Lesson Title: Have You Ever Seen the Rain?

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Topic: Rain Gauges and Precipitation

Targeted Grade Level: High School (Regents Earth Science – Grades 9-12); this lesson is intended for an advanced 8th grade section of Regents Earth Science

Time Needed: 3 x 40-minute periods for the base of the lesson; One month for collection of weather data

Subject Integration: The different subject areas addressed in this lesson are science, engineering, and English Language Arts.

Justification: Science, particularly atmospheric science, provides the background for this lesson. Incorporation of scientific ideals and helps provide meaning for the necessity of constructing accurate measurement tools and devices. Secondly, engineering processes are primary focus for assessment criteria for the lesson and selected standards provide the vehicle by which scientific content is being delivered. Students could easily be given well-crafted, manufactured rain gauges, but creation and subsequent evaluation allows for the teaching of hydrological phenomena such as evaporation which students may identify as a factor which must be given attention during the design process. Finally, the inclusion of ELA standards into the lesson is appropriate because it allows students to practice communicating scientific explanations and justifying arguments with evidence. The ability of a scientist or engineer to communicate their procedures, findings and reflections through writing is a critical part in the repertoire of a STEM professional.

Standards:

NGSS Performance Expectations:

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	ETS1.B: Developing Possible Solutions • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	Non-applicable for the NGSS standard being assessed

Common Core State Standards:

ELA:

Common Core English Language Arts Standards: Writing: Grades 6-8:

Text Types and Purposes:

- CCSS.ELA-LITERACY.WHST.6-8.2
  Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
  - CCSS.ELA-LITERACY.WHST.6-8.2.E
    Establish and maintain a formal style and objective tone.
  - CCSS.ELA-LITERACY.WHST.6-8.2.F
    Provide a concluding statement or section that follows from and supports the information or explanation presented.

ITEEA Standards

Standard 9. Students will develop an understanding of engineering design.

- **Grade Level: 6-8**
  - **Benchmarks:**
    - **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum.
    - **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

Other Standards

New York State P-12 Science Learning Standards (NYSSLS):

- **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

New York State - Physical Setting /Earth Science Core Curriculum:

- **1.2g:** Earth has continuously been recycling water since the outgassing of water early in its history. This constant recirculation of water at and near Earth's surface is described by the hydrologic (water) cycle.
- **2.1c:** Weather patterns become evident when weather variables are observed, measured, and recorded. These variables include air temperature, air pressure, moisture (relative humidity and dewpoint), precipitation (rain, snow, hail, sleet, etc.), wind speed and direction, and cloud cover.
- **2.1d:** Weather variables are measured using instruments such as thermometers, barometers, psychrometers, precipitation gauges, anemometers, and wind vanes.

Measurable Student Learning Objectives:

- Students will be able to understand and describe the importance of measuring and recording the rainfall of a given area by utilizing student-made rain gauges to record rainfall over a period of weeks and will report their results in a table format
- Students will be able to communicate the necessity of having instruments that are standardized and calibrated correctly by creating their own rain gauges and then analyzing the functionality and drawbacks of their designs in a short analytic report.

Nature of STEM:

This lesson addresses the nature of science by emphasizing several aspects of the NOS including that scientific knowledge is based on empirical evidence, that science is a way of knowing and that science is a human endeavor. Our class be collecting empirical evidence in the form of rainfall data which will be driven by the understanding of students that science is a way of knowing. For scientists to learn about the natural world we are required to use of senses and make observations of the environment around us. The empirical data which we collect will further our investigations about precipitation related phenomena in the future therefore highlighting science as a way of knowing. Lastly, in regard to science is a human endeavor, the student scientists in my classroom like professionals are also encouraged to be accepting of new ideas, practice healthy skepticism and be comfortable with ambiguity that often presents itself during the course of an investigation.

Additionally, this lesson also addresses the nature of engineering. The NOE is highlighted by the implementation of the engineering and design process by the students as they create a solution to their problem, "How can we measure rainfall?" As science provides the way of exposing the hidden mysteries of the natural world (in this case the focus is rain) engineering provides a way in this lesson provides the means to execute an effective investigation.

