Evolution of STEM in the United States

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Abstract

The teaching of the integrated subjects of science, technology, engineering, and mathematics (STEM) is gaining importance in Grades K–12 in the United States (U.S.). STEM is viewed by many as an opportunity to collapse the teaching of these subjects individually by using a more interdisciplinary approach to learning. This paper will define STEM and provide a discussion of why STEM is important in education in the U.S. today. Additionally, the paper will address how STEM can be implemented in schools, along with how it can be implemented with the nationally-developed educational standards and assessments in the U.S.

The concept of integrating subjects in U.S. schools, especially at the secondary school level, generally is not new and has not been very successful in the past. Some people consider STEM as an opportunity while others view it as having problems. STEM appears to offer some positive ways to integrate subject matter in four very important subjects.

Introduction

In the past few years, the integration of science, technology, engineering, and mathematics (STEM) has gained momentum in education in the United States (U.S.). This is partly because of the increased emphasis on it by the National Science Foundation (NSF), federal funding of legislation for STEM, and some states and localities changing their technology education offerings to be inclusive of the "T" and "E" in STEM by teaching "Technology and Engineering." Another contributing factor has been the evolution and implementation of nationally-developed content standards in almost all of the subject matter areas in schools. Many states and localities have, as a result, developed their own standards. To further complement this effort, the International Technology Education Association (ITEA) changed its name in March 2010 to the International Technology and Engineering Educators Association (ITEEA).

As with any new educational venture, some people consider STEM as an opportunity while others view it as having many problems. This paper will discuss the evolution of STEM and present the current level of implementation in the U.S.

What Is STEM?

STEM is an acronym for science, technology, engineering, and mathematics. It may be defined as the integration of science, technology, engineering, and mathematics into a new cross-disciplinary subject in schools. The study of STEM offers students a chance to make sense of the integrated world we live in rather than learning fragmented bits and pieces of knowledge and practices about it.

Historically, STEM was first "coined" as an educational term by the National Science Foundation (NSF) in the early 2000s. In the past decade and a half, NSF has funded (or partially funded) a number of STEM projects, including the Technology for All Americans Project (TfAAP) (1994-2005) under the International Technology Education Association (ITEA) that produced *Standards for Technological Literacy: Content for the Study of Technology* (*STL*) (ITEA, 2000 with additional printings in 2002 and 2007) and *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (*AETL*) (ITEA, 2003). The project was funded by NSF and the National Aeronautics and Space Administration (NASA).

Definitions Related To STEM

In order to better understand STEM, some current definitions used in the U.S. are relevant for comprehension. These are:

S — Science, which deals with and seeks the understanding of the natural world (NRC, 1996, p. 24), is the underpinning of technology. Rodger Bybee, Past-President of the Biological Sciences Curriculum Study (BSCS), explains more about the relationship between science and technology.

> A lack of technological literacy is compounded by one prevalent misconception. When asked to define technology, most individuals reply with the archaic and most erroneous, idea that technology is applied science. Although this definition of technology has a long standing in this country (Stokes, 1997), it is well past time to establish a new understanding about technology. So, my interest in technological literacy is fairly simple: it is in the interest of science, science education, and society to help students and all citizens develop a greater understanding and appreciation for some of the fundamental concepts and processes of technology and engineering. (ITEA, 2000, p. 23–24)

Science is very concerned with what is (exists) in the natural world. Many of the courses in schools, colleges, and universities reflect the natural world. These courses deal with biology, chemistry, astronomy, geology, etc. Some of the processes that are used in science to seek out the meaning of the natural world are "inquiry," "discovering what is," "exploring," and using "the scientific method."

