**Defining STEM as Pedagogy**

*Are we ready to go beyond the acronym?*



**The Presence of STEM Education**

The words “STEM Education” are everywhere. Schools are talking about it, industry is talking about it, and yes, the President is talking about it. Yet at the same time, there are many who don’t really know what STEM education is, how it works or why we need it. Even school personnel automatically assume STEM education is mathematics and science. We have that, but that is not STEM Education.

The United States has historically been a leader in innovation and discovery. Recently, other nations have caught up. Much of the infrastructure in our country has fallen behind. Our roads and bridges and power grids are not ready to withstand some of the stress the world places on them, through extreme weather or just plain use. We are no longer the most significant world force in science and discovery.

The world is changing. In today’s world what I learned as a young student is not enough, not enough for my children, or for your children. We must be forward thinking. We must visualize what we can’t yet imagine. If the world continues to progress at the same rate as in the past fifty years, what will the world be like for our children when they are grown and have families of their own?

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Education must keep up. We can’t say it cost too much or there isn’t enough time. The truth is, what will it cost if we don’t change things now? There is a human price, the future of our children. How will the next generation survive and take care of their families? We cannot assume that it will be okay and that struggling families will figure out how to make it. Why aren’t we thinking ahead to appropriately prepare children for the future? Students must be career and college ready.

In recent years, the reaction to the realization that students weren’t learning and that many were well behind grade level was to add verifiable accountability. Test them. I am all for accountability, but the testing them part isn’t going so well. We have given the message that memorizing stuff and performing on high stakes testing is the answer. We have lost the art of solving a problem, finding an answer, perhaps more than one answer, learning from a mistake, and above all, that there is nothing that replaces hard work in learning, fostering creativity and ingenuity.

The simple answer to protecting and readying students for the future is STEM education. The jobs of the future will demand that students are STEM literate. There is no debate. There are jobs unable to be filled because they are STEM jobs. Our students are not prepared. We need a qualified and diverse workforce ready for the future. We need to ensure that all of our students are learning and are prepared, not just some.

STEM education is a large part of the answer to the problem. Implementing it is more difficult. Teachers need to be enlightened and aware. They need training in a variety of areas. Teachers need to understand that STEM education is integrated in itself, that it combines all of those disciplines. It is not simply Math and Science, which is already taught. For the most part “many educators have not yet come to the realization that STEM education is more than simply a new name for the traditional approach to teaching science and mathematics. Nor do they understand that it is more than just the grafting of “technology” and “engineering” layers onto standard science and mathematics curricula.” (Bybee 2009). So the end result is more of the same in secondary schools rather than a reorganizing or restructuring of the curriculum to meet new needs. (Bybee 2009)

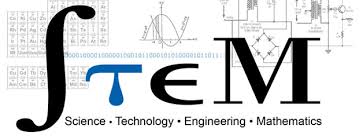
In addition, STEM curriculum must include the Arts and Humanities. Students must be great thinkers, communicators and collaborators to enhance their creative skills for the 21st century. As educators, we must understand what STEM education is and how to deliver it. We must morph current subjects and topics a little at a time to be less restrictive and more all-inclusive. We must orient schoolwork to be inquiry based and include new contexts. The myths of what STEM education is and isn’t must be clarified, defined and the intent of this important initiative made clear.

**WHAT IS STEM?**

Another acronym? The public loves a shortcut, a nickname, and as a result, sometimes understanding of that shortcut is limited by what that shortcut expresses or implies.

Although the acronym was created for simplicity, its meaning gives different implication and nuance to people, depending on their basic knowledge and experience. Its meaning in industry is different from that in education. Teachers may see this acronym as meaning something different and so they either embrace or shy away. This paper will focus on education because without education in STEM, you can’t get a job in STEM. In recent years, the protocol is to individualize subjects and select teachers based on a mastery of that subject. The idea of a Renaissance education or multi-disciplinary or cross-curricular class makes it too hard for everyday teachers to discern a demonstration of knowledge, and as a result content, in that specific area. Public education has become a tableau of “silos” of knowledge instead of systems to learn or team learning experiences.

A common definition is  
*STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy.* (Tsupros, 2009)



One of the reasons for the acronym was to simplify and draw attention to STEM as “The Next Big Thing.” Well, as it turns out, it really is a big thing, bigger than the acronym or any short definition can accurately reflect.

This attention to STEM Education started because the United States wasn’t producing enough competitive graduates in science and engineering to fill the jobs for today, let alone the jobs of the future. The US was no longer always in the forefront of Innovation. Add to that, the multitude of foreign graduates from our universities taking full advantage of our programs, but not participating in our workforce. Instead they are taking jobs from US citizens who failed to get the necessary training to be competitive. This fact has huge economic implications. The US has many young diverse students who need to be guided in STEM directions. They have the ability. What they lack is appropriate parental guidance and support or mentorship from the community or from teachers. This exposure to STEM subjects and way of thinking must begin in the early grades. Students can’t know about something they haven’t directly seen or experienced. Enter: Teachers trained in STEM curriculum. It is time for a paradigm shift.

