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What Is STEM Education and Why Is It Important?

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This article looks at many aspects of STEM education, both in k-12 education as well as the post-secondary arena. The article provides a historical perspective regarding the roots of STEM and then follows up with the contemporary aspects of STEM education. The "T & E" of STEM education are also explored. The article culminates with the roles teaches play in STEM education.

Introduction

What is this term they call STEM education? Most people are in the dark and moreover, most educators and students are as well. When one hears the acronym "STEM" within an educational setting, they may think along the lines of stem cell research or something dealing with flowers (Angier, 2010). However, STEM stands for Science, Technology, Engineering and Mathematics.

On January 25, 2011, the first sitting President of the United States spoke the words "Science, Technology, Engineering and Math" in his State of the Union Address The President stated:

> Let's also remember that after parents, the biggest impact on a child's success comes from the man or woman at the front of the classroom. In South Korea, teachers are known as "nation builders." Here in America, it's time we treated the people who educate our children with the same

> level of respect. (Applause.) We want to reward good teachers and stop making excuses for bad ones. (Applause.) And over the next 10 years, with so many baby boomers retiring from our classrooms, we want to prepare 100,000 new teachers in the fields of science and technology and engineering and math (Whitehouse.gov, 2011).

This was a milestone for STEM Education, but it is not a new concept derived by the White House. STEM Education (in one form or another) has been around for decades; however, legislators and educational administrators are now recognizing its importance. This research will attempt to provide a clear definition of STEM through a historical narrative as well as contemporary aspects in which STEM is being implemented.

The initial knee-jerk reaction of people who have heard of STEM (in an educational setting) but don't know the history and contemporary implementation of STEM education is that STEM has something to do with science and/or computers. While science and computers are a part of STEM, they are educational mechanisms and concepts that are used by STEM stakeholders to implement and/or produce a STEM outcome.

Historical Aspects

STEM Education was originally called Science, Mathematics, Engineering and Technology (SMET) (Sanders, 2009), and was an initiative created by the National Science Foundation (NSF). This educational initiative was to provide all students with critical thinking skills that would make them creative problem solvers and ultimately more marketable in the workforce. It is perceived that any student who participates in STEM Education, particularly in the K-12 setting would have an advantage if they chose not to pursue a post-secondary education or would have an even greater advantage if they did attend college, particularly in a STEM field (Butz et al., 2004).

Although the use of STEM concepts (historically) were being implemented in many aspects of the business world; i.e., the Industrial Revolution, Thomas Edison and other inventors, it was not being utilized in traditional educational settings. The use of STEM was primarily used in engineering firms to produce revolutionary technologies such as the light bulb, automobiles, tools and machines, etc. Many of the people responsible for these innovations were only slightly educated and/or were in some type of apprenticeship. For example, Thomas Edison did not attend college (Beals, 2012), nor did Henry Ford; although Ford did work for Thomas Edison for a number of years. These "giants" of innovation used STEM principles to produce some of the most prolific technologies in history: however, STEM in education was virtually non-existent (Butz et al., 2004).

STEM Education was the result of several historical events. Most notable was the Morrill Act of 1862. This Act was responsible for the development of land grant universities that, in the beginning, focused mostly on agricultural training, but soon engineering based training programs formed (Butz et al., 2004). For example, The Ohio State University was established in 1870, but was originally named the Ohio Agricultural and Mechanical College (Background of Ohio State, 2012). As more and more land grant institutions were being established, more and more STEM Education training was ultimately being taught and eventually assimilated into the workforce. Other historical events pushed STEM Education to grow and flourish. Two such events were World War II, and the launch of the, then, Soviet Union's Sputnik.

World War II

The technologies invented and implemented during WWII are almost immeasurable. From the Atomic Bomb (and other types of weaponry) to synthetic rubber to numerous types of transportation vehicles (both land and water), it was clear that American innovation was flourishing. Scientists, mathematicians, and engineers (many from academia) worked hand-in-hand with the military to produce innovative products that helped win the war and to further STEM Education (Judy, 2011).

It must also be noted that the NSF was formed at the end of the WWII in an effort to not only recognize the immense contribution of the talented men and women who created prolific commodities, but to preserve the research and documentation of those commodities (Mervis, 2010).

