Scaffolds for scientific explanations

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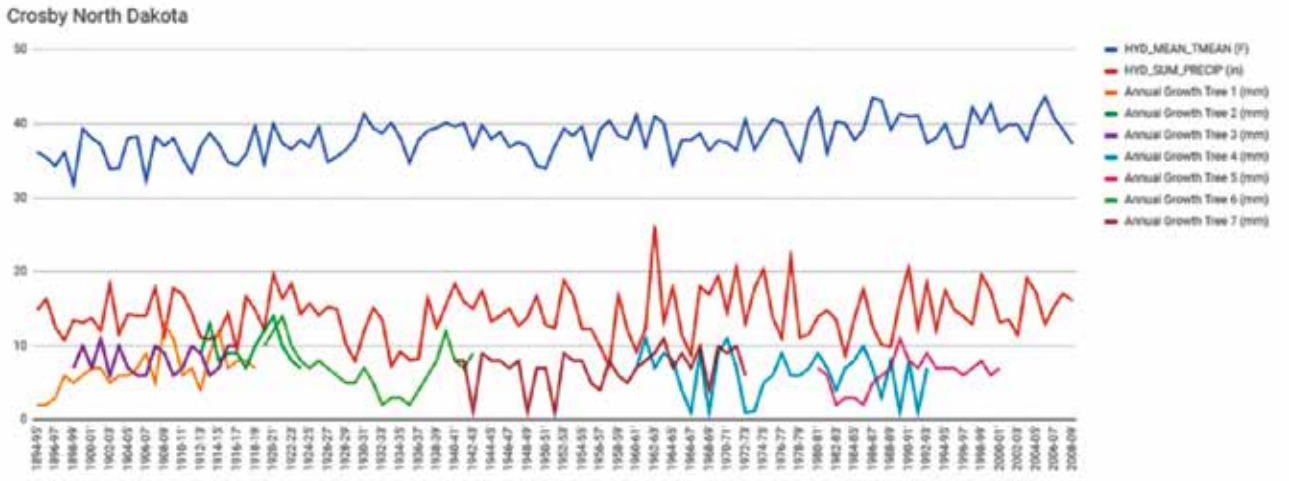
Many of the *Next Generation Science Standards* (*NGSS*) performance expectations (PEs) require students to use the science and engineering practice (SEP) of Constructing Explanations and Designing Solutions. When setting expectations for students' performance with constructing explanations, consult Appendix F of the *NGSS* (see sidebar, p. 32). The components clarify the level of skill students must demonstrate before entering middle school and define the target level of skill development for students as they leave for high school. The following is an example of an activity that guides middle school students through the formation of a scientific explanation.

What is a scientific explanation?

A scientific explanation has three parts: a claim, evidence, and reasoning. *Claims* are statements answering a question or providing a conclusion to the original problem. *Evidence* can be data from investigations, observations, or research or archived sources supporting the claim. *Reasoning* uses scientific principles to justify the data as evidence.

It has been my experience that students struggle with the evidence and reasoning parts of the scientific explanation. Specifically, they have trouble providing the relevant data that can be used as evidence. Also, they have difficulty incorporating appropriate scientific concepts into their reasoning.

FIGURE 1: Student graph of tree-ring growth data for Crosby, North Dakota



Recently, my students constructed a scientific explanation based on evidence obtained from their measurement data and a database. Students attempted to explain how temperature and precipitation affect tree growth. As part of the task, students measured the width of tree rings, which were simulated on paper instead of tree cookies, and entered the data into a spreadsheet. Using their data coupled with data from United States Historical Climatology Network database, students generated a graph using Google Sheets (Figure 1) that they analyzed for trends in the data set and relationships between variables.

A simple approach to data analysis for students to use is HLPA (High, Low, Pattern, and Anomaly). First, I ask students to check whether the high points (H) for tree-ring width correspond to high points (H) in precipitation. Students typically answer, "Several do." Students write this observation on a piece of paper or in their science notebooks. Next, students look for high points (H) in the tree-ring width corresponding to high points (H) in temperature and make more observations on their paper or notebook. Then they compare low points (L), look for a pattern (P), and check for anomalies (A), adding more observations to their paper or notebook.

Once students complete HLPA, provide them a writing table (Figure 2). Figure 2 guides students by scaffolding the writing process by first asking them to write the investigation question. For this investigation, the question was, "What is the relationship between tree-ring width and precipitation?" Next, students provide evidence based on data from the investigation, observations, or research or archived sources. For the tree-ring

FIGURE 2: Table to assist students with explanations

Question:	
Evidence: Data from investigations, observations, or research or archived sources	**Science concepts:** Answers the questions, "Why do the data count as evidence?" and "What science explains why we were able to make the observation?"
Claim: A statement that answers the question	

FIGURE 3: Writing frame and sentence starters

What you need to write	Sentence starters
Support your claim with evidence from your investigation[s], reading, videos, etc. Use all data that counts as evidence. Include both qualitative and quantitative evidence. Units should be used with quantitative evidence.	I think this because ... For example ... For instance ... The evidence is ... The data show ... The data provide evidence that ...
Add support from additional evidence you have from your investigation[s], reading, videos, etc.	In addition, ... Furthermore, ... Also, ...
Add scientific reasoning, if required. These are scientific principles that link the claim and evidence. It tells why the data counts as evidence. Be sure to include at least one crosscutting concept.	[evidence] ... because [science concept] ... I think this because ... Using [insert crosscutting concept] explains why or how ...

investigation, students use the observations made while analyzing data using HLPA. To be considered as evidence, the observations must be related to the question. For each observation, students must add the science concept to the table.

When filling out the graphic, students ask, "What science concept?" I then ask students, "How did we know the period of years the tree was alive?" Students reply, "Tree rings are a regular pattern marking yearly growth." I point out that their answer is the science behind why we can use tree rings to match historical weather data to a specific ring. I follow up with two general questions for students to use: "Why did the data count as evidence?" and "What science explains why we were able to make the observation?" (Figure 2).

After students complete the evidence and science concept sections, they write a claim. Students write a claim after those sections to develop the idea that claims are based on evidence. Once the table is complete, they are ready to write their explanation. Students have the option of either writing their explanation on the back of their paper before typing or heading directly to the computer to type their explanation.

Seeing the related science concept adjacent to the evidence helps students understand what it means to justify a claim. However, students tend to write a sentence for the evidence and a sentence for the science concept without bridging the two ideas together. To assist students with writing a scientific explanation, provide students with simple sentence starters to help them convey their thinking with clarity (Figure 3). The chart provides a framework for students to organize their writing and helps them construct sentences. Initially, all students use the chart as a scaffold. With practice, students begin to work independently.

Appendix F (NGSS Lead States 2013)

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- **Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.**
- **Construct an explanation using models or representations.**
- **Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**
- **Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.**
- **Apply scientific reasoning to explain how the data or evidence support the explanation or conclusion.**

Conclusion

Writing clear scientific explanations is no easy task for middle school students. Using HLPA and sentence starters provides necessary scaffolds for analyzing data and writing a scientific explanation. The end result is improved student success with communicating their thinking in written form. ●

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REFERENCES

NGSS Lead States. 2013. Next Generation Science Standards: For states, by states. Appendix F: Science and Engineering Practices in the NGSS. Washington, DC: National Academies Press. *http://bit.ly/2C3Ttft*.