T — Technology, on the other hand, is the modification of the natural world to meet human wants and needs (ITEA, 2000, p. 7). This definition is comparable with the definition provided in the *National Science Education Standards* which state, "The goal of technology is to make modifications in the world to meet human needs" (NRC, 1996, p. 24). Similar to these definitions, the American Association for the Advancement of Science's (AAAS)

Benchmarks for Science Literacy presents the following: “In the broadest sense, technology extends our abilities to change the world; to cut, shape, or put together materials; to move things from one place to the other; to reach further with our hands, voices, and senses” (AAAS, 1993, p. 41). In the National Academy of Engineering (NAE) and the National Research Council’s (NRC) publication, *Technically Speaking: Why All Americans Need to Know More About Technology*, technology is described as “…the process by which humans modify nature to meet their needs and wants” (NAE & NRC, 2002, p. 2). All of these nationally-recognized definitions of technology in the U.S. are very much alike and reinforce each other. Technology is very concerned with what can and should be (designed, made, and developed) from natural world materials and substances to satisfy human needs and wants. Some processes used in technology to alter and change the natural world are “invention,” “innovation,” “practical problem solving,” and “design.”

E — “Engineering is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind” (Accreditation Board for Engineering and Technology [ABET], 2002, back cover). There are strong philosophical connections between the disciplines of technology and engineering. The engineering profession has begun to work with technology teachers to develop alliances for infusing engineering concepts into K–12 education. The alliances will provide a mechanism for greater appreciation and understanding of engineering and technology. The National Academy of Engineering is a valid supporter of technological and engineering literacy.

M — “Mathematics is the science of patterns and relationships” (AAAS, 1993, p. 23). It provides an exact language for technology, science, and engineering. Developments in technology, such as the computer, stimulate mathematics, just as developments in mathematics often enhance innovations in technology. One example of this is mathematical modeling that can assist technological design by simulating how a proposed system may operate.

Why Is STEM Gaining Importance In Education In The U.S. Today?

In the U.S. last year (2009), approximately 1.25 million children left school without a high school diploma (or about 7,000 students a day) (Furger, 2008). Many citizens in the U.S. believe that technology and engineering education is not relevant to our youth today. Rodger Bybee, who was quoted earlier in this paper, states the following about the lack of relevant education in technology and engineering in our schools today: “For a society so deeply dependent on technology and engineering, we are largely ignorant about technology, engineering concepts, and processes, and we have largely ignored this incongruity in our educational system” (Bybee, 2000).

At the college and university levels, there are major concerns that the U.S. is loosing its technology and engineering leadership to other countries in the world. The Aerospace Industries Association of America reported in 2008 that the U.S. is currently experiencing a chronic decline in homegrown STEM talent, and is increasingly dependent on foreign scholars to fill the workforce and leadership voids (The Aerospace Industries Association of America, 2008). Similarly in 2007, the total number of foreign citizens studying in the U.S. (including undergraduates) has passed the half-million mark. Nearly one-third of all graduate students enrolled in the U.S. universities now come from abroad (The National Academies, 2007).

In 2003, only four percent of U.S. college graduates majored in engineering compared to 13 percent of European students and 20 percent of students in Asia. This is very shocking since there appears to be data supporting careers and jobs in STEM occupations. This is all supported by a recent report by the U.S. Business Roundtable, which warns that if the current trends continue, more than 90 percent of all scientists and engineers in the world will live in Asia (Business Roundtable, 2005). STEM education in the U.S. can help solve these problems in the future.

A new snapshot of parent perceptions of STEM education in the U.S. was released following a survey conducted by Public Agenda. While there is broad support from parents and the general public for K–12 national standards, more than half of parents (52%) say the math and science their child is getting in school is “fine as it is,” contents Public Agenda in the survey report titled, *Are We Beginning to See the Light?* (Johnson, Rochkind, & Ott, 2010).

Survey results also indicate that the general public favors a “national curriculum” as one way of improving STEM education: eight in ten Americans say establishing a national curriculum in math would improve STEM education, with more than half (53%) saying it would improve it “a lot.” Seventy eight percent say the same about a national curriculum in science, with 48% reporting it would improve it “a lot.”

Seventy percent of parents surveyed said they would also like to see their local schools spend more money on up-to-date and well-equipped science labs, more equipment for hands-on learning (69%), and more equipment to help students learn computer and technology skills (68%). The majority of parents with children in Grades 6–12 say they want to see more emphasis in their child’s school on STEM topics, such as computer programming (65%), basic engineering principles (52%), and statistics and probability (49%).

