Published Online: June 17, 2014

CTQ Collaboratory

Complete Coverage

# Six Characteristics of a Great STEM Lesson

By Anne Jolly



STEM is more than just a grouping of subject areas. It is a movement to develop the deep mathematical and scientific underpinnings students need to be competitive in the 21st-century workforce.

But this movement goes far beyond preparing students for specific jobs. STEM develops a set of thinking, reasoning, teamwork, investigative, and creative skills that students can use in all areas of their lives. STEM isn't a standalone class—it's a way to intentionally incorporate different subjects across an existing curriculum.

Here's a quick rundown of the STEM acronym:

**S**cience: The study of the natural world.

**T**echnology: One surprise—the STEM definition for technology includes any product made by humans to meet a want or need. (So much for all technology being digital.) A chair is technology; so is a pencil. Any product kids create to solve a problem can be regarded as technology.

**E**ngineering: The design process kids use to solve problems.

**M**ath: The language of numbers, shapes, and quantities that seems so irrelevant to many students.

STEM lessons often seem similar to science lessons and experiments, and in some ways, they are. After all, genuine science experiences are hands-on and inquiry-based. But if you look at the basics of an "ideal" STEM lesson, you'll see some substantial differences.

Here are six characteristics of a great STEM lesson. I hope you'll use these guidelines to collaborate with other teachers and create lessons that apply technology to what students are learning in science and math (and other subjects as well).

**1. STEM lessons focus on real-world issues and problems.** In STEM lessons, students address real social, economic, and environmental problems and seek solutions. My biggest "aha" STEM moment came when I moved to a new position and faced a class of science students who had given up on school. I had the class identify a **real-world problem** right there on campus, and suddenly we found ourselves head over heels in a STEM project—before the familiar acronym had even burst onto the scene. See **Real World STEM Problems** for some suggestions for projects students might focus on.

**2. STEM lessons are guided by the engineering design process.** The EDP provides a flexible process that takes students from identifying a problem—or a design challenge—to creating and developing a solution. If you search for "engineering design process images" online, you'll find many charts to guide you, but most have the same basic steps. In this process, students define problems, conduct background research, develop multiple ideas for solutions, develop and create a prototype, and then test, evaluate, and redesign them. This sounds a little like the scientific method—but during the EDP, teams of students try their own research-based ideas, take different approaches, make



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mistakes, accept and learn from them, and try again. Their focus is on developing solutions.

**3. STEM lessons immerse students in hands-on inquiry and open-ended exploration.** In STEM lessons, the path to learning is open ended, within constraints. (Constraints generally involve things like available materials.) The students' work is hands-on and collaborative, and decisions about solutions are student-generated. Students communicate to share ideas and redesign their prototypes as needed. They control their own ideas and design their own investigations.

**4. STEM lessons involve students in productive teamwork.** Helping students work together as a productive team is never an easy job. It becomes exponentially easier if all STEM teachers at a school work together to implement teamwork, using the same language, procedures, and expectations for students. If you want a jumpstart on building specific student-teamwork skills, **contact me** and I'll send you a draft of a student teamwork document.

**5. STEM lessons apply rigorous math and science content your students are learning.** In your STEM lessons, you should purposely connect and integrate content from math and science courses. Plan to collaborate with other math and/or science teachers to gain insight into how course objectives can be interwoven in a given lesson. Students can then begin to see that science and math are not isolated subjects, but work together to solve problems. This adds relevance to their math and science learning. In STEM, students also use technology in appropriate ways and design their own products (also technologies).

Best case scenario: Involve an art teacher as well. Art plays a critical role in product design. Teams will want their products to be attractive, appealing, and marketable. When the arts are added, the STEM acronym becomes STEAM.

**6. STEM lessons allow for multiple right answers and reframe failure as a necessary part of learning.** Sometimes I designed my science labs so that all teams would replicate the same results or verify or refute a hypothesis. Students were studying specific science content and the whole idea was to provide insight into cause and effect by manipulating variables.

STEM classes, by contrast, always provide opportunity for multiple right answers and approaches. The STEM environment offers rich possibilities for creative solutions. When designing and testing prototypes, teams may flounder and fail to solve the problem. That's okay. They are expected to learn from what went wrong, and try again. Failure is considered a positive step on the way to discovering and designing solutions.

**Creating STEM lessons**

So where can you find quality STEM lessons? An online search of "STEM lessons" will yield plenty of results. A word of caution, however: Not everything that claims to be STEM is actually STEM. If it doesn't meet the criteria described above, you may want to move on.

