Wacky Weather

An integrative science unit combines science content on severe weather with the engineering design process.

By Amy Sabarre and Jacqueline Gulino

What do a leaf blower, water hose, fan, and ice cubes have in common? Ask the students who participated in our integrative science, technology, engineering, and mathematics (I-STEM) education unit, Wacky Weather, and they will tell you "fun and severe weather"—words you might not have expected! The purpose of this unit was to interweave science content on severe weather with the engineering design process. The unit included concepts such as properties of materials, connections to architecture, and the relevance of engineering to our lives.

The engineering design process is the crux of integrative STEM education. Integrative STEM education is "the application of technological/engineering design-based pedagogical approaches to intentionally teach content and practices of science and mathematics education concurrently with content and practices of technology/engineering education" (Sanders and Wells 2010). This unit will provide an example of intentional integration of the *Next Generation Science Standards (NGSS)* core ideas and practices (Achieve Inc. 2013).

Designing an Integrative Science Unit

In our school district, the STEM coordinator, elementary teachers, and specialists collaborated to create a model I-STEM education program that gives all students access to the engineering design process based on science concepts. Goals for this unit included:

- conducting and applying research
- analyzing charts and graphs of weather data to determine type of severe weather
- planning, creating, testing, and evaluating their team's design
- identifying weather instruments and interpreting the measurements

True to the definition of integrative STEM education, each unit integrates multiple disciplines so students see the connections between content areas. Units are planned according to the four-part design process: plan, create, check, and share. This simplified engineering/technological design process better fits the elementary realm because it is easy for young children to understand and use. Since all students in our school system participate in the I-STEM units, it is important that our units support the large English language learner population in our district. We are very purposeful in including research-based best practices, such as language objectives, sentence frames, graphic organizers, and strategies to scaffold instruction.

The Design Brief

The Wacky Weather I-STEM unit was developed for teachers to use in their classrooms to supplement weather lessons already being taught. Based on science standards, this week-long unit follows the design brief steps of plan, create, check, and share.

Background

In third grade, students study weather and focus on a technical understanding of the tools and methods used to forecast future atmospheric conditions. This unit was designed to follow classroom instruction on weather phenomena, weather measurements, and meteorological tools (performance expectations: Earth's systems 3-ESS2-1 and 3-ESS3-1; Engineering design 3-5-ETS1-1 and 3-5-ETS1-2 [Achieve Inc. 2013; see Internet Resources]). Students worked in teams to analyze weather data, predict forthcoming weather phenomena and fortify a previously built structure to withstand an impending "storm."

There are also several Common Core math standards integrated into the lessons, including metric measurement, and collecting, organizing, displaying, and interpreting data from a variety of graphs. A large number of Common Core language arts standards were also incorporated such as using effective oral communication strategies, expanding vocabulary when reading, demonstrating comprehension of nonfiction text, and writing for a variety of purposes.

Plan

In the plan phase, students gained the background knowledge needed to be able to complete the design challenge. Observing, exploring, researching, brainstorming and drawing designs all took place in this phase of the process. On day 1, the students were hooked by an opening activity in which they wrote in their design notebook about a time they had personally experienced severe weather (crosscutting concept: cause and effect, 3-ESS3-1 [Achieve Inc.

FIGURE 1.

Severe weather research sheet.

Complete the chart below using information you find on the websites about each type of storm.

	Tornado	Hurricane	Thunderstorm
Wind			
Precipitation			
Air Pressure			
Other Characteristics			

2013; see Internet Resources]). The timing could not have been better because over the summer a large storm with high winds had knocked down many trees and power lines. Quite a few students wrote about this event and what they observed. This activity naturally differentiated itself because some students wrote a few sentences, others a full paragraph and a few drew pictures and explained to the teacher verbally. Then students were given time to share with an elbow partner and a few shared their story with the entire class.

Next the students watched three video clips to review the types of severe weather included in the science standards. The clips focused on thunderstorms, tornadoes, and hurricanes and visually demonstrated the characteristics of each. After students turned and talked with a partner, the teacher recorded characteristics of each type of weather in a whole class chart. The teacher posed questions and tasks such as, "Compare and contrast each type of severe weather." One student responded, "Each storm had wind but the wind made different things happen to the houses."

