GLOBE Program in Niger

Trees and Wood in Our Backyard

Identifying our Trees

Trees and Wood in Our Backyard – Lesson 1

Materials / Preparations:

- Meter stick
- Tape measure
- Students' GLOBE notebooks
- Investigation questions 1-7 written on the board *(the questions are below)*
- Choose the trees that you are going to assign to the groups. If possible, pick a unique species for each group.

Note: Some classes may have difficulty getting through these lessons during one class session based on their ability and work speed. It is perfectly OK to divide these lessons into smaller units as necessary; simply ensure that you are maintaining a good flow between the smaller units through review and planning.

Lesson Plan:

Introduction to the GLOBE Program

1. Write the word "globe" on the board and ask the students "What is a globe?"
2. Explain that "GLOBE" is also the name of our program.
3. Explain that GLOBE is an acronym that stands for "Global Learning and Observations to Benefit the Environment." Write this on the board.
4. Explain that the program started in 1996. In the following 10 years it has grown and now includes over 7500 schools in 111 countries. The students of these schools have become scientists and they do environmental research on the environment. In addition, they share their data with real scientists and other schools around the world through the vehicle of the internet.
    a. Definition: The **internet** is a network that allows computers around the world to communicate. (It is like the network for cell phones, but for computers.)
5. The Nigerien government invited the GLOBE Program into the country in 2005 and it is now within the Ministry of Education and managed by the *Cellule Pour la Généralisation et Pérennisation de l'Éducation Environnementale* (CGPE).

Goals of the GLOBE Program

1. The GLOBE Program has two linked objectives, **science** and **education**.
2. At out level, the program has the goal of helping you to:
    - Become good scientists
    - Better understand your environment
    - Understand the scientific method
    - Use scientific instruments

- Take measurements and analyze them
- Use the internet to make your data available to students and scientists around the world, and
- Create links between science, math, technology, and the environment.

3. GLOBE student scientists study five aspects of their environment:
   - Atmosphere
   - Hydrology
   - Soil
   - Land cover (vegetation)
   - Seasonal changes
4. We will start with the study of trees as part of Land Cover.

Explain the Questionnaire and Form Groups

1. Explain to the students that they are going to learn about the "Trees and Wood in Our Backyard."
2. Divide the class in groups of 4-6 students who will work together for the whole module. The groups should be named after the trees that each group will study.
3. Assign a different species of tree in the school yard to each group of students. Explain that each group will study their tree throughout the unit.
4. Explain to the students that we are going to start by collecting some information about the trees we will be studying though **observation**. We will use our senses (sight, touch, smell, taste, and sound) to collect this information. Information that is collected using the senses and that does not include numbers is called **qualitative data**.

Explain the Questionnaire

1. Ask the students to copy the seven questions below into their notebooks, leaving a few lines after each question for the answers. *(The italicized notes are explanatory aids for the teacher – they do not need to be copied on the board with the questions.)*

    1. The name of your tree:
        a. In English (French):
        b. In local language:

    2. Estimate the height of your tree, in meters:

    3. Estimate the circumference of your tree, in centimeters:

    4. Draw a picture of your tree:

    5. Make a drawing or imprint of a leaf:

    6. Where do you usually find this tree?
    (In courtyards, gardens, or the countryside?)

7. Describe the characteristics of your type (species) of tree:
    a. Size: *(Is it one of the biggest species?)*
    b. Trunk: *(Is it fat or thin? Rough or smooth?)*
    c. Branches: *(Do they have thorns?)*
    d. Leaves: *(Their shape? Their color? Do they fall?)*
    e. Flowers: *(Their shape? Their color? Season of flowering?)*
    f. Fruits: *(Their shape? Their color? Fruit bearing season?)*

2. Go over the questions with the students to make sure they understand what each question means

Practice Making Estimates

1. Ask them, "What is an estimate?" Explain that an **estimate** is an educated guess of the dimensions or the quantity of something without taking exact measurements with instruments. Explain why being able to make an accurate estimation is important.
2. Ask a student to come to the blackboard. Ask each group to estimate the height of the student. Write their responses on the board. Measure the student and identify groups that did well and groups that could use some more practice.

   Note: If the students' initial measurements are not even close to the reality, hold up a meter stick and encourage the students to base their estimations against something that they already know like the length of a meter. Ask the students to revise their estimates based on this new information.

3. Repeat the exercise, this time estimating the "circumference" of a second student.
4. Explain that they are going to do the same thing for trees.

Go Outside and Make Observations (Take Qualitative Data)

1. Ask the students to go outside to their designated tree and use it to answer the seven questions they just wrote down. Specify that each student should do his or her own work on the estimations and observations and they should each write down their answers in their notebooks. Remind them that for the moment they shouldn't measure the trees with a ruler but should rather make estimates.

Preparation for the Next Lesson

1. Tell the students to keep their answers to questions 1-7, as we will be going over them and using them in upcoming lessons.
2. Write the following question (Question 8) on the board and ask the students to copy it into their notebooks. Explain that this is homework and that they should go and ask their parents for an answer to this question and to write down the response. They will share their answers during the next lesson.

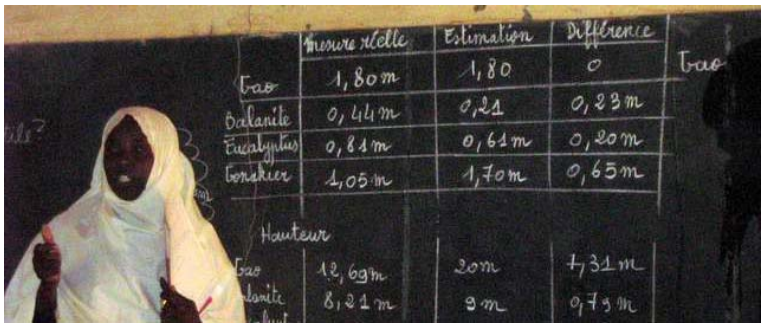
    8. What are the uses of my tree, the _____ :
        a. For men and for women:
        b. For animals:
        c. For the environment:

Importance and Usefulness of Trees

Trees and Wood in Our Backyard – Lesson 2

Materials / Preparation:

- Verification of the students' responses *(see "Guide to Some Trees of the Sahel" in the back of this section)*
- Students' GLOBE notebooks



Lesson Plan:

Responses to the Questionnaire

1. Explain to the students that they are going to share the information that they got from their parents with the rest of the class.
2. Draw a table up on the board with the names of the trees in the left-hand vertical column and the three categories of beneficiaries (humans, animals, and the environment) across the top of the grid. Then as each group presents what they have learned, the teacher can place each use into the table. Here is an example:

	Uses for Humans	**Uses for Animals**	**Uses for the Environment**
Tree One:	- Edible berries - Bark used as medicine		
Tree Two:		- Animals eat the leaves during the dry season	
Tree Three:			

3. Ask each group to present the various uses of their tree for humans. (If they have missed a use, add it to the presentation yourself. Possible uses are listed in the *"Guide to Some Trees of the Sahel"* in the back of this section)
4. After each group has presented, make sure that the students in the group have written down any uses that you have just added for their tree to their personal lists as they will need them later.

5. Then do the same (steps one and two) for the uses for animals and the environment.
    a. Two important uses of trees for the environment that the students may not know but should be taught are as follows:
        i. Trees store carbon dioxide from the atmosphere and thus help to slow Global Warming, as carbon dioxide in the atmosphere acts like a blanket for the Earth.
        ii. Many trees help create nitrogen in the soil that the tree and other plants can use to help them grow well. Nitrogen is an important plant nutrient.
6. Remind the students not to lose their answers because we will need them again in a few lessons' time.

Theater

1. Tell the students to think about the question, "What would life be like without trees?
2. Ask each group to prepare a short (3 minute) skit on what life would be like without trees.
3. Have the students perform the skit in front of the class.
4. Make sure that the students applaud for each group after their skit!

Preparation for the Next Lesson

1. Explain that during the next lesson they will make a tool that permits them to measure the height of a tree or another tall object without climbing it. They will use it to measure the height of their trees and judge the accuracy of their estimations.
2. Ask the students to bring the following items for the next lesson:
    - A piece of cardboard at least as big as a piece of notebook paper
    - A piece of nylon or cotton string, 25 cm long
    - The empty tube of a ballpoint pen
    - A washer or a coin or an old key – something made of metal that can be hung from the string to add a little weight to it. (A small piece of cardboard will <u>not</u> work because it is not heavy enough.)
    - A ruler
    - Scissors or a razor blade, if possible

Building a Clinometer

Trees and Wood in Our Backyard – Lesson 3

Note: For secondary schools, the next three lessons have been modified and are located in the appendix of this section.

