Lab Framework

Text:Core Unit 3

Unit number and title:

Short Description: Build a Vernier Scale and use it to measure several objects in the classroom.

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Lab Title

Unit 3 DIY Vernier

LAB PLAN

TEACHER: Teacher Prep/ Lesson Plan

- **Lab Objective**
- To Familiarize students with the use of the Vernier scale, and to understand how it works. To create a simple measuring device that uses a vernier scale. Students will also get to work with some fractions and ratios.

- **Statement of pre-requisite skills needed**

- We will be using some fractions, doing some measurement in both the metric and standard systems.

- **Vocabulary**
  - Ratio
  - Vernier
  - Caliper
  - Centimeter
  - Millimeter
  - Index mark
  - Gradation
- **Materials List**

Two pieces stiff colored or white paper
Ruler marked in cm, and mm.
Pencils
Scissors

Handout – Brief explanation of Vernier

Data Chart

VERNIER

Sometimes the index mark on the caliper does not fall directly on a line on the caliper scale. To make possible readings even smaller than thousandths, an ingenious device is introduced in the form of an additional scale. This scale, called a VERNIER, was named after its inventor, Pierre Vernier. This ingeneously simple and technically advanced idea to increase the precision of a scale by a factor of ten or more (his scale can be ten times smaller than the fine markings on a normal scale) was thought up in 1631. It is still in use today, though digital technologies are starting to predominate. The vernier makes possible accurate readings to the ten-thousandth of an inch.

Principle of the Vernier in a caliper (It is also used in micrometers)

Suppose a ruler has markings every tenth of an inch (or any unit) but it is desired to read accurately to hundredths. A separate scale (fig. 6-3) is added to a sliding part ruler. It has 10 markings on it that take up the same distance as 9 markings on the ruler scale. Thus, each space on the vernier is 1/10 of 9/10 inch, or 9/100 inch. How much smaller is a space on the vernier than a space on the ruler? The ruler space is 1/10 inch, or 10/100 and the vernier space is 9/100 inch. The vernier space is smaller by the difference between these two numbers, as follows:

10/100 - 9/100 = 1/100

A vernier space is the space difference between the scale on the vernier – 9/100 (the sliding part) and the space of the

scale on the ruler. (1/10)

Each vernier space is 1/10 smaller than a ruler space. So if the ruler space is 1/10 then the the vernier space is 1/100. Units don't really matter – it can be inches or cm

- **State Standards addressed**

Math:

2.3.A Identify objects that represent or approximate standard units and use them to measure length. At this level, students no longer rely on non-standard units. Students find and use approximations for standard length units, like a paper clip whose length is about an inch, or the width of a particular student's thumbnail that might be about a centimeter. They might also use commonly available classroom objects like inch tiles or centimeter cubes.

2.3.B Estimate length using metric and U.S. customary units. Students could make observations such as, "The ceiling of the classroom is about 8 feet high."

2.3.C Measure length to the nearest whole unit in both metric and U.S. customary units. Standard tools may include rulers, yardsticks, meter sticks, or centimeter/inch measuring tapes. Students should measure some objects that are longer than the

6.1.E Multiply and divide whole numbers and decimals by 1000, 100, 10, 1, 0.1, 0.01, and 0.001.

6.1.F Fluently and accurately multiply and divide non-negative decimals. Students should understand the inverse relationship between multiplication and division, developed in

A1.1.B Solve problems that can be represented by linear functions, equations, and inequalities.

Writing: State GLE"S

3.2.2
3.3.1
3.3.2
3.3.3

- **Leadership Skills**

1. Honestly, integrity, and trust;

2. Respect for self and others;
3. Responsibility for personal actions and commitments;
4. Self-discipline and moderation;
5. Diligence and a positive work ethic;
6. Healthy and positive behavior; and

- **SCAN Skills/Workplace Skills**

  Construction Trades : Though the vernier scale is not used much in the general construction trades, the concept of measurement is very valuable.

  Machinist: Machinists use the vernier scale all the time. Though many of the digital technologies are becoming automated, the micrometer and caliper are still frequently used.

  Automotive Technologies: This field uses the vernier scale frequently

  Bicycle mechanic: Vernier scale is used to measure inside and outside diameters of various components.

- **Set-up information**

  Students divide into groups of two or one. Each group gets a worksheet and two pieces of paper, scissors, paperclip, and a pencil.

