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| **Introduction** | In this lesson, students are going to look at sensors and how they are used in many applications. The lesson is connected to the STEM initiative, and gives students an opening to the world of science and engineering. Students are going to investigate different sensors that are around them and what these sensors are gathering. Students are going to draw and design a hygrometer which measures humidity levels, select from everyday items to build their hygrometer, test their machine using a spray bottle to increase humidity, evaluate the effectiveness of their construction and present their findings to the class.  Lesson Goal Lesson focuses on how sensors are used in many applications to gather information about our environment. This lesson focuses on the hygrometer, a sensor used to measure humidity. Through this lesson, students work in teams to design and build a hygrometer out of everyday items to measure humidity levels. The student hygrometers are not meant to be exact, but are expected to indicate a change. Students select from everyday items to build their hygrometer, test their machine using a spray bottle to increase humidity, evaluate the effectiveness of their system and those of other teams, and present their findings to the class. |
| **Real Science Application** | Humidity is a word that students understand in the generic sense of the word. It is the amount of water vapor in the air. Relative humidity is the ratio of the amount of moisture in the air compared to the amount the air is capable of holding at a given temperature, which is expressed as a percentage. All fields of engineering have to deal with the humidity factor, whether a civil engineer building a museum which has to preserve objects or a chemical engineer who has to work with different chemicals and gases. Therefore, this lesson will satisfy many scientific aspects. |
| **Curriculum Alignment** | This section contains the curriculum alignment of the lesson to the North Carolina [NC Essential Standards](http://www.ncpublicschools.org/acre/standards/new-standards/) of Science or Math.   |  |  |  |  | | --- | --- | --- | --- | | Content Area | Grade Level | NC Essential Standards | NGSS / Common Core Math | | Math | 8th | Understand data in terms of graphical displays, measures of center and range. | CCSS MATH.CONTENT 8.SP.A.1  **Investigate patterns of association in bivariate data.**  Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear | | Science | 8th | Understand how the cycling of matter (water and gases) in and out of the atmosphere relates to Earth’s atmosphere, weather and climate and the effects of the atmosphere on humans | 7.E.1.4 Predict weather conditions and patterns based on information obtained from:  • Weather data collected from direct observations and measurement (wind speed and direction, air temperature, humidity and air pressure. | |
| **Learning Outcomes** | Students will be able to accomplish the following concepts.   * As a result of this activity students will collect data and problem solves data collected. * Learn about engineering design. * Learn about planning and construction. * Learn about team work and working together in groups with specific roles to play. |
| **Time Required and Location** | This lesson will take two 45 minute classes and the entire lesson will be in the classroom. |
| **Materials Needed** | Materials list:  Classroom materials:   * Water, spray bottle that can emit mist. * For each group, water absorbing materials such as cotton balls, tissue. paper, writing paper litmus paper, wood blocks, plastic or paper cups, straws, cardboard, cotton balls, foil, rubber bands, tape, toothpick, paper towels, wire.   Worksheet List.   * What Is Humidity? * Design Your Own Hygrometer * Student Evaluation Form * Rubric for Evaluation |
| **Safety** | * Safety goggles. |
| **Student Prior Knowledge** | Students should:  1. Be familiar with the terms relative humidity, diameter and centimeter.  2. Be able to describe how relative humidity is measured.  3. Be able to analyze data given in a relative humidity table. |
| **Teacher Preparations** | * Students should be divided in groups, with 4 students at most. * Prepare and provide reference sheets for students prior to the investigation. * Make sure that when students design their hygrometers, they need to choose a numerical scale. |
| **Activities** | Teacher will begin the class dividing the class into groups, at which point student will choose different roles according to the principles of cooperative learning, such as: Group leader, materials handler, presenter, time keeper.  Teacher will give out the materials and go through all the items and explain to the students what the different materials are to be used for. She/he will also give out precautionary instructions to the students if applicable for safety reasons.  Teacher will give out *What is Humidity?* sheet which gives basic information about humidity, and sensors and information about how a Hygrometer works?   1. **Explore and Evaluate**: Using your IPADs, find all types of sensors that you find around you in everyday use starting from the time you wake up until the next day. You may also want to see if there is anything we use during the night while we sleep. Note your findings on the table provided. Discuss your findings with your group.   Students will now go to a website: [www.hpc.ncep.noaa.gov/html/dewrh.shtml](http://www.hpc.ncep.noaa.gov/html/dewrh.shtml).  Locate the Relative Humidity Calculator and choose 5 hottest days during the months of May, June, July, August and September in 2013, and calculate the relative humidity and dew points.  Now take the months of November, December, January, February and March and calculate the relative humidity and dew points of the days with the coldest temperatures. Graph the data on a graph paper giving the title of the graph, title the axis, give a legend. Use appropriate scale. Then answer the following question: At what point was the dew point higher than the humidity?  MAIN ACTIVITY: This will deal with the designing and building of the hygrometer.  1. Show student "engineering" teams *What is Hygrometer?* And *Design Your Own Hygrometer*. These may be read in class, or provided as reading material for the prior night's homework.  2. Divide students into groups of 2-3 students, providing a set of materials per group.  3. Explain that students must work as a team to design a hygrometer out of everyday items that can indicate a change in humidity. Explain that they may base their design on a pivoting gauge (such as the Coventry Hygrometer), or may come up with their own design.  4. Students meet and develop a plan for their hygrometer, including a list of all materials they require for construction.  5. Student teams draw their plan and present their plan to the class. Students may adjust their plan based on feedback received at this stage.  6. Student teams build their hygrometer. They may determine that additional materials are needed to complete this step. If so, they need to indicate the new materials or quantity of materials on their design worksheet.  7. Note that students will have to develop their own scale for their hygrometers. They may choose a numerical scale, or mark one section "humid" while another section is "dry."  8. During the testing phase, the hygrometers will be left overnight in the classroom to generate a base "reading" of humidity. These measurements will be recorded. Then, the hygrometers will be exposed to humidity by a soft spray of water. The hygrometer readings after exposure to humidity are then measured and recorded.   |  |  |  |  | | --- | --- | --- | --- | | Reading on Hygrometer before exposure to mist | Reading on Hygrometer after exposure to 4 sprays of mist | Reading on Hygrometer after exposure to 8 sprays of mist | Reading on Hygrometer after exposure to 16 sprays of mist | |  |  |  |  |   9. Teams then complete a *Student Evaluation Form*, and present their findings to the class.  Tips: Younger student teams may require assistance in setting up a balanced pivot for their hygrometer. Extension Ideas • Have the class test what happens if one of the student designed hygrometers is left in a sealed container with a cup of very salty water. (If left overnight, the hygrometer should show a relative humidity level of 75%.) |
| **Assessment** | Students will be assessed on the following parts of the lesson   1. Explore: ‘Sensors around you’. 2. Calculate the ‘Relative Humidity’ of the given months. 3. Designing the Hygrometer: Rubrics. 4. Constructing the Hygrometer: Rubrics 5. Evaluations.   These points are all listed in the rubric. |
| **Modifications** | Use lesser number of questions for students with IEPs and 504s. |
| **Alternative Assessments** | Questions to answer:  1. What is a hygrometer?  2. Go to Google research and find out what a hygrometer is and how you can use it to find humidity of a room temperature.  3. What are sensors? How many types of sensors can you find that we use in everyday living?  4. Build your own Hygrometer to test how temperature is evaluated in a room.  5. Explain your findings in a 250 words.  6. Come up with 5 questions that you may ask a group of your peers about sensors and hygrometers. |
| **References** | • U.S. Science Education Standards (<http://www.nap.edu/catalog.php?record_id=4962>)  • U.S. Next Generation Science Standards (<http://www.nextgenscience.org/>)  • International Technology Education Association's Standards for Technological Literacy (<http://www.iteea.org/TAA/PDFs/xstnd.pdf>)  • U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (<http://www.nctm.org/standards/content.aspx?id=16909>)  • U.S. Common Core State Standards for Mathematics (<http://www.corestandards.org/Math>)  • Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html) |

