

Sensing and Sensors:
Observing and Making Sense of Our World

Senses and Sensors: Observing with the Tools of Science

Introduction

All that we understand about our world comes from our senses. This introductory science skills unit embraces the idea that one of the primary tasks of scientists is to utilize these senses and sensors to help human beings increase their understanding of this world and beyond. The students will first focus on the basic human senses and the types of natural and man-made sensors. Second, students will then focus on the factors that govern sensor creation. Third, the students will explore hi-tech and specialized sensors. Finally, students will engage in a final task to create a new sensor or improve an existing sensor to address a real-world problem.

Through this set of lessons, the students will focus on the following main concepts:

1. There are five basic senses that humans use to make qualitative and quantitative observations which allow us to gain a better, though not always perfectly clear, understanding of the world around us.
2. A sensor will be defined, for our purposes, as any substance or device that receives and responds to a stimulus.
3. Sensors may be natural or man-made.
4. Multiple sensors are sometimes better than one for giving a more full understanding of a phenomenon or system.
5. Where natural sensors fall short, technological sensors and tools, high-tech or low-tech, must be developed to gain insight.
6. Sensor creation/improvement are governed by need and ability and other factors including public opinion, financial constraints, and hazards posed.
7. Driving forces behind sensor production include agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing, and communication.
8. Scientific sensors alone do not always provide enough information to develop a solution to a problem.

Indiana State Standard Indicators Addressed:

6th Grade Science

Standard 1 — The Nature of Science and Technology

- 6.1.2 Give examples of different ways scientists investigate natural phenomena and identify processes all scientists use, such as collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses* and explanations, in order to make sense of the evidence.
- 6.1.3 Recognize and explain that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.
- 6.1.7 Explain that technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
- 6.1.8 Describe instances showing that technology cannot always provide successful solutions for problems or fulfill every human need.

Standard 2 — Scientific Thinking

- 6.2.5 Organize information in simple tables and graphs and identify relationships they reveal. Use tables and graphs as examples of evidence for explanations when writing essays or writing about lab work, fieldwork, etc.
- 6.2.8 Analyze and interpret a given set of findings, demonstrating that there may be more than one good way to do so.

Standard 4 — The Living Environment

- 6.4.13 Give examples of how human beings use technology to match or exceed many of the abilities of other species.

7th Grade Science

Standard 1 — The Nature of Science and Technology

- 7.1.8 Explain that technologies often have drawbacks as well as benefits. Consider a technology, such as the use of pesticides, which helps some organisms but may hurt others, either deliberately or inadvertently.
- 7.1.9 Explain how societies influence what types of technology are developed and used in fields such as agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing, and communication.
- 7.2.6 Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, or temperatures, and choose appropriate units.

8th Grade Science

Standard 1 — The Nature of Science and Technology

- 8.1.7 Explain why technology issues are rarely simple and one-sided because contending groups may have different values and priorities.
- 8.1.8 Explain that humans help shape the future by generating knowledge, developing new technologies, and communicating ideas to others.

Standard 2 — Scientific Thinking

- 8.2.6 Write clear, step-by-step instructions (procedural summaries) for conducting investigations, operating something, or following a procedure.
- 8.2.7 Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- 8.2.8 Use tables, charts, and graphs in making arguments and claims in, for example, oral and written presentations about lab or fieldwork.
- 8.2.10 Identify and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, an analogy is not apt, no mention is made of whether the control group is very much like the experimental group, or all members of a group are implied to have nearly identical characteristics that differ from those of other groups.

Lesson Portion	Estimated Duration
Part I Paying Attention to Our Senses Main Concepts: 1-4	2 Classes (50 minutes each)
Part II: Science Fiction Sensing To Reality Main Concept: 5	2-4 Classes (50 minutes each)
Part III: Factors That Govern Sensor Creation Main Concepts: 6-8	2 Classes (50 minutes each)
Part IV: It's Your Turn Main Concepts: 1-8	1-5 Classes (50 minutes each)

Part I: Paying Attention to Our Senses

Author: Purdue Homeland Security Institute
Draft Date: August 3, 2006

Content Area: General Science
Grade Level: 6-8

Background:

In part I, students will be developing an operational definition for a what a sensor is as well as focusing on the natural senses of sight, touch, taste, smell, and hearing. Students will explore the uses and limits of each sense while evolving their skills in the art of observing, and inferring.

Central Concepts

1. There are five basic senses that humans use to make qualitative and quantitative observations which allow us to gain an understanding of the world around us.
2. A sensor will be defined, for our purposes, as any substance or device that receives and responds to a stimulus.
3. Sensors may be natural or man-made.
4. Multiple sensors are sometimes better than one for giving a more full understanding of a phenomenon or system.

Guiding Questions:

1. What are senses and sensors?
2. Are all senses equal?
3. What are examples of natural and manmade sensors? What are they used for?
4. What qualities of quantitative and qualitative observations make them each uniquely helpful?

State Standards (Indiana)

- 6.1.2 Give examples of different ways scientists investigate natural phenomena and identify processes all scientists use, such as collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses* and explanations, in order to make sense of the evidence.
- 6.2.8 Analyze and interpret a given set of findings, demonstrating that there may be more than one good way to do so.
- 8.2.7 Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- 8.2.10 Identify and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, an analogy is not apt, no mention is made of whether the control group is very much like the experimental group, or all members of a group are implied to have nearly identical characteristics that differ from those of other groups.

