where the more knowledgeable adult tutors the child to complete a task the child would be unable to do on his/her own. With the help of scaffolds, learners can complete more advanced activities and engage in more advanced thinking (Bransford et al., 2000). Although Wood et al. did not originally connect scaffolding to Vygotsky’s zone of proximal development, a number of educational researchers since then have explicitly made this connection (Hogan & Pressley, 1997; Palincsar & Brown, 1984). The zone of proximal development (ZPD) defines the area between a child’s independent problem solving capabilities and the level of potential problem solving capabilities with the guidance of people or tools (Vygotsky, 1978). Stone (1993) argues that scaffolds allow students to achieve a higher level of understanding within their zone of proximal development. In order for a scaffold to promote student understanding, it needs to reside within a students’ current ZPD. If a scaffold provides too much information, the student will not be challenged to learn more. The scaffold should provide just enough information that the learner may make progress on his/her own (Hogan & Pressley, 1997).

In their study of reciprocal teaching, Palincsar and Brown (1984) discuss Vygotsky's idea that at first the parent or expert guides much of a child's cognitive activities and over time the child takes on more and more of those responsibilities. Eventually, the child performs the activities by herself, without the help of the scaffolds. In fact, Wood et al. (1976) described scaffolding as a flexible process contingent on what a child knows and the characteristics of the learning task. This suggests that scaffolds should be adjusted over time rather than remaining constant in order to allow students greater responsibility over their own learning. Palincsar and Brown's study (1984) supports this idea of adjusting scaffolds based on students' understanding. In studying teacher-student interactions during reciprocal teaching, they found that initially the teacher provided modeling, feedback, and practice to students. Over time as the student became better able to complete a task, the teacher decreased his or her support. By the end, the teacher's role was one of supportive audience member and the student had taken over the expert responsibilities. This shift to greater control over knowledge construction resembles the shift from child to adult status where adults retain a more regulatory role controlling the cognitive interaction in their ZPD (Scardmalia & Bereiter, 1991).

Decreasing the support or "fading" (Collin, Brown & Newman, 1989) is an essential characteristic of scaffolds. There are numerous supports within learning environments that are not scaffolds; rather they can be instrumental for both experts and novices to complete a task. In these situations, the supports serve to distribute the knowledge across the physical environments (Brown, Collins, & Duguid, 1989). Such supports have been given various names such as acts of distributed cognition or distributed intelligence (Pea, 2004) and cultural tools (Tabak, 2004). Tabak (2004) describes the difference between a cultural tool and a scaffold by using the example of a vertical array representation to find the solution to a multiplication problem, such

as 343 multiplied by 822. Both experts and novices might use the vertical array to find the solution; consequently, it is considered a cultural tool. In contrast, scaffolds serve to help learners complete a task independently and as such should be faded as learners develop their own understanding. For example, a novice unfamiliar with using a vertical array may be provided with a special notational template to help them complete multiplication problems. Eventually, when learners achieve mastery of the vertical array representation, the template would no longer be used, so it is considered a scaffold. Based on this idea that scaffolds are specifically developed to help learners, we define scaffolds as temporary supporting structures provided by people or tools to promote learning of complex problem solving.

Traditionally, scaffolding has been discussed in terms of one-on-one interactions. There has been little research on teacher-student scaffolding in whole class settings (Hogan & Pressley, 1997). Hogan and Pressley argue that one of the reasons there has been little research in this area is because in a large classroom a teacher cannot possibly interact with every child individually. Ideally, the teacher would react to the current situation and modify the scaffolds based on all of the students' needs. When a teacher addresses the whole class he or she is confronted with multiple zones of proximal development. There is concern that teacher-student scaffolding cannot be carried out effectively in such whole class settings (Stone, 1998).

One possible solution to this problem is having students work in groups and then scaffolding those groups. But this can still be problematic because of the number of groups in a classroom. Another possibility is to provide students with tools, such as computers or written materials, which provide students with scaffolds. Here the interaction is between the student and the computer or written materials. Because external tools (like computers or written artifacts) cannot include the dynamics of adult-child or even peer interactions, they can be seen as limited

in the use of the scaffolding metaphor (Stone, 1998). Palincsar argues that one way researchers “have hobbled the use of scaffolding is by attributing scaffolding only to interactions that occur between individuals, and typically between individuals of significantly different expertise... (I)t is helpful to recall that ZPDs include not only people but also artifacts, and that ZPDs are embedded in activities and contexts” (1998, p. 371).

Fading Written Scaffolds

Although previous research suggests fading encourages greater student independence, the majority of these studies have looked at adult-child interactions where the adult can individualize the scaffolds for the particular student’s needs. Written supports obviously do not have that advantage though continuous written prompts, which are provided throughout an instructional unit, have been shown to increase student learning. One example of the benefits of continuous written prompts includes the ThinkerTools curriculum created by White and Frederiksen (1998; 2000). They designed their curriculum to scaffold students’ development of scientific inquiry processes, modeling, and metacognitive skills and knowledge. In order to develop metacognitive skills, they developed a set of reflection prompts that guided students’ evaluation of their work at the end of each phase of the inquiry cycle. To determine the effectiveness of the metacognition prompts, White and Frederiksen compared two versions of the curriculum, one with reflection prompts and one without reflection prompts. They found that students who received the reflective prompts resulted in greater understanding of the inquiry practices.

Davis (2003) also examined the role of continuous prompts in supporting students’ reflection. In this case, she integrated the prompts into the Knowledge Integration Environment (KIE) software where she investigated the role of two different types of reflection prompts:

Developing a Scientific Explanation Tool

What is the question that you want to answer?