While only three in ten Americans see a demand for science and math-focused jobs in the current economy, 84% agree that there will be a lot more jobs in the future that require math and science skills. Nine in ten Americans say studying advanced math and science is useful even for students who do not pursue a STEM career. Additionally, 88% of the public agree that students with advanced math and science skills will have an advantage when it comes to college opportunities (Johnson, Rochkind, & Ott, 2010).

Integration Versus Isolation For STEM Disciplines

There are a number of ways that STEM can be taught in Grades PK–12 in schools today. One way is to teach each of the four STEM disciplines individually in schools. Some refer to this as S–T–E–M, or teaching each discipline as in a “silo” as an independent subject with little or no integration.

Another way is to teach each of the four STEM disciplines with more emphasis going to one or two of the four (which is what is happening in most U.S. schools today). This may be referred to as SteM.

A third way is to integrate one of the STEM disciplines into the other three being taught. For example, engineering content can be integrated into science, technology, and mathematics courses. This may be referred to as: E

S T M.

A more comprehensive way is to infuse all four disciplines into each other and teach them as an integrated subject matter. For example, there is technological, engineering, and mathematical content in science, so the science teacher would integrate the T, E, and M into the S.

There are a multitude of delivery models and teaching strategies that can be used in teaching STEM. Unfortunately, more work needs to be done that probes into which model or strategy works best in a given school or community.

STEM and Nationally-Developed Standards

Standards for education are statements about purposes—priorities and goals (Hiebert, 1999). As of 2010, there are no nationally-developed standards for STEM in the U.S.

Currently, there is a lack of research in the U.S. on the content standards needed to be mastered to become literate in STEM. The closest set of standards for the “T” and “E” of STEM has been *Standards for Technological Literacy (STL)* (ITEA, 2000/2002/2007). The technology and engineering education profession is currently in the early stages of further refining *STL*, so validated content standards will be available to properly reflect what every student will need to know and be able to do for them to be technologically and engineering literate.

There is research underway in the U.S. by the National Research Council (NRC) to develop a *Framework for Science Education.* This will be the forerunner to revise the *National Science Education Standards* (NRC, 1996) **.** The NRC framework includes four core disciplinary ideas, one of which deals with engineering and technology as part of science.

The National Council for Teachers of Mathematics (NCTM) developed *Principles and Standards for School Mathematics* (NCTM 2000) which does not specifically address STEM. Also, there are no nationally-developed standards for the teaching of engineering in Grades K–12 the U.S.

National Assessment Of Educational Progress (NAEP) And The T And E Of STEM

For the first time ever, technological literacy will be part of the National Assessment of

Educational Progress (NAEP), also known as The Nation's Report Card™. This is funded by the National Assessment Governing Board, which awarded WestEd a contract to develop the *2014 NAEP Technology and Engineering Literacy Framework and Test Specifications*. WestEd—a national education research and development organization based in San Francisco—has completed the framework and test specifications for the assessment in 2010. Ultimately, this task will lead to ways to define and measure students' knowledge and skills in the understanding of technology and engineering.

The *NAEP Technological Literacy Assessment* is the United States' first nationwide assessment of student achievement in this area. The work comes at a time when there are no nationwide requirements for technology and engineering literacy. Few states have adopted separate tests in this area, even as more business representatives and policymakers voice concern about American students' abilities to compete in a global marketplace and keep up with quickly evolving technology.

Several groups assisted WestEd with the 18-month project, including the Council of Chief State School Officers, the International Technology and Engineering Educators Association, the International Society for Technology in Education, Partnership for 21st Century Skills, and the State Educational Technology Directors Association. With this assistance, WestEd convened two committees that included technology experts, engineers, teachers, scientists, business representatives, state and local policymakers, and employers from across the country. The committees advised WestEd on the content and design of the assessment and made recommendations to the board on the framework and specifications for the assessment.

The Governing Board reviewed and approved the technology and engineering literacy framework in March 2010.

"We all know that engineering and technologies in all forms—including computers, communications, energy usage, agriculture, medicine, and transportation—affect everything we hear, see, touch, and eat," said Alan J. Friedman, a physicist and member of the National Assessment Governing Board's Executive Committee. "With this new framework and the tests it will guide, we'll discover how well students today are learning to understand and use these immensely powerful tools."