I generally start with the following sites to jumpstart my thinking when I plan a STEM lesson: **Design Squad Nation**, **NASA STEM lesson**, **National Geographic Education**, **STEMWorks**, **TeachEngineering**, and **The Air Force Collaboratory**. (Please add your own favorite sites in the comments section.)


Can't find any lessons you like? Look at your course objectives, come up with a real world challenge, and write your own lesson. Check out my blog posts **Perfect Stem Lessons** and **12 Steps to Great STEM Lessons** for some "how to" ideas. You can also get a free "starter lesson" to introduce your students to the engineering design process by contacting **Melissa Dean**. (Put "Free Launcher Request" in the subject line.)

For the ultimate resource, I invite all of you—whether or not you are STEM teachers—to join the Center for Teaching Quality's **Collaboratory**, a professional and safe virtual network to post your ideas and questions about STEM (and other topics of interest). We'd love to share our knowledge and experiences with you.

For those of you in the trenches, have fun creating your lessons—and thank you for being STEM teachers.

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*Anne Jolly is a Virtual Community Organizer for the* ***CTQ Collaboratory*** *and a member of the CTQ Thought Leaders Circle. Anne taught middle school science for 16 years in the Mobile County Public School System and is a former Alabama State Teacher of the Year. She is a published author and currently writes middle school STEM curriculum. Anne blogs regularly at* ***STEM by Design*** *on* ***MiddleWeb****. Her Twitter handle is* ***@ajollygal****.*

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Dick Larson
8:24 AM on June 19, 2014
Score: 0
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Please add MIT BLOSSOMS to your set of STEM lesson sites.

**http://blossoms.mit.edu**

1 reply

T Gerber

Score: 0

Report Abuse

4:25 PM on June 22, 2014

Please add AAAS' Science NetLinks to your STEM lesson sites.

**http://sciencenetlinks.com/**

1 reply

BFindell

Score: 0

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7:40 PM on June 23, 2014

A pure science lesson is a STEM lesson, as is a pure math lesson. STEM is both the individual disciplines AND their integration.

5 replies

John Sole

Score: 0

Report Abuse

11:47 AM on June 24, 2014

Here are those 6 characteristics in action:

**http://guerillaeducators.typepad.com/ge/2014/03/best-practices-design.html**

1 reply

VocabularySpellingCity

Score: 0

11:50 AM on June 24, 2014

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I'm intrigued by this article. I had understood STEM to be a collection of subjects and as other people have already commented: "A pure science (or math) lesson is a STEM lesson." Are you saying that STEM lessons are distinct from them and need to take the approach you describe?
For younger students, there are 5E Instructional Model lessons:
**http://www.science4us.com/demo/**

2 replies

R South

Score: 0

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1:52 PM on June 24, 2014

Problem-Based Learning is a great vehicle for teaching the Engineering Design Process while integrating multiple disciplines and technology. Hundreds of Cases are available through Wake Forest Problem-Based Learning **www.wakeproblembasedlearning.com.** Because of the shorter duration of these Cases and small group sizes, there is more opportunity for repeated practice with the process and collaborative involvement of all students.
Contact Rick for more information at rsouth@sergsales.com

2 replies

Kondath

Score: 0

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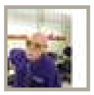
2:24 PM on June 24, 2014

STEM education is necessary to make a nation competetive in today's knowledge based economy. How wealthy a nation would be depends on how much better a nation's products are and how much demand the world has for a nation's products.

**www.edugain.com** is an initiative to provide STEM education to our young generation in a scientific way. I will urge the author to kindly review and tell the audience about it.

1 reply



Ebasco

Score: 0

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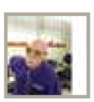
2:07 PM on June 25, 2014

I have a number of serious concerns about these "truths." But first, I am a professional engineer with 25 years of large consulting (problem solving) experience, two masters (physics and engineering), and 12 years math/physics/PLTW-engineering teaching in a large urban magnet school.
1. The dependence on team problem solving is a new phenomenon of engineering in huge firms that can afford it. Most American engineering jobs consist of designing sewers and industrial systems. As a PE, I don't want a group of junior engineers rethinking how to build a bridge. Use the manual, follow my directions, and get it done as fast as possible for my review. This model you advocate works at Microsoft and Google, but not for most real STEM jobs.
2. Math without science is silly puzzles.
3. Science without math is 400 years out of date.
4. Engineering is the science of the human built environment. It belongs in science and as a science credit.

