

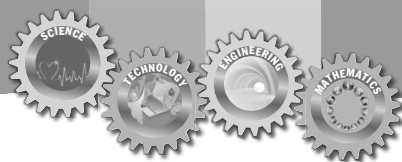
# STEM



## Lesson Essentials, Grades 3-8



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## Lesson Essentials, Grades 3–8

*Integrating Science, Technology, Engineering, and Mathematics*

Jo Anne Vasquez  
Cary Sneider  
and Michael Comer

Foreword by Rodger Bybee

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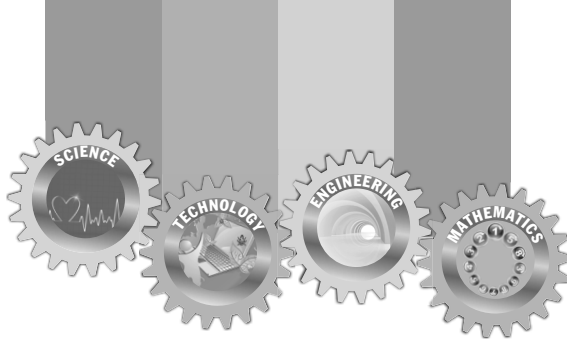
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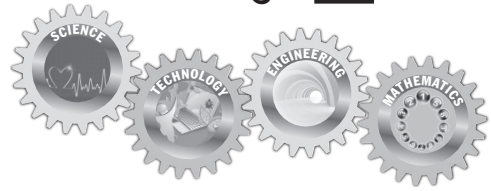


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# CHAPTER 1



## You May Already Be a STEM Teacher

*What students learn about the science disciplines, technology, engineering, and mathematics during their K–12 schooling shapes their intellectual development, opportunities for future study and work, and choices of career, as well as their capacity to make informed decisions about political and civic issues and about their own lives. A wide array of public and personal issues—from global warming to medical treatment to social networking to home mortgages—involve science, technology, engineering, and mathematics (STEM). Indeed, the solutions to some of the most daunting problems facing the nation will require not only the expertise of top STEM professionals but also the wisdom and understanding of its citizens.*

—*Successful STEM Education: A Workshop Summary*, National Research Council (2011, 1)

**BEFORE YOU READ THIS CHAPTER,** write down your own definition of STEM education.

### Meet Stacey Greene

Stacey Greene is a fifth-grade teacher from Scottsdale, Arizona. Her capabilities as a teacher were recognized in 2006 when she received a Presidential Award for Mathematics and Science Teaching. She is also a National Board–certified teacher who has honed her craft through years of practice

and taking advantage of many professional development opportunities. Stacey has been incorporating many of the tenets of STEM teaching in her classroom since long before it was actually called STEM. Here, in Stacey's words, is an experience she had with a parent who questioned her teaching.

Recently I had a mother come into my classroom and say, "My son says he is not doing math in math class." I was taken aback. No math in math class? Then I realized, this mom was expecting the usual worksheets with thirty division problems on them, or a list of numbers to find the mean, median, and mode, or a table of numbers to place onto a graph after they were told "Today is bar graph day" or "Today we are only making line graphs." It was then that I realized that I had to educate my parents about my method of STEM teaching.

Having a deep love for science teaching, I naturally begin with science as a springboard for learning and applying in a meaningful way the other STEM concepts we are learning in our curriculum. For example, in math we were studying data analysis and in science we were studying force and motion. Therefore, I joined the units together into a single series of classes about roller coasters.

On this particular day, the students designed roller coaster ramps and then timed a marble going down a ramp at one-second intervals. They then compiled their data onto one graph. Through this experiment they began to see that they were effectively measuring how quickly the marble was speeding up. Not only did they have to plot the data from seven groups on one graph, they had to decide what kind of graph to use (line or bar) and which data to use (mean, median, or mode).

I was feeling quite proud of my students: They had done data analysis using real data they obtained from an experiment that they had devised, made it meaningful by deciding the best way to utilize the data (mean, median, or mode), created a way to communicate the findings, and really understood how evidence is used to support a conclusion. All this without a worksheet of numbers to crunch, graphs to make with numbers that were irrelevant, and outliers that were just different but who knew why. Now I knew they understood these concepts because they had applied them in a meaningful way. Not to mention, I had a cool graph I could refer to throughout the school year to remind them of these concepts, and their understanding was enhanced.

This was all well and good and the students were learning in a meaningful way but I now realize that this way of teaching means I have to educate my parents as well. I have to walk them through this type of experience so they can begin to see the interdisciplinary approach that I use to teach different concepts and that the students are not missing out on anything. In fact, my students score higher on tests than students in the other classrooms. I've realized that if we don't make learning meaningful and relevant to our students, then they will just learn the answer for the test and forget it after it is done.

I don't think I'm doing anything magical or radical. I believe that all of this is just good teaching. The subjects are meaningful, and the understanding deeper. Now that the time allocated for instruction in each subject adds up to more than the minutes students are in class, this type of relevant interdisciplinary teaching is essential for our students today. I hope other teachers will see how true STEM teaching and learning will actually make their lives easier once they have designed the lessons and units of study.

