IMPROVING REASONING AND INTRODUCING DATA LITERACY SKILLS TO K-12 STUDENTS

• Abigail Kamrowski • Master In Teaching • Elementary Education • Washington State University • Pullman, Washington •

HOW CAN WE IMPROVE STUDENTS' REASONING SKILLS WITH DATA?

Inquiry Statement: The Claim-Evidence-Reasoning process is a method I can use in my own classroom to improve students' reasoning abilities while teaching next year. I can qualitatively study the effects of using this structure while using what I have learned about Educational Data Literacy to bolster my content delivery and instruction to improve student reasoning.

T-PEP alignment: Criterion 4: Providing clear and intentional focus on subject matter content and curriculum.
Descriptor: Content knowledge; using content area knowledge, standards, appropriate pedagogy and resources to design and deliver curricula and instruction for student learning.

Purpose: Educational shortcomings in quantitative and information literacy are becoming more problematic as science and society increasingly rely on quantitative information found in data sets.[9] To prevent this, it is recommended that the connections between science and mathematics be made as early as possible and that quantitative skills be integrated across disciplines.[9] The reform of national K–12 science standards stemmed from realization that students need to learn core scientific knowledge and actively practice principles and skills simultaneously.[9] "Students can't just memorize facts to solve problems in today's fast-paced world. They must be creative problem solvers."[12]

