How do we prepare our youth for a world of big data?

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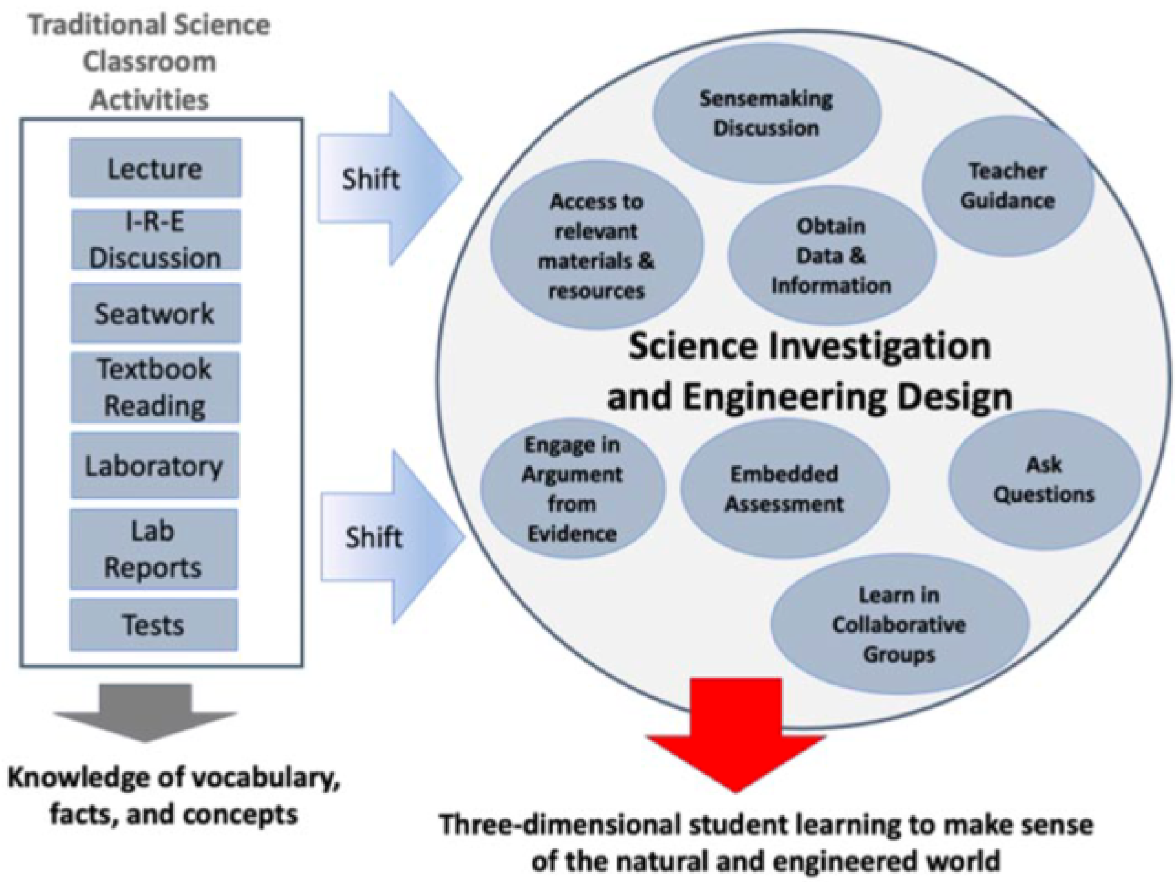

Figure: Shifts needed in science curricular programs (from NASEM, 2019, p. 83)

Nancy Butler Songer, Associate Provost of STEM Education at the University of Utah, considers the importance of developing primary and secondary school programs in STEM fields that support students in developing the competencies with big data

We all know something about Big Data. This term describes massive volumes of structured and unstructured data that influence nearly every decision in our lives. A recent report by the United States National Academies of Sciences, Engineering, and Medicine stated, 'We live in a world where nearly every interaction—both personal and professional—is mediated through data'. (1) As dedicated scientists and educators, it is our crucial responsibility to develop and evaluate primary and secondary school programs in Science, Technology, Engineering, and Mathematics (STEM) that can identify and guide students in developing the competencies with data that students need to navigate the Big Data world of the present and future. But what are these competencies?