Materials

Paper for K-L Chart, (1copy) “Student Guide” per student, (1copy)”Bag Activity” per student,
3 sets of 10 brown sacks labeled A-J with objects inside fit for testing (all bag A’s are the same ,all bag B’s are the same, etc.), Blindfolds,

Possible Misconceptions or Student Difficulties

- Sensors are not biological, but are instead must be man-made devices.
- Only inferences and hypotheses that turn out to be correct are valuable

Safety Issues

- Be aware of any food allergens or skin allergens, such as peanuts or latex, which your students may have to appropriately select bag items.

THE LESSON

A. Set

1. Bell Ringer:

- a. Students are to pick up a copy of the **Student Guide**.
- b. Students should divide the back of their **student guide** into two columns. They should title the paper “Sensors”. The leftmost column should be labeled with the letter ‘K’ and the rightmost column should be labeled with the letter ‘L’

B. Pre-Activity Discussion

1. Start with a **K-L Chart** to gain insight into the students’ conceptions about the five senses and sensors in general. (Information on a **K-L Chart** is at the end of this mini-unit.) **(3-5 minutes)**

*Students are to write the 3 questions below and their responses in the “K” column of their papers.

1. What does it mean to be a sensor?
2. What are examples of sensors?
3. What good are sensors?

*They do not have to write in paragraph form. Short sentences, key words and pictures are desirable.

2. Invite the students to write their responses on a class **K-L Chart** on large paper at the front of the classroom. (5 minutes) **Do not** discuss the responses yet. **Do not** allow the students to critique other students’ responses at this time.

3. Hold an open discussion about the 5 basic human senses by addressing:

- a. What are they?
- b. What do they do?
- c. What sense do you think is your strongest sense? Why? (Each student is to write down his own answer on his **student guide** for future reference.)
- d. What sense do you think is your weakest sense? Why? (Each student is to write down his own answer on his **student guide** for future reference.)
- e. Allow students to verbally share their strengths and weaknesses and reasoning through a pair-share or trio-share.
- f. Allow a few students to verbally share out in a whole-group setting.

C. Bag Activity

The students are to use the 5 basic human senses through the “Bag Activity” inquiry activity where they will observe contents of a bag using only one sense. The students will then classify the observations into qualitative and quantitative observations. They will be asked to provide a final guess of what the bag contains but they will not be told what the contents of most of the bags are. This is because in science, often scientists don’t “know” if their conclusions are absolutely correct.

1. Have the students work in pairs for this activity. (Pass out the **Bag Activity** hand-out)

2. Begin with Sight.

- a. The teacher will show the item to the class to model how to “host” the observer.
- b. All of the students are observers for this part and should record as many statements about the object as they can. Remind them that statements are to be based upon only what can be seen.
- c. They will have **20 minutes** to complete the remaining portions of the activity.
- d. Discuss what was noted and look for examples of other senses. “It smells like oranges” is not an appropriate response for sight observations. **(No Guessing the identities yet!)**
- e. There are not enough bags for each group to have their own set of 10 bags. The students will be sharing should skip around on the testing based upon available bags.
- f. Allow the students to move on in pairs now with objects from the bags following the

- instructions from the Bag Activity. Each student is to observe using each of her senses once and host his partner. Remember, they are not trying to determine what is in the bag. They are to focus on writing statements about the contents of their bag using the single sense assigned.
- g. With the students now in their original seats, have them look at their list of statements individually and write down their best guess as to what each object was. **NO TEAMWORK HERE!**

D. Follow-up Discussion

1. Begin by asking the students to hold a hand up if the **Bag Activity** supported their predictions about which of their senses was strongest.
2. Follow this by asking the students to hold a hand up if they feel the **Bag Activity** supported their predictions about which of their senses was weakest.
3. Feel free to take any commentary from the students about their results and predictions relating to why their predictions were or were not affirmed.
4. Discuss what students felt the identities of the bag content were. Allow students to share out evidence and discuss with other classmates in a positive way when they disagree about the identity of the bags. Focus here on the idea that the evidence must match the conclusions and that there may be more than one reasonable conclusion. What would be the next step in such a case? **DO NOT** provide the students with the actual identities of the bag contents. It is a real scientific understanding worth learning that sometimes, your best conclusion is all you've got! That's real science.
5. Ask the students to think back to the activity that they just did. What would they say a sensor is? Each student should discuss his answer with a partner. When the pairs have agreed upon a definition of what a sensor is, they should write it down on a scrap piece of paper.
6. Discuss the answers as a class and fine tune it until the definition is "any substance or device that receives and responds to a stimulus." This should be added to the students "L" column of their **K-L Chart** as well as their **student guides**.
7. Based on this definition of a sensor, ask the students to write a response in the "L" column of their **K-L Chart** that corrects or defends their answer to question 2 (What are examples of sensors?) in their "K" column. In other words, if they wrote an answer in the "K" column that was incorrect, incomplete, or I don't know, then they should correct their answer. If the student feels that their original response to the question was correct, then they explain why they feel it was correct in the "L" column.
8. Whole class discussion:
 - a. Share out answers to "L" column.
 - b. Be sure that the students understand that the primary body sensors for human body are:
 - a. sight – eyes
 - b. sound – ears
 - c. feeling – skin
 - d. taste – tongue
 - e. smell – nose

E. Observations Discussion

1. Begin by having the students fill in question number 3 on their **student guides**. Do not give and guidance at this time other than to do the best they can. They may write, "I don't know" if they choose.
2. Hold a short discussion to explain what a scientific observation is.
 - a. Observations are information gathered using the five senses or tools. They are typically written as complete sentences. (Students should fill in their **student guides**.)
 - b. Give the students four correct examples of observations to add to their **study guides**. Two should be qualitative and two should be quantitative. Do not identify them as such at this point.