After that, students worked in groups of two on iPads and/or laptops to conduct research using preselected websites that were differentiated by reading level and took notes (see NSTA Connection for a list of websites). Websites were selected based on student accessibility and reading level, engaging content and the specific content needed for the student research. The websites were reviewed by

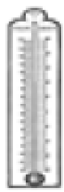
FIGURE 2.

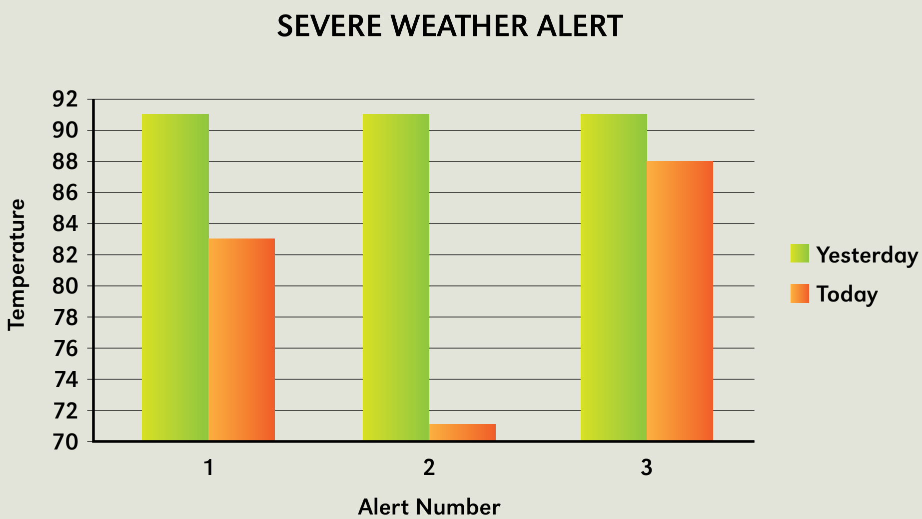
Wacky Weather rubric.

Wacky Weather Rubric	Student	Teacher
Group Work		
We only talked about our I-STEM project.		
We listened to each other.		
We used kind words.		
Total	/3	/3
Product		
We included recycled materials.		
Our structure was < 40 cm wide.		
Our structure was < 30 cm tall.		
Our structure included a base, four walls, and a roof.		
We included one idea from each person in our design.		
We redesigned our structure to protect it from severe weather.		
Total Points	/6	/6
Presentation		
I made eye contact with the audience.		
I spoke clearly and the audience could hear me.		
I stood up straight.		
Total	/3	/3
Total Points		

FIGURE 3.

Severe weather alert chart.

	Yesterday’s Forecast	Severe Weather Alert 1	Severe Weather Alert 2	Severe Weather Alert 3
	5 mph	111 mph	164 mph	30 mph
	980 mb	964 mb	900 mb	920 mb
	0 in	9 in	½ in	2 in
	see graph	see graph	see graph	see graph
Cloud cover	cirrus clouds	stratus clouds	funnel cloud	cumulonimbus
Precipitation	none	heavy rain	none	possible hail



several teachers. Students needing additional support had the research material read aloud to them. All others worked with a partner and recorded information in the data table on characteristics of one type of severe weather (see Figure 1, p. 38, and NSTA Connection). At the end of class, students met in groups to share their notes. The students were excited to share with each other about each storm. One animatedly exclaimed, "A tornado has 300 mph winds! That's faster than a racecar!"

During the second day of the unit, students reviewed the four weather instruments by completing a matching activity (see NSTA Connection). After demonstrating an understanding of what each instrument was used for, the teacher led an analysis of various charts and graphs with data from weather instruments (see NSTA Connection). Students applied what they had researched and made connections between weather phenomena and the corresponding data weather instruments would measure. One student noted, "Zero centimeters on the rain gauge means there was no precipitation and since the anemometer read five meters per hour, there was very little wind."