Materials / Preparations:

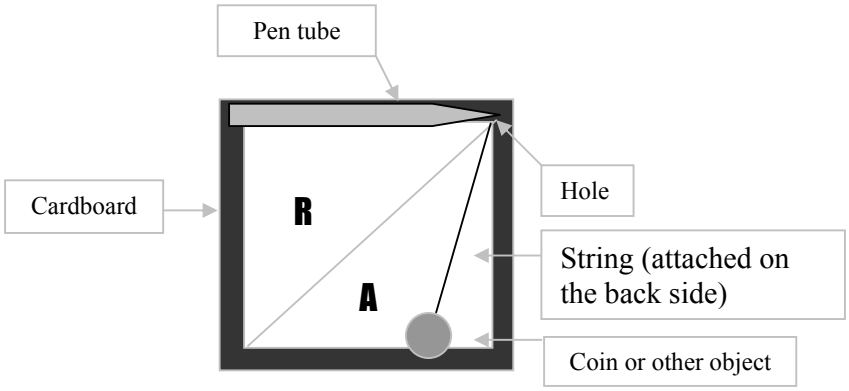
- A roll of scotch tape *(to save time, cut a 25 cm piece for each student)*
- Scissors or a razor blade
- Clinometer materials for each student (They should have brought these themselves)
- Materials for you *(the teacher)* to make a clinometer:
  - A piece of cardboard at least as big as a piece of notebook paper
  - A piece of nylon or cotton string, 25 cm long
  - The empty tube (housing) of a ballpoint pen
  - A washer, a coin, an old key – something made of metal that can be hung from the string to add a little weight to it
  - A ruler
  - Scissors or a razor blade, if possible

Lesson Plan:

Note: All the activities should be done by the teacher at the same time as the students. Based on the level of the students, each student can make a clinometer, or one per table, or one per group.

Explain and Distribute the Materials

1. Verify that each student has brought the necessary materials. If not, pair the students up so that each pair has a complete set of the materials.
2. Give a piece of scotch tape to each student.
3. Explain to the students that they are going to make an instrument with which they can measure the height of any object without climbing it. This tool is called a **clinometer**. It will permit the class to know which group had the best estimate of the height of their tree.
4. Ask the students to repeat the word "clinometer."



Construction of the Clinometers

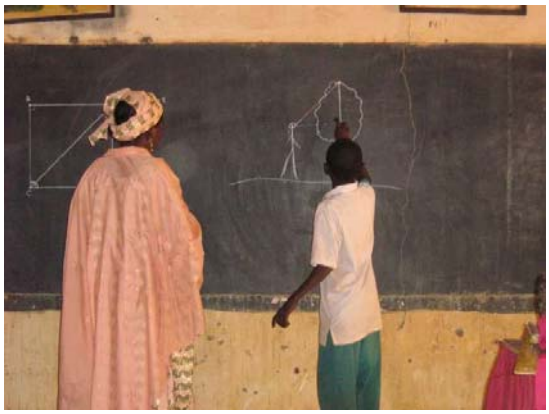
1. Ask the students to measure and cut a 13 cm by 13 cm square from a piece of notebook paper. Pass through the class to verify that the students have made their squares properly as the success of the clinometer is based on this square.
2. Trace the diagonal of the square, from the bottom left corner to the top right corner.
3. Tape the square to the cardboard.
4. Make a hole at the end of the diagonal by the upper right corner. Make sure the hole pokes through to the other side.
5. Tape the ballpoint pen tube exactly along the upper edge of the paper, and make sure the end of the pen does not cover up the hole or go past the hole. Don't put tape over the ends of the pen as that will prevent you seeing through the pen.
6. Put the string through the hole and attach it on the back side.
7. Attach the weight (washer, coin…) to the end of the string on the front side. The weight should not hang off of the cardboard so that it can slide across the surface of the cardboard without catching on the edge.
8. Ask the students to write "R" (for "reverse" or "move backward") in the triangle on the top (between the diagonal and the pen), and "A" (for "advance" or "move forward") in the triangle on the bottom.
9. On the backside of the clinometer, ask them to write the word "clinometer", their own name, the name of their group, and what they attached to the string (in case it accidentally falls off).
10. Collect all the clinometers and put them away for the next session.

Preparation for the Next Lesson

1. Explain that next week we are going to learn how a clinometer works and practice using it.

Explaining How a Clinometer Works

Trees and Wood in Our Backyard – Lesson 4



Materials / Preparations:

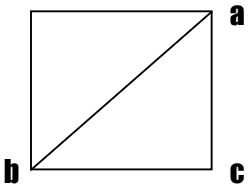
- Meter stick or measuring tape
- T-square for the blackboard
- Protractor for the blackboard
- Students' GLOBE notebooks

Lesson Plan:

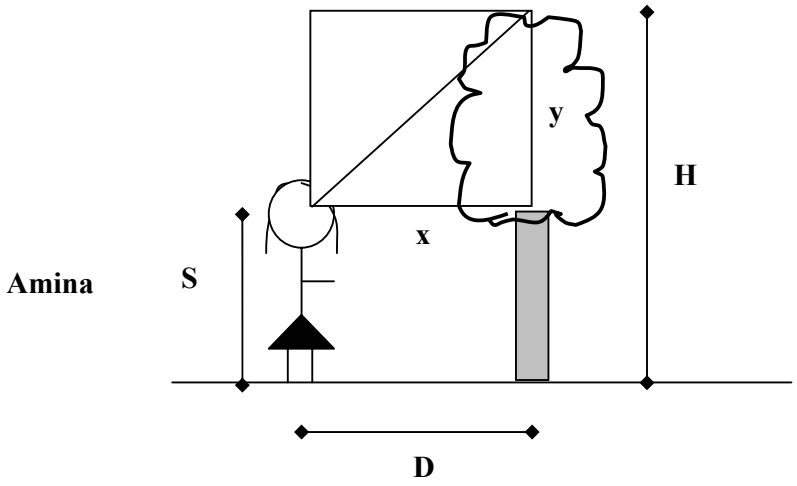
Theoretical Explanation of How a Clinometer Works

Note: Modify as necessary depending on the level of the students. The essential information below is that the height of the student's eyes plus the distance to the tree equals the height of the tree, when the student is looking at the top of the tree through the clinometer and the string falls along the diagonal.

1. Ask: When you made a clinometer, what was the first step?
   - They should respond that they started by making a square.
2. Draw a square on the blackboard and ask: What is a square?
   - They should respond that it is a geometric shape that has four equal sides.
3. Ask: What are the angles of a square?
   - They should respond that all the angles are right angles.
4. Ask: Who would like to come and measure a right angle?
5. Choose a student to come to the board and measure the 90º.
6. Ask: After you drew a square, what did you do?
   - They should say that they traced the diagonal.
7. Trace it and ask: Then, if you cut the square along the diagonal, what will you get?
   - They respond, "Two triangles."
8. Are the sides (segments) of the square always the same size, e.g. ac and bc?
   - They should respond, "Yes."
9. Ask: Then this is what type of triangle?
   - They respond (or are taught) that they are isosceles triangles.
10. Ask: And the angles? Do they have the same value as for the square? (<abc and <acb?)
    - They should respond, "No, the 90° angles cut in two become 45° angles." Or have them come to the board and learn that they are 45° angles.



11. Ask: If you have a triangle that has two 45° angles and one right angle, it is what type of triangle?
    - They respond (or are taught) that it is a rectangular isosceles triangle.
12. Explain that now we are going to measure a rectangular isosceles triangle in nature. Without erasing the square, draw the tree and the girl below.



13. Explain that Amina is near the tree and looking at its top through her clinometer. Imagine that someone has traced lines in the air that connect the eyes of Amina, the tree trunk, and its summit. As there is a 45º angle and a right angle we know that this represents a rectangular isosceles triangle just like we have on our clinometer.
14. Ask: And if it is a rectangular isosceles triangle, what do you know about the sides?
    - They respond that the two sides must be equal.
15. Explain: Exactly, the side "x" equals the side "y". If, in measuring, we find that the distance between the girl and the tree is 5m then we know that the other side is also 5m. You must simply add the height of the girl **just up to her eyes** to find the height of the tree. Let's assume that there is 1.5m between the floor and Amina's eyes. Use the following equation to calculate the height of the tree:

    H=D+S
    where
    H=height of the tree
    D=distance between the girl and the tree
    S= size of the girl up to her eyes.