Stacey Greene has been a STEM teacher for a long time, although she has only recently been able to put a name to it as the idea of STEM teaching and learning has entered the mainstream. This is true of many elementary teachers who have naturally integrated the disciplines in self-contained classes. It is also true of many middle school teachers assigned to teach science, math, or technology but who recognize the value of crossing disciplinary boundaries. In fact, chances are that if you are reading this book, you are also a STEM teacher, at least some of the time.

## **STEM Teaching and Learning in Action**

We will learn more about the details of this lesson in Chapter 4. From this quick overview, however, we can see how Stacey Greene is applying all four of the STEM subjects. The students used their *mathematics* knowledge and skills to measure distances, calculate speed, and plot data on a graph. They interpreted the graph using *science* concepts that describe motion in terms of distance, time, and speed, and they learned that an object increases its speed as it rolls downhill. To accomplish this, they had to become familiar with the lab *technology*

(stopwatch, marble, ramp, and measuring tape). Finally, the students applied principles of *engineering* to create their own roller coaster. They also worked collaboratively, shared their information by communicating their results, and participated in class discourse. In other words, they participated in a STEM learning activity. Stacey used science as the content springboard for application of mathematics, technology, engineering, communication, and collaboration to design an interdisciplinary experience for her students.

## **STEM Education, an Operational Definition**

We, the authors of this book, have agreed on a definition of STEM education. Through much discussion with professional colleagues from all over the country and with careful vetting for clarification and understanding, we offer this definition to help guide our discussion of STEM education in this book.

STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering, and mathematics and integrates them into real-world, rigorous, and relevant learning experiences for students.

Unlike the well-trodden paths of mathematics and science teaching, STEM education is relatively new. For the past decade, we have been exploring this new frontier, and we don't claim to have all the answers. However, we believe we have learned enough to share our insights with you, the reader; and so we invite you to join us on our STEM journey. Here are some of the questions we will explore along the way:

- What is STEM teaching and learning? What does it look like in different classroom settings?
- What is STEM literacy?
- What are the different interdisciplinary levels of STEM teaching?
- How can an elementary teacher in a self-contained classroom begin to create STEM lessons and units?

- How can a content-specific teacher work with others to connect the STEM disciplines with each other and with language arts, social studies, art, and music?
- How will STEM help you do a better job of teaching the big ideas in the content areas and make the learning relevant for your students?
- How does STEM teaching and learning promote twenty-first-century skills?
- How can you help others in your district cross disciplinary boundaries to create a richer, more meaningful environment for students in your school and district?

Here is an overview of your STEM journey as you travel with us through this book:

Chapter 2 defines STEM literacy and explains why it's important for everyone to become STEM literate.

Chapter 3 lists the five guiding principles for effective STEM instruction:

(1) focus on integration, (2) establish relevance, (3) emphasize twenty-first-century learning skills, (4) challenge your students, and (5) mix it up by providing a variety of instructional tasks and ways for your students to demonstrate their understanding.

Chapter 4 provides an example of what these principles look like in the hands of a master teacher.

Chapter 5 describes science and engineering practices as well as the practices in technology and mathematics. Figure 5.1 at the end of the chapter invites you to compare practices across the four fields to view their similarities and differences and see how they complement each other.

Chapter 6 describes an activity involving toy gears that is designed to engage students in guided activities in which they put practices to work in all four STEM fields.

Chapter 7 focuses on the two new partners to science and mathematics instruction—technology and engineering—and explains why they are important.

Chapter 8 describes three broad approaches to STEM education: *multidisciplinary*, in which teachers of several subjects coordinate their teaching to emphasize connections across the curriculum; *interdisciplinary* teaching, in which two or more subjects support each other; and *transdisciplinary*, that reflects students' interests and questions,

Chapters 9–11 give examples of what these levels of integration look like in the classroom. Chapter 9 describes what an interdisciplinary integrated science and mathematics lesson looks like at the elementary (3–5) grade level. Chapter 10 describes a middle school STEM unit that reflects all three integrated approaches, and Chapter 11 describes what these approaches look like from the perspective of a seventh-grade mathematics teacher.

Chapters 12–14 offer additional ideas for developing STEM lessons.

Chapter 12 describes project-based learning, an especially powerful form of transdisciplinary instruction, and Chapter 13 offers suggestions for assessing integrated STEM units. Chapter 14 provides a template for getting started on planning a STEM lesson or unit and describes how the template was used to develop the Gears unit in Chapter 6.

Chapters 15 and 16 look at implementing STEM instruction at the school or district level. Chapter 15 provides an example of how a team of middle school teachers are applying these principles in the context of a unit of study that incorporates not only the four STEM fields but also language arts and social studies. Chapter 16 is a story of how an entire K–8 school district adopted an integrated STEM approach for all their students.

Chapter 17 provides a listing of other resources that go beyond this book to help you begin to implement STEM teaching in your classroom, school, or district.

## Concluding Thoughts

Writing this book has engaged our thinking over the past year not only about where we want to go with STEM education but also about where we've been. Each of us has been a STEM teacher at some point in our careers, and these recollections helped us crystallize those ideas. In the following chapters, you'll hear about some of our teaching adventures and from others, like Stacey Greene, who blazed trails between and among the STEM fields long before STEM had a name, let alone a definition.

### Reflection

- Compare your definition of STEM education with the operational definition given in this chapter. How is it similar? How is it different?
- Think back to Stacey's lesson example. Was there a time when you used a similar approach in your classroom or with other teachers?
- Are you a STEM teacher?

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