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STEM Awareness Starts at the Elementary and Middle Schools

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Abstract

Is there a shortage of talented workers in the fields of science, technology, engineering, and math (STEM) in America? Yes is the answer to this question when various statistics of data are considered from different authentic government sources. Then the next question is how do we increase the STEM skills among the young Americans who pursue their K-12 education? This paper explores the different case studies and literature data available up to date to figure out how the importance of STEM education can be instilled in the young minds of the K-12 school system. The author strongly feels that the STEM education should start at the Elementary or Middle School level covering the first to eighth-grade students based on the fact that grooming the young minds at the very early age matching their educational interests is easy. This paper will explore the details of how one can use different methods of pedagogy enhancing the knowledge of STEM in Elementary and Middle School students.

Keywords

STEM, Elementary, Middle, methods, technologies

Introduction

At the elementary school level, STEM education provides an introduction to the STEM as well as an awareness of STEM (California Department of Education, 2014). For middle school students, STEM allows students to begin the exploration of STEM-related careers. Finally, for the high school, STEM prepares students for successful post-secondary education and beyond[1].

Among the four areas of the STEM, the research in technology and engineering education in elementary and middle schools is less mature because those subjects are not as commonly taught in K-12 education. The nature and potential value of integrated K-12 STEM education are the focus of an ongoing study of the National Academy of Engineering and the National Research Council by the Committee on Integrated STEM Education. The primary driver of the future economy and accompanying creation of jobs will be innovation, largely derived from advances in science and engineering. Four percent of the nation’s workforce is composed of scientists and engineers; this group disproportionately creates jobs for the other 96 percent.

The main objective for STEM education in elementary school is twofold; foremost, policymakers advocate for garnering interest in STEM subjects and careers, explaining that early years of education are pivotal for enticing students to get excited about mathematics, science, technology, and engineering. Another important aspect is to ensure students gain a strong proficiency in mathematics and science, and problem-solving, which will serve them well as they advance in their studies[2].

In the United States, the education of STEM is arguably, the most discussed educational topic of the 21st century[3]. Generally, the STEM initiatives have two main interconnecting objectives. At the national level, the STEM initiatives strive to increase the pool of qualified workers that the nation supposedly needs in order to stay economically competitive in the global marketplace. At the individual citizen level, the STEM initiatives aim to produce citizens who are able to procure financially secure employment in an ever-increasing technological world[4-5].

To begin with, STEM reforms targeted higher education and career readiness programs in an effort to get talented individuals to enter STEM fields. As STEM education became better known, policymakers realized that in order to obtain more STEM-qualified workers, they needed to focus on K-12 education. In recent times, more attention is being paid to elementary education (K-6) since that is where the initial interest in STEM fields is thought to occur. Private and public organizations such as the National Council of Teachers of Mathematics (NCTM) and the *Partnership of 21st Century Skills* advocate for the importance of earlier exposure to STEM fields, particularly to promote creative and problem-solving abilities in young people, believed to be so integral to future employment and democratic citizenship. At the elementary level, researchers advocate that STEM education ought to involve interactive problem solving, inquiry-based activities that inspire young learners. This meaningful hands-on problem solving and inquiry-based learning often also includes fostering creative capacity[6].

STEM IN ELEMENTARY CLASSROOMS

Elementary schools in the United States have been the terrain of a highly politicized push for improved reading and mathematics attainment, as well as calls for increased importance to be given to science, technology, engineering, and mathematics (STEM). With priorities placed on basic skills, however, instructional time in subjects such as science in the elementary years has been greatly diminished. In 2009, Frederick Douglass Elementary (FDE) is a K–5 school in relatively a small Midwestern town was selected to function as magnet school including STEM-focused curriculum in their academic programs. Through generating and articulating a common vision, the teachers were able to tap into their own professional knowledge bases and create a STEM-focused curriculum aligned to standards and their own understanding of best practice.

The teachers involved in the STEM-school creation faced many of the same challenges as teachers involved in the other magnet schools. Because of their work together, the teachers were able to argue for targeted STEM-related professional development, including pedagogical strategies throughout the curriculum writing and implementation process. In the process of school development, teachers developed a vision of both STEM curriculum and their school and translated the abstractions of policy and standards to the particular and teachable. Moreover, this development role required teachers to revision themselves professionally. They became, in practical terms, individuals that reinterpreted curricular ideas, adapting them to suit local circumstances and becoming curriculum developers[7].

Science and mathematics in elementary school classrooms are typically characterized by asking students to learn something in a matter of days that could have taken hundreds or thousands of years to understand. The push for incorporating STEM education in elementary school has become increasingly important, yet most educators and publishers have offered problem-based activities, without considering one of the most important pedagogical entry points to lesson planning – the hook or the opening. Each activity is designed to use everyday materials so that teachers of elementary schools can implement the problem or activity in their classrooms.