- c. Point out that observations are not feelings. They must be readily detectable through the five senses or tools. They are not judgments. So, it would be correct that “He is showing his teeth” is an observation, but not to say that “the boy **is** smiling” or that “the boy **is** happy.” The latter two are actually judgments or conclusions that the observer is drawing.
- d. Ask the students to try and divide the four sample observations into two distinct groups. Try and guide them to groupings that involve observations that involve measurements or quantities and observations that do not indicate measurements or quantities. Then express to the students that observations do indeed come in these two forms. Go on to define each.
 1. Qualitative observations are information gathered using the five senses or tools that do not indicate quantity or amount.
 2. Quantitative observations are information gathered using the five senses or tools that must indicate quantity or amount.
- e. Give the students 2-3 minutes to classify the four sample observations in the blanks next to the observations on the **student guide**.
- f. Have the students discuss their results with the person sitting next to them. This is a good time for a walk around spot check to listen to discussions, probe and read responses.
- g. Discuss the answers to the four samples to check for misconceptions.

F. Closure:

1. Give the students 3-5 minutes to allow them to add any other ideas that they have learned or believe is worthy of note to their “L” column of their **K-L Charts**.

G. Assessment- Hand out the assessment sheet for this section. It indicates that the students are to do the following:

1. Assignment or in class practice:
 - a. Revise/rewrite 10 of the statements from the bag activity to make them observations as needed.
 - b. Label each statement (observation) as “Qual” if it is a qualitative observation or with a “Quant” if it is a quantitative observation.
2. Respond to the following prompt with a 5-8 sentence paragraph response.

During the bag activity, we only used one sense at a time to try and gather information about the bag’s contents. Is this realistically how one determines information about objects in real life? Defend your answer.

Student Guide

Student Name: _____

Topic: Observations

Science Class: _____

1. What is your strongest sense? Why? _____

2. What is your weakest sense? Why? _____

3. What does it mean to observe in your own words? _____

4. Classroom definition: _____

5. Classroom Observations: Write down the 4 observations that the teacher highlights.

_____ a. _____

_____ b. _____

_____ c. _____

_____ d. _____

6. Define the two types of observations according to the classroom discussion below then identify each of your statements above as “Qual” for qualitative or “Quant” for quantitative.

Qualitative: _____

Quantitative: _____

Observer Name: _____

Host Name: _____

****This answer sheet belongs to the observer and should have the observer's responses only.**

Bag Activity

Students are to work in pairs to record information about mystery objects in bags that they are able to discern using only one sense at a time. One person will be the host and the other will be the observer. The host will choose **one bag** from the table and have the observer record the letter of the bag on their observation sheet. The host will then be sure that the observer is set up according to the instructions and then allow him to make observations. When the observer has completed each of his sensory tests, the two students will switch roles and begin again. Do not use any bag more than once total. **Remember to skip around based upon available bags.**

Sight Test: Bag A or B (Circle one) **Observer** is to direct the host to move the object, **Host** must hold the object

Information noted:

- 1.
- 2.
- 3.
- 4.
- 5.

What do you think it is? _____.

Taste Test: Bag C or D (Circle one) **Observer** is blindfolded, **Host** must give Observer material to be tasted

Information noted:

- 1.
- 2.
- 3.
- 4.
- 5.

What do you think it is? _____.

Smell Test: Bag E or F (Circle one) **Observer** is blindfolded, **Host** must hold object near observer's nose (No contact!)

Information noted:

- 1.
- 2.
- 3.
- 4.
- 5.

What do you think it is? _____.

Sound Test: Bag G or H (Circle one) **Observer** is blindfolded, **Host** must hold object and move it to generate sounds

Information noted:

- 1.
- 2.
- 3.
- 4.
- 5.

What do you think it is? _____.

Touch Test: Bag I or J (Circle one) **Observer** is blindfolded and must touch object, **Host** moves the object to the observer

Information noted:

- 1.
- 2.
- 3.
- 4.
- 5.

What do you think it is? _____.

Name: _____

Date: _____

Class: _____

Assessment

I. Observations

- a. Revise/rewrite 10 of the statements from the bag activity to make them observations as needed.
- b. Label each statement (observation) as “Qual” if it is a qualitative observation or with a “Quant” if it is a quantitative observation.

1. _____	_____

2. _____	_____

3. _____	_____

4. _____	_____

5. _____	_____

6. _____	_____

7. _____	_____

8. _____	_____

9. _____	_____

10. _____	_____

II. Senses and Sensors

Respond to the following prompt with a 6-8 sentence paragraph response. (1 sentence to state your point, 5-7 sentences to defend your answer.) **You may use the back of this sheet if you need more space.**

During the bag activity, we only used only one sense at a time to try and gather information about the bag’s contents. Is this typically how one gathers information about objects in real life? Defend your answer.