Sputnik

In 1957, the (then) Soviet Union attempted and was successful in launching Sputnik 1. This was a satellite that was the size of a beach ball and orbited the earth in about an hour and a half. This was a technological milestone that started the "Space Race" between the United States and the Soviet Union.

The significance of this event propelled the United States to look at initiating and furthering technological advances in terms of space travel and exploration. "The Sputnik launch changed everything. As a technical achievement, Sputnik caught the world's attention and the American public off-guard" (National Aeronautics and Space Administration, 2008, p.1). Sputnik became a national defense issue and in 1958, Congress passed the "Space Act" that formed the National Aeronautics and Space Administration (NASA). NASA's mission was to "expand and improve" the United States space presence and to use science and engineering in the most effective ways to complete that mission (Dick, 2008).

Since the birth of NASA, the space industry obviously has thrived and produced several technological triumphs including putting a man on the moon; however, NASA has been responsible for many STEM Education initiatives. Funding through NASA grants has been responsible for bringing STEM Education initiatives to both pre and post secondary education for the past five decades.

> During summer 2010, more than 150 events, led by NASA Centers and 130 participating partners from across the Nation, engaged over 150,000 students in NASA experiences. Of these, nearly 22,000 students received at least 40 hours of STEM engagement and instruction (NASA 2012, p.12).

Sputnik's effect on the United State's demonstrative affect of the promotion of STEM Educational endeavors (most notably NASA), in addition to STEM industry advancements is immeasurable.

Kelly (2012) states:

> Americans were shocked when the Russians put the Sputnik satellite into space in 1957 and grabbed a lead in global technology. We responded with a massive push to upgrade math and science education. The problem now is no less urgent. While our interest has diminished, the rest of the world's has grown (p.1).

Although Kelly's (2012) assertions may be true, the government and industry leaders are taking steps to produce more STEM educators at all levels through scholarships and grants.

Contemporary Aspects of STEM Education

Although history has played and continues to play a part in STEM Education, there are many variations and opinions of what STEM Education is and how it should be taught. This section will attempt to wade through the complexities of STEM in education fields and how they are imparted to students and other stakeholders.

STEM Fields Defined

The four strands of STEM; Science, Technology, Engineering, and Mathematics, have been staple forms of all students' academic careers; particularly science and mathematics. They are defined as:

> ***Science:*** the systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms (Science, 2012).
> ***Technology:*** the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science (Technology, 2012).
> ***Engineering:*** the art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants (Engineering, 2012).
> ***Mathematics:*** a group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space and their interrelationships by using a specialized notation (Mathematics, 2012).

Although these definitions are the well known usual and/or established descriptive terms for STEM fields, there is obviously more to them. Science and Mathematics are at the forefront of STEM Education mainly because these are the most recognizable fields that most people can relate to in terms of academia. Technology and Engineering are the fields that are not only the most underrepresented, but also the most underfunded in education, specifically in the k-12 arena

(Miaoulis, 2011). The question is how do those in education interpret and integrate into their classrooms?

What about the "T and E" of STEM Education?

The "T and E" of STEM Education appears to be a stumbling block to producing a meaningful STEM experience to k-12 education students. There are several possible reasons for this and are as follows:

1) As mentioned Science and Mathematics are the most recognizable fields in STEM Education and most educators in these areas feel comfortable teaching them.
2) Many educators that are not in the fields Engineering and/or Technology are intimidated with processes that are associated with them.
3) Although Engineering is a recognizable word that most educators can somewhat relate, many who are not in the field(s) are not sure what engineers actually do in terms of education.
4) Many consider Technology as just a computer related field.
5) Many educators are comfortable in their fields and create "educational silos"

Technology and Education Defined

Technology Education has a long and rich history not only nationally, but globally as well. As society evolved from the Agrarian Age, to the Industrial Revolution and now the Information Age, through several paradigm shifts, Technology Education has grown and expanded and is now in the midst of yet another paradigm shift. The current shift is aligning science, engineering and mathematics with Technology Education in what is called the *integrative STEM initiative* (Sanders, 2009). An extra emphasis on engineering specifically is also being called for by many technology educators. Furthermore, the trend indicates that several institutions of higher learning are changing the names of their programs to *Engineering and Technology Education*.