What did you do to collect evidence that will be used to support your explanations:

Support for your explanation

Claim that is based on the evidence	Evidence (observations)

Scientific Explanation = Claim + Evidence + Science Reasoning

My claim is _____ because _____ (evidence and science reasoning)

(Write a paragraph that includes all three parts to a scientific explanation)

Brief Lab Reports

	Part	Purpose
<input type="checkbox"/>	1. Title	Write a sentence that relates the independent and dependent variables that were investigated.
<input type="checkbox"/>	2. Question/Problem	Describe the question you were trying to answer or the problem you were trying to solve.
<input type="checkbox"/>	3. Hypothesis	Write a prediction or possible explanation related to your question. What do you think will happen?
<input type="checkbox"/>	4. EDD (Experimental Design Diagram)	<ul style="list-style-type: none"> • Begin the EDD by drawing a rectangle. • Write the independent variable (IV) across the top of the rectangle. • Divide the rectangle into labeled columns to represent the different levels of the independent variable. • Indicate the number of trials in each column. • Write the dependent variables (DV) and constants (c) beneath the rectangle.
<input type="checkbox"/>	5. Procedure/Methods	<ul style="list-style-type: none"> • List the steps followed to complete the investigation. Check the list carefully for accuracy. • Include your method for data collection and representation. • If you are using a procedure from your text book or from the teacher, you may reference that procedure instead of re-writing it.
<input type="checkbox"/>	6. Results	Complete a data table, and/or graph or other means of representing your data. Use the guidelines below.
	<input type="checkbox"/> Data Table	<ul style="list-style-type: none"> • Make a table containing vertical columns for the independent variable, dependent variable, and derived quantity. • Subdivide the column for the dependent variable to reflect the number of trials. • Order the values of the independent variable – preferably from smallest to largest. • Record values of the dependent variable. • Compute the derived quantity.
	<input type="checkbox"/> Graph	<ul style="list-style-type: none"> • Draw and label the X and Y axes of the graph. • Write data pairs for the independent and dependent variables. • Determine an appropriate scale for the x and y axes; subdivide the axes. • Plot the data pairs on the graph. • Summarize the data trends on the graph.
	<input type="checkbox"/> Other	

Brief Lab Reports

□ 7. Conclusion

Points to include:

- Purpose or question investigated
- Major findings/data/evidence, including patterns, relationships, examples and surprises from data
- Is the hypothesis supported by the data? If so, connect to evidence.
- Compare data with other research or scientific information. Are data consistent with other information on the same topic? This may include class data versus group data. (optional)
- Explanation for findings as related to scientific concepts
- Recommendations for further study and/or improving the investigation

Adapted from *Students and Research*, 2000, Cothron, Giese and Rezba

Brief Lab Report Scoring Guide

	Title	Question/ Problem	Hypothesis	EDD (Experimental Design Diagram)	Procedure/ Methods	Results	Conclusion
4	The title clearly states both the independent and dependent variables. The title of the report is written in a clear declarative statement	The question or problem that the experiment was designed to answer is well articulated and testable. The question is scientific in nature.	The hypothesis is clearly stated and makes a reasonable prediction about the influence of the independent variable on the dependent variable.	All parts of EDD are complete and accurate. Independent variables, dependent variables and constants are correctly identified.	A detailed, logical step by step set of procedures is listed or referenced. Methods for data collection and representation are included.	Data table(s), graph(s), and or other representations of data are complete and accurate including appropriate labels.	All parts of conclusion are complete and accurate. Conclusion clearly states whether hypothesis was supported and cites evidence. Explanation effectively connects results to scientific concepts using sound logic and good understanding of underlying concepts.
3	The title clearly states either the independent or dependent variables.	The question or problem that the experiment was designed to answer is testable. The question or problem is scientific in nature.	The hypothesis is stated and makes a prediction about the influence of the independent variable on the dependent variable.	Most parts of EDD are complete and accurate. Independent variables, dependent variables and constants are correctly identified.	A detailed, logical step by step set of procedures is listed or referenced.	Data table(s), graph(s), and or other representations of data are mostly complete and accurate. Only one or two components are missing or inaccurate.	Most parts of conclusion are complete and accurate. Conclusion states whether hypothesis was supported. Explanation attempts to connect results to scientific concepts and reveals adequate understanding of those concepts.

Brief Lab Report Scoring Guide

2	The title is clearly connected to the experiment, but does not mention the dependent or independent variables.	The question or problem is scientific in nature, but the question is not testable.	The hypothesis is stated and makes a prediction.	Most parts of EDD are complete and accurate. Of the independent variables, dependent variables and constants, 2 out of 3 are correctly identified.	A logical step by step set of procedures is listed or referenced, but some steps are missing or incomplete.	Data table(s), graph(s), and or other representations of data are partially complete and accurate. Two to four components are missing or inaccurate.	Some parts of conclusion are complete and accurate. Explanation reveals partial understanding of those concepts.
1	The title is present but not does relate directly to the experiment.	The question or problem is present, but is not scientific in nature.	The hypothesis is present but does not make prediction.	Some parts of EDD are complete and accurate.	A logical step by step set of procedures is listed or referenced, but many steps are missing or incomplete.	More than four components are missing or inaccurate.	Explanation attempted but does not reveal that student had any understanding of underlying scientific concepts.
0	Not attempted	Not attempted	Not attempted	Not attempted	Not attempted	Not attempted	Not attempted