Engaging Context/Phenomena:

Flooding, the world's most common natural disaster, is the engaging phenomena for this lesson. The NASA Earth Science Disasters Program has several informational videos on predicting and analyzing floods, one of which will be shown to students. The video will be preceded and followed by class discussions.

Data Integration:

Students will be collecting a month's worth of rainfall data using their own created rain gauges. This information will be used to evaluate, in part, the effectiveness of the rain gauges at the end of the month. Students will be comparing their daily rainfall data to a control rain gauge which was supplied by the citizen science non-profit group, Community Collaborative Rain, Hail and Snow Network or CoCoRaHS. In addition, the rainfall data which is collected will be submitted to CoCoRaHS for their initiative to measure and map rain, hail and snow measurements on the ground. CoCoRaHS is a partner with NASA's Global Precipitation Measurement (GPM) program.

Differentiation of Instruction:

- For students, whose IEP or 504 requires it and for students who are hearing impaired, written directions will be given to the students in addition to oral directions.
- Desks will be arranged in the room so that students with mobility impairments will have ample room to navigate the classroom.
- Electronic copies will be made available to all students including students with educational accommodations and students who have low vision or are blind to be used with a device with text to speech features or brail functionality, like a brail tablet.
- Directions will be repeated with clarity, consistency, and frequency to help students who have trouble focusing stay on task
- For English Language Learners, written materials will be provided in those students first languages

Real-life Connection:

The middle school in which the lesson takes place is in the City of Port Jervis. The city is located along the Delaware River in southern NY in the tri-state intersection of New York, New Jersey, and Pennsylvania. Port Jervis Middle School is a short five-minute walk to the bank of the Delaware and a minute walk from the Neversink River, a main tributary of the Delaware, which is directly behind the school's parking lot. Being next to a substantial body of water, the city has been historically frequented by floods. Taking accurate measures of rainfall in an area is an important preemptive measure in flood prediction. Given the frequency of floods it is essential for students to have an understanding of the factors which can lead to the most likely natural disaster which could affect the area, including the school, local businesses and the homes of students. The two social studies teachers in the 8th grade have agreed to provide a short mini-lesson in their classrooms on the history of flooding in Port Jervis to help facilitate engagement and connection for students.

Possible Misconceptions:

- Water only gets evaporated from the ocean or lakes.
- Water from the faucet comes directly from the ocean.
- The water cycle involves freezing and melting of water.
- Rain occurs because we need it.
- We can never have a water shortage because the Earth is over 70% water on the surface.

Lesson Procedure:

5E Model	5E Objectives
Engage	**Procedure:** The teacher will begin by presenting an image on the Smart Board for the Student's Do Now. Two questions will be posted underneath this picture for students to answer in their in-class science notebooks 1.) What do you think caused the situation shown in the picture above? 2.) Do you think this could ever happen in Port Jervis? As the students are writing their answers to the Do-Now's, the teacher will circulate through the room to keep students on task. After 3-5 minutes the teacher will call the class to attention and will then lead class discussion about student's answers for the Do-Now questions. Following the initial class discussion, the teacher will how the video, "Sizing Up Floods from Space: NASA Science for U.S. Flood Response" https://www.youtube.com/watch?v=wqLghXCMxBI Next the teacher will post two questions on the board and facilitate a Think-Pair-Share activity using the following questions: 1.) How could ***you*** predict a flood? 2.) Are there any questions that you have after watching the video or is there anything else you would like to learn/know about flooding? After the think-pair-share activity has concluded, the teacher will transition the lesson to the next stage.