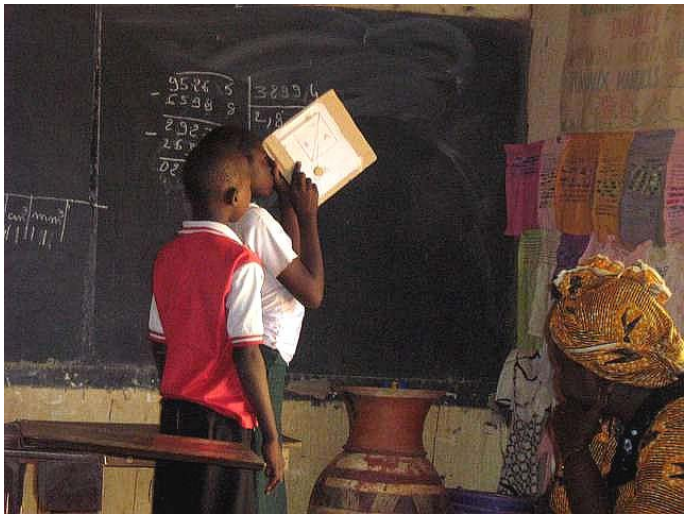
16. They should calculate and show that 5m plus 1.5m equals 6.5m.
17. Do another example with different numbers.
18. So, it is the clinometer that permits us to make rectangular isosceles triangles in nature. When you see the summit of the tree through the tube of the pen, if the string falls on the diagonal there is a rectangular isosceles triangle between the eyes of the observer and the summit of the tree.

Review How to Read a Ruler or Tape Measure (Optional)

1. Many students will need a lesson or a review on reading a ruler or tape measure. Here are a few steps to facilitate the explanation if need be:
    a. Line up the zero mark of the ruler or tape measure with one end of the thing that you are measuring.
    b. Most of the rulers or tape measures that we use in class have a mark for every centimeter and the number written on every fifth centimeter.
    c. So, to read a ruler, move along the ruler by fives (0, 5, 10, 15…) until the end of the object that you are measuring comes before the next multiple of five on the ruler. (If using a tape measure be sure to note when you hit major increments such as 1 mèter, 2 mèters, etc.)
    d. Return to the last unit of five and then count up on the marks by ones until you reach the edge of the object that you are measuring (0, 5, 10, 15, 16, 17, 18 cm).
    e. Note that some rulers are further divided into half-centimeters and millimeters for more accurate measurements.

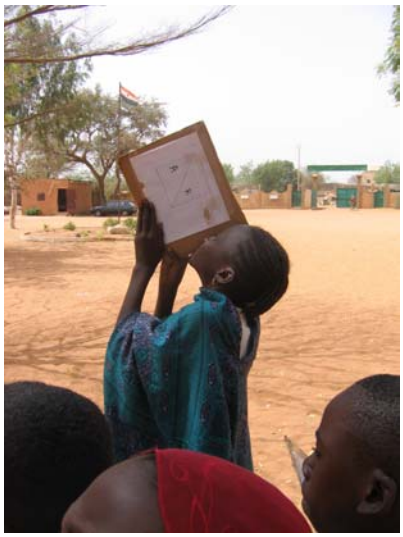
In-Class Demonstration

1. Point to a picture or a mark high on the wall. Ask each group to estimate its height (distance above the floor). Invite a student to look at the top of the object through the clinometer's pen tube, and have the class help you tell him or her whether to move forward or move backwards, until the string falls exactly on the diagonal line.
2. Measure the distance between the student and the base of the wall, and add this value to his or her own height just up to his or her eyes.
3. Now check the measurement made with the clinometer. With the meter stick, measure the actual height of the object. The two measurements should be about equal.
4. Let the students practice in class. One student should observe the top of an object through the clinometer. The other members of his group should tell him or her whether to "advance" (move forward) or "reverse" (move backward), just until the string falls on the diagonal line. Then have them measure, calculate, and confirm the height of the object.



Measuring the Trees

Trees and Wood in Our Backyard – Lesson 5



Materials / Preparation:

- Long measuring tape
- Clinometers
- Students' GLOBE notebooks

Lesson Plan:

Measure Some Students

1. Briefly review how to use a clinometer.
2. Copy the table below onto the blackboard without the example numbers. Ensure that there is a row for each group.

Group	Student Height	Distance	Tree Height	Estimated Height	Difference	Circ.	Estimated circ.	Difference
[Tree Name]	1.2 m	12.9 m	14.1 m	100 m	85.9 m	80 cm	60 cm	20 cm
[Tree Name]				28 m			30 cm	
[Tree Name]				10 m			15 cm	

3. Ask each group to report their estimations of height and circumference that they made during the first lesson and write them in the table.
4. Explain that they are going to find the difference between the estimations and the actual dimensions of the tree.
5. Explain that they must choose one member of their group to hold the clinometer.
6. Ask the students to copy the following data sheet to prepare for data collection:

   Data Needed for Calculating the Height of a Tree:
   a. Height of student (up to the eyes) + Distance = Height of our tree
   b. Distance between the estimated height and the actual height:
   c. Distance between the estimated circumference and the actual circumference:

7. Measure the height (just up to the eyes) of the designated member of each group, and write this data on the board. The students must also write down their group member's height on their data sheet for their calculations.

Go Outside to Measure the Heights and Circumferences of the Trees

1. Explain that once outside, each group should go to their tree. The designated student should look at the very top of the tree through the clinometer and the other students should tell him or her to move forward or backward, until the string hangs exactly along the diagonal line. At this moment, they should make a mark in the soil at the feet of the measuring student to mark the spot, then sit and wait for the teacher.

2. When the teacher has seen a group in which all the members are sitting, the teacher should go to that group with the meter stick or measuring tape and let the students measure the distance from the student to the tree. Make sure that they write down this measurement!

   Note: It might be a good idea to check the clinometer use of the students as well before measuring the distance.

3. The teacher should then help the group measure the circumference of their tree, at 1.35 meters above the ground (called the circumference at chest level). If, at this level, the tree splits into branches, measure just below the split. Make sure the students write the data into their notebooks.
4. Explain that once each group finishes, they should return to class and calculate the height of their tree and the differences between their estimations and the real dimensions while they are waiting for the other groups to finish.

Data Collection and Analysis

1. Once back in class, have each group report their data and place it in the data table. Then, help the students to do a comparison between their estimates and the actual values. Reinforce, once again, the importance of making accurate estimations.
2. Make sure that the students have copied down their tree dimensions for use during the next session.

Preparation for the Next Lesson

1. Tell the students that next week they are going to use all the data they collected to make an identity card for each tree.

Creating Tree Identity Cards

Trees and Wood in Our Backyard – Lesson 6

Materials / Preparations:

- The students' answers to the Questionnaire *(from the first lesson)*
- Information on the chosen trees to verify the students' responses *(see the Guide to Nigerien Trees at the end of this section)*
- A blank Identity Card for each student, either photocopied or copied from the board
- Small pieces of tracing paper (or thin paper) for making leaf imprints
- Scotch tape for attaching the imprints to the Identity Cards
- A leaf from each tree if possible Students' GLOBE notebooks

Lesson Plan:

Go Over the Questionnaire

1. Do an oral review with the students about what they know about their trees at this point: dimensions, uses, and the answers to their questionnaires that they did at the start of these lessons.
2. Ask, "What is an Identity Card? What is it used for and why is it important? What information is on the card? (Name, address, height, photo, fingerprints, etc.)
3. Explain that they are going to make an Identity Card for each tree.

Fill Out the Cards

1. Pass out a photocopied identity card to each student (or group) or have them make one in their notebooks following the model that you have drawn on the blackboard.
2. Ask them to fill in the Identity Cards for their trees with all of the information that they have collected over the previous several weeks. If there is not enough space to list all of the uses of their trees, tell them to only write two or three examples.
3. To take an imprint of the leaf, place it under a piece of tracing paper. Then, rub a dull pencil lightly over the paper until the outline of the leaf appears.

   Note: If you are only having the students make one identity card per group, choose the student with the best drawing on his questionnaire to draw the image for the group and to take the leaf imprint.

Preparation for the Next Lesson

1. Ask each student to ask his or her mother how much she spends each day for wood for cooking. If she doesn't know, ask her how many bundles of wood she buys, and the price of each bundle, and how many days the bundle lasts for. If she does not buy wood, ask her to count how many already split pieces she burns every day. Then for the calculations, assume that four already split pieces sell for 50 CFA.