HIGHLIGHTED FACTS

- Quantitative Reasoning is a way of viewing the world through "mathematical eyes" and approaching everyday problems with logical reasoning.[8]
  - The development of reasoning skills to make claims from evidence has become a priority[9] in careers filled with datafication.
- To ensure that quality science education is accessible to all students, the Next Generation Science Standards intend to equip students to think critically, analyze information, and solve complex problems.[7]
- Data literacy for teaching is "the key ability to transform information into actionable instructional knowledge and practices."[8] Educational research supports that it is an area of improvement for the existing workforce.
- Claim-Evidence-Reasoning is a current structure for constructing written explanations in science and other core subjects.
- Content needs to be practically applied. Connecting science to learners' everyday place-based context makes it more accessible, particularly for culturally and linguistically diverse students.[3]
  - Most class periods should provide opportunities for students to apply ideas to real-world contexts.[7]
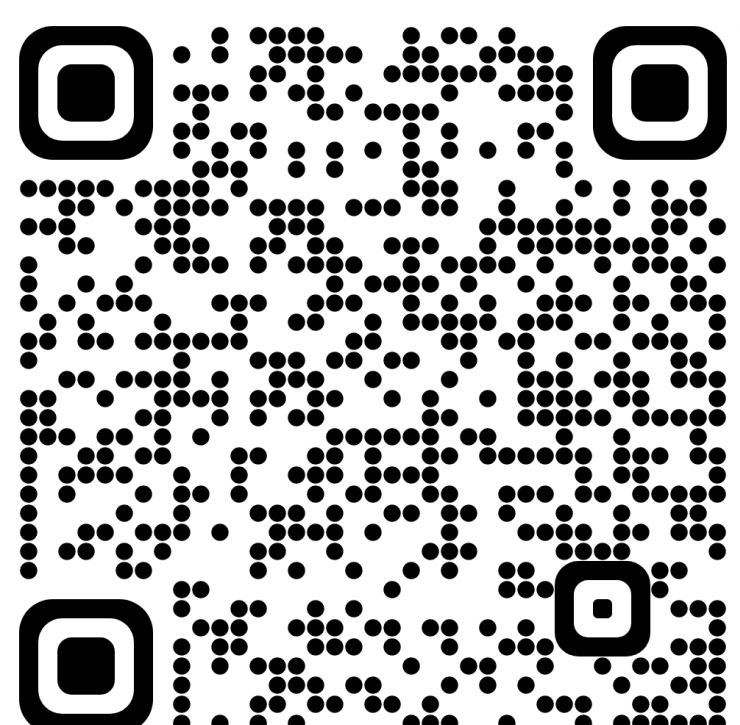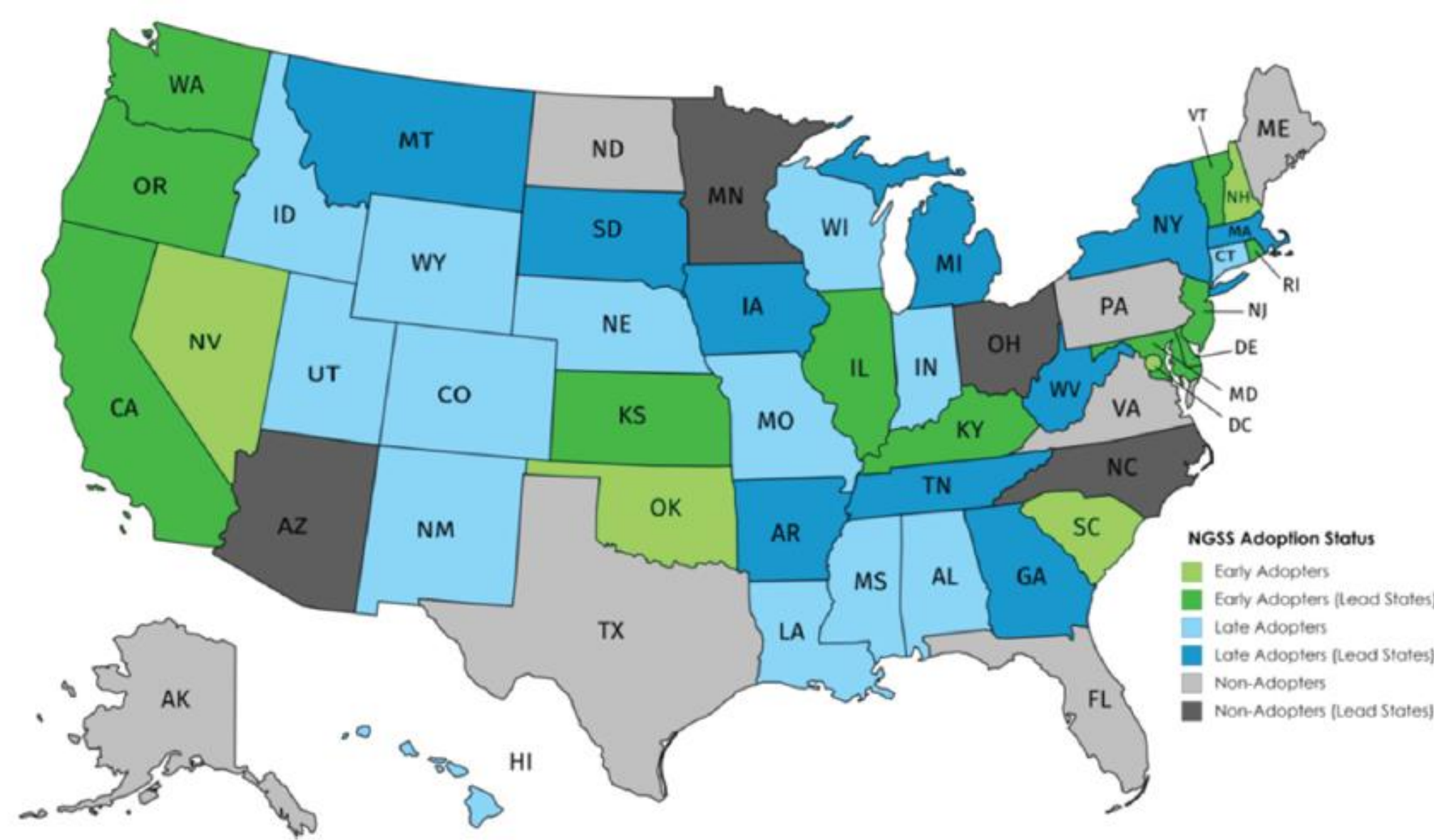
Figure 2. Adoption of NGSS or NGSS-like standards – August 2018.