	Modifications: See "Differentiation of Instruction" (Page 5); All appropriate accommodations will be made so that this part of the lesson will be accessible to all members of the classroom
	
	Standards Addressed:
	
	• **New York State - Physical Setting /Earth Science Core Curriculum:**
	  ○ **1.2g:** Earth has continuously been recycling water since the outgassing of water early in its history. This constant recirculation of water at and near Earth's surface is described by the hydrologic (water) cycle.
	  ○ **2.1c:** Weather patterns become evident when weather variables are observed, measured, and recorded. These variables include air temperature, air pressure, moisture (relative humidity and dewpoint), precipitation (rain, snow, hail, sleet, etc.), wind speed and direction, and cloud cover.
	  ○ **2.1d:** Weather variables are measured using instruments such as thermometers, barometers, psychrometers, precipitation gauges, anemometers, and wind vanes.
	
	Formative/Summative Assessments: Formative assessments will be provided by class discussion and by the teacher observing and listening to peer to peer interactions. The written Do-Now in student's in-class notebooks are collected and evaluated by the teacher bi-weekly and will serve as a tangible formative assessment.
	
	Resources: Picture of house underwater (see page 15); Video from The NASA Earth Science Disasters Program https://www.youtube.com/watch?v=wqLghXCMxBI

Explore	**Procedure:** The teacher will introduce the next part of the lesson at this stage. Students will be given a handout which will lead them through the construction of a student-built rain gauge. At this point the teacher will also have assigned students to their predesignated heterogenous learning group of three students. There will two parts to the "Explore" stage, which are detailed in the student handout. • **Part 1: Brainstorming:**

- During the brainstorming stage, the teacher will introduce the assignment and will then prompt students to begin brainstorming good ideas/qualities for a rain gauge. Before releasing students, the teacher will direct the students' attention to the front board which shows six types of rain gauges, three commercial and three homemade which the students can look to for inspiration. The teacher will then ask the student groups to brainstorm at least five ideas/qualities of a good rain gauge with their group, and remind them to keep the following questions in mind:
  - What is the primary function of a rain gauge?
  - Does the type of material the rain gauge is made of matter?
  - The materials that are available for construction
- Students will write down their qualities/ideas for their rain gauge and then draw a model for their rain gauge.
- The teacher will circulate the room and aid students where needed while they are working

- **Part 2: Construction:**
  - During the construction stage, students will construct their modeled rain gauges using the materials which have been supplied and the teacher will continue to circulate the room and aid students where needed while they are working.
  - The teacher will clarify that all rain gauges must meet two criteria:
    - The rain gauge can hold water without leaking
    - There are markings on the rain gauge to show change in water height (Markings must be made using the metric scale)
  - All other modifications, designs or stylistic choices will be left to the discretion of the students
  - The teacher will "ok" student groups when they are ready to move to the next part of the activity after they have completed their construction.

Modifications: See "Differentiation of Instruction" (Page 5); All appropriate accommodations will be made so that this part of the lesson will be accessible to all members of the classroom

Standards Addressed:

- **Standard 9. Students will develop an understanding of engineering design.**

	○ **Grade Level: 6-8** ▪ **Benchmarks:** • **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. • **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. **Formative/Summative Assessments:** Tangible formative assessment will be provided by the written ideas/qualities of a good rain gauge that student groups brainstormed. Informal formative assessment will occur as the teacher observes students and listens to peer to peer interactions during brainstorming and construction. **Resources:** The student handout, construction materials and the pictures of rain gauge examples shown on pages 16-19 will be needed for the Explore stage.
Explain	**Procedure:** During the explain stage, students will evaluate their rain gauges for two criteria and will have their handout stamped by the teacher after meeting both criteria • The rain gauge can hold water without leaking • There are markings on the rain gauge to show change in water height (Markings must be made using the metric scale) Next Students will complete a written post-construction evaluation which will focus on three questions: • Look at the various rain gauges that people are making. Which design do you think is the most efficient? Why? • If you were to redesign your rain gauge, what aspects of your gauge would you change? Why? • What did you find the most difficult about this activity?

	The teacher will circulate the room and aid students where needed while they are working. This will conclude the most time-consuming parts of the lesson. For the next 30 days students will be collecting rainfall data which will be detailed in the Elaborate stage.
	
