Educational Module

Title:

Light and Well-Being: Exploring Data Representation and Statistical Relationships

Author:

Brad M. Avery

Grade Level / Subject:

10^{th} - 12^{th} grade / Advanced Algebra with Trigonometry or Statistics course

Curriculum Standard (from *Benchmarks for Science Literacy* by Project 2061):

- When calculations are made with measurements, a small error in the measurements may lead to a large error in the results. (9A 9-12 #3)
- Any mathematical model, graphic or algebraic, is limited in how well it can represent how the world works. The usefulness of a mathematical model for predicting may be limited by uncertainties in measurements, by neglect of some important influences, or by requiring too much computation. (9B 9-12 #3)
- Tables, graphs, and symbols are alternative ways of representing data and relationships that can be translated from one to another. (9B 9-12 #4)
- The way data are displayed can make a big difference in how they are interpreted. (9D 9-12 #4)
- …A believable correlation between two variables doesn't mean that either one causes the other; perhaps some other variable causes them both or the correlation might be attributable to chance alone. A true correlation means that differences in one variable imply differences in the other when all other things are equal. (9D 9-12 #6)
- Consider the possible effects of measurement errors on calculations. (12B 9-12 #9)
- Learn quickly the proper use of new instruments by following instructions in manuals or by taking instructions from an experienced user. (12C 9-12 #1)
- Suggest alternative ways of explaining data… (12E 9-12 #6)

Overview:

In this lesson students will explore and learn about correlation through an experimental approach. Student will use light meters to attempt to find a correlation between illumination and distance. The students will graph their results and also explore the statistical phenomena of misrepresentation and sources of error,

Purpose:

The purpose of this lesson is to introduce students to the concept of correlation while continuing to investigate sources of error and misrepresentation of data. Through the concept of correlation is this authentic activity, students will hopefully be able to make connection involving correlation to other phenomena, particularly the inverse square law.

Learning Objectives:

After completing this lesson, students will be able to:

- Operate and record data from a light meter and understand what is being measured.
- Understand how the scale of a graph or chart can influence interpretation of that data.
- Realize that measurement is not precise. Measurement can be a source of error.
- Understand that small measurement errors can result in large errors in conclusions.
- Identify and determine several sources of error.
- Realize that a set of data can have more than one explanation
- Understand the concept of correlation.
- Understand that although two characteristics or sets of data *appear* to be related, that does not mean that there is a true correlation between them.

The following two rubrics provide a tool to evaluate performance for the group and individual work of students during this lesson.

Group Work Rubric:

Criteria	"Non-proficient"	"Proficient"	"Advanced"
a. group contribution	each member present during group work	each member's name on group work	each member's name on work with list of their contributions
b. organization & completeness	incomplete graphs, data, observations, results, or lack of organization	all data, graphs, observations, and results present but lacking organization	all data, graphs, observations, and results recorded and well organized
c. graphs	no labels, units, or title, graph and data do not match	missing or inaccurate labels and units, but graph and data match	all labels and units correct with title, data and graph match
d. data	incomplete or missing illumination data and graphs	complete illumination data and graphs	complete illumination data and graphs plus interpretation of data and graphs
e. sources of error	no sources of error mentioned or included in work	many potential sources of error included in work	many sources of error included with consideration of impact on data
f. presentation	incomplete summary of observations, data, graphs, or sources of error	complete summary of observations, data, graphs, sources of error.	complete summary and recommendations for further investigation

Individual Work Rubric:

Criteria	"Non-proficient"	"Proficient"	"Advanced"
a. organization & completeness	incomplete graphs, data, observations, results, or lack of organization	all data, graphs, observations, and results present but lacking organization	all data, graphs, observations, and results recorded and well organized
b. graphs	no labels, units, or title, graph and data do not match	missing or inaccurate labels and units, but graph and data match	all labels and units correct with title, data and graph match
c. data	missing or incomplete illumination data	complete illumination data	complete illumination data plus data interpretation
d. sources of error and alternative explanations	no sources of error and alternative explanations offered	many sources of error and alternative explanations offered	both offered with consideration of impact on data and correlation
e. correlation and defense of position	conclusion on correlation reached, no defense from criteria "d"	conclusion reached, defended with weak connections to criteria "d"	conclusion reached, defended well with in depth connection to criteria "d"

Vocabulary:

error	relationship	light meter
source of error	correlation	foot-candle
qualitative data	natural light	lux
quantitative data	artificial light	

Resources & Materials:

handouts	graph paper
masking tape	butcher paper
light meters (1 per group)	markers
measuring tapes	calculator
meter sticks	rulers

Preparatory Activities & Prerequisite Knowledge:

Students should already know or be familiar with the following:

independent variable	how to read a graph (x and y axes)
dependent variable	how to plot/construct a graph (x and y axes)
light	measurement and various measurement devices

Before the first day of the lesson, the following should be done as a preparatory activity (preferable the day before this lesson is begun). Have students write about what they know about light in their journals for a few minutes.

- How is light intensity and brightness measured?
- What types of light are there?

Then discuss with the class what their ideas and perceptions are. Do not give any answers. Ask students to continue to think about these questions and have them add to their journal entry as homework in preparation for the following day's lesson.

Main Activities (3 days in block schedule with 90 minute periods):
<u>Day 1</u>

Introduction (10-15 minutes)

Go over Plan of the Day (P.O.D.)
Have students briefly share their ideas/findings/questions in their journal entries from the preparatory activities

Introduce Laboratory and assignments

Introduce/discuss student evaluation components:
<u>Group Work</u>
Evidence of *every* member contributing/participating
Recorded process of thoughts, actions, observations, and results
Explanation of sources of error in your work (ongoing review)
Present graphs and illumination data from posters
Individual Work
Design your own correlation experiment
Collect data
Record process of thoughts, actions, observations, and results
Explain sources of error in your work (ongoing review)
Consider alternative explanations for your data
Complete graph and interpret in terms of correlation
Correlation worksheet

Show students how to read and use the light meters
What does a foot-candle/lux measure? (½ page Handout)
Consider doing a demonstration of the definition of foot-candle with a candle

Group Work (50 minutes)

Students break into groups
Provide lab handout (one handout per group, with grading rubric)
Briefly answer any questions
Checkout materials to groups
Let students go to their location and begin collecting data
Goal: Finish data collection by end of class period
Observe students and don't answer questions outright, instead ask if they could find an answer to their question or see if someone else in their group can help first.

Class Wrap Up (5 minutes)

Check-in lab materials
Quick review of group assignment/expectations
Any questions/confusion/observations?

<u>Day 2</u>

Introduction (15 minutes)

Go over P.O.D.
Have students describe the group assignment to refresh and refocus

Group Work Wrap-Up (25-30 minutes)

Each group receives two sheets of butcher paper for their poster presentation
Students work in classroom on their graphs and sources of error

Group Presentations & Discussion (35 minutes)

Each group spends no more than five minutes presenting their data, graphs, observations, and sources of error.
Each student is responsible for recording each of the presented data on illumination.

Class Wrap-Up (10 minutes)

For homework, ask students to write what they think correlation is in their journals. Be prepared to discuss for tomorrow's lesson.
Clean up the classroom.
Handout individual work rubric (class set).
Respond to student questions/comments/concerns.

Day 3

Introduction (25 minutes)

Class discussion: What is correlation?

What does correlation look like graphically? Caution: give an example graph for students to look at. Ask if the two variables/characteristics are correlated. Let the students answer in their journals, then ask questions that help the students discover the potential for assumption of correlation. Then ask students what is necessary to determine if two variables/characteristics are correlated.