STEM education is most effective when a child is taught to think and act as a scientist, mathematician, inventor, or engineer. Use of STEM biographies (Biographies of successful Scientists, Mathematicians, and Engineers) not only reveals appropriate science, mathematics, and engineering behaviors and practices but also "provides a background and alternative perspective of previous work". History and biographies in the STEM disciplines can enable teachers to examine "the story" behind a scientific or mathematical principle. Teachers, along with the children, can collaboratively explore how a particular scientist, mathematician, inventor, or engineer arrived at his/her discovery. Many students have not had the opportunity to have history and biography integrated into science/math education; they suffer because their understanding of these topics has been limited[8].

It is hoped that, with the emergence of new learning standards, schools will begin to fully understand the importance of including the historical context of STEM principles in the elementary curriculum. Biographies in STEM have immense potential in the elementary classroom because they show that research and exploration are continually on-going; that is, one question arises from another question[9].

Do-it-yourself projects often involve the application of STEM competencies. Collaborating to create a geometry lesson, the school librarian might suggest engaging youngsters in creating their own comic strips. Drawing books are as popular as graphic novels in elementary schools, and these art books can be used to talk about using geometric shapes to create the images and frames in students' own comic strip creations. "Adventures in Cartooning" is a great guide to the creation of cartoons or comic strips; this is also a book that could be used to promote the critical reading of the format to understand how artists use various techniques to convey meaning. Project a page of a graphic novel on the interactive whiteboard or screen, and have students pick out the ways the author used relative size of the frames or objects in the frames to convey the point of view or relative importance. Much of Mathematics involves patterns and sequencing; both can be illustrated visually through a series of connected images[10].

Researchers from the University of Nebraska describe the evaluation of the quality and impact of the program called "NE STEM 4U" intervention on youth in elementary school grades. Specifically, the study focused on the following research question: How does the NE STEM 4U program influence the (a) excitement, (b) curiosity/inquiry, and (c) understanding of STEM concepts of elementary school participants? From this study, and the quantitative Dimensions of Sucess data, it was observed that the NE STEM 4U program within elementary schools was most effective in Space Utilization, Relationships, Materials, Organization, and Youth Voice (average scores greater than 3.5). Scores were high (greater than 3) across most categories. The weakest observation category was Relevance, though it still received an overall average score of 2.7. These results emphasize that NE STEM 4U is a highly effective STEM learning model for elementary school students, which maximizes the learning environment with the smooth delivery of STEM learning activities and use of appropriate materials to enhance engagement and understanding of STEM concepts. Further, undergraduate and graduate mentors build rapport with students via one-on-one interactions, thus encouraging them to share their perspectives and make meaningful scientific decisions. Importantly, this intervention has led to improved curiosity, inquiry, and scientific thinking among youth in elementary schools. Sustained partnerships and high-quality after-school programs help to build and maintain the STEM pipeline. The NE STEM 4U program serves as a model for other metropolitan universities to recruit youth into the STEM pipeline by raising STEM awareness and curiosity during a highly influential time in their development[11].

The technology of remote laboratories also opens up a wide range of possibilities, because it breaks physical barriers and allows access to them from any computer at any location and at any time using the Internet. In addition, remote laboratories must be used through a computer connected to the Internet, and this allows the use of advanced features that enhance the learning experience -- thus richer learning experiences can be created. Furthermore, from a pedagogical point of view, these remote laboratories open new fields of innovation based on the development of different competencies and, by involving parents, new opportunities for collaborative learning can be developed.

With regard to the elementary school, the basic competencies that are pursued are 1) Linguistic communication, 2) Mathematical competences and basic competences in science and technology 3) Digital competence, 4) Sense of initiative and entrepreneurship, and 5) Cultural awareness and expression[12].

STEM at Middle Schools

Why Target Middle School Students in the STEM?

Before students enter the eighth grade, they conclude many of the STEM subjects are too challenging, boring, and/or uninteresting (President's Council of Advisors on Science and Technology [PCAST], 2010), which in turn, limits their participation in STEM subjects and activities. It is at this key juncture in the students' educational career that their interest in STEM must be roused. Research has shown the importance of motivating students to learn STEM content in the middle grades. "Students who express interest in the STEM in eighth grade are up to three times more likely to ultimately pursue STEM degrees later in life than students who do not express such an interest" (PCAST, 2010, p. 19). Therefore, it is imperative that we prepare and inspire all students, specifically students of color, females, and students from low socioeconomic backgrounds, to learn STEM content[13].