Tree Identity Card

<table>
<tr><td colspan="2">Name:</td><td rowspan="10">Official Photo (Sketch of the tree)</td></tr>
<tr><td>Zarma Name:</td><td>Hausa Name:</td></tr>
<tr><td colspan="2">Home (field, garden, countryside, house):</td></tr>
<tr><td colspan="2">Date and Place of Birth:</td></tr>
<tr><td>Height:</td><td>Circumference:</td></tr>
<tr><td colspan="2">Size (big, medium, small)</td></tr>
<tr><td colspan="2">Trunk:</td></tr>
<tr><td colspan="2">Branches:</td></tr>
<tr><td colspan="2">Leaves:</td></tr>
<tr><td colspan="2">Flowers:</td><td rowspan="7">Imprint / Drawing of the Leaf:</td></tr>
<tr><td colspan="2">Fruits:</td></tr>
<tr><td colspan="2">Importance for Humans:</td></tr>
<tr><td colspan="2">Importance for Animals:</td></tr>
<tr><td colspan="2">Importance for the Environment:</td></tr>
<tr><td>Delivered on:</td><td>By:</td></tr>
</table>

Calculating the Volume of Wood Consumed by a Family Each Day

Trees and Wood in Our Backyard – Lesson 7

Note: Try this step at least one time before doing it in class. If the wood you bought is of an inferior quality, the volume might be greater than the average. We did this step eight times and our average was 2.9 dm³ for 100 CFA of wood.

Materials / Preparation:

- 1 bundle of wood for 100 CFA (8 pieces), broken into pieces that are small enough to completely fit inside a bucket
- Graduated cylinder or empty cans of a known volume
  - Small jar of mayonnaise: ~ 270 ml
  - Small tomato paste can: ~ 70 ml
  - Lid of a 1.5 liter disposable bottle: ~7 ml
- 2 buckets, full of water
- 1 large basin
- Students' GLOBE notebooks

Lesson Plan:

Taking the Volume and Making a Conversion

1. Collect the students' responses on their families' daily consumption of wood. Write them on the black board. Choose the median response (the response that the most students gave) to use during the example.
2. Show the students the bundle of wood that you brought and explain that you bought it for 100 CFA.
3. Place one of the buckets in the basin.
4. Ask a student to pour more water into the bucket until the bucket is absolutely full. That is to say, fill it until it is so full that if one adds another drop, it will spill out of the bucket. This is a very important step.
5. Ask the students, "What will happen if we put the wood in the full bucket?
   - Response: Some water will spill out.
6. "Will all of the water spill out? If not, what quantity will leave?"
   - If they don't know the answer, explain that the spilled water will equal the volume of the wood.
7. Have some students come up and gently push the wood down into the water until it is totally covered. It will be necessary to push the sticks down with your fingers in order to submerge it all at one time. As the students do this, make sure that they are not sticking their fingers into the water as well.

8. Wait until the water stops spilling
9. Carefully remove the bucket from the basin, taking care not to spill any more water out of the bucket.
10. Measure the water that is in the basin, using the graduated cylinder or the cans of known volumes. The volume of the water that spilled out into the basin equals the volume of wood.
11. Write the volume in dm^3 (1 L = $1dm^3$, so the volume of 1350 ml = 1.35 dm^3)
12. Multiply the answer so that it is equal to the average amount of wood the families consume (For example, if you bought wood for 100 CFA but the students said their families consume 200 CFA of wood, multiply by 2).
13. Then, by multiplying the result by 365, calculate the amount of wood consumed annually by that family.
14. Record the results, because you will need them for next week!
15. Ask each group to choose a member (whose family consumes an amount of wood different from the example) and calculate the volume of wood consumed at his or her house each day and each year.
16. If time permits, you can have each student do their own calculation for their own family.

Preparation for the Next Lesson

1. Have the students find the formulas for the circumference of a circle, the surface area of a circle, and the volume of a cylinder and bring them to class next time.

Volume of a Tree Compared to Volume of Wood Consumed by a Family

Trees and Wood in Our Backyard – Lesson 8

Materials / Preparation:

- Identity Cards, all filled out *(at least the circumference and height of a tree)*
- Results from the last lesson: the volume of 200 CFA of wood
- Students' GLOBE notebooks

Lesson Plan:

Estimations

1. Remind the students of what they calculated in the last lesson – the volume of wood that a family consumes each year if, for example, the family buys 200 CFA of wood each day.
2. How many trees does this family consume each year? Ask each group to make an estimate of the number of trees, and write their estimates on the board.

More Estimations

1. Choose one of the trees that the groups have studied.
2. If possible, show them the actual tree.
3. Ask each group to estimate the volume of the tree, in cubic meters (m^3). It might be a good idea to measure out a cubic meter with a meter stick in a corner of the room to give them an idea of the dimensions of a cubic meter.
4. Write their estimates on the board.

Explanation

1. Explain that we're going to calculate the volume of this tree.
2. "How do you find the volume of a tree? You could cut down the tree and measure the volume using the same method as the last lesson, but is it good to cut down a tree for this reason?" The students should reply, "No, that would be a waste of a tree."
3. Explain that instead, you can calculate the volume of a tree if you know only the circumference and height of the tree.
4. "This is because: if you know the circumference, you can find the radius, and then the surface area. If you know the surface area and the height, you can find the volume. That's what we're going to do right now."

Calculations

Note: Even though you are demonstrating this process to the students, have the students do the calculations themselves in their notebooks to ensure their participation and provide them with practice.

1. Look at the Identity Card of the tree and write on the blackboard the circumference and height of the tree.
   Circumference (C) = _____m
   Height (H) = _____m
   Keep these numbers on the blackboard.

2. Ask the students for the formula of the circumference ($C=2 \times \pi \times R$) and write it on the blackboard. Note that to make the calculations easier for elementary level students, we have substituted 3 for π.
   So, $C = 2 \times 3 \times R$
   And so, $C = 6 \times R$

3. Explain that now we need to find the radius of the circle.
   So, $R = C/6$

4. Replace the letter "C" with the real circumference, and then do the calculation.
   R = _____ m

5. Ask for the formula for the surface area of a circle. ($A = \pi \times R \times R$).
6. Replace π with 3, replace the letter "R" with the real radius from above, and calculate the area in m^2.
   A = ____m^2

7. Multiply the area (A) by the height (H) of the tree to find the volume in m^3.
   V = A x H
   V = _____ m^3

8. Congratulations – you have found the volume of a tree!
9. Check which group had the best estimate at the beginning of class.
10. "Now, we are going to change the units so that they are the same as the volume of wood."
11. Do a unit conversion from cubic meters (m^3) to cubic decimeters (dm^3). You can do this with a unit conversion table or multiply m^3 by 1000 to get dm^3.
12. If you have the time, have the students calculate the volume of another tree in groups for practice. Circulate and help the students that are stuck.

Comparison

1. Compare the volume of the wood consumed in a year to the volume of a tree. Ask them to calculate how many trees they use in a year. (Divide the volume of wood consumed annually by the volume of a tree.)

   Note: For Sahelian trees, expect consumption to be around 2 large trees per year. However, these calculations depend on several factors, so the number of trees consumed will vary.

2. By multiplying this number by the number of students in the class, you can roughly calculate the number of trees used by all the families of the class (or the whole school or even the whole village).

Conclusion

1. Ask: This is a lot of trees, isn't it?
2. Ask the students to recall the usefulness of trees, written on their identity cards.
3. Ask them what will happen if we continue to consume this many trees without planting more.
    - What will happen to the environment?
    - What will happen to the animals?
    - What will happen to humans?
    - What will happen to the economy of Niger?
4. Ask if their families have planted enough trees to replace the ones they have consumed. If not, why not? What can they do to change this situation? What can we, as a school, do to replace the trees that we have consumed?

    Note: This lesson could serve as the motivation for the students to start a school tree nursery to help replace the trees that they are consuming each year.

Investigating Erosion

Trees and Wood in Our Backyard – Lesson 9

Materials / Preparation:

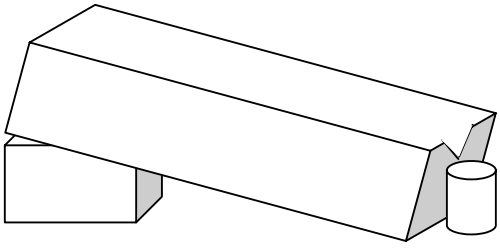
- Two cardboard boxes of the same dimensions, ideally cut to a height of 8-12 cm
- 1 small plastic teapot
- Enough water to fill the teapot *(divided into two equal parts)*
- 2 empty mayonnaise jars (the same size) or 2 graduated cylinders
- 2 small bricks, rocks, or cardboard boxes to raise one side of each box about 10 cm.
- Dried organic matter such as leaves, straw, and weeds
- 10 small sticks of wood
- Students' GLOBE notebooks

Lesson Plan:

The Problem

1. "What is erosion?" **Erosion** is the loss of soil through the action of water, wind, or another natural force.
2. Explain that we are going to try to answer the problem (question), "What is the role of trees and plants in keeping the soil in place and avoiding erosion?" Tell the students to recopy this question in their notebooks under the title, "The Problem (Question) of this experiment:"
3. Say that we are going to make two boxes to do an experiment that will answer this question.
4. Explain that one of the boxes represents earth without trees and plants, and the other represents earth with trees and plants.