In most dictionaries, technology is defined as "applications of tools and methods" or something similar. To the general public, and especially in education, the term technology is spelled "c-o-m-p-u-t-e-r-s," equating "technology" to one technological tool. A computer is a tool, but provides a very narrow view of the scope of technology as a whole. Computers are definitely one form or type of technology, but technology is much, much more than computers alone. Technology encompasses several different constructs that have been categorized by several state and national programs, organizations and standards. They include: Bio and Medical Technologies, Construction, Engineering and Manufacturing Technologies, Electronics, Energy and Power, Information Technologies and Transportation. Within these constructs are a plethora of sub-technologies. For example, Energy and Power technologies can include sub-technologies from automobile engines to green energy sources such as solar and wind energy.

Technology and Engineering Education Defined

The *Technology for All Americans Project* (ITEEA, 2011) that is sanctioned by the International Technology and Engineering Education Association (ITEEA) which sets standards for the study of technology and engineering, defines technology as "how humans modify the world around them to meet their needs and wants or to solve practical problems." Thus, Technology and Engineering Education is problem-based learning by students utilizing math, science, engineering and technology principles. These studies involve:

- Designing, developing, and utilizing technological systems
- Open-ended, problem-based design activities
- Cognitive, manipulative, and effective learning strategies
- Applying technological knowledge and processes to real world experiences using up-to-date resources
- Working individually as well as in a team to solve problems (ITEEA, 2011)

The Difference Between Technology Education and Educational Technology

As stated, Technology Education is problem-based learning by students utilizing math, science, engineering, and technology principles. Educational Technology (also referred to as Instructional Technology) is the use of technology to educate students. Seels and Richey (1994), state: "Instructional Technology is the theory and practice of design, development, utilization, management and evaluation of processes and resources for learning." (p. 6) Thus, Educational Technology uses technology (mainly computer-based) in pedagogical methods of instruction and assessment. This can include the use of PowerPoint, Blackboard, digital assessment programs, Web searches, DVDs and videos in addition other instructional multimedia.

Technology Education teachers may use educational technology to deliver lessons and for assessment; however, the confusion between the two disciplines is clearly a problem for most educators. The ITEEA and other leaders in Technology and Engineering Education recently made a name change from "Technology Education" to "Technology and Engineering Education" in an attempt to alleviate the confusion and have a solid identity within the educational community.

Overarching Goals of Technology and Engineering Education in Pre and Post-Secondary Schools

The overarching goal for Technology and Engineering Education is to make all citizens technologically literate (ITEEA, 2011). This can be accomplished through technology and engineering education alone, but also by integrating math and science principles into technology/engineering education programs. This is being done not only in the State level, but nationally as well (Brown, Brown, Reardon, & Merrill, 2011).

The overarching goals of Technology and Engineering Education in k-12 education

The overarching goals of Technology and Engineering Education in post-secondary schools are to produce certified Technology and Engineering Education teachers that are equipped with the knowledge, skills and dispositions to be effective educators and leaders.

What is a STEM Educator?

STEM can have different meaning to different people. STEM in higher education is somewhat straightforward. A student enrolled in a STEM related program, other than teacher education, is in a stand-alone STEM field. For example, if a student is majoring molecular biology, they will enter the STEM workforce as a scientist. They may or may not be exposed to technology, engineering or mathematics that specifically pertains to their field, but chances are they will be exposed in some way shape or form. Therefore, integration in terms of STEM may or may not occur; however, it must be noted they are within a STEM field.

This is not the case with teacher education. Consider a High School Science Teacher that just teaches science, but does not integrate technology, engineering or math into their curriculum or that do not collaborate with other STEM faculty. Although this teacher is in a STEM field the fact that they do not integrate or collaborate makes them just a science teacher, not a STEM educator. This is true with all teachers with the STEM field who teach k-12 education.

Conclusion

The consensus of the literature indicates that integrative and/or collaborative STEM education is a viable endeavor that will introduce k-12 students to STEM concepts (Barakos, Lujan, & Strang, 2012; Brown, Brown, Reardon, & Merrill, 2011). These concepts may lead to the student perusing a STEM major in higher education and ultimately chose a STEM career within the workforce. Barkos et al. (2012), stated:

> Perhaps for the first time since the launch of Sputnik, educators broadly agree on the value of STEM education for ensuring America's edge in the global economy. Yet teachers, administrators, and policy-makers find themselves confused about what it means to successfully implement STEM programs and initiatives (p.2).

It appears the there is a great need for all stakeholders to come to an agreement of what STEM education is and how the dissemination regarding education might be standardized?

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