Part II: Science Fiction Sensing to Reality

Author: Purdue Homeland Security Institute
Draft Date: August 3, 2006

Content Area: General Science
Grade Level: 6-8

Background:

In this phase, students will give examples of how human beings use technology (tools and sensors) to match or exceed many of the abilities of other species. Students will also explain that technology (tools and sensors) is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information. Quantitative observations will become more evident, reliable and accurate while qualitative observations will become more detailed. The students will practice with science tools in this section as well to improve proficiency with those items. The items used will depend upon the needs of the teacher.

Central Concepts

5. Where natural sensors fall short, technological sensors and tools, high-tech or low-tech, must be developed to gain insight.

Guiding Questions:

1. What if we want to make observations of something that our human sensors are not able to adequately detect?
2. If man-made sensors are better than human sensors, then what is the point of using human sensors at all?

State Standards (Indiana)

- 6.1.2 Give examples of different ways scientists investigate natural phenomena and identify processes all scientists use, such as collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses* and explanations, in order to make sense of the evidence.
- 6.1.3 Recognize and explain that hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations.
- 6.1.7 Students will explain that technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
- 6.2.5 Organize information in simple tables and graphs and identify relationships they reveal. Use tables and graphs as examples of evidence for explanations when writing essays or writing about lab work, fieldwork, etc.
- 6.2.8 Analyze and interpret a given set of findings, demonstrating that there may be more than one good way to do so.
- 6.4.13 Students will give examples of how human beings use technology to match or exceed many of the abilities of other species.
- 7.2.6 Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, or temperatures, and choose appropriate units.
- 8.2.6 Write clear, step-by-step instructions (procedural summaries) for conducting investigations, operating something, or following a procedure.
- 8.2.7 Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- 8.2.8 Use tables, charts, and graphs in making arguments and claims in, for example, oral and written presentations about lab or fieldwork.
- 8.2.10 Identify and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given, an analogy is not apt, no mention is made of whether the control group is very much like the experimental group, or all members of a group are implied to have nearly identical characteristics that differ from those of other groups.

Materials

(1 copy) “I Can’t Sense This.....Yet” packet per student,

(1 copy) teacher planner packet for the teacher,

(1 set of 4) Sensor Investigation Cards per group

Other Materials will vary depending upon which science tools you wish the students to practice with.

They could include:

Touch Sensors: Triple Beam Balances, Spring Scales, Seismograph, Thermometer

Taste Sensors: pH Indicator, Salinity Testing, Indicator Dyes

Smell Sensors: Smoke Detector (be careful, may contain radioactive elements and should not be disassembled)

Sight Sensors: Microscope (tool), Rulers, Graduated Cylinders

Sound Sensors: Sound Recorders, Music Equalizer, Decibel Recording Machine, Tuning Forks, Water

Possible Misconceptions or Student Difficulties

- Man-made sensors (technology) are always superior to natural sensors.
- Most man-made sensors are conceived of through the imagination of humans.

THE LESSON

A. Set

1. Whether the students completed Part I or not, discuss/review the following points.
 - a. What is the difference between a sense and a sensor?
 - b. Compare and contrast qualitative observations and quantitative observations with illustrative examples not used in class.
 - c. Why is it generally better to use more than one sense to make observations about an object?
 - d. If the students did complete Part I, reread their 'L' responses written on their **K-L Chart** to remind them of the conclusions they had drawn at the close of the section.
**Address any misconceptions as needed.
2. Ask the students what the purpose of using a scientific tool or sensor is? *Guide them to the conclusion that it is to gather information.*
3. What were examples of the sensors that students use during class to help them in class? *Examples would include eyes, ears, hands (for guiding pencils/pens), etc.*
4. Do these sensors seem to be all we need to understand our world? Do they do everything that we want/need them to do? What limitations do they have? *The idea here is to get the students to see that our sensors are very good, but have limitations.*
5. What do we do when the things that we want to observe are not easily observed with our sensors? We use other tools. If our eyes are not functioning as we'd like, we wear glasses or contacts. If we need to fill bags with equal amounts of popcorn, we use measuring cups. These tools are all forms of technology that allow our sensors to function better or allow us to use our sensors to make observations we couldn't easily make such as the measuring cups.
6. Inform the students that this lesson's focus is to learn to use tools in conjunction with our body sensors to make improved observations. It will also be to help them to become more proficient with some of the basic tools of science such as common measuring devices and microscopes. Most, if not all, of the tools that the students will utilize in this lesson will be utilized extensively in lessons to come. (It would be helpful to provide samples here for the students to see such as graduated cylinders, beakers, etc.)

B. Low-Tech Tools/Sensors Activity

For this portion of the lesson, the teacher should determine which tools he or she would be having the students use in class for upcoming labs and activities. Use these tools as the tools for the students to practice with. The students could move through stations with each tool to gain experience, the teacher could have all of the students working with the same tools in a teacher-led exploration/tutoring session. This is the part of the lesson that will determine the overall length of the lesson. The more tools you highlight, the longer the students will need to gain proficiency. Following will be a planning form to help the teacher individualize this portion to fit their classrooms. Be sure to add elements of graphing and data table creation/interpretation here. Also focus on providing activities that push the students to draw conclusions rather than just documenting the use of the tools and sensors.