Construct the Two Boxes



1. Go outside with the two boxes.
2. Cut a "v" in one side of each box, like the drawing to the right.
3. Fill one of the boxes with soil to just over the bottom of the "v".
4. Pack the soil into the box so that it forms a valley shape with the bottom of the valley above the bottom of the "v".
5. Fill the other box with soil and compact it well in the same manner as the first. Then, cover it with a wide-ranging mixture of wood pieces, leaves, straw, grasses, etc. Push about 10 sticks into the soil upright, to hold the mixture in place.

6. Return to the classroom with the two full boxes.
7. Put the two boxes on a table in front of class. Put each box at an angle, raised up by a brick, rock, or cardboard box. The side with the "v"-shaped hole should be at the bottom of the incline (*see the drawing*).

Make Hypotheses

1. Say to the students that we are now going to make **<u>hypotheses</u>**.
    - Ask: What is a 'hypothesis?'
    - If they don't know, explain that it is a prediction of the results of the experiment.
    - Explain that all the good scientists in the world make a hypothesis before doing an experiment.
    - Explain that when you make a hypothesis, there is no right or wrong answer. It is only a guess.
2. Forming a hypothesis is one of 5 steps of an experiment. The 5 steps are:

    1. **Describe the Problem**
    2. **Make a Hypothesis**
    3. **Explain the Procedure**
    4. **Conduct the Experiment & Take Data**
    5. **Form a Conclusion.**

3. Say that each student must write a hypothesis that responds to the question, "If you pour water into each box and you collect the water as it comes out the other end, what will be the differences in the quantities of water and soil that come out of each box?"
4. **<u>Attention</u>**: The teacher must not give the students an answer. Also, he must insist that each hypothesis be their own and that **there is not a right or wrong answer at this point. All the responses have value!** The teacher, without saying an answer, can guide the students by explaining that their hypotheses can follow the form below:

    "When water is added to the top of each box, the quantity of soil that comes out of the box with no groundcover will be _____ (more than / less than / equal than) than that which comes out of the box with groundcover because _____."

5. Choose 5 students to share their hypothesis with the class. *(Remember that all the hypotheses are valuable and merit encouragement!)*

Conduct the Experiment

1. Fill the teapot half-full of water.
2. Pour water into the top of one of the boxes. As you pour, keep the spout of the teapot near the top end of the erosion box.
3. With the empty mayo jar or graduated cylinder, collect the water that falls out of the v-shaped hole on the other end.
4. Leave the jar or graduated cylinder for several minutes. (The soil will settle at the bottom.)
5. Do the same thing with the other box.
6. While waiting for the soil to settle, tell the students to copy the following table in their notebooks below their hypothesis and under the title "Data".

	Quantity of water (cm or ml)	Quantity of Soil (cm or ml)
Without Trees		
With Trees		

7. After the soil has settled in each jar, tell a student to measure the quantity of soil and the quantity of water that left the boxes, with a ruler in cm or with the scale on the graduated cylinder in ml.
8. Tell the students to fill in their tables with this data.

Conclusion

1. Ask the students to write two sentences about what happened, under the title "Observations". Ask some students to share their observations, and guide them to the idea that the box containing trees and plants was better at retaining both the soil the water than the box without trees or plants.
2. Ask the students "If trees and plants aren't there holding the soil in place, what will happen?"
    - They should respond that a lot of the soil will be lost.
3. Ask, "If the soil is lost; then what will happen?"
    - They should respond that it will be difficult to grow crops, etc.
4. Ask, "If the soil isn't retaining water, what will happen?"
    - It will be difficult to grow crops, the land won't be green, the soil will be blown away by the wind, etc.
5. Ask, "If it is difficult to grow crops, what will happen?"
    - Response: We will go hungry.
6. Ask, "Also, what will happen if you have a lot of soil in our water?
    - Death of fish, filling-up of dams, etc
7. Ask the students to write a short two or three sentence summary in their notebooks under the title "Conclusion," including whether or not their individual hypothesis was supported or not supported by the experiment.

Modeling a Watershed Basin

Trees and Wood in Our Backyard – Lesson 10

Materials / Preparations:

- Spray bottle or another method of sprinkling water on a plastic sheet
- Large plastic sheet (preferably clear or white) of at least one square meter
- Some objects to create "hills" *(ex. rocks, bucket, teapot; backpack, etc)*
- A few sprinkles of Jolly Jus or another water coloring agent to represent pollution
- A small stone
- Sponges or pieces of cloth to model forests
- A bucket filled with water
- Cup
- Plastic classroom meter stick
- Students' GLOBE notebooks

Lesson Plan:

Introduction and Explanation of Gravity

1. Ask the students, "Where does the water in our river/lake/dam come from?" (From other countries, the rain, etc.)
2. Explain that we are going to make a model that shows where the water comes from.
3. Hold a ruler horizontally. Ask if you pour several drops of water on it, will the water run or will it stay in one place? Put the water on the ruler and show that the water doesn't move.
4. Hold the ruler at an angle and ask if you pour the same quantity of water on the ruler, will that water run or stay in the same place? Pour the water on the ruler and show that the water will run downhill.
5. Ask what makes the water run in the second example? Explain that it is the Earth's attraction to the water that makes it run downhill. This attraction is called **gravity**.

Prepare for the Experiment

1. Arrange some diverse objects like books, rocks, cups etc on a table or on the floor. Place the objects in such a way that when they are covered by the sheet of plastic, they will form a watershed basin. That is to say, if you pour some water anywhere on the plastic it will all eventually run to the same point at the edge of the plastic sheet.
2. Explain that this represents mountains and hills.
3. Show the students the spray bottle and explain that this will represent rain.
4. Say that now we are going do a small experiment with our model.

Problem and Hypothesis

1. Ask: "What is the first of the five steps that all scientists do when they do an experiment?" Remind the students they learned this in the last lesson. If they don't remember, remind them that you **Write the Problem**.
2. Write the following problem on the board and ask the students to copy it in their notebooks: Problem: What will happen when it rains on the hills? Where will the water go?

3. Ask the students for the second step that all scientists do when they want to do an experiment. If they don't remember from the last lesson, remind them that you **Make a Hypothesis.**
4. Review: What is a "hypothesis?" It is a prediction, their guess at the results of the experiment.
5. Ask each student to write their own hypothesis to answer the problem. Have them write it in their notebooks under the title **Hypothesis**. *Remember, there are no correct or incorrect answers at this point. All responses are valuable and merit encouragement!*
6. Choose five students to share their hypothesis with the class.
7. Ask "What are the third and fourth steps that scientists do during an experiment?" **Describe the Procedure** and **Do the Experiment**. Since the procedure is simple, you can skip the description of it this time and go directly to doing the experiment.

Do the Experiment, and Make Observations

1. Ask for a volunteer to play the role of a storm and, with the spray bottle, make it rain on the "hills".
2. Observe how the water runs downhill.
3. Explain that water always runs down a slope, towards the lowest place, because of gravity.
4. Explain that this is the same for all rivers and runoff: water runs down the hills and then downstream following the slope.
5. Explain the term "watershed": A **watershed** is an area of land in which all water that runs on its surface will eventually pass through a single river. A watershed can be very big or relatively small.
6. Explain that we are going to see how all the things that share a watershed are linked together.

Modeling a Polluted Watershed

1. Choose a spot on the watershed model where all of the water that is put on the model must cross. Tell the students to imagine that this is the location of the school. Place a stone here to mark the spot.
2. Put a little Jolly Jus or other coloring on one of the hills that is not in a direct line with the "school". Explain that this represents a source of pollution.
3. Ask the students, "The coloring could represent what type of pollution?"
    a. The list of possibilities that they generate must include: a pile of trash, human feces, slaughterhouses, mechanics' shops, a place where soap is made, a place where animals come to drink and subsequently pee or defecate, a place where people wash their clothes, a mine, a dying shop, etc.
4. Ask if the people downstream can always see the pollution. (No.)
5. Ask each student to make a second hypothesis that responds to the following question: What will happen to the pollution when the rain falls on our watershed?
6. Ask several students to share their hypothesis with the class.
7. With the squirt bottle, make it rain on the "hills" and watch the pollution run down to the school.
8. Through questioning, help the students to arrive at the conclusion that the pollution above their village in the watershed, even if it comes from another village, will make its way to their sources of water.