Journaling

Work Time (25 minutes)

Pass out the "Exploring Correlation" worksheet and have students work on these individually or in small groups. Have students do the graphs on graph paper.

Observe student work to get a feel for whether they believe the two variables in either worksheet activity are correlated.

Roundtable Discussion (15-20 minutes)

Arrange desks in a circle and be a facilitator an open dialogue between students

- What do their graphs look like?
- Was correlation observed in either worksheet activity?
- Why do they feel/believe what they do?
- Listen for alternative explanations

Lesson/Class Wrap-Up (20 minutes)

Explain the individual correlation assignment. Explain that the process should be like that followed in the group work, but that the topic of investigation for correlation is their own. These will be collected the following Monday. Pass out the individual work grading rubrics for students to refer to.

The Exploring Correlation worksheet, if not finished in class, can be completed as homework and turned in tomorrow.

Journaling

Provide brief introduction/explanation of tomorrow's lesson.

What does a foot-candle/lux measure?

Lux and foot-candles both measure illumination. The lux is the European and SI unit for illumination measurement, while the foot-candle is the U.S. unit for illumination measurement.

The lux is a unit of illumination determined by the illumination from a uniform light source of one square meter that is placed one meter away.

The foot-candle (fc) is a unit of illumination determined by the illumination from a uniform light source of one square foot that is placed one foot away.

$1 \text{ lux} = 1 \text{ lumen} / \text{m}^2$ and $1 \text{ fc} = 1 \text{ lumen} / \text{ft}^2$

since $1 \text{ ft} = 0.3048 \text{ m}$, then $1 \text{ ft}^2 = 0.0929 \text{ m}^2$ then

$1 \text{ lux} = 0.0929 \text{ fc}$ and $1 \text{ fc} = 10.764 \text{ lux}$

What does a foot-candle/lux measure?

Lux and foot-candles both measure illumination. The lux is the European and SI unit for illumination measurement, while the foot-candle is the U.S. unit for illumination measurement.

The lux is a unit of illumination determined by the illumination from a uniform light source of one square meter that is placed one meter away.

The foot-candle (fc) is a unit of illumination determined by the illumination from a uniform light source of one square foot that is placed one foot away.

$1 \text{ lux} = 1 \text{ lumen} / \text{m}^2$ and $1 \text{ fc} = 1 \text{ lumen} / \text{ft}^2$

since $1 \text{ ft} = 0.3048 \text{ m}$, then $1 \text{ ft}^2 = 0.0929 \text{ m}^2$ then

$1 \text{ lux} = 0.0929 \text{ fc}$ and $1 \text{ fc} = 10.764 \text{ lux}$

Illumination Laboratory

During this lab, you will be graded on the following (see rubric on back)

- Evidence of *every* member contributing/participating
- Recorded process of thoughts, actions, observations, and results
- Explanation of sources of error in your work (ongoing review)
- Present graphs and illumination data from posters

Make sure that you understand how to use the light meter. If you are not sure, ask me

Gather the materials that you will need:

masking tape	graph paper
light meters (1 per group)	rulers
measuring tapes	calculator
meter sticks	this handout

Divide responsibilities: Do this however you like, but make sure that everyone participates.

Day 1

Objectives:

- To collect illumination data from the room for which your group conducted a survey. By the end of today you should have all of your data recorded.
- To begin considering sources of error in your work

Day 2

Objectives:

- To organize your data into two graphs on butcher paper and present to the class. (I will provide butcher paper and markers)
- Critically analyze your results
- Consider alternative explanations for your data and observations

Tips

While some group members are recording data or drawing the graphs, this might be a good time for other group members to brainstorm possible sources of error.

over, please

Group Work Grading Rubric

The following rubric will be used to evaluate your group work during this lesson:

Criteria	"Non-proficient"	"Proficient"	"Advanced"
a. group contribution	each member present during group work	each member's name on group work	each member's name on work with list of their contributions
b. organization & completeness	incomplete graphs, data, observations, results, or lack of organization	all data, graphs, observations, and results present but lacking organization	all data, graphs, observations, and results recorded and well organized
c. graphs	no labels, units, or title, graph and data do not match	missing or inaccurate labels and units, but graph and data match	all labels and units correct with title, data and graph match
d. data	incomplete or missing illumination data and graphs	complete illumination data and graphs	complete illumination data and graphs plus interpretation of data and graphs
e. sources of error	no sources of error mentioned or included in work	many potential sources of error included in work	many sources of error included with consideration of impact on data
f. presentation	incomplete summary of observations, data, graphs, or sources of error	complete summary of observations, data, graphs, sources of error.	complete summary and recommendations for further investigation

Exploring Correlation

Below you will find two sets of data. For each set of data, you will first make a prediction of whether the two variables are correlated or not. Then, using your own graph paper, plot the data. Then answer the questions that follow.

Data Set #1:

Before you look closely at the data, do you think that height and weight are correlated? Why or why not?

_____

_____

_____

Plot the data on your graph paper. Make sure to label the axes and provide units, and title your graph. Please attach the graph to this paper before turning this assignment in.

Name:	Height (cm)	Weight (kg)
Anastasia	167	56.7
Tom	160	63.5
Jevon	180	65
Anne	162	58
Juan	170	74
Autumn	175	59
Austin	165	63.5
Kendra	170	60
Maria	157	61
Pierre	172	66

Now, based on your graph, do you believe that height and weight are correlated? Justify your answer based on your graph.

_____

_____

_____

_____

If your prediction differed from the answer you determined from your graph, explain what changed your mind. Be specific; don't just say "the graph". If your prediction and the answer you determined from the graph are the same, compare your reasons from each. What changed and why?

_____

_____

_____

_____

What alternative explanations could explain what you observed in your graph? What other factors could have influenced the data or graph?

_____

_____

_____

_____

Data Set #2:

Before you look closely at the data, do you think that height and weight are correlated? Why or why not?

_____

_____

_____

Plot the data on your graph paper. Make sure to label the axes and provide units, and title your graph. Please attach the graph to this paper before turning this assignment in.

Name:	Hours spent studying	Grade on last test
Anastasia	2.1	95%
Tom	1.5	86%
Jevon	1	71%
Anne	2.5	98%
Juan	2.3	94%
Autumn	1.7	84%
Austin	0	65%
Kendra	1.9	91%
Maria	1.3	76%
Pierre	2	89%

Now, based on your graph, do you believe that height and weight are correlated? Justify your answer based on your graph.

_____

_____

_____

_____

If your prediction differed from the answer you determined from your graph, explain what changed your mind. Be specific; don't just say "the graph". If your prediction and the answer you determined from the graph are the same, compare your reasons from each. What changed and why?

_____

_____

_____

_____

What alternative explanations could explain what you observed in your graph? What other factors could have influenced the data or graph?

_____

_____

_____

_____

Individual Work Grading Rubric

The following rubric will be used to evaluate your individual work during this lesson:

Criteria	"Non-proficient"	"Proficient"	"Advanced"
a. organization & completeness	incomplete graphs, data, observations, results, or lack of organization	all data, graphs, observations, and results present but lacking organization	all data, graphs, observations, and results recorded and well organized
b. graphs	no labels, units, or title, graph and data do not match	missing or inaccurate labels and units, but graph and data match	all labels and units correct with title, data and graph match
c. data	missing or incomplete illumination data	complete illumination data	complete illumination data plus data interpretation
d. sources of error and alternative explanations	no sources of error and alternative explanations offered	many sources of error and alternative explanations offered	both offered with consideration of impact on data and correlation
e. correlation and defense of position	conclusion on correlation reached, no defense from criteria "d"	conclusion reached, defended with weak connections to criteria "d"	conclusion reached, defended well with in depth connection to criteria "d"