ALIGNMENT WITH STANDARDS

- Students in the United States "consistently lag in science education outcomes."[8] Standards support the effort to bolster America's edge in an increasingly global economy.[7]
- Educational standards and reform such as the Next Generation Science Standards (NGSS) focus on students' ability to analyze and interpret data, use mathematical thinking, and communicate arguments based on evidence.[9]
- The NSSME provided baseline data for NGSS implementation in 2013.[10] They assessed the standards in 2018 and found:
  - Less than 1 in 2 secondary classes and 1 in 4 elementary classes emphasized students learning how to do science.[10]
  - Students most often engaged in components of science related to conducting investigations and analyzing data, although even these are infrequent.[10] Students were occupied even less frequently in activities related to modeling, explanation, and argumentation.[10]
  - Very few of the surveyed classes allowed students weekly practice of these skills.[10]
- In NGSS adopting states, half of science courses using commercial materials depended on those published before 2009.[10]
  - Old materials were almost certainly not aligned with the NGSS: leaving teachers to change instruction, assemble their own materials or adapt the ones designated for them.[10]
- Educators agree that science should be taught as an "active process: instead of students memorizing facts in textbooks, the focus should be placed on students' ability to generate new knowledge by testing hypotheses and interpreting data."[9]
- However, "it is often difficult for teachers to integrate reforms into their classrooms, because of either a lack of training to deal with educational reform or a lack of resources."[9]

DATAFICATION IN EDUCATION

- Data Literacy (DL) is the ability to understand, learn from, and use data as part of regular reasoning for solving real-world problems.[8]
- Data related competences (to use data; collect, analyze, and interpret the data, and take instructional action) are necessary skills for 21st century teaching.[8]
- "Training educational professionals on acquiring data literacy competences is essential on the way to digitalized education."[8]
- Findings indicate that professionals are not EDL competent yet.[8]

Goals: for representatives and policy makers to unite and discuss the action steps necessary to ensure that educators know how to use data to inform their practice.[5]

Steps for implementation: "If we expect teachers to orchestrate learning in a radically different way than they are used to, we have to create excellent opportunities to learn, and we have to give them time to participate in those opportunities."[10]
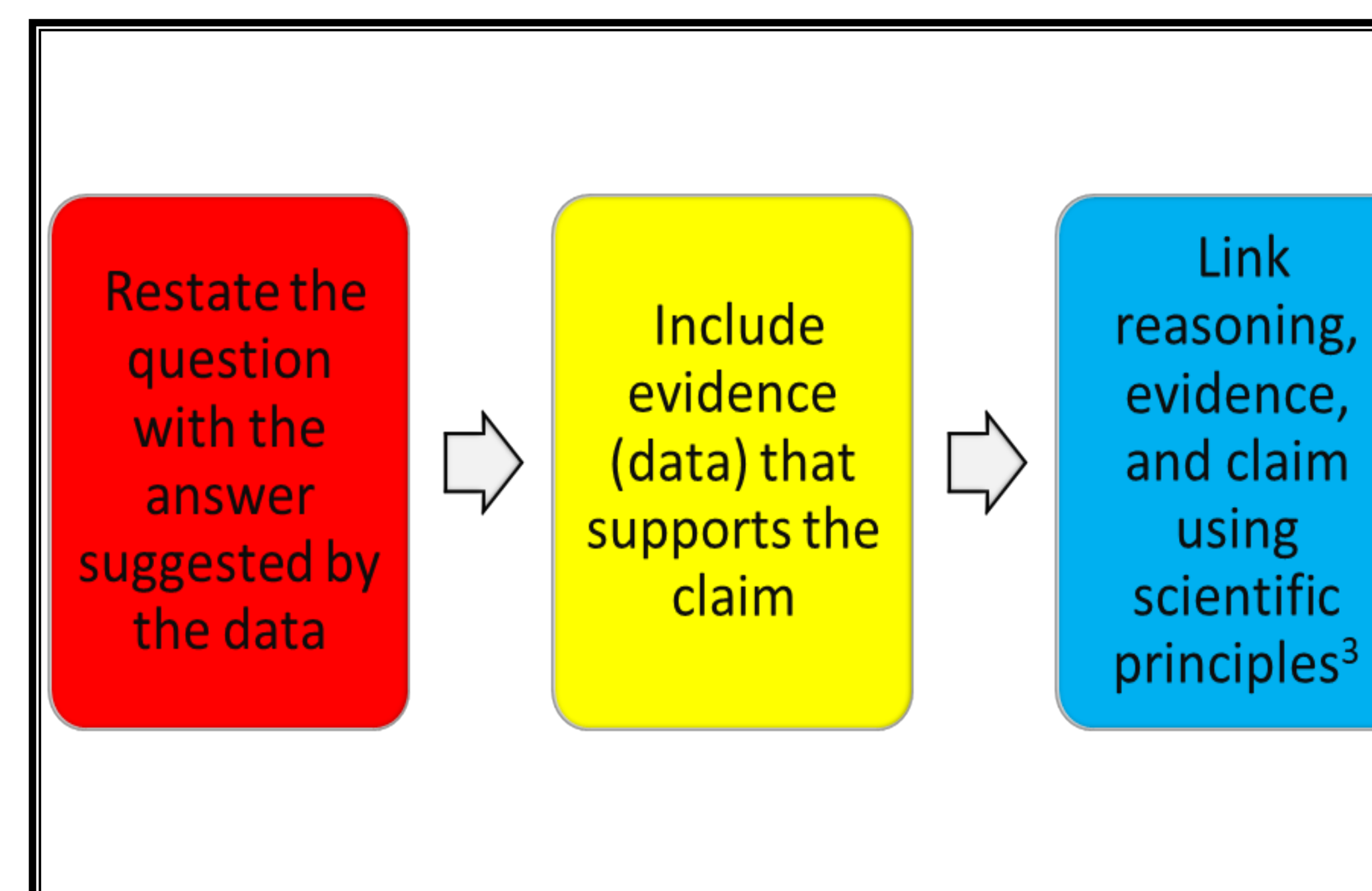- Both will require commitments by schools and districts.[10]