9. Ask them to write a few observations in their notebooks concerning what they have seen in this trial.
10. Ask: How should this knowledge influence what we drink and what and how we throw things away?

Adding Trees to our Model

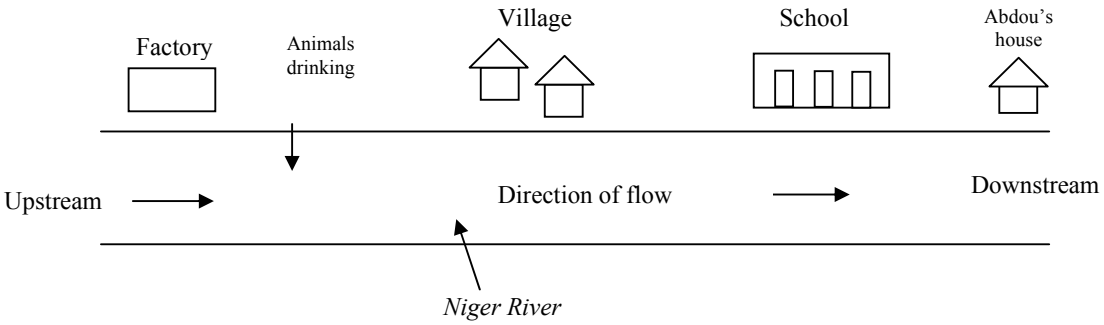
1. Wipe the colored water from the plastic.
2. Place some scraps of cloth or sponges on the hills of the watershed and explain that they represent forests and other vegetation.
3. This time, place some coloring in a place that will force it to run into one of these pieces of material or sponge.
4. Ask each student to make a third hypothesis at this time: What will happen to the pollution once the rains come to the watershed?
5. Ask some students to share their hypothesis with the class. *Do not criticize any hypothesis.*
6. Make it rain once again and observe what happens.
7. Ask: What happened to the pollution this time?
    - Response: It was stopped by the vegetation.
    - So, we can see that plants play a role in the filtration of our water.
    - But, they can't filter out all of the pollution, and they could also be killed by it.

Conclusion

1. "What is the last step of an experiment?" **Write a Conclusion**.
2. Ask the students to write some sentences in their notebooks under the heading **Conclusion** about what happened during the experiment and if their hypothesis was supported or not supported.
3. Ask several students to read their conclusions to the whole class.

Verification of Comprehension

1. Draw the following image on the blackboard:



2. Tell the students to look at the drawing and list all of the things that affect the water in the river that flows past the school.
3. Ask the students to add other things that could affect the quality and quantity of the water but that are not on the drawing. Help them to create a good list.
4. Ask them to talk about the effects that their own activities might have on those that live downstream from them, like the family of Abdou.
5. Ask: What can you do to make sure that you do not ruin the water of others and to make sure that their waters are in good health?

Follow-on Activities

Trees and Wood in Our Backyard – Appendices

Review

1. Congratulate the students on the completion of the module!
2. It would be a good idea to take one or two classes at this point to review with the students all that they have learned. Especially the calculations, which will help them in math class and the environmental ideas that have been discussed.

Tree Nursery

1. According to the resources of your school, do a tree nursery to offset the school's tree consumption. Each student or each group should plant a tree and take care of it as it grows, giving it plenty of water.
2. One time per month, the students should measure and mark down the size of their tree on a large data table hanging in the classroom. (This will encourage the students to really be interested in following the growth of their trees.) After some time, this data would be great to use as a graphing exercise.

Guide to Some Trees of the Sahel

Trees and Wood in Our Backyard – Appendices

S: Scientific name – E: English – F: French – Z: Zarma – H: Hausa

E: Wild Date – F: Dattier Sauvage – Z: Garbeye ya – H: Uwa adduwa – S: Balanites aegyptica

Location where it is found: Often in fields and the brush
Height: Small to medium
Trunk: Rough, brown/grey
Branches: Spiny
Leaves: Small simple leaves
Flowers: Little yellow flowers, flowers appear between October and February
Fruits: 3-4 cm, oval, yellow at maturity.
Uses for humans: Fabrication of tools (mortars, bowls...), firewood, charcoal, screening, edible fruits, medicine, insecticide
Uses for animals: Can eat the leaves and fruits
Uses for the environment: Holding the soil in place / prevention of erosion

E: Acacia nilotica – F: Gonakier – Z: Giti ya – H: Bagarouwa – S: Acacia nilotica

Location where it is found: Old fields and ancient sand dunes
Height: Tall, up to 20m
Trunk: Grey to black, fissured
Branches: Spiny
Leaves: Very small, double-compound leaves
Flowers: Small, gold, in tufts
Fruits: Seed pod is long and resembles a yellow string of pearls
Uses for humans: Seeds are used as a spice, charcoal, fire wood, construction wood and used for making tools, medicinal uses, curing leather, black, red, and yellow dyes.
Uses for animals: The seeds are good for animals to eat
Uses for the environment: Holding the soil in place / prevention of erosion

E: Eucalyptus – F: Eucalyptus – Z: Turare ya – H: Uwa Turare – S: Eucalyptus camaldulensis

Location where it is found: Fields and plantations
Height: Tall, over 20 m
Trunk: Smooth and white
Branches: Smooth and long
Leaves: Leaves simples and long, blue-grey, a strong and distinct scent, do not fall during the dry season.
Flowers: In tufts, white, 1cm long
Fruits: Very small (5mm) in groups at the tips of branches
Uses for humans: Oil for making soaps, firewood, construction, charcoal, used as a windbreak, perfume, incense, medicine
Uses for animals: Can eat the leaves
Uses for the environment: Holding the soil in place / prevention of erosion; it is not at all good for the health of the soil nor for the health of other plants

E: Neem – F: Neem – Z: Mille ya – H: Dogon Yaro – S: Azadirachta indica –

Location where it is found: In villages and courtyards
Height: Small to medium (5 to 20 m)
Trunk: Grey-brown or reddish brown, smooth and straight
Branches: Smooth and very long
Leaves: Serrated leaves, dark green
Flowers: Small, cream, white, or yellow colored, smells of honey
Fruits: 1-2cm, round, yellow-green, contain a large seed
Uses for humans: Tree is resistant to heat and drought, very good for enriching soil quality, fire wood, construction of houses and tools, soap is made from the seed oils, buds and flowers are edible, used as a natural insecticide, medicine
Uses for animals: Leaves edible to camels, sheep, and goats
Uses for the environment: Holding the soil in place / prevention of erosion, enrichment of the soil

E: Gao – F: Gao – Z: Gao Ya – H: Uwa Gao – S: Acacia albida

Location where it is found: Throughout the bush
Height: Tall (15 to 25 m)
Trunk: Earth gray, rough, fissured, coarse bark, fissured
Branches: Spiny, white / light grey
Leaves: Small double compound leaves, blue-green
Flowers: Tuft of cream colored, fragrant flowers
Fruits: Orange-brown dry pod in the form of a ring
Uses for humans: Enriches the soil especially for groundnuts, peanuts, and millet, fabrication of soap, wood for tools, food during periods of famine
Uses for animals: Can eat the leaves and fruits
Uses for the environment: Holding the soil in place / prevention of erosion, enrichment of the soil

E: Mango – F: Manguier – Z: Mangu – H: Mangoro – S: Mangifera indica

Location where it is found: fields, plantations, and courtyards
Height: Medium – over 10 m
Trunk: Brown and smooth when young turning to black and rough at maturity
Branches: Branches smooth and thick
Leaves: Somewhat large simple leaves, dark green
Flowers: Very small, white and red in fibrous groups
Fruits: Large, yellow-red, flesh is yellow and surrounds a large pit
Uses for humans: Fruit is a cash crop and a food source, honey that is produced from these flowers is very fine
Uses for animals: Can eat the leaves and fruits
Uses for the environment: Holding the soil in place / prevention of erosion, enrichment of the soil

E: Lime/lemon tree – F: Citronnier – Z: Leemu Kayna – H: Uwa Lemu – S: Citrus limon

Location where it is found: Fields
Height: Small to medium
Trunk: Somewhat rough
Branches: Spiny

Leaves: Medium simple leaves, light green, smooth
Flowers: Small and fragrant
Fruits: Pretty large, green or yellow, fleshy sections around many seeds.
Uses for humans: Fruit is edible and a cash crop
Uses for animals: Can eat the leaves and fruits
Uses for the environment: Holding the soil in place / prevention of erosion