Students were then introduced to the design challenge, constraints, and rubric (Figure 2, p. 39; see NSTA Connection). Their design constraints were as follows:

Design Challenge: Your team will design and create a structure that will withstand a given form of severe weather (thunderstorm, hurricane, or tornado).

Constraints:

- Must use recycled materials
- Must be < 40 cm wide
- Must be < 30 cm tall
- Must have a base, four walls, and a roof
- Must include one idea from each member of your team

Students were allowed time to ask questions about the challenge or constraints. Many students asked questions about the measurement portion to clarify what was meant by wide or tall. Students also asked questions like, "Do we have to have windows or a door?" The teacher referred the students back to the design challenge and asked if this was a constraint. When the students saw that it was not, the teacher then asked, "Do most structures have doors or windows?"

Next, the materials were presented so the students could see what was available and begin brainstorming the design of their structure. Materials included cardboard, Styrofoam, craft sticks, tape, glue guns, and a variety of recycled materials such as water bottles, paper towel rolls and flattened cereal boxes. Students should use caution when cutting materials and using glue guns. Goggles are to be worn during the investigation, cleanup, and hand washing. Close teacher supervision is strongly advised.

Celebrating the test

CAUTION

The students brainstormed in groups of three and drew a team plan for their structure. They labeled their drawing indicating the materials they planned to use. Each team was reminded to include at least one idea from each team member and to meet with the teacher to get approval for their design plan (disciplinary core ideas: Defining and delimiting engineering problems ETS1.A, Developing possible solutions ETS1.B) (Achieve Inc. 2013; see Internet Resources).

Create

On the third day, students gathered materials and began to build their structure. As students built, the teacher circulated asking open-ended questions such as, "Tell me about your design." This elicits responses that show the teacher areas where guidance or further questioning is needed. For example, "How will your structure support its roof?"

Prior to the end of class, a scrolling weather alert came across the interactive white board and each group of students was given a column in the severe weather alert chart

Keywords: Forecasting the weather
www.scilinks.org
Enter code: SC101301

(Figure 3, p. 40; see NSTA Connection). Based on this information, the groups had to determine what type of severe weather the information in their column represented. The teacher modeled how to interpret weather data and determine the type of severe weather using an example. Each group met to discuss their data from the severe weather alert and referred to previous pages in their design notebook that held their research from the previous day to determine their storm type. The notebook also contained their meteorological tools matching and their group brainstorming. Next they brainstormed potential problems their structure might encounter and safety measures they could add to ensure their structure would withstand the severe weather. After discussing, they worked as a team to draw a plan of the modifications they would make to their structure (disciplinary core idea: Developing possible solutions ETS1.B) (Achieve Inc. 2013; see Internet Resources).

As the teacher approved each groups' redesign, the students gathered more materials and modified their structures. Students were again asked to return to the criteria and revisit the weather conditions for their type of severe weather. As students built, the teacher moved around the room and asked questions to prompt thought about a specific problem that might occur. For example, the teacher noticed a team with a very light structure and asked them to think about the tornado video they had watched. One student in the team said, "We don't want it to blow away, we have to hold it down." Then all the team members suggested possible ways to anchor their structure. The students needed all of the class period to modify their structures. Several strategies that our students used during this time were filling water bottles to create weight inside their house, covering their structure with waterproof materials, such as pieces of a plastic trash bag, and placing stakes around the outside to penetrate the ground so the structure would not blow away. Students should use caution when placing stakes because there is the potential for a stake to injure them. Teachers should model pushing a stake through a material by pushing away from their body and carefully supervise students during this process (disciplinary core idea: Engineering and design, ETS1.B) (Achieve Inc. 2013; see Internet Resources).

Check

In order to simulate severe weather, a variety of tools were used on the fourth day to test the stability of the structures. Leaf blowers were used at close range to simulate the power of the wind in a tornado, and at a distance of thirty centimeters for the hurricane. Teams that determined their severe weather was a tornado also had their homes pelted with ice cubes to simulate hail. Precipitation was further simulated with a water hose for a hurricane and spray bottles filled with water for a thunderstorm. Teachers should closely supervise the testing and should operate all water hoses, fans, and blowers. Electricity and water should be separated. This was extremely engaging for the students and cheers and laughter rang out throughout the testing. Picture three girls laying one hand on top of each other and cheering, "3, 2, 1—go, Team Hurricane!" Then they all throw their hands in the air as if they are at a sporting event. Another group whose structure withstood a "tornado" shouted, "We did it! It survived!"