THE CLAIM-EVIDENCE-REASONING (CER) PROCESS

As with the traditional scientific process, the Claim-Evidence-Reasoning (CER) process involves a structured set of steps to work through.

- The claim takes on the role of a hypothesis or a prediction, and students are required to use evidence to support their claim.[12] A scientific question is answered by a claim supported by evidence.[6]
- Evidence: Scientific data that supports the student's claim. Can come from an investigation or other source such as observations, reading material, archived data, or other.
- Reasoning: Justification that links the claim and evidence. Shows why the data counts as evidence to support the claim, using appropriate scientific principles.[11]

The Basis for Scientific Conclusions (using CER)

Restate the question with the answer suggested by the data → Include evidence (data) that supports the claim → Link reasoning, evidence, and claim using scientific principles[3]

Scientific explanations can support students to develop academic writing skills, provide an understanding of science concepts, use logical reasoning, consider and critique alternative explanations, and most importantly, use evidence to support a claim.[1]

As found by researching teachers, the structure of claim, evidence, and reasoning (CER) ties in well with inquiry and mirrors the organizational structure in an ELA class.[2]

- Further, the CER format could be used in any academic class.[2]
- Consistent use of the model for writing allowed students to see how writing is connected across the content areas.[6]

FIGURE 5 Scientific explanation graphic organizer

Directions: Write notes only in the boxes below to help organize your writing—*not* complete sentences!

Claim:

Evidence:

Reasoning, Part 1 (why the evidence supports the thesis):

Reasoning, Part 2 (explain the underlying concept):

Conclusion:

After noticing that students needed to plan out their ideas before writing, researchers created graphic organizers (Figure 5) to help them structure their thoughts before writing.[2]
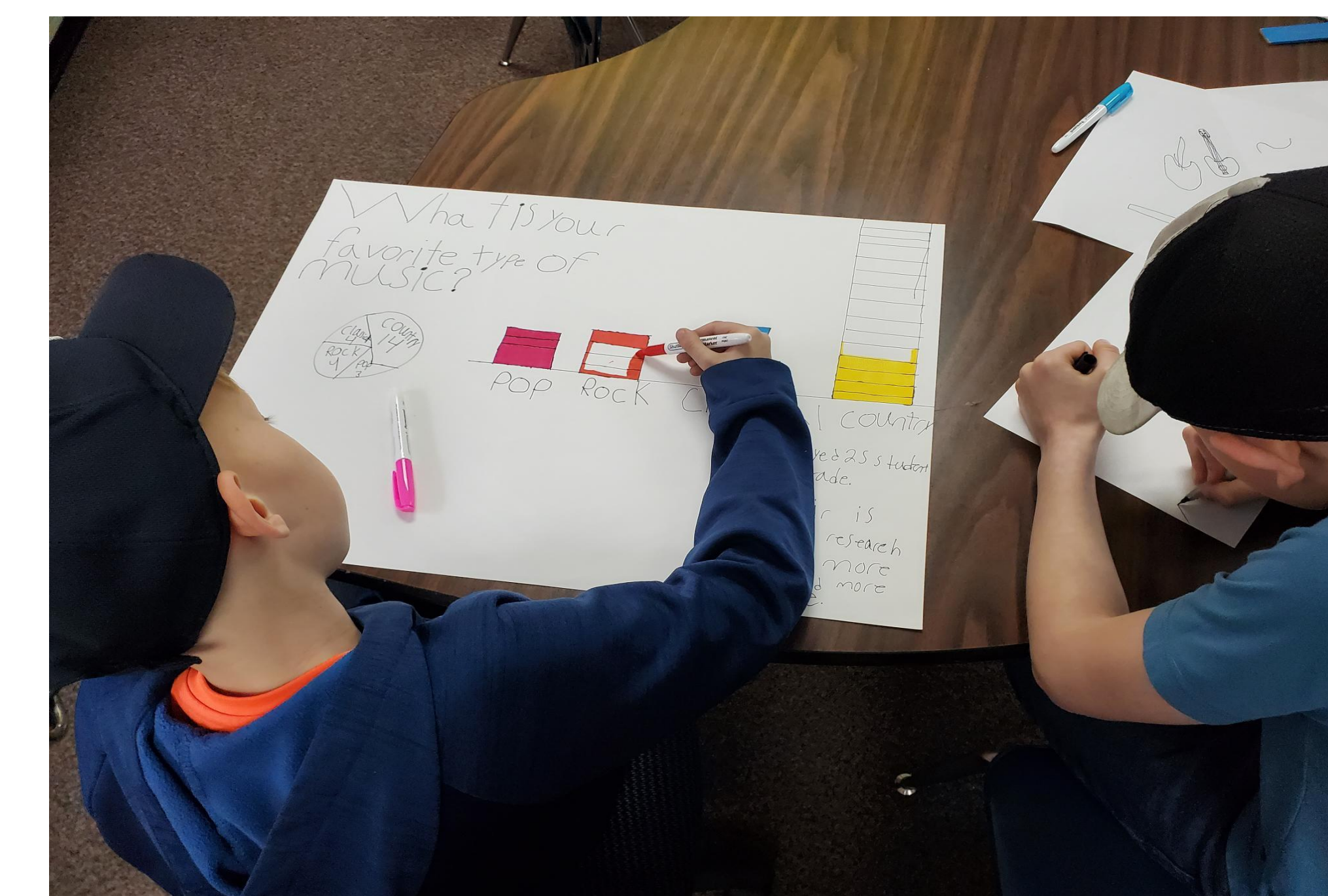
4th grade students graphing their data.

DATA IN ACTION

Through repeated use of Data Nuggets, students will:

1. Understand science is an active process.

2. Differentiate between scientific questions, hypotheses, and predictions.

3. Build quantitative skills by working with data, graphing, and interpreting quantitative information.

4. See science as an approachable and attainable career.[3]

- "Exposure to contemporary research, especially projects done by early-career scientists, will help students recognize that they too can become researchers in the near future."[9]

- Students are challenged to answer a scientific question using the data set to support their claim and are guided through the construction of graphs to facilitate data interpretation.[9]

- At the end of each Nugget, students discuss whether the data supported the hypothesis, the experiment fully answered the scientific question, if new questions could be investigated, and what future data could be collected.[9]

- Data Nuggets allow for differentiated instruction, where teachers can choose which worksheet to assign based on a student's reading and quantitative skills.[9]

- Nuggets can be tied into existing curriculum and complement a topic already discussed in class, or students can independently research the topic.[9]
  - "This focus on depth rather than breadth leaves time for teachers to further develop reasoning skills that are necessary for analyzing scientific content and data."[9]

- Data Nuggets walk students through the process of science (interpreting, investigating, evaluating), in a relevant fashion.
  - They have the potential to develop skills that will better prepare students for college and beyond.[8]
  - Each worksheet serves as practice for what students might see on the ACT test.[9]

- Data Nuggets not only help students understand the scientific process, but also facilitate mathematical skills.[9]
  - Basic statistics are provided with the data set or must be calculated by students.[9]
  - Both Common Core standards and Data Nuggets intend for students to use math in an applied fashion to reinforce the bond between skills and everyday life.[9]
  - While learning about current scientific research, students are also developing quantitative skills they can use in their own discipline.[9]