Teachers tend to view each subject as an individual entity and have a very hard time crossing these lines horizontally. It is not all their fault; it has much to do with their training. Teachers think STEM is science and mathematics in which students use technology, in other words students are computer literate.

I am not sure where or what they think the “T” and the “E” are — both often absent from this picture. The “T” has to include the use and understanding of technology - how it works and what the possibilities are for the future, not just computer facility or literacy. The “E” must bring students to problem solving, design and practicality. Students explore solutions (Bybee, 2009), and through those solutions they can personalize and explore their learning through math and science. The Multiple Intelligences come into context here allowing students to learn through their strengths and expand on their weaknesses.

STEM literacy is necessary for everyone as we progress through the 21st century. Many jobs involve STEM—building roads, making new scientific discoveries in medicine, creating better materials, sustainable food, predicting and managing national disasters, information technology, and communications, just to name a few. All of these jobs spinout more jobs. Maybe everyone isn’t on the discovery level, but support staff is needed to make things happen and work. Labs have assistants and technical help. Coders and programmers are needed for the labor-intensive job to implement new ideas and discoveries in software and program development. Mechanics are needed to run robots and troubleshoot. We need people to create healthy menus and understand future lifestyle to keep people healthy. The fields of Medicine, health services, computer and information technology are growing exponentially. These jobs will replace some of the manufacturing and labor jobs of the past.

STEM is for all jobs of the future, not just the great designers and innovators. Think outside the box and decide how to make a better chair or desk. What are the metrics used to understand money and finance? Understand the route to get from home to school—what are possibilities? We need better roads and transportation and people to design and build. There are problems that need to be solved. We need clean water and air and those to put these products in place in our lives. We need to think in 3-D. Aptitude in Mathematics and Science is needed, but not everyone needs to be the inventor. At the same time, no one knows what potential may lie in a student if given an open door and opportunity.

*Taken separately, the four STEM subjects are defined by the National Research Council as:*

* ***Science****is the study of the natural world, including the laws of nature associated with physics, chemistry, and biology and the treatment or application of facts, principles, concepts, or conventions associated with these disciplines.*
* ***Technology****comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves.*
* ***Engineering****is a body of knowledge about the design and creation of products and a process for solving problems. Engineering utilizes concepts in science and mathematics and technological tools.*
* ***Mathematics****is the study of patterns and relationships among quantities, numbers, and shapes. Mathematics includes theoretical mathematics and applied mathematics.*

*STEM education can be an interdisciplinary or trans-disciplinary approach to learning where rigorous academic concepts are coupled with real-world problem-based lessons. At this level, STEM education exemplifies the axiom "the whole is more than the sum of the parts."*

STEM is a way of life for the future, not just an acronym that represents four academic disciplines. It is our new perspective and no matter what it means to each individual or industry, it means that we must move forward. So, whatever you believe STEM is, open your mind to collaborate with your colleagues and community members and bring your school into the future.

A video of a student explaining her science project to the President. I think she knows what STEM is!! [Video of student explaining her science project to the President](http://youtu.be/XMq979v4tSw)

**What is STE[a]M?**

The need to include STE[a]M in a comprehensive definition of STEM Education is essential. STE[a]M includes the harder to define pieces. The 21st Century Skills Of Collaboration, Communication, Creativity and Critical Thinking evidence themselves here. It is impossible to be innovative if you can’t communicate what you are doing. Ideas spring from collaborative efforts.

STE[a]M is another acronym which leaves its meaning open to discussion. First, one must fully understand what STEM is to begin to incorporate the needs for creating STE[a]M. It is impossible to fathom education without the use of the arts, reading, writing and communicating. If you can’t read and express, it is hard to do anything. The 21st century world demands communication now available in many formats. Students must still read and write, but in addition, they can use graphic design, photos and video formats for expression. Long past are the days of a poster board with glued on pictures and diagrams. We have Power Point, Prezi and Photoshop.

STE[a]M invites to integrate other components, and at the same time, one must understand that STEM is a body of already integrated disciplines. The inclusion of all of these skills helps to make a student career and college ready and at the same time, offers a wide variety of learning opportunities for a variety of learners. It is a way of life, a way of thinking. We need the arts and our ability to communicate to do anything. We must view things from the eye of a critical thinker that is one who constantly wants to solve problems or make things work more efficiently.

STEM is hard to define, and STE[a]M becomes personal. It is the experiential, the hands on happening and connection. It is the opportunity to solve diverse problems, and for students to be in charge of what and how they learn. Don’t let the acronym limit. It is a chance to open the box and watch the learning happen. It is the opportunity to include the 21st century skills of problem solving, critical thinking, communication, creativity and innovation.

The how-to piece of STE[a]M becomes the challenge. For STEM education students must learn the separate disciplines and how they all work together. This learning includes the ability to be problem solvers who gather information, test that information, use it, draw conclusions and then apply their knowledge to something new. In doing those activities, students can creatively use science, mathematics and technology and apply it to the design process. In learning how to do and use all of those things, students will become innovative and self-reliant. They will understand how things follow logically and how to test and invent. (Morrison 2006) All of that becomes STE[a]M.

