Using Statistical Analysis to Determine The Density of Minerals

Grade Levels: 10 – 12
Course: Geoscience

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This unit plan is my original work completed specifically for ENG5101. All work that has been adapted/adopted for use in this Unit Plan has been properly cited.

Signature

Date
Unit Overview

Learning Goals:
- Find the volume of a given sample of minerals
- Determine the density those minerals
- Write out an accurate procedure to determine the density of a mineral
- Find the class median, mode and mean of each mineral sample
- Create a box and whisker plot using class data for both samples
- Create a frequency table of class data for both samples
- Create a histogram of class data for both samples
- Calculate the standard deviation for both samples
- Compare class data to actual density of minerals

Connection to other Units:
- Density of objects is first practiced in the Geoscience math unit at the beginning of the year.
- Density is a very important concept for students to understand because it is mentioned in many units in Geoscience such as Plate tectonics, Weathering and erosion, and Meteorology.
- In this unit students will prepare their own procedure for the scientific method and this was discussed in the Into to Geoscience unit which deals with math and the scientific method.

Prior Knowledge:
- Steps in the Scientific method
- How to find the volume of odd shaped objects
- How to find the mass using an electronic scale
- How to calculate the average of an ordered set of numbers

Relationship to ENG5101:
- In this course, Mr. Matt Zimmer instructed the class on how to use statistics in science. He specifically taught us how to create box and whisker plots, histograms and calculating standard deviation. After taking this course I realized that I do not provide my students with enough opportunities to use math skills in science. I realize now how important it is for students to practice math in other setting besides the math class.
Books/Sources Consulted


[3] “Data from running a robot for a time of 8 seconds,” class notes for ENG5101, Michigan Technological University, Summer 2006.
Learning Objectives:

Knowledge and skills students will gain:

- Creating a detailed list of procedures to complete the task of finding the density of mineral samples.
- Finding the volume of an odd shaped object using new techniques such as water displacement.
- Calculating density of a mineral sample using the data that they have collected.
- Calculating the mean, median and mode of the class data for both mineral samples.
- Creating a box and whisker plot of class data for both mineral samples.
- Creating a histogram of class data for both mineral samples.
- Finding the standard deviation for both mineral samples.
- Comparing class data to the actual densities of specific minerals.

Measurable Outcomes:

- Students will be asked to complete the statistical analysis of the second mineral sample by themselves. As a class we would have done the first mineral sample analysis together.
- Students will be shown the rubric for grading the Density of Mineral task sheet.
Michigan Content Expectations:

Science/ Strand 1/ Content Standard 1/ High School

- Benchmark 1: Ask questions that can be investigated empirically
- Benchmark 2: Design and conduct scientific investigations
- Benchmark 3: Recognize and explain the limitations of measuring devices

Mathematics/ Strand 3/ Content Standard 1/ High School

- Benchmark 1: Collect and explore data through observation, measurement, surveys, sampling techniques and simulations
- Benchmark 2: Organize data using tables, charts, graphs, spreadsheets and data bases.

Mathematics/ Strand 3/ Content Standard 2/ High School

- Benchmark 2: Describe the shape of data distribution and determine measures of central tendency, variability and correlation.
Lesson Day 1

Learning Objectives:

- Creating a detailed list of procedures to complete the task of finding the density of mineral samples.
- Finding the volume of an odd shaped object using new techniques such as water displacement.
- Calculating density of a mineral sample using the data that they have collected.

Materials (per class):
Electronic scale (3), overflow cup (15), mineral samples A and B (15 of A and B), graduated cylinder (15), beaker with water (15), calculator (30), science journals (30)

Time: 55 minutes

Anticipatory set (5 minutes):

- Students will write in their science journals for 5 minutes about the following topic:
  Describe in your own words what density is.
- After 5 minutes allow students to share their responses

Review of prior knowledge (5 minutes):

- Define mass (how much matter is in an object)
- Define volume (how much space an object takes up)
- Define density (how much matter is in a given amount of space)
- Equation for density = mass/volume

Input (10 minutes):

- Students will be introduced to the task they must complete by the end of the hour. The teacher will read the student task sheet with the students and answer any questions that may follow. (see student task sheet) Also found in cited text [1].
- Students should also be given the rubric for this task. (see rubric) Also found in cited text [1].
- Students should work in groups of two and collect materials needed to complete the task.

Activity (30 minutes):

- Students will work to complete the Density of Minerals student task sheet. All questions must be answered and area cleaned up after they are finished.

Closing (5 minutes):

- When students have completed the task have them get out their science journals and provide a response to the following prompt:
  “What should you have learned after today’s class period?”
**Density of Minerals**  
*Student Task Sheet*

**Task:** You are to determine the mass, volume and density of two mineral samples. Record your data and calculations precisely and accurately within the limits of the measurement tools.

**Materials:**  
Metric balance, overflow cup, mineral samples A and B, graduated cylinder, beaker with water, calculator

**Background:**  
Minerals are the different materials that make up the various rocks of the earth. Each mineral has its own set of identifying properties. Density is one of the properties often used to identify minerals. Rocks are composed of one or more minerals that have been formed in different ways. The properties of the rocks, made of the same minerals, may be different depending on how the rocks were made. Mineral densities are nearly always the same.