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
• Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. Compare predictions to what occurred (observable events).	• Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. • Analyze and interpret data to make sense of phenomena using logical reasoning, mathematics, and/or computation.	• Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. • Use graphical displays of large data sets to identify temporal and spatial relationships. • Distinguish between causal & correlational relationships. • Apply concepts of statistics and probability to analyze and characterize data using digital tools when feasible. • Consider limitations of data analysis and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	• Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims. • Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible. • Consider the limitations of data analysis when analyzing and interpreting data. • Compare and contrast various types of data sets to examine the consistency of measurements and observations. • Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Table: Examples of analyzing and interpreting data practices (from NGSS Lead States, 2013).

Data literate students

First, we need students who are data literate, e.g., comfortable gathering, analyzing, and applying data towards explanations or solutions. Second, we need students who are fluent in critical data literacy, e.g., primary and secondary students who can apply critical lenses to distinguish appropriate from inappropriate uses of data. This work is not just important; it's crucial, as we recognize that 'ignorance of data is not just a lack of knowledge, it's harmful to individuals and society'. (1)

STEM learning

In the United States, the Next Generation Science Standards (3) emphasize the perspective that students of all ages, from kindergarten through secondary school, must engage in classroom activities that shift from traditional approaches such as lectures or cookbook laboratories to science investigations and engineering design. This shift places data collection, data analysis, sensemaking, and engaging in arguments from evidence as fundamental to all STEM learning.

This shift also changes what knowledge is essential: from an emphasis on facts or concepts to a focus on knowledge generated through investigation and engineering design, which we call three-dimensional science knowledge. In these classrooms, analyzing and interpreting data are at the core of classroom activities.

Over the past eight years, we have developed instructional programs for youth ages 11-14 that foster data literacy and critical data literacy activities. In the six-week unit, students collect and analyze data on one local invasive insect, such as the Spotted Lanternfly, make predictions of the impact on health, agriculture, or ecological stability, and design a trap to mitigate the effects of the insect. Student data are represented in graphical displays and, along with other information, used to predict how the invasive species can cause damage to the local economy or ecosystem.

Toward the end, students use their data analyses to engage in two rounds of engineering design and build of a solution (insect trap) to catch their local insect, culminating in placing the trap and analyzing data on effectiveness. Critical data literacy is an essential component of the unit, as student teams educate others through presentations of their design, results, and suggestions for addressing the impact on local ecosystems.

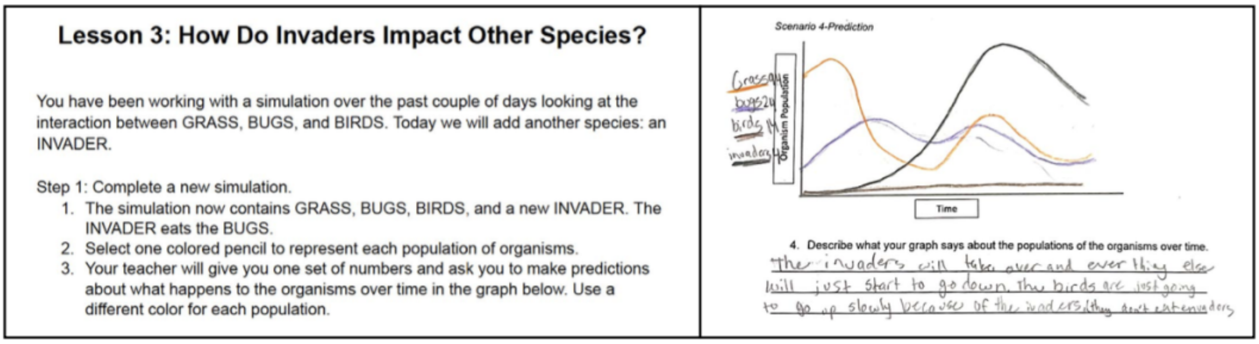

Figure: Example student prediction of the impact of invasive species on other species

Big data of the future

While our work has only begun to address the question of what data competencies students need to navigate the world of our present and future, we welcome continued dialogue on how to build instructional programs that foster not just critical thinking but also ask questions about how to collect and analyze data, what data are needed, who has access, and what are appropriate uses for data. Such thinking is crucial for all our futures.

References

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