1. Explain to the students how (the method) they will be learning about each tool.
2. Show the students various examples of tools and sensors relating to as many senses as possible. Don't forget common examples like smoke, radon, and carbon monoxide detectors.
3. Ask the students to express how each of the tools improve an existing sense or sensor or how the tool gives an additional sense to the observer.
4. Conduct the activity.
5. Have the students add to the **K-L Chart** any new information they have gained about senses or sensors. (Use a different marker/pen color for this part so that you can differentiate what was from Part I and what was from Part II.

C. Assessment

1. Individual checks for each tool/sensor that the students were directed to become proficient with. The checks could be written mini-quizzes, verbal checks by the teachers, informal walk-through observations by the teacher. Just be sure to ascertain that the students are able to correctly utilize the tools/sensors. (I suggest each student receive a list of tools/sensors that she is to be able to use with a list of what they are expected to be able to do with the tool/sensor. As they demonstrate proficiency, check them off on your list and the student's list.)

D. Closure

1. Pass out the **“I Can't Sense This.....Yet!”** packet and explain the project to the students.
2. Explain to the students that there will be a final project that requires them to address a problem that requires a sensor as a solution. At this point do not give them many details other than to say that they need to keep their minds and senses open to identify problems that they could solve using sensing technology.
3. Have the students begin to brainstorm a list of problems that sensors for the final project could address. They could address home problems, school problems, or other problems. For example, to help more people survive fires smoke detecting sensors were created. To help scuba divers know when their oxygen tanks were low gauges were developed. Geiger counters were developed to detect the presence of radioactivity. Telescopes were developed to allow our eyes to see more distant objects with clarity and detail that the eye alone could not attain. Make sure the students focus on problems at this time not the sensor itself. The more problems they can identify the better. Students should keep the lists for future reference and additions.

E. Assessment-

1. Assign the students to **“How Could You...”** Activity as an assessment to do in the classroom in groups of 4.

Part II Teacher Planning Form

1. What tools do you want the students to work with in labs and activities in the next 9-12 weeks? Write them down on the blanks next to each letter. Use as many blanks as you have tools. Do not worry about filling in all the blanks. Only fill in the blanks for the tools you plan to use. If you only plan to use four tools, then only fill in blanks a-d. Some items to consider are listed in the materials section of this lesson.
2. Next to each tool type you've listed, write down the number that you have available for the students to use.
3. Identify any safety concerns pertaining to the tool. I.e. Beakers are glass and break easily.
4. Determine the way that you wish to have the students learn about each tool and list it below each tool/sensor you've identified. (Stations, Demonstrations, Whole Class Activities, etc. or combinations)
5. Determine if the room layout needs to be changed to meet your needs.
6. Determine whether the students will be working alone or in groups or if it will change depending on the tool.
7. Plan the supporting materials that would be helpful for the students in their learning as they study each of the tools.
8. Based upon the students, number of tools and what activities/instruction you have planned for the students to partake in to improve their understanding of each tool/sensor, estimate the amount of time that this portion of the lesson will take in class periods for your planning purposes.

Tool/Sensor	Qty.	
a. _____	_____	Safety Concerns: Method of instruction: _____
b. _____	_____	Safety Concerns: Method of instruction: _____
c. _____	_____	Safety Concerns: Method of instruction: _____
d. _____	_____	Safety Concerns: Method of instruction: _____
e. _____	_____	Safety Concerns: Method of instruction: _____
f. _____	_____	Safety Concerns: Method of instruction: _____
g. _____	_____	Safety Concerns: Method of instruction: _____
h. _____	_____	Safety Concerns: Method of instruction: _____
i. _____	_____	Safety Concerns: Method of instruction: _____

How Could You...

You will be given several situations that will ask you to create a plan to solve the problem. You and your group members are to follow the instructions carefully as you work together.

Step 1 Individual- Write down a plan to determine how many paperclips are in the container without counting each of them one-by-one and without opening the container? Items you could use: balance, graduated cylinder, paperclips similar to the ones in the container. You may use other materials as long as your teacher approves them.

Write your plan below.

Step 2 Whole Group- Each member of your group is to share his or her plan. Write down any differences between your plan and theirs.

Differences

Step 3 Whole Group- Decide on one plan to use to solve the problem and write it out in steps below. This plan may be one person's plan or a new plan made up from input from all group members.

Step 4 Show your plan to the teacher for approval.

Teacher Initials_____

Step 5 Group- Complete the steps of you approved plan.

Step 6 Write down the number of paperclips that you have concluded are in your container. _____

Step 7 Check in with your teacher to see how close your prediction was.

Step 8 How successful was your plan at obtaining a reasonable answer to the problem? Explain what worked as well as what did not work so well.

Step 9 What would you change about your plan if you were going to attempt to get more accurate results?

Part III: Science Fiction Sensing To Reality

Background:

Students will understand that technologies generally arise from specific needs. They will describe instances showing that technology cannot always provide successful solutions for problems or fulfill every human need. Students will explain how societies influence what types of technology are developed and used in fields such as agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing and communication. Students will identify ways that technology has strongly influenced the course of history and continues to do so. Students will explain why technology issues are rarely simple and one-sided because contending groups may have different values and priorities. In exploring these ideas, students will be exposed to some of the latest sensory technology being developed including technology being produced, studied or improved by the Purdue Homeland Security Institute.