Summary

This paper has provided an insight into science, technology, engineering, and mathematics (STEM) as a school subject or integrated school subject. In many respects, STEM is in its infancy in the U.S. Currently, there is considerable effort underway by the federal government, many states and localities, professional associations, and educators on what it is and how it can be best implemented in schools today.

STEM offers a closer alliance within the study of technology, science, mathematics, and engineering. Mathematics and science are very well established disciplines in Grades K–12 today in U.S. schools. Engineering education is a new subject with much to offer and few good examples of success stories of implementation in schools. The study of technology is fairly well established as an elective subject in most states today. The power and position of science (S) and mathematics (M) in STEM education and the tendency to say STEM when one really means science or mathematics is a significant barrier to the fully-integrated STEM for the future. The S, T, E, and M are separate and not equal. The inequality really becomes clear, for example, when one considers the fact that science, technology, and mathematics have national standards, and by 2014, all three will have national assessments. In addition, science and mathematics are prominent in the international assessments, Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) (Bybee, 2009).

The future looks promising for STEM in the U.S. as a viable, integrated subject area in schools. The success or failure of the STEM movement will depend on the acceptance and buy-in that schools and teachers give to the integration of these four disciplines in an already crowded curriculum. Moreover, change in education is difficult to implement. As cited in his recent book, *The World is Flat*, Thomas Friedman writes, "The world may be flat but our educational system is as mountainous as ever" (Friedman, 2005).

The wealth and success of a nation is based on many factors. Education is key in this wealth and success. An educational system that is based solely on the basics (reading, writing, and arithmetic) does not prepare future citizens to compete and be successful in the technological world of today and tomorrow. The required study of STEM for all students in an educational system will provide a more relevant and meaningful preparation for students in the future.

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mathematics (STEM) is gaining importance in Grades Kâ€“12 in the United States (U.S.). STEM is viewed by many as an opportunity to collapse the teaching of these subjects individually by using a more interdisciplinary approach to learning. This paper will define STEM and provide a discussion of why STEM is important in education in the U.S. today. Additionally, the paper will address how STEM can be implemented in schools, along with how it can be implemented with the nationally-developed educational standards and assessments in the U.S.Â This paper will discuss the evolution of STEM and present the current level of implementation in the U.S. What Is STEM? 1 STEM is an acronym for science, technology, engineering, and mathematics. The Evolution of STEM and STEAM in the U.S. By Jennifer Gunn. Facebook.Â It was his call for the United States to ramp up technological innovation to stay competitive with other nations, spur economic growth, preserve national security, and propel ingenuity. Harkening back to the 1957 space race with Russia that spurred rapid growth in science and technological innovation, Obama called for the United States to seize this modern moment for our youth, asking educators to prioritize 21st-century skills learning. With millions in funding for teacher training, grants, research, and measurability, STEM is now a household name in education practice. The history of STEM an Stem cell laws and policy in the United States have had a complicated legal and political history. Stem cells are cells found in all multi-cellular organisms. They were isolated in mice in 1981, and in humans in 1998. In humans there are many types of stem cells, each with varying levels of potency. Potency is a measure of a cell's differentiation potential, or the number of other cell types that can be made from that stem cell. Embryonic stem cells are pluripotent stem cells derived from the inner The STEM Education Strategic Plan, Charting a Course for Success: America's Strategy for STEM Education, published in December 2018, sets out a federal strategy for the next five years based on a vision for a future where all Americans will have lifelong access to high-quality STEM education and the United States will be the global leader in STEM literacy, innovation, and.Â It represents an urgent call to action for a nationwide collaboration with learners, families, educators, communities, and employersâ€"a "North Star" for the STEM community as it collectively charts a course for the Nation's success. The Department is an active participant in each of the interagency working groups focused on implementation of the Plan. Abstract STEM education is particularly a new area at primary level in Turkey. Therefore, primary school teachers encounter numerous difficulties in adapting the new STEM integration reforms into their classrooms because of a lack of knowledge and experience. The aim of this participatory action research is preparing and implementing successful STEM activities in primary schools with primary school teachers. The study contains participant teachersâ€™ planning, implementing STEM / STEAM activities and professional development sections though the cyclical action process. And to explore teachersâ€™ p