E: Jujubee – F: Jujubier – Z: Darey ya – H: Magaria – S: Ziziphus mauritiana

Location where it is found: In the brush
Height: Small to medium (4 to 12 m)
Trunk: Brown or grey
Branches: Carry lots of spines
Leaves: Small, simple, shiny leaves in groups of three, serrated leaf edges
Flowers: Small yellow flowers in groups of four or five
Fruits: 1-2 cm in diameter, round, red, and contain a large seed
Uses for humans: Fabrication of houses and tools, consumption of dried fruits or fresh fruit drink, sweets, rich in Vitamin C, leaves are edible in sauces, used in hedges
Uses for animals: Can eat the leaves and fruits
Uses for the environment: Holding the soil in place / prevention of erosion

E: Cashew – F: Pomme D'acajou – Z: Sayitu ya – H: Yazawa, Fisa – S: Anacardium occidentale

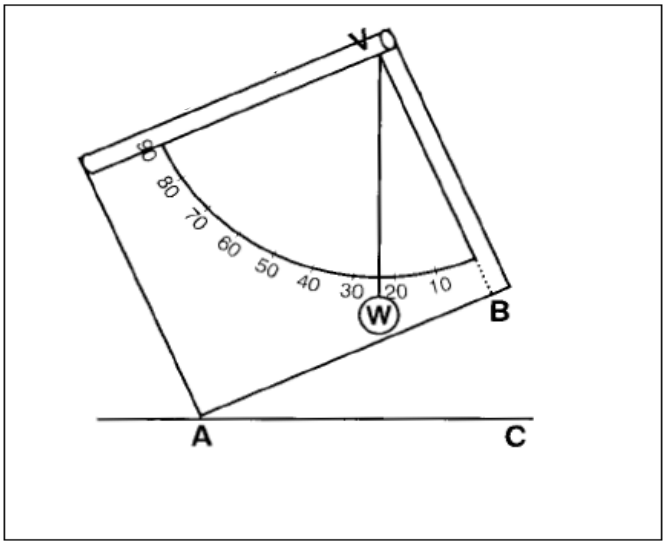
Location where it is found: In the bush and in fields
Height: Medium (to 15m)
Trunk: Smooth
Branches: Long and smooth and they curve down to the earth
Leaves: Large simple leaves that are 10-20cm across, oval, thick and shiny
Flowers: Groupings of small green or red-violet flowers
Fruits: Red-yellow that resembles a little apple. They produce cashew nuts.
Uses for man – Cashew nuts are a cash crop, fruit is edible and prepared in several ways, rich in calcium, iron, phosphorous, and Vitamin C, medicine, industrial oil, stains, and leather curing.
Uses for animals: They eat the fruits
Uses for the environment: Holding the soil in place / prevention of erosion

Building a Clinometer
(Lesson 3 Modified for Secondary Level)
Trees and Wood in Our Backyard – Appendices

Materials / Preparations:
- One roll of scotch tape *(to save time, cut a 25 cm piece for each student)*
- Scissors or a razor blade
- Materials for <u>each</u> student and you *(the teacher)* to make a clinometer
    - A piece of cardboard a little bit bigger than a piece of notebook paper
    - A copy of the clinometer page found at the end of this section
    - A piece of nylon or cotton string, 25 cm long
    - The empty tube of a ballpoint pin
    - A washer, a coin, or an old key – something made of metal that can be hung from the string to add a little weight to it
    - A ruler
    - A pair of scissors or a razor blade, if possible

Lesson Plan:

<u>Note</u>: All the activities must be done by the teacher at the same time as the students in order to clearly show them what they should be doing. According to the level of the students, they can each make a clinometer, or one per table, or one per group.



Explain and Distribute the Materials
1. Explain to the students that they are going to make an instrument with which they can measure the height of any object without climbing it. This tool is called a **<u>clinometer</u>**. It will permit the class to know which group had the best estimate of the height of their tree.
2. Verify that all the students have their materials.
3. Give a piece of scotch tape and a copy of the clinometer page to each student.

Prepare the Clinometers

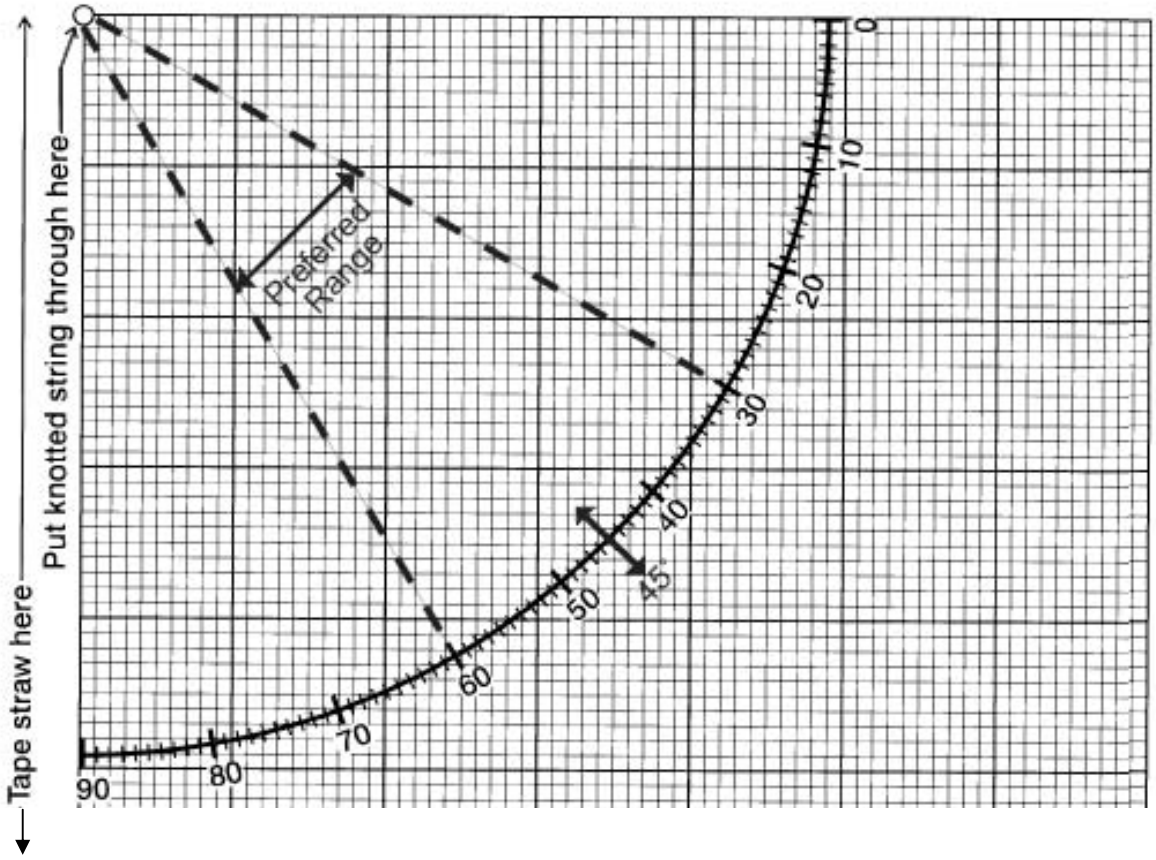
1. Paste a copy of the clinometer on the piece of cardboard. Make sure that the two are about the same size.
2. Punch a hole through the circle marked on the paper. Pass the piece of string through the hole and attach its end on the back side of the cardboard.
3. With scotch tape or a knot, attach a nut, a washer, or a coin at the other end of the string.
4. Tape a drinking straw or an empty ballpoint pen tube along the line marked on the paper. Be sure the scotch tape doesn't get in the way of the ends of the straw or pen tube.
5. Ask them to write the word "clinometer", their own name, and the name of their group on the backside.
6. Collect all the clinometers and put them away for the next session.

Alternative Methods of Construction

1. If the level of the students is too low for them to be able to understand the geometry of a triangle, use the method and clinometer in the "Trees and Wood in our Backyard – Primary Level". It would still be interesting for secondary students, with the only difference being the level of calculations required.
2. If you are only lacking a photocopier, you can still make a clinometer with a protractor taped upside-down on the cardboard. The string will be suspended from a hole in the center of the flat side on a line of zero degrees, and the straw or pen tube should be aligned along the flat side of the protractor.
3. Instead of taping the protractor to the cardboard, you could trace it directly to the cardboard and continue construction as explained above.