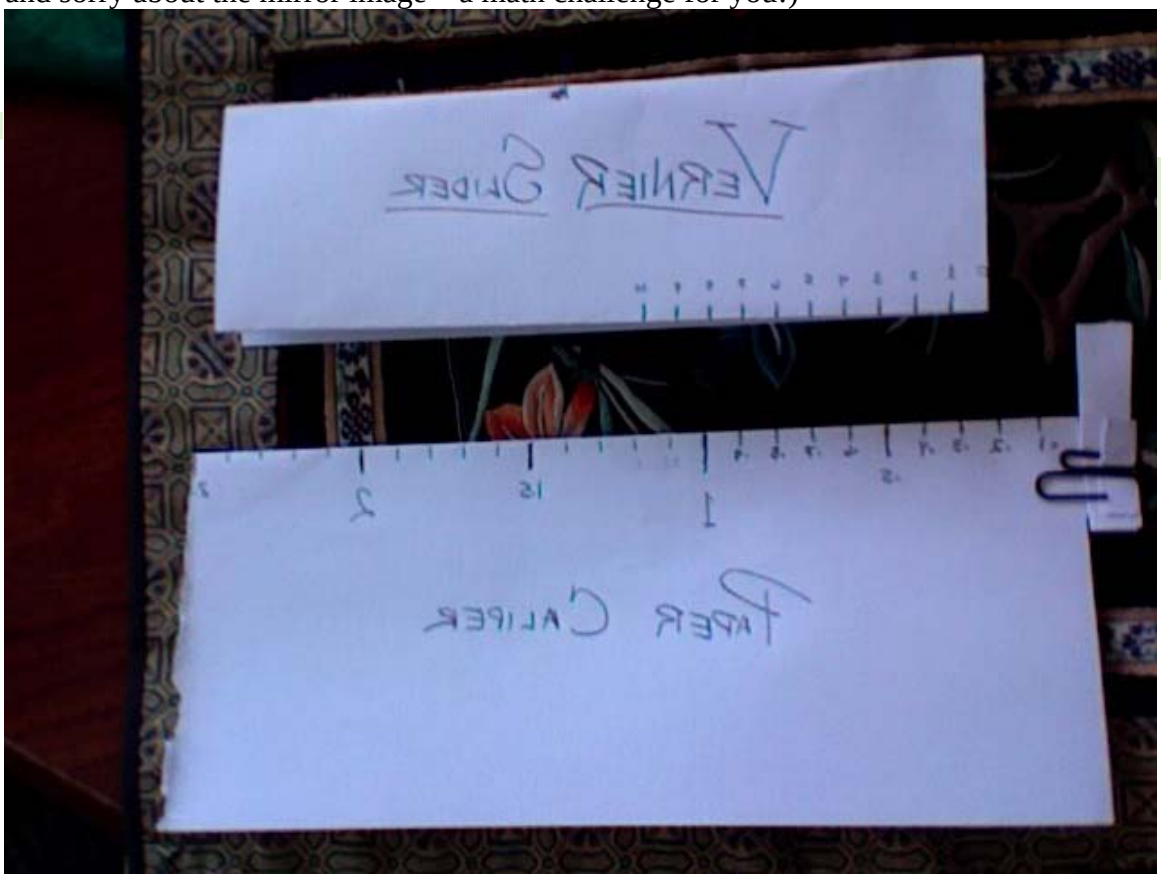
- **Lab organization**
- 30 – 45 minutes

  Divide class into groups of two – if odd number, choose an independent student to work alone. Handout the handout. Read the handout as a group, letting students take turns reading. Let the class know that they will be making a functioning vernier scale measuring device that will measure to the nearest millimeter, even though the closest lines on their scale will be 9 mm apart.

  Begin the lab. Stress that all work needs to be done very carefully. Sloppy lines will give lousy results, and less credit.

  1. Each student will get two pieces of paper. They will be told to fold one paper "longways" and the other shortways. (One will be 8 1/2" x 5 1/2" and the other will be 11" x 4 ¼")
  2. Handout rulers and Instruct students to make a pencil mark every cm (starting at one edge of the fold) on the long folded sheet (We will call this the **Paper Caliper**)– the marks should be about ½ cm long and perpendicular to the edge of the fold. They should have 25 marks. Label the 10cm mark as your "1" unit, the 20 cm will be 2 and have them mark the rest in their respective tenths. (i.e. the 5^{th} mark would be .5 , etc)
  3. Now the tricky part – Students will make another scale on their shorter folded sheet. First they will fold it one more time to make it 8" x2.75" – this will make it a bit stiffer. This scale will be laid out just like the other one except they will make a mark every 9/10 of a centimeter instead of every centimeter. First have them write down the the multiples of nine from 9 – 90. This will be the numbers of millimeters on their scale. Their scale will only have 10 marks and they can make the fifth and tenth mark longer or even label them 1-10. This sheet will be called the **Vernier Slider.**

4. Now we will make a little end piece for our longer sheet at the "0" mark. This is just a short stiff piece that can be attached to the end with paper clips. (see photo and sorry about the mirror image – a math challenge for you!)



Now the students have made their own caliper and can try them out. They should mesure some object you supply (pennies, length or pen, width of four fingers, etc.) In order to use the vernier scale the object cannot be much longer than 15cm.
Have students carefully fill out their data sheet and hand them in along with their caliper with their names on them. They should get somewhat close agreement with their partner and other students on their measurements.

Teacher Assessment of student learning

Observation of lab work &
Scoring Guide :
10 pts Caliper + 5 pts data table
Caliper - 5pts folding
5pts even gradations

Data Table - 5pts - completely filled in with units and neat script.

- **Summary of learning** (to be finished after student completes lab)
  -discuss real world application of learning from lab – use of calipers
  -opportunity for students to share/present learning – compare class results

- **Optional activities**
  Graph data,
  Create vernier caliper with tongue and groove lumber
  Make a finer scale
- **Career Applications**
  Working in a team
  Data comparison
  Machine concepts

Lab Data Chart

Vernier Measurements

Object to be measured	Length of object in mm

Bonus Questions

1. Some vernier scales have more or less than 10 gradations on the sliding scale. If your main scale was marked in 1/16ths and your sliding scale was marked out with 8 equal marks over $15/16^{th}$ on the main scale, then how far apart would the vernier marks be? (Is that a confusing word problem or what?)

2. Some Verniers read to the 1/1000 of an inch. The main scale has marks .025 apart and the vernier scale will have 25 marks. How many marks will the main scale have? _____

3. Write .025 as a fraction. .025 = _____. Now reduce this fraction to lowest terms. _____

4. Referring to #2, how far apart will the vernier marks be?

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