So do we need another acronym? Probably not, however we need to define and understand the ones out there in common use so we have a vocabulary with which to speak about them. The definitions have some consistency and uniformity for students’ education. Standards of practice and consistent, understandable definitions are needed in order for STEM or STE[a]M education programs to be replicable.

It is arguable that STEM is STE[a]M and STE[a]M is STEM. The point is not to be locked in the box. The point is to include pieces of integration, innovation, and imagination that inspire. Students must learn to observe, create, evaluate and correct. Their experience must include design, experiment, and experience, and yes, they need to fail, analyze, and try again. Students and parents must learn that education is a process. So should we call it STEM [I] or iSTEM? Or is it TIMES?

Regardless of what we call it, we must understand what it is and not try to force it into some already existing protocol. It is a new definition for this century, for our children to become career and college ready. Today.

**Who Teaches STEM/STE[a]M?**

Teachers for the most part are not prepared to teach STEM subjects. First, they have not been trained to do this and of course, they need to understand exactly what it is. It will take time and program evolution for all of the universities to be on the same or similar page to train teachers. There are a few outstanding programs now; some are undergraduate programs, some master’s degree programs and some certificate programs for those who already hold a master’s degree. The following components should be considered to certify teachers for STEM education:

**Teacher Training:**

* Gender specific activities and understanding of gender-neutral teaching.
* Activities and materials for diverse populations.
* Age appropriate activities that evolve from K-12, P-20.
* College/ Career focus.
* NGSS and CCSS understanding, alignment, and full spectrum use of formative and summative assessments.
* Use of Habits of Mind, Project Based Learning, Inquiry Based Learning(5E Model), and Understanding by Design.
* Degree in a cross-curricular discipline such as Humanities, the arts etc. if possible.
* Understanding and experience with social/emotional wellness.
* Benefits of tinkering and makerspace, allow students to be “messy.”
* Understand that students may be intelligent and talented in varying degrees, but stress the process and work ethic needed to be successful.
* What will public education look like in the future? Will teachers facilitate and use online existing programs? Teachers must have professional development to stay current on learning strategies.

**Are There Barriers to STEM Education?**

* Understanding of what the individual disciplines are and how they connect and integrate.
* Bridge the curriculum gap created by implementing STEM/STE[a]M and what current standards and assessments dictate.
* Technology is not computer literacy.
* Some students will fail and need to learn from those failures.
* STEM education is not just science and mathematics but the integration of those disciplines with 21st century skills.
* Although these disciplines are academically demanding and rigorous, they can be made age appropriate.

**We need to think in 3-D**

* Understanding the differences between science (discovery) and engineering (problem solving).
* Teacher engagement – teachers constantly asked to do new things and may not see immediate benefit to this ‘New Thing”.

**CONCLUSION**

**STEM** means different things to different people. It could be the part of a plant that attaches to the flower, or a component for genetic research, or as intended here, an acronym to mean the disciplines of Science, Technology, Engineering and Mathematics. Observing, questioning, reaching conclusions, testing those conclusions and making adjustments are the foundation to solving problems in whatever discipline.

STEM education and STEM workforce are not the same and at the same time, one needs to engage in STEM Education to be workforce ready. STEM education needs industry professionals involved with students as mentors and role models. A student needs not only to learn the meat that becomes a STEM integrated education, but also understand what exactly one does in specific jobs. The possibilities are unlimited as none of us can accurately guess and gauge what the jobs of the future will be. We need to be prepared, and that preparation includes the ability to be creative and innovative about solving a problem. There needs to be a process and a method. The community must be involved in STEM education.

So to that end, we need to collaborate. We need the best educators, thinkers, and industry professionals to coalesce and create a framework for STEM that includes its integrated nature with itself and other core disciplines. We must create an education that connects academics to real world activities. We can change the acronym or work with what is in place while making a better effort to define and understand. As time passes, the definition will evolve, as this author’s thinking and understanding of STEM has evolved. The key is to open the door and continue the discussion.

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iSTEM

Pedagogy guiding education through the 21st Century

**STEM** *is an integrated approach to education through which the subjects of Science, Technology, Engineering and Mathematics fuse to enhance the innovative, problem solving and critical thinking skills of students. The goal is not only to learn content, but also to use that knowledge and apply it to new things while being able to communicate through a variety of media. Students will be prepared for career or college and understand the global marketplace.*

**Standards of Practice:**

* Students will understand and be able to use concepts in the STEM disciplines with rigor and integrated capacity, using creativity and imagination.
* Students will communicate through the STEM disciplines with mastery at age appropriate levels.
* Students will use inquiry and experience in learning; reflection in self-assessment.
* Students will be collaborative.
* Students will think logically and use their experience to make assertions.
* Students will participate and guide their own learning through strengths while addressing weaknesses.