	Modifications: See "Differentiation of Instruction" (Page 5); All appropriate accommodations will be made so that this part of the lesson will be accessible to all members of the classroom
	
	Standards Addressed:
	
	• ETS1.B: Developing Possible Solutions
	  ○ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
	• CCSS.ELA-LITERACY.WHST.6-8.2
	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
	  ○ CCSS.ELA-LITERACY.WHST.6-8.2.E
	Establish and maintain a formal style and objective tone.
	  ○ CCSS.ELA-LITERACY.WHST.6-8.2.F
	Provide a concluding statement or section that follows from and supports the information or explanation presented.
	
	Formative/Summative Assessments: The meeting of the previously outlined criteria for the rain gauge will serve as formative assessment. Summative assessment will be supplied by the paragraph where students are writing their post-construction evaluations of their designed rain gauge.
	
	Resources: The student handout, construction materials and access to running water will be needed for this stage.

Elaborate	**Procedure:** During the elaborate stage, students will be placing their rain gauges outside at either their home or a pre-determined location at school where the gauges will remain undisturbed. The gauges will remain in place for one month. Each day students will record in the table provided in

	the student handout the date, time of day, precipitation, and weather. The teacher will provide the students precipitation data from a CoCoRaHS rain gauge and data from the GPM.
	
	In-class discussions regarding the rain gauges and precipitation may occur spontaneously over the course of the month and can be facilitated as needed at the discretion of the teacher.
	
	Modifications: See "Differentiation of Instruction" (Page 5); All appropriate accommodations will be made so that this part of the lesson will be accessible to all members of the classroom
	
	Standards Addressed:
	
	• **Standard 9. Students will develop an understanding of engineering design.**
	  ○ **Grade Level: 6-8**
	  ▪ **Benchmarks:**
	  • **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.
	• **New York State - Physical Setting /Earth Science Core Curriculum:**
	  ○ **2.1d:** Weather variables are measured using instruments such as thermometers, barometers, psychrometers, precipitation gauges, anemometers, and wind vanes.
	
	Formative/Summative Assessments: Completion of data collection by the student and in-class discussions will serve as formative assessment.
	
	Resources: student rain gauges, a CoCoRaHS rain gauge and data from the GPM

Evaluate	**Procedure:** During the evaluate stage, students will complete a written post-data collection evaluation which will focus on four questions: • How did the data that you collected compare to the data from the CoCoRaHS data? GPM data? • What were some shortfalls or errors in your design that you think may have led to variations between your data and the CoCoRaHS or GPM data? • What outside factors aside from the rain gauge itself may have led to the variations in the data collected by you and the CoCoRaHS rain gauge or the GPM?

	• After collecting a month's worth of precipitation data, are there any modifications that you would make to your rain gauge?
	
	The teacher will circulate the room and aid students where needed while they are working.
	
	Modifications: See "Differentiation of Instruction" (Page 5); All appropriate accommodations will be made so that this part of the lesson will be accessible to all members of the classroom
	
	Standards Addressed:
	
	• ETS1.B: Developing Possible Solutions
	  ○ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
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	  ○ CCSS.ELA-LITERACY.WHST.6-8.2.E
	Establish and maintain a formal style and objective tone.
	  ○ CCSS.ELA-LITERACY.WHST.6-8.2.F
	Provide a concluding statement or section that follows from and supports the information or explanation presented.
	
	Formative/Summative Assessments: The written post-data collection evaluation will serve as a summative assessment for the lesson.
	
	Resources: student handout

Teacher Background:

To properly execute this lesson, it would beneficial for the instructor to:

- Have a strong understanding of the engineering and design process
- Have a good background with meteorological sciences
- Be familiar with the global, nationwide, and local organizations which collect weather data for those affected areas

- Be efficient and orderly in helping students to collect their rainfall data
- Be able to lead class-discussions and facilitate peer interactions and conversations

This lesson was modified in part from two lessons on rain gauges developed by NASA's Global Precipitation Measurement Mission. The following links lead to those lessons.
https://gpm.nasa.gov/education/sites/default/files/document_files/Janney%20Rain%20Gauge%20lesson%20plan.pdf

https://gpm.nasa.gov/education/sites/default/files/interactive_files3/Rain%20Gauge%20Design%20Challenge-%20Instructions.pdf