**What is Humidity**?

**Humidity** is the amount of water vapor in the air. In daily language the term "humidity" is normally taken to mean relative humidity. Relative humidity is defined as the ratio of the partial pressure of water vapor in a parcel of air to the saturated vapor pressure of water vapor at a prescribed temperature. Humidity may also be expressed as absolute humidity and specific humidity. Relative humidity is an important metric used in forecasting weather. Humidity indicates the likelihood of precipitation, dew, or fog. High humidity makes people feel hotter outside in the summer because it reduces the effectiveness of sweating to cool the body by preventing the evaporation of perspiration from the skin. This effect is calculated in a heat index table.

**Measuring Relative Humidity** The measurement of relative humidity requires two facts: the temperature, and the dew point. The dew point is the temperature the air must be cooled to in order for condensation to occur. The higher the humidity, the closer the dew point is to the air temperature. When the humidity is 100 percent, the dew point and the temperature are the same. The dew point can never be higher than the temperature of the air at any given time. Humidity can be measured in several different ways, but most commonly humidity is reported as the "relative humidity." Relative humidity is the ratio of the amount of moisture in the air compared to the amount the air is capable of holding at a given temperature, expressed as a percentage. An online humidity calculator may be found online at the U.S. National Oceanic and Atmospheric Administration website: [www.hpc.ncep.noaa.gov/html/dewrh.shtml](http://www.hpc.ncep.noaa.gov/html/dewrh.shtml).