Indiana State Standards Addressed

- 6.1.8 Describe instances showing that technology cannot always provide successful solutions for problems or fulfill every human need.
- 7.1.9 Students will explain how societies influence what types of technology are developed and used in fields such as agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing and communication.
- 7.1.10 Students will identify ways that technology has strongly influenced the course of history and continues to do so.
- 8.1.7 Students will explain why technology issues are rarely simple and one-sided because contending groups may have different values and priorities.

Materials

Multiple computers with Internet access or one computer with Internet access and a multimedia projector or large television monitor (If technology is not reasonable available in the school, the teacher could go to the websites and print them out as overheads or as packets for the students instead.)

Time

This portion will probably take 1 class period of 45 minutes each to complete.

Guiding Questions:

1. How accurate is it to say that given enough time, science can solve any problem?
2. What factors beyond simple scientific curiosity drive the need for technological advancement in the form of sensors?
3. What types of sensing technology are on the new horizon under the direction of the Purdue Homeland Security Institute?

Activity:

A. Pre-Activity Discussion

1. Discuss examples of manmade sensors and tools that students have encountered so far and the reasons that they were developed. Guide them to the idea that problems usually drive the development of sensors and tools. Accidental discoveries do too, but it isn't the driving force.

In other words, for most tools and sensors that the students come in contact with, there was someone with a need for the tool or sensor.

2. Ask student what other types of sensors people might want? Why would they want them? Explore the idea for common everyday uses as well as specialized purposes such as deep-sea divers, truck drivers, grocery store owners or astronauts.
3. Ask the students to respond to the following statement, "Given enough time, science can solve any problem." Do they believe this is true? Why or why not? Is time the only factor that determines whether a solution can be had or not? What about money, morality, politics, knowledge, physical laws?
4. The remainder of this lesson will focus on sensing technology that is now on the horizon under the direction of the Purdue Homeland Security Institute.
 - a. Nano-sensors
 - b. Smart Bio Adhesives
 - c. Ion Trap Mass Spectrometers
 - d. Chemical Nano-sensors
 - e. Neutron-Based Detectors
5. Why?
 - a. Protect Food
 - b. Stop the Spread of Disease
 - c. Fight Terrorism
 - d. Prevent Nuclear Disasters

B. Activity

1. Students will go to websites that highlight the technology identified above written at a middle School level. The site would explain the basic function of the technology, provide visuals of how it works, the needs it would serve (i.e. what problems does it address), and explain where the technology is in its development.
2. Hold a whole group discussion about the technology.
 - a. What was most interesting?
 - b. Does it seem like science fiction?
 - c. How does the technology seem to relate to the average citizen in this country?
3. Have the students add onto their list of problems that their sensors for the final project could address.

Part IV: It's Your Turn

Background:

The students will create a final project in the form of a sensor or a device to enhance the quality of an existing sensor. The sensor or device must meet an actual need and be fully functional.

Indiana State Standards Addressed

- 6.4.13 Students will give examples of how human beings use technology to match or exceed many of the abilities of other species.
- 6.1.7 Students will explain that technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.
- 7.1.9 Students will explain how societies influence what types of technology are developed and used in fields such as agriculture, manufacturing, sanitation, medicine, warfare, transportation, information processing and communication.
- 7.1.10 Students will identify ways that technology has strongly influenced the course of history and continues to do so.
- 8.1.7 Students will explain why technology issues are rarely simple and one-sided because contending groups may have different values and priorities.

Materials

General building materials such as construction paper, glue, scissors, tape, aluminum foil, Other materials will vary depending upon whether the students will actually construct the sensor or whether they will only design the sensor.

Time

This portion will probably take 1-5 class periods of 45 minutes each to complete depending on whether the students are to design a sensor only or whether they are to design and build the sensor. If they are building the sensor, they will need time to brainstorm, plan, construct, modify and finish their sensor.

Guiding questions:

1. How does one create a sensor to solve a problem?
2. Are more complex sensors better than simple ones?

Activity:

- A. Pre-Activity Discussion
- B. Activity

Differentiation:

- Level 1 Teacher provides problem and general ideas about how the sensor or device might function
- Level 2 Teacher provides the problem and the student provides the solution
- Level 3 Student identifies a problem and a solution

Can't Sense This.....Yet!

Student Project Description

In this project you are to assume the role of inventor. You will identify a problem that a sensor would solve or improve. You will then design the sensor and construct a working model of the sensor. The model should be fully functioning. The teacher must approve all sensors prior to construction.

Stage 1 Brainstorming

Create a list of potential problems to solve. Do not focus on how to solve them, just jot them down. The more the better.

Stage 2 Problem Selection

- A. Several days into this mini-unit, the teacher will ask you to look at your list of potential problems from your brainstorm list. You will determine which of the problems you believe you could create a sensor for to address the problem. Record the problems as your official problem by writing it on the **Project Evaluation** sheet. .
- B. You are to write a one paragraph explanation of the problem that you are going to address as well as why you chose to address the problem. **DO NOT** explain your solution at this time. Remember that the paragraph will be evaluated using the writing rubrics for “Organization” as well as “Scientific Ideas and Content.” A paragraph is 8-10 sentences in length. Remember to have an opening sentence and a closing sentence.
- C. Begin to consider what type of sensor would address this problem. It will be helpful to have more than one idea.