5. Real problem solving means act like a lawyer and defend your answer beyond a shadow of a doubt.
6. Brainstorming doesn't work. Google the New Yorker article, and read the Dilbert cartoons. Great method to make you look good for an evaluation. Simply useless, and wasteful, for solving problems. Read Kepner and Tregoe and understand who, what, why, and how. Consultants can't afford to go away, spend $100K, and come back empty handed.
7. STEM really means engineering. We are wayyyy over stocked in biology and chemistry. Not really needing more mathematics and physics. We need engineers! Civil, mechanical, electrical, chemical. Software engineering is a burn-out blip on the screen. Let's get real, for a change.
8. Inquiry science and discovery math are very detrimental techniques for teaching gifted engineers to be. I've never had a student at Harvard, Yale, Stanford, MIT write me back and say, "wish you had used inquiry methods and projects." What I hear is, "thank you for covering so many topics. When the professor starts talking, I know I've heard those ideas before." I "teach" the four laws of thermodynamics to students in ten minutes: temperature, energy, entropy, absolute zero. Every student exiting our high schools should know the fundamentals that control every mechanical and living system. And they don't.

2 replies



Ebasco

2:33 PM on June 25, 2014

Score: 0

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I wrote my thoughts up on this in a preliminary group of essays last March.

http://isounderstandthatnow.wordpress.com/2014/03/

I borrowed my title from a SpEd girl who gushed that statement when, as a sub teacher, I explained that the Y-intercept was the amount of money she had in her pocket before she started working that day.

Alex Kluge

Score: 0

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5:04 PM on June 26, 2014

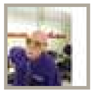
This still growing, open source, toolkit makes it easy for content authors and teachers to create interactive models of electric charges and fields.
http://www.vizitsolutions.com/portfolio/efield/

There is even a collection of prepared visualizations that can be loaded into existing content with just a few lines of HTML.
http://www.vizitsolutions.com/portfolio/catalog/

There is even an example of their use in a highly interactive physics lesson on the application of Gauss's law to find the electric field for different charge configurations.
http://www.vizitsolutions.com/portfolio/gausslaw/

So much of what we do simply takes content as it would appear on a page and presents it in a digital form, or captures the lecture and presents it in digital form. We can do so much more. Digital content must invite exploration, it must encourage students to play and ignite their curiosity. Providing meaningful interactivity plays a significant role in this. It helps transform the learner from a passive consumer to an active, engaged learner.

2 replies



Ebasco

Score: 0

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3:16 PM on June 28, 2014

As a physicist and engineer, I find it very difficult to interact with "science teachers" who are on a STEM mission. When I point out that the nation doesn't need more biologists and chemists, I step on a lot of sensitive teacher toes. When I state that science must be mathematical, and mathematics must be directed by science, more sensitive toes! This author is committed to STEM education with as much fervor as the geocentric believers before the Copernican Revolution. Wrong but so sure of themselves. I wrote, Google the New Yorker article on brainstorming, it doesn't work.
**http://www.newyorker.com/reporting/2012/01/30/120130fa_fact_lehrer?currentPage=all**
Kepner and Tregoe told NASA how to solve problems: watch carefully in Apollo 13 when the simulator astronaut solves the battery problem when lives are on the line. Still you cling to the misconception that as a teacher and "expert" it must be right. Reread my enumerated comments. They are certainly true. Do you understand the laws of thermodynamics, at least conceptually? All of this truly wrong STEM education is sending hordes of students into colleges only to change majors when they realize they are so ill-prepared for engineering. You

are an award winning middle school science teacher. I was in dozens of middle school classrooms this year asking the simple question, what is science? The silence was deafening. I am an award winning math teacher with degrees in physics and engineering. Read my blog.

Alex Kluge

Score: 1

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3:18 AM on June 29, 2014

I noticed that the overwhelming majority of comments about the value of STEM knowledge and education focus on the learner's eventual career. While career impact is important, there is more to the question. Some foundational knowledge of, and work with, STEM is important to their future as part of the decision making process in a healthy democracy. Understanding the nature of science, the scientific method and the importance of repeatable verification or refutation through solid experimentation will make them less susceptible to specious claims and more able to participate in public policy debates and decision making. Perhaps including education policy.



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