Do Now Picture:

Photo by: Scott Yandell; https://www.kjrh.com/news/local-news/photos-flooding-storm-damage-in-oklahoma

Rain gauges to show students for inspiration:

https://www.123rf.com/photo_100212071_meteorology-with-rain-gauge-in-garden-measurement-of-precipitation.html

https://sites.google.com/site/msswcgi/the-inquiry-cycle/step-2-collecting-data/-measuring-precipitation-rain-gauge

https://www.gearhungry.com/best-rain-gauge/

http://cdn.communityplaythings.com/-/media/images/cpus/resources/article-photos/2017/rain-gauge/rain-gauge-3.jpg?h=244&w=400&la=en&d=20170404T150714Z

https://cdn.instructables.com/FDB/WRWF/GS3BEWD5/FDBWRWFGS3BEWD5.LARGE.jpg?auto=webp&frame=1&fit=bounds

https://cdn.instructables.com/FPX/3VZ6/GS3BEWD2/FPX3VZ6GS3BEWD2.LARGE.jpg?auto=webp&frame=1&fit=bounds

Name: _____ Period: _____

Have You Ever Seen the Rain?

Now that we have discussed the importance of measuring rainfall, you will construct your own rain gauge with your group. You will be using the data collected from this rain gauge as a part of our Weather Reporting Project.

Part 1: Brainstorming

During this part you will be brainstorming the qualities needed for a good rain gauge.

Look at the types of the various types of rain gauges that are shown on the Smart Board for inspiration when designing the model for your rain gauge.

Keep the following questions in mind:

- What is the primary function of a rain gauge?
- Does the type of material the rain gauge is made of matter?

Keep in mind the materials made available to you for construction including:

- A wide assortment of plastic and metal containers
- Tape (Scotch/Duck)
- Plastic graduated cylinders of different sizes
- Metric rulers
- Watering-can for simulating rain
- Scissors
- Measuring tape

There are other miscellaneous materials/extras in the back located with the items listed above.

Feel free to go look at the materials available.

Write Your Ideas Below. Come up with at least five ideas/qualities for a rain gauge:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Name: _____ Period: _____

Draw a Picture of Your Design Below:

- Be sure to include labels and descriptions if needed

Call me over when you are done, and I will clear you to move to the construction stage.

Part 2: Rain Gauge Construction

Using the materials provided in the back of the room you will construct a rain gauge that meets the following criteria:

- The rain gauge can hold water without leaking
- There are markings on the rain gauge to show change in water height (Markings must be made using the metric scale)

All other modifications, designs or stylistic choices are up to you. When you have completed construction of your rain gauge, call me over and I will clear you to move on to Part 3. If you need any help during construction I will be around to help.

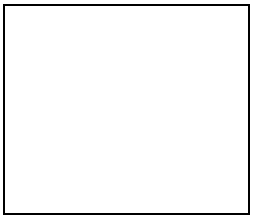
Good Luck! 😊

Name: _____ Period: _____

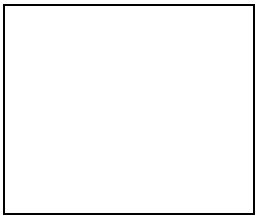
Part 3: Post-Construction Evaluation of Your Rain Gauge

Call me over and I will provide the water so you may test your rain gauge. I will stamp your paper for the two criteria listed below. If your rain gauge does not meet the criteria below, you must return to Part 2 and then re-try after making modifications to your design.

- The rain gauge can hold water without leaking



- There are markings on the rain gauge to show change in water height (Markings must be made using the metric scale)



Answer the following questions in a well-constructed paragraph. Be sure to cite specific examples from either your experience during the activity or with reference to other groups.

- Look at the various rain gauges that people are making. Which design do you think is the most efficient? Why?
- If you were to redesign your rain gauge, what aspects of your gauge would you change? Why?
- What did you find the most difficult about this activity?