Design of the Professional Development (PD) Model TESI (Teachers Exploring STEM Integration) was a 2.5-year project funded by a state Math–Science Partnership grant. The overarching goal of the project was to enable teams of middle school teachers to implement interdisciplinary STEM Design Challenges (DCs). The professional learning model targeted three areas of need: (a) increasing teachers' content and pedagogical content knowledge in mathematics and science; (b) helping math, science, and CTE (Career Technical Teachers)

teachers understand and integrate scientific, technological, engineering, and mathematical practices into their lessons; and (c) addressing teachers' beliefs about the feasibility and efficacy of engaging historically underperforming students in challenging problems.

Project teachers participated in two weeklong summer PD institutes in each of the first two years. The first institute, which occurred each June, focused on mathematics and science content relevant to STEM DCs written by project staff. Engaging project teachers in design challenges during the institutes served three purposes. First, it familiarized teacher participants with the goals, content, and processes involved in engineering design (see Figure 1), and ways in which these intersect with content and practice standards from CCSS (Common Core State Standards) and NGSS (Next Generation Science Standards). Second, it allowed the project team to model ambitious instructional practices associated with engaging all learners in authentic design challenges. Third, it provided the teacher participants with a tangible example of a DC they could enact in their own classrooms during the school year. Throughout the week, teachers worked in interdisciplinary teams to generate questions, then research and design solutions to a specific problem. In Year 1, the challenge was to grow crystals with properties desired for particular business or industry use, and in Year 2 the teachers used LEGO robotics to complete challenges related to rising sea level and global climate change. Both of these challenges aligned with 8th-grade district learning goals[14].

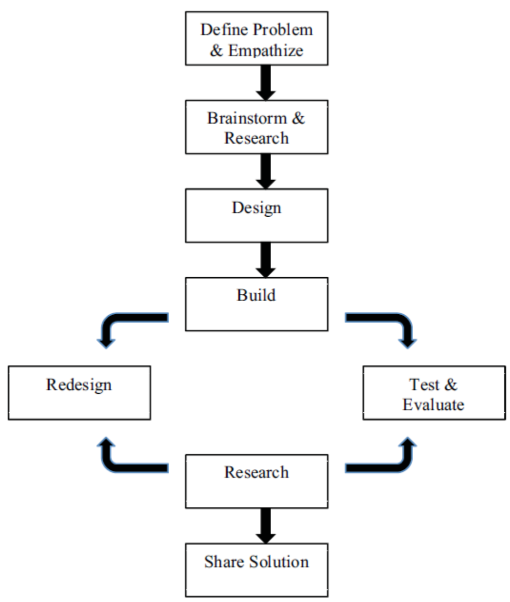

Figure 1 Engineering Design Process used in TESI project

STEM program was offered to sixth to eighth-grade students through rotation class method in Manchester Middle School. The rotation method involves several design challenges used by more than 125 students within 45 days. The sixth grade STEM program is a virtual reality class trip to Mt. Everest. The trip is for the students to use the engineering design process to prepare to climb Mt. Everest. The program consists of three design challenges. The first is "Gearing Up", where they have to test materials to design a hiking coat. The second "Crevasse Crisis", we encounter the Khumbu Icefall and need to build a ladder bridge to cross the crevasse. Finally, the third is "Sliding Down", where one of our hikers gets ill and they need to design a zip-line to get down Mt. Everest. The sixth graders maintain a digital notebook to document their experience in the STEM.

The seventh-grade program is a virtual reality class trip to New Zealand. The trip is for the students to see where The Lord of the Rings was filmed. The program consists of three design challenges. The first is “Stranded”, the second “We Need Water!”, and the third “Balancing Act”. Throughout these design challenges, the student uses the engineering design process, as well as many science and mathematical concepts, while maintaining a digital notebook to document research, designs, and team experiences.

The eighth-grade program is the building of an underwater robotic vehicle (ROV) sponsored by the Office of Naval Research. The program which they have designed allows teams of students to work together to build, acquire tool safety, understand how to use tools, electronics, and develop a fictitious company that uses ROV’s for some particular challenge. Many of the students also join the engineering club to enter challenges using their underwater robots.

These tasks require all students to communicate, strategize, plan, and decide upon solutions to complete the challenges[15].

Conclusions

STEM programs should be started at the elementary school level because it is easier to align the younger fresh minds on the path of STEM education by displaying it in different playful ways.

After the Elementary School STEM education, the students need to be introduced to their career path to choose the field of study in STEM areas that they want to explore for future.

Finally, the High School will prepare the students for the STEM higher education so that they can pursue their higher education in Colleges or Universities.

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