Stage 3 Sensor Design and Construction

You will design and build a working model of the sensor that addresses your problem. The sensor must not be overly complicated or too simplistic. It will be your responsibility to share your ideas with your teacher prior to building. **NO BUILDING WILL BE DONE AT HOME!**

- A. Consider each of the ideas for sensors that you have brainstormed so far.
- B. Select the sensor that you believe is most likely to work and that you will be able to construct and then fill in the **Project Evaluation** sheet entitled, “Brief description of the sensor and how it functions.”
- C. You are to write a one-paragraph description of how the sensor that you’ve devised is to address the problem. **DO NOT** explain your solution at this time. Remember that the paragraph will be evaluated using the writing rubrics for “Organization” as well as “Scientific Ideas and Content.” A paragraph is 8-10 sentences in length. Remember to have an opening sentence and a closing sentence.

Stage 4 Sensor Testing and Final Assessments

- A. The sensor will need to be tested to show that it works. Test it and revise it as needed.
- B. When you are ready, inform your teacher and they will stop class so that you may demonstrate your sensor.
- C. After the demonstration, you are to write a two-paragraph reflection explaining:

1. how well the sensor functioned
 2. what you would redesign AND not redesign about your sensor and why.
- D. The final part is to complete the evaluation form with the three written pieces stapled to it **by the next class period.**
- E. Turn in your paragraphs and evaluation form to your teacher.

Can't Sense This.....Yet!

This four page packet includes the evaluation rubrics for the final project on sensor design and the project evaluation sheet. Please refer to them as you work on your project. This packet details the required elements as well as the way in which those elements will be evaluated.

Checklist

- ____ 1. The student has written a one-paragraph description of the problem he or she has chosen to solve and why it was chosen.
**Remember that the paragraph will be evaluated using both the Organization and Content rubrics.*
- ____ 2. The student has written a one-paragraph description of how the sensor that he or she has devised is to address the problem.
**Remember that the paragraph will be evaluated using both the Organization and Content rubrics.*
- ____ 3. The student has written a two-paragraph reflection explaining how well the sensor functioned and what they would redesign AND not redesign about their sensors and why.
**Remember that the paragraph will be evaluated using both the Organization and Content rubrics.*

Paragraph Writing Rubric Based upon 6+1 Writing Traits Rubrics Northwest Regional Educational Laboratory, Portland, Oregon

	Emerging	Satisfactory	Excellence
Organization	<p>The writing lacks a clear sense of direction. Ideas, details, or events seem strung together in a loose or random fashion; there is no identifiable internal structure. The writing reflects more than one of these problems:</p> <p>A. Connections between ideas are confusing or not even present.</p> <p>B. Sequencing is generally out of synch.</p> <p>C. Problems with organization make it hard for the reader to get a grip on the main point.</p>	<p>The organizational structure is strong enough to move the reader through the text without too much confusion. It includes an opening and closing sentence.</p> <p>A. Transitions often work well; at other times, connections between ideas are fuzzy.</p> <p>B. Sequencing shows some logic, but not under control enough that it consistently supports the ideas.</p> <p>C. The organization sometimes supports the main point; at other times, the reader feels an urge to slip in a transition or move things around.</p>	<p>The organization enhances and showcases the central idea or theme. The order, structure or presentation of the information is compelling and moves the reader through the text. The opening and closing sentences are short and to the point.</p> <p>A. Thoughtful transitions clearly show how ideas connect.</p> <p>B. Details seem to fit where they've been placed; sequencing is logical and effective.</p> <p>C. Organization flows so smoothly the reader hardly thinks about it; the choice of structure matches the purpose and audience.</p>

Paragraph Writing Rubric
Based upon 6+1 Writing Traits Rubrics
Northwest Regional Educational Laboratory, Portland, Oregon

	Emerging	Satisfactory	Excellence
<h2>Scientific Ideas & Content</h2>	<p>As yet the writing has no clear sense of purpose of central theme. To extract meaning from the text, the reader must make inferences based upon sketchy or missing details. The writing reflects more than one of these problems:</p> <p>A. Information is limited or unclear or the length is not adequate for development.</p> <p>B. The idea is a simple restatement of the topic or an answer to the question with no attention to detail.</p> <p>C. The writer has not begun to define the topic in a meaningful way.</p> <p>D. Everything is as important as everything else; the reader has a hard time sifting out what is important.</p> <p>E. The text may be repetitious, or may read like a collection of disconnected, random thoughts with no discernable point.</p>	<p>The writer is beginning to define the topic, even though development is still basic or general.</p> <p>A. Support is attempted, but doesn't go far enough yet in fleshing out the key issues or storyline.</p> <p>B. Ideas are reasonably clear, though they may not be detailed, personalized, accurate, or expanded enough to show in-depth understanding or a strong sense of purpose.</p> <p>C. The writer seems to be drawing on knowledge or experience, but has difficulty going from general observations to specifics.</p> <p>D. The reader is left with questions. More information is needed to "fill in the blanks."</p> <p>E. The writer generally stays on topic, but does not develop a clear theme. The writer has not yet focused the topic past the obvious.</p>	<p>This paper is clear and focused. It holds the reader's attention. Relevant anecdotes enrich the central theme.</p> <p>A. Relevant, telling, quality details give the reader the important information that goes beyond the obvious or predictable.</p> <p>B. Reasonably accurate details are present to support the main ideas.</p> <p>C. The writer seems to be writing from knowledge or experience; the ideas are fresh and original.</p> <p>D. The reader's questions are anticipated and answered.</p> <p>E. Insight- an understanding of life and knack for picking out what is significant- is an indicator of high-level performance, though not required.</p>