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Name: _____ Period: _____

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Part 4: Taking Rainfall Measurements

- Set your container outside for the allotted period of time. Do not forget to leave the container in an open area so that nothing is blocking the rain from getting in!
- Every time you take a measurement, record the amount of rain, time of day, and what the weather was like.
- I will provide the CoCoRaHS and GPM Data for comparison to the precipitation measured by your rain gauge for each day.

Date	Time of Day	Precipitation	Weather	CoCoRaHS Data	GPM Data

Name: _____ Period: _____

Date	**Time of Day**	**Precipitation**	**Weather**	**CoCoRaHS Data**	**GPM Data**

Name: _____ Period: _____

Part 5: Final Evaluation:

Answer the following questions in a well-constructed paragraph. Be sure to cite specific examples from either your experience during the activity or with reference to other groups.

- How did the data that you collected compare to the data from the CoCoRaHS data? GPM data?
- What were some shortfalls or errors in your design that you think may have led to variations between your data and the CoCoRaHS or GPM data?
- What outside factors aside from the rain gauge itself may have led to the variations in the data collected by you and the CoCoRaHS rain gauge or the GPM?
- After collecting a month's worth of precipitation data, are there any modifications that you would make to your rain gauge?

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This activity was modified in part from two lessons on rain gauges developed by NASA's Global Precipitation Measurement Mission. The following links lead to those lessons.
https://gpm.nasa.gov/education/sites/default/files/document_files/Janney%20Rain%20Gauge%20lesson%20plan.pdf

https://gpm.nasa.gov/education/sites/default/files/interactive_files3/Rain%20Gauge%20Design%20Challenge-%20Instructions.pdf

Name: _____ Period: _____

Writing Rubric for Post-Construction Evaluation and Final Evaluation					
	Excellent (4)	**Satisfactory (3)**	**Emerging (2)**	**Below Satisfactory (1)**	**Points Earned**
Focus	Successfully answers all the prompting questions listed with clear purpose to create a very effective evaluation	Answers almost all the prompting questions listed with clear purpose to create an effective evaluation	Does not answer many of the prompting questions listed with clear purpose and creates a somewhat effective evaluation	Unsuccessfully answers or does not answer all the prompting questions listed with clear purpose and creates an ineffective evaluation	_____
Organization	Correctly uses a topic and closing sentence, and effectively transitions ideas, and provides supporting evidence	Does not do one of the following: use a topic and closing sentence, effectively transition ideas, or provide supporting evidence	Does not do two of the following: use a topic and closing sentence, effectively transition ideas, or provide supporting evidence	Needs improvement using a topic and closing sentence, and ineffectively transitions ideas, and does not provide supporting evidence	_____
Grammar & Use of Vocabulary	Consistently has proper word/vocabulary usage, good sentence structure, and subject/verb agreement	Almost always has proper word/vocabulary usage, good sentence structure, and subject/verb agreement	Sometimes has proper word/vocabulary usage, good sentence structure, and subject/verb agreement	Needs improvement making proper word/vocabulary choices, has poor sentence structure, and has poor subject/verb agreement	_____
Spelling & Capitalization	Consistently spells words correctly, begins sentences properly and capitalizes proper nouns, adjectives, etc.	Almost always spells words correctly, begins sentences properly and capitalizes proper nouns, adjectives, etc.	Sometimes spells words correctly, begins sentences properly and capitalizes proper nouns, adjectives, etc.	Needs improvement spelling words correctly, beginning sentences properly and capitalizing proper nouns, adjectives, etc.	_____
Punctuation	Consistently ends sentences correctly and accurately uses apostrophes, commas, etc.	Almost always ends sentences correctly and almost always uses apostrophes, commas etc. accurately	Sometimes ends sentences correctly and sometimes uses apostrophes, commas etc. accurately	Needs improvement ending sentences correctly and inaccurately uses apostrophes, commas etc.	_____
			Total Points: _____/20		