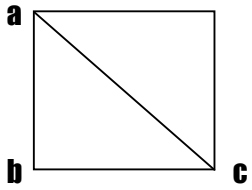
Clinometer

Trees and Wood in Our Backyard – Appendices



Explaining How a Clinometer Works
(Lesson 4 - Modified for a Secondary Level)
Trees and Wood in Our Backyard – Appendices

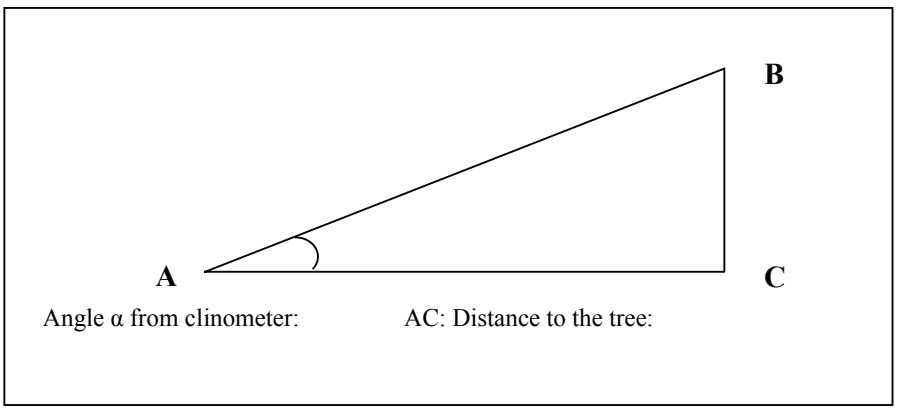
Materials / Preparations:
- Meter stick or Measuring tape
- T-square for the blackboard
- Protractor for the blackboard
- Students' GLOBE notebooks



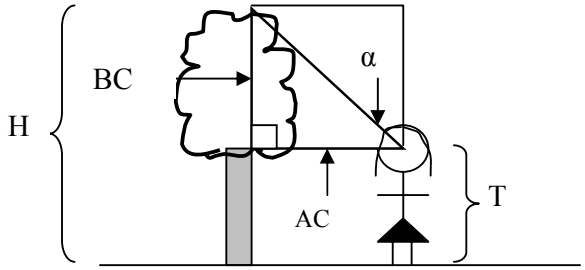
Lesson Plan:

In-Class Demonstration and Practice
1. Point to a picture or other thing hanging on the wall and explain that it is the top of an imaginary tree. Ask each group to estimate the height. Write these estimations on the blackboard.
2. Invite a student to come up to the front of the class with his clinometer. Have him look at the top of the object (tree) through the clinometer's pen tube. Make sure his hands don't impede the swinging movement of the string as it crosses the angles marked on the clinometer.
3. Invite another student to come up and read the angle indicated by the string on the clinometer.
4. The friend should then tell him to move forward or backward, just until the angle is between 30-60°. Record this angle.
5. Then, with the tape measure, measure the distance between the student's feet and the ground directly below the object. Record this distance.
6. Then, measure the distance between the floor and the student's eye as he is looking through the clinometer. Record this value.

Organization of the Data in Geometric Form
1. Tell the students to copy the below image of the triangle below into their notebooks and fill in the measurements that they just took (the angle shown on the clinometer and the distance to the tree).



2. If they don't realize it, explain that the triangle represents the triangle that they created outside with their eye, the top of the tree, and a point on the tree trunk at the same height as their eyes. In following the rules of trigonometry for triangles that have a right angle, we can calculate the height of BC.



Calculate the Height of the Tree or any other Object

1. Use the table of tangents (found at the end of this lesson) and the following equation to obtain the height of BC.

$$\tan \alpha = BC/AC \quad \text{or} \quad BC = (\tan \alpha) \times AC$$

2. Now, the height of the tree is equal to the height calculated there, plus the distance between the clinometer and the ground – that is to say, the distance between the eye of the student and the ground.

$$H = BC + T$$

H = Height of the tree
BC = Distance that you just calculated
T = The height of the student up to his eyes

<u>Note</u>: If you want to find the average size of a species of tree, repeat all these steps for 5 different mature trees. Then, add all 5 heights and divide by 5 to find the average height of the species.

$$T_m = (T_1+T_2+T_3+T_4+T_5) / 5$$

Verification of the Accuracy of the Estimation Made with the Clinometer

1. With the meter stick or tape measure, measure the actual height of the object (pretend tree) from the floor to its top. The two measurements should be about equal.

<u>Note</u>: Often you will have a different of a couple of centimeters between the actual distance and the measured height using the clinometer. This is acceptable because a difference of a few centimeters is negligible for our needs when the object is meters tall. For those that are interested, the difference arrives from: inaccurate placement and reading of the tape measure, not marking the soil directly under the student's eye, the width of the pen tube, etc.

Further Practice

1. Let the students practice in class for other objects on the walls within their groups.

Preparation for the Next Session

1. Collect the clinometers and place them in a safe place until the next class session.
2. Explain to the students that during the next class session the students will use their clinometers to measure the height of their group's tree and to not forget what they have learned today.

Table of Tangents

Trees and Wood in Our Backyard – Appendices

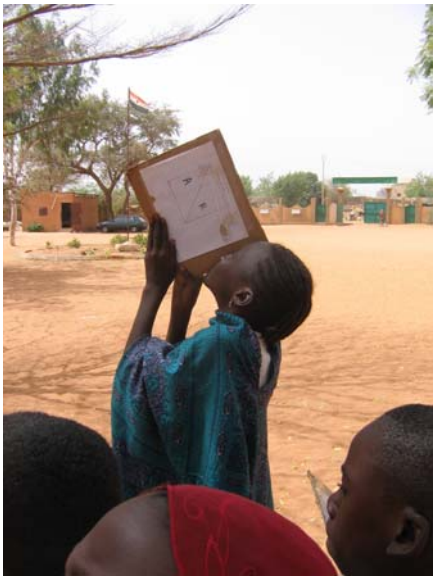
Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.	Angle	Tan.
1°	.02	17	.31	33	.65	49	1.15	65	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
8	.14	24	.45	40	.84	56	1.48	72	3.08
9	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

Example: Assume you have established a baseline distance of 60.0 meters. Assume that you have measured the tree top to an angle of 34°. From the Table, you will see that the tangent of 34° is 0.67. Therefore, the tree height above your eye height is 60.0 m x .67 = 40.2 meters. By adding your eye height above the ground (1.5 m), the total tree height is 41.7 meters.

Measuring the Trees

(Lesson 5 Modified for a Secondary Level)

Trees and Wood in Our Backyard – Appendices



Materials / Preparation:

- Meter stick or long measuring tape
- Tree Identity Cards
- Clinometers
- Students' GLOBE notebooks

Lesson Plan:

Measure the Heights of a Few Students

1. Briefly review the function of a clinometer.
2. Ask the students to copy the following data collection sheet into their notebooks in preparation to go and take data:

   Data Needed for Calculating the Height of a Tree

   a. Height of student (up to the eyes) + Distance = Height of our Tree
   b. Distance between the estimated height and the actual height:
   c. Distance between the estimated circumference and the actual circumference:

3. Copy the table below onto the blackboard and ensure that each group has a row.

Group	Student Height	Distance	Tree Height	Estimated Height	Difference	Circ.	Estimated Circ.	Difference
(Name of tree)								
(Name of tree)								
(Name of tree)								

4. Ask each group for their estimations of their tree's height and circumference that they did the previous lesson and copy them into the table on the board. Explain that they are going to calculate both the height of the tree as well as the *difference* between their estimations of the height of the tree with and without the clinometer.
5. Explain that they must choose one member of their group to hold the clinometer.
6. Measure the distance between the floor and the eyes of the designated member of each group as they hold up the clinometer. Place these values on the black board.

Measuring the Trees

1. Explain that once outside, each group should go to their tree. The designated student should hold the clinometer and look at the very top of the tree, and the other students should read the angle on the clinometer. At this moment, they should mark in the sand the position of the designated student, then signal the teacher. The teacher should go to that group with the meter stick or measuring tape, verify their work, and then allow them to measure the distance from the student to the tree.
2. The teacher should then help the group measure the circumference of their tree, at 1.35 meters above the ground. (Scientists call this the *circumference at chest height*.) If, at this level, the tree splits into branches, measure just below the split.
3. Explain to each group that while they wait for you to help the other groups, they should calculate the height of their tree and then the difference between their estimates of the height and the actual height.

Data Collection and Analysis

1. Once back in class, have each group report their data and place it in the data table. Then, help the students to do a comparison between their estimates and the actual values. Reinforce, once again, the importance of making accurate estimations.
2. Make sure that the students have copied down their tree dimensions for use during the next session.

Note: Return at this point to lesson 6 in the unmodified section of ABC.