**Directions:**

1. Record the code number of each mineral sample and find the mass of each to the nearest tenth of a gram.
2. Record the code number and find the volume of each mineral sample to the nearest whole cubic centimeter (ml).
3. Write out a description of the procedure you used to find the volume of the minerals.
4. What is the density of the mineral samples? Record your answers to the nearest tenth place. Show all your work.

\[ \text{Density} = \frac{\text{mass}}{\text{volume}} \]

5. The metamorphic rock quartzite and a sedimentary rock sandstone are both made of the mineral quartz that has a density of 2.65 g/cm\(^3\). A geologist determined a sample of quartzite to have a density of 2.65 g/cm\(^3\) and determined the sample of sandstone to have a density of 2.45 g/cm\(^3\). In complete sentences, explain why the sample of quartzite has a different density from the sample of sandstone. In complete sentences, explain why densities of the quartz and the sample of quartzite are the same.
Density of Minerals
Scoring Rubric

Task 1: Mass 6 points total
Performance standard: Students determine and record precise measurements of mass.
Criteria:
A. Mass of mineral A
   - allow 2 points if the mass is +/- 0.2 g
   - allow 1 point if the mass is +/- 0.5 g
   - no credit is given if the mass is +/- >0.5 g
B. Mass of Mineral B
   - allow 2 points if the mass is +/- 0.2 g
   - allow 1 point if the mass is +/- 0.5 g
   - no credit is given if the mass is +/- >0.5 g
C. Labeling
   - allow 1 point for labeling both measurements with units
D. Recording
   - allow 1 point for all data accurately recorded to the nearest tenth of gram

Task 2: Volume 6 points total
Performance Standard: Students determine and record precise measurements of volume using the displacement method.
Criteria:
A. Volume of mineral sample A
   - allow 2 points if the volume is +/- 1cm^3
   - allow 1 point if the volume is +/- 2 cm^3
   - no credit is given if the volume is +/- >2cm^3
B. Volume of mineral sample B
   - allow 2 points if the volume is +/- 1cm^3
   - allow 1 point if the volume is +/- 2 cm^3
   - no credit is given if the volume is +/- >2cm^3
C. Labeling
   - allow 1 point for labeling both measurements with units
D. Recording
   - allow 1 point for all data accurately recorded to the nearest tenth of gram

Task 3: Volume Procedure 2 points total
Performance Standard: Students describe the displacement procedure for determining volume.
Criteria:
   - allow 2 points for a clear, accurate description of the displacement method
   - allow 1 point for a partially accurate or partially unclear description
Task 4: Density Calculations  
8 points total
Performance Standard: Students calculate the density of mineral samples and show work.

Criteria:

Mineral Sample A:
A. Substitution
   - allow 1 point for correct substitutions into the equations
B. Calculations
   - allow 2 points if the density is +/- 0.2 g/cm^3
   - allow 1 point if the density is +/- 0.5 g/cm^3
   - no credit is given if the density is +/- >0.5 g/cm^3

Mineral Sample B:
A. Substitution
   - allow 1 point for correct substitutions into the equations
B. Calculations
   - allow 2 points if the density is +/- 0.2 g/cm^3
   - allow 1 point if the density is +/- 0.5 g/cm^3
   - no credit is given if the density is +/- >0.5 g/cm^3

Labeling and Recording:
A. Labeling
   - allow 1 point if both answers are labeled correctly
B. Recording
   - allow 1 point if both answers are recorded to the nearest tenth of a g/cm^3

Task 5: Rock Differences  
3 points total
Performance Standard: Students give a logical, scientifically accurate explanation for differences or similarities in rock densities.

Criteria:
A. Sedimentary vs. Metamorphic rock
   - allow 2 points for a logical statement in complete sentences
   - allow 1 point for a logical answer that is not given in complete sentences
   - no credit for inaccurate answers
B. Quartzite
   - allow 1 point for a correct response
   - allow no point for an incorrect response
Lesson Day 2

Learning Objectives:
- Calculating the mean, median and mode of the class data for both mineral samples.
- Creating a box and whisker plot of class data for both mineral samples.

Materials (per class):
Calculators (30), white boards (30), science journals (30)

Time: 55 minutes

Anticipatory set (8 minutes):
- Students will write in their science journals for 5 minutes about the following topic:
  What is the purpose of finding the mean, median and mode in the real world?
- After 5 minutes allow students to share their responses
- **Real world purpose** – these 3 terms are called measures of central tendency. They are important because they allow you to compare data. They are used in engineering, industry, technology and grading assignments.

Review of prior knowledge (7 minutes):
- What is density? – how much matter in a given amount of space
- Which is more dense lead or ice? How can you tell? Lead, because it sinks in water and ice floats.
- Students will be comparing the density of the mineral samples using the **mean**, **median** and **mode**.