**Engineering Implications** Engineers in many disciplines must consider humidity levels in their work. A civil engineer, for example, might be designing a building to house rare books which might be damaged by excessive moisture. Or, and air conditioning and refrigeration engineer might be developing a system to protect rare tapestries in a museum. Chemical and petroleum engineers may face situations where gases and condensing vapors co-exist. Reliable tools are important to engineers as they solve the challenges they face in many fields.

Student Resource: What is a Hygrometer? υ How Hygrometers Work Hygrometers are instruments used for measuring humidity. It measures water vapor content in the air and communicates changes in humidity visibly and immediately through a graph or a dial.

There are several types including:

• Hair hygrometer - uses a human hair as the sensing instrument. The hair lengthens when the air is moist and contracts when the air is dry, but remains unaffected by air temperature. This system works, but the hair does not respond instantly to changes and requires time for measurement.

• Mechanical hygrometer - uses absorbent paper as the sensing instrument. The paper becomes heavier as it absorbs water from the air.

• Electric hygrometer - uses a plate coated with carbon. Electrical resistance of the carbon coating changes as the moisture content of the air changes.

• Infrared hygrometer uses a beam of light containing two separate wave lengths to gauge atmospheric humidity. One of the wavelengths is absorbed by water vapor, the other is unaffected, providing an extremely accurate index of water vapor for paths of a few inches or thousands of feet. **Student**

**Design Your Own Hygrometer**

You are part of a team who have been given the challenge of developing an instrument to detect changes in humidity -- a hygrometer. You'll have lots of materials to choose from, and will likely have to incorporate a pivot and gauge within your hygrometer. If your system works, you'll be able to report a change in the humidity in your classroom. How you accomplish the task is up to your team!

**Planning Stage:**  Meet as a team and discuss the problem you need to solve. You'll need to determine which materials you'll request from the many everyday items your teacher has available. As a team, come up with your best design and draw it in the box below. Be sure to indicate the materials you anticipate using, including the quantity you'll request from your teacher. Present your design to the class. You may choose to revise your teams' plan after you receive feedback from class.

**Design Your Own Hygrometer: (Page 2)**

In the box below, draw the scale that you will use to "measure" changes in humidity. You may use numbers or words in your scale. You may wish to copy the one you draw to use within your hygrometer, or make another one that fits the size of your instrument during construction.

**Testing Phase**: Leave your hygrometer overnight to generate a base "reading" of humidity. The next day, record the "normal" humidity measurement in the box below. Next, the hygrometers will be exposed to humidity by a series of sprays of mist/water. Mark your hygrometers "readings" after each spray.

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**Evaluation Phase**: Teams then complete an evaluation/reflection worksheet, and present their findings to the class.

**Student Evaluation Form**

1. Did you succeed in creating a hygrometer that indicated a change in humidity?

2. What aspect of your design do you think worked best? Why?

3. What hygrometer "engineered" by another student team did you find most inspiring? How did it work better than yours, or what did feature did you appreciate that the other team came up with?

4. Did you decide to revise your original design while in the construction phase? Why? How?

5. Hygrometers have been measuring humidity for hundreds of years. Do you think that technology has improved the hygrometer? How?

6. How durable do you think your hygrometer is? Would it be able to continue to work for a week, two weeks, a year, a decade? What would you have to do to your hygrometer to make it reliable for a longer period of time?

7. Do you think you would have been able to complete this project easier if you were working alone? Explain…

8. If you could have used a material or materials that were not provided to you, what would you have requested? Why do you think this material might have helped with the challenge?

9. Can you identify five sensors in your school building? 10. What was your favorite part of the challenge?

**Rubric for evaluation:**

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|  | **% of marks given and remarks** |
| **Best Design (10%)**  *Drawn to scale.*  *Precise*  *Measurements provided.* |  |
| **Materials used. (10%)** |  |
| **Research (10%)** *Sources cited.*  *Findings* |  |
| **Construction of the Hygrometer (15%)**  *Was the hygrometer sturdy?*  *Did it take accurate*  *Measurements.* |  |
| **Testing Phase (15%)**  *(your findings)* |  |
| **Presentation (20%)**  *(Technology or strategy used)* |  |
| **Evidence of group work. (20%)** |  |
| **Final Grade** |  |