Sensor Construction Rubric

	Emerging	Satisfactory	Excellence
<h3>Sensor Construction</h3>	<p>As yet the sensor's construction is incomplete or is unsatisfactory for more than two of the following reasons:</p> <p>A. It is unfinished to the degree that the sensor's sensing components are missing or not operating.</p> <p>B. The sensor is too simplistic.</p> <p>C. The sensor replicates the design of other sensors and shows little or no originality of design.</p> <p>D. The sensor fails to stay within one or more design limits imposed in advance by the instructor in terms of size, weight etc.</p>	<p>The sensor is a generally complete and working model.</p> <p>A. It is finished to the degree that the sensor's sensing components are present and operating.</p> <p>B. The sensor is overly complicated.</p> <p>C. The sensor does not replicate the design of other sensors or only replicates other designs in the most mundane ways such as being the same outside geometric shape, but does show evidence of originality.</p> <p>D. The sensor stays within all design limits imposed in advance by the instructor in terms of size, weight etc.</p>	<p>The sensor's construction is complete in every detail and looks to be a final finished product set for sale. All portions of the sensor physically operate as designed.</p> <p>A. The sensor's sensing components and all of the other components are present and operating as designed No parts are missing</p> <p>B. The sensor is not overly complicated nor is it too simplistic.</p> <p>C. The sensor appears to be unique in design in terms of the sensing methods and equipment as well as the overall shape.</p> <p>D. The sensor stays within all design limits imposed in advance by the instructor in terms of size, weight etc.</p>
<h3>Sensor Function</h3>	<p>At this time, the sensor doesn't function or functions so poorly that data it provides is unreliable. It reflects more than one of these problems:</p> <p>A. The sensor does not operate.</p> <p>B. The sensor is as likely to provide inaccurate responses as accurate responses.</p> <p>C. The sensor does not address the problem stated.</p> <p>D. The sensor is not reasonably safe to operate.</p>	<p>The sensor seems to function generally well. The results tend to be reliable most of the time.</p> <p>A. The sensor operates most of the time.</p> <p>B. The sensor is more likely to provide accurate responses than inaccurate responses.</p> <p>C. The sensor addresses the stated problem, but may or may not include other unplanned data.</p> <p>D. The sensor is reasonably safe to operate and poses no significant threat to others.</p>	<p>The sensor seems to function exactly as planned without flaw or worry.</p> <p>A. The sensor operates every time.</p> <p>B. The sensor gives accurate results every time.</p> <p>C. The sensor exactly addresses the identified problem, and provides only that data.</p> <p>D. The sensor is completely safe to operate.</p>

Project Evaluation

Student Name: _____ Science Class: _____ Date: _____

Problem addressed: _____

Brief description of the sensor and how it functions: _____

	Points Possible	Student Assessment	Teacher Assessment
Paragraph I: Problem Explanation			
Organization Score	_____	_____	_____
Scientific Ideas and Content Score	_____	_____	_____
Paragraph II: Solution Explanation			
Organization Score	_____	_____	_____
Scientific Ideas and Content Score	_____	_____	_____
Paragraph III: Reflection of Sensor			
Organization Score	_____	_____	_____
Scientific Ideas and Content Score	_____	_____	_____
Sensor Development			
Sensor Construction	_____	_____	_____
Sensor Function	_____	_____	_____
Sensor problem (check one)			
<input type="checkbox"/> Given by teacher	_____	_____	_____
<input type="checkbox"/> Determined by student	_____	_____	_____
Sensor solution (check one)			
<input type="checkbox"/> Guided by teacher suggestions	_____	_____	_____
<input type="checkbox"/> Determined by student	_____	_____	_____
Total Points for Project	_____	_____	_____
	Final Score for Project		_____

Support Page

Because teachers too have different backgrounds and at times use different jargon, this section has been added to create a common meaning for some of the concepts utilized in this mini-unit.

K-L Chart

This is most commonly referred to as a K-W-L chart. The 'K' refers to what the students think they know about a topic. It can be done as a whole class chart or an individual student chart or both. In this mini-unit it is an individual chart.

The 'W' stands for what the students would like to know or ask about the topic. The 'L' refers to what the students have learned after studying the topic. It is very much a before, during, and after tool. The 'K' easily serves as a pre-assessment of the collective understanding of the class. The 'W' provides springboards for study. The 'L' shows the growth the class or student has made overall and helps identify any lingering misconceptions. For this activity, we will only use the 'K' and 'L' portions as a pre and post assessment. We are skipping the 'W' section.

K-W-L Chart

Prompt: _____

K (What do you KNOW?)	W (WHAT do you want to know?)	L (What have you LEARNED?)
	<h1>X</h1>	

Rubrics

Rubrics are tools that express the expectations of a given task in incremental form where one end expresses low achievement and the opposite end expresses high achievement. The rubrics that accompany this mini-unit have three levels. Students could actually fall between the boxes outlined if they meet most of the criteria for one box, but not all of the criteria for the next level up. Note that no point values have been assigned to the rubrics. This is totally up to the teacher utilizing this mini-unit. Be aware that the middle box would indicate where the average student would be expected to fall. If the boxes were assigned the numbers 1, 3, and 5 respectively, the 3 would be only a 60% if the score were used as 3/5. Consider carefully how you will convert the students' grades from the rubric into a numerical score to be sure it is reasonable.