Input (10 minutes):
- Mean – sum of the terms / # of terms
- Median – middle term (terms must be ordered in numerical order)
- Mode – most frequent number

Example (do together):
4, 10, 5, 2, 6, 1, 5, 7
  What is the average? 5
  What is the median? 5
  What is the mode? 5

- Write class data for the density of sample A on the board.
- Have students order data numerically and then find the mean, median and mode.

Check for understanding (15 minutes): Have students write answers on white boards and then hold up once they have the answers. Correct those who have a miscalculation.
- Write numerical order of sample A densities on the board.
- Draw a line thru the median (this is like half time)
- To find the end of the first quarter you find the median of the first half.
- To find the end of the third quarter you find the median of the second half.
- Do the first quarter with the students and have them do the third quarter and write their answer on their white board.
- Students should now list the Median, First quartile, and Third quartile on their data sheet [3]
Students will now learn a method to get rid of outliers

- Find the IQR (inter quartile range) Q3 – Q1
- Take 1-5 * IQR
- To find the upper limit = Q3 + (1.5 * IQR)
- To find the lower limit = Q1 – (1.5 * IQR)
- This means numbers above the upper limit and those below the lower limit are outliers and should not be counted in the box and whisker plots

**Check for understanding (10 minutes):**

Have students perform these operations with the class data and report answers on their white boards. Teacher should check answers.

- **Box and whisker plot** –
  - Draw a number line for the class data
  - At the median draw a vertical line up from the number
  - At the Q1 draw another vertical line
  - At the Q3 draw another vertical line
  - This will make your box
  - Put a point at the lowest term or lower limit (which ever comes first)
  - Connect that point to the box (makes a whisker)
  - Put a point at the highest term or upper limit (which ever comes first)
  - Connect that point to the box (makes the other whisker)

Students will now create a box and whisker plot for their data from sample A

**Check for understanding:**

- After students have completed the first box and whisker plot ask the following questions, “How does the number of terms in the first quarter compare to the number of terms in the second quarter?”

**Independent Practice/Closing (5 minutes):**

The remaining part of the period, students will do the same steps for mineral sample B. They must come to class the next day with the data and whisker plot for the second sample.
Data Sheet: Mineral Sample A and B

Mineral Sample __________

<table>
<thead>
<tr>
<th>Group #</th>
<th>Density in g/cm^3</th>
<th>Ordered list of densities</th>
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Median –
First Quartile –
Third Quartile –
IQR –
Upper limit –
Lower limit –

Box and Whisker plot
Lesson Day 3

Learning Objectives:
• Creating a histogram of class data for both mineral samples.

Materials (per class):
Calculator (30), rulers (30), science journals (30), graph paper (30 sheets)

Time: 55 minutes

Anticipatory set (5 minutes):
• Students will write in their science journals for 5 minutes about the following topic:
  What is the importance in analyzing data?

Review of prior knowledge (5 minutes):
• The data from sample B will be displayed on the board and students are to check their data.
• What is meant by the term frequency? – how often something occurs

Input (20 minutes):
• Creating a histogram of class data for both mineral samples.
• Students will be making a histogram of both samples of data. Sample A will be done as a class and sample B will be done alone.
• The first step is to make a frequency table

<table>
<thead>
<tr>
<th>Data Range</th>
<th>Number of samples</th>
<th>Relative frequency</th>
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</table>

• Relative frequency – # samples/ total samples – thought of as a percent
• Have students set up a data range for sample A. Check that the ranges are in equal intervals.
• Next have them count the number of samples in each range
• Calculate the relative frequency
• Next students will be graphing this information on graph paper
  o The y – axis will be relative frequency
  o The x – axis will be density (data range)

Check for understanding (5 minutes):
What percent are in _____________ range?
Does this follow a normal distribution (bell curve)?

Independent Practice/Closing (20 minutes):
Students will complete the above steps for sample B.
Lesson Day 4

Learning Objectives:
• Finding the standard deviation for both mineral samples.
• Comparing class data to the actual densities of specific minerals.

Materials:
Calculators (30), science journals (30)

Time: 55 minutes

Anticipatory set (5 minutes):
• Students will write in their science journals about the following topic:
  o Why did groups have different densities for the same mineral tested?

Review of prior knowledge (5 minutes):
• Have on the board the data from sample B and have students check their answers
• “Why wasn’t the density of sample B the same for every group?”

Input (10 minutes):
• Standard deviation is used to measure the spread of an entire data set around the mean. [2]
• Step 1: Find the deviation (term value – mean)
• Step 2: Square the deviation
• Step 3: Sum the square of deviation
• Step 4: Find the variance (Square of deviation / total samples)
• Step 5: Find sigma or standard deviation (square root of variance)
• A large standard deviation means your numbers are not very close to the mean and are very spread out
• A small standard deviation indicates a small amount of variation in your data (this is what you want)

Check for understanding (20 minutes):
Students will find the standard deviation for both samples A and B.

Real world application/Closing (15 minutes):
Compare data from samples A and B to the actual densities of samples A and B. Ask the following questions and have students respond first in their journals and then ask for volunteers to respond.
• Why is there a variation in both data sets?
• Why are the densities not the same as the actual density of each mineral?
• What was the purpose of analyzing the data we found about our minerals?
• Why is density an important characteristic in identifying minerals?