To facilitate sharing, each group's test was recorded on video. During the testing, teachers continued to ask the groups questions about what they predicted would happen and what they observed. Groups were encouraged to record any problems their structure had and to make the connections between the leaf blower or fan and the force of wind for each type of severe weather.

Share

Allowing students time to communicate their ideas and observations is an essential component of the design process. On day 5, teams met to discuss their results and different modifications they could have made to protect their structure from severe weather. Sentence frames were included in the lessons for students who needed them to organize their thinking. Each team watched their video to observe any additional factors that might have influenced the stability of their structure.

Before presenting their results and reflections with the class, they referred to the rubric. Each team then shared with the class, pointing out unique features of their design, aspects that protected their structure from the severe weather, and thoughts on how they could further improve it. The other students enjoyed watching the video clips and actively responded by posing questions and offering suggestions (disciplinary core idea: Optimizing the design solution, ETS1.C) (Achieve Inc. 2013; see Internet Resources).

Model What You Teach

We have offered an overview of one integrative STEM education unit, which can be adapted to different grade levels. Integrative STEM education requires creative thinking, problem solving, application of knowledge, and collaboration. The process we used with the students is also modeled with teachers in the design and implementation of the units. At the conclusion of the unit, teachers met to reflect on their observations of student performance and engagement and to analyze student design notebooks. The students had an opportunity to self-assess their work using the Wacky Weather rubric. Then teachers evaluated each design notebook and provided feedback. Based on the evaluation of student work across the grade level, 90% of the students understood the characteristics of severe weather and were able to recognize, name, and explain the types of weather measurements for each instrument.

In addition to reflecting on student performance, teachers also reflected on the lessons and their instructional delivery. When our teachers met to debrief, the overwhelming response centered on the high level of student engagement. They also commented on the noticeable transfer of knowledge that occurred as a result of analyzing the weather data and the range of possible solutions and creativity that were demonstrated by the students. Most of the suggestions that arose were about tailoring the lessons to meet the needs of individual classrooms. Many teachers shared how they had implemented the share portion of their unit with their students. While we provided the lessons sequentially, teachers often suggested bringing in parts of the lesson during other content times to allow more time to complete the unit. The integrated curriculum allows for much flexibility during the school day.

All students should have access to high-quality, rigorous, and relevant science instruction. It is this vision that allows our district to continue expansion of STEM programs. The following quote from *Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation's Human Capital* encompasses this vision clearly. "The possibility of reaching one's potential should not be met with ambivalence, left to chance, or limited to those with financial means. Rather, the opportunity for excellence is a fundamental American value and should be afforded to all" (National Science Board 2010). We believe I-STEM education provides this opportunity. ■

Amy Sabarre* (asabarre@harrisonburg.k12.va.us) *is a PK–12 STEM coordinator and PK–5 science coordinator at Harrisonburg City Public School in Harrisonburg, Virginia. Jacqueline Gulino is an enrichment specialist at Keister Elementary School in Harrisonburg, Virginia.

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National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

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Internet Resources

Downloadable Smart Board Activities:
https://docs.google.com/a/harrisonburg.k12.va.us/file/d/0B_dUrNTXooKGVjYtX2xQUXZyUkE/edit

NGSS Table: 3-ESS2 Earth's Systems
www.nextgenscience.org/3ess2-earth-systems

NGSS Table: 3-ESS3 Earth and Human Activity
www.nextgenscience.org/3ess3-earth-human-activity

NGSS Table: 3-5-ETS1 Engineering Design
www.nextgenscience.org/3-5ets1-engineering-design

NSTA Connection

Visit *www.nsta.org/SC1310* for an internet safety note, a list of preselected severe weather websites, a severe weather research sheet, weather instruments matching activity sheet, sample chart and graph with data from weather instruments for student analysis, rubric, and severe weather alert chart.