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Strategies, Research, and Examples for Elementary Teachers to Integrate STEM

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Abstract

Over the past decade, STEM has become an important goal in schools because of the strong global initiatives for improving education. In fact, the 2010 President's Council of Advisors on Science and Technology indicated that there was a need to provide individuals with strong STEM backgrounds in order for the United States to be educationally competitive internationally. This article provides ideas to successfully integrate STEM (science, technology, engineering, and mathematics) concepts into all elementary grade levels (K-6), research to provide support for the STEM integration ideas, and examples on how to integrate the ideas. Specifically, the ideas range from encouraging creativity to providing hands-on experiences. While these are important at all grade levels, the article supports the idea that elementary is the foundation that builds students' willingness and ability to 'think outside the box' or understand there is more than one way to solve problems.

Keywords: STEM, Elementary, Teaching

While some educators may argue that creativity, problem solving, and team building have been part of elementary curricula for generations, other educators argue that since the implementation and rollout of the Common Core State Standards, and other similar standard sets around the country, there is a more developed and pointed focused on classroom learning around collaboration, perseverance, problem solving, and questioning or critiquing presented information. Part of the shift to integrated team-building and problem solving was not only guided by the Common Core State Standards, but also by the coining of the ideas focused on 21st century skills (http://www.p21.org/). Specifically, the learning and innovation skills highlighted in the 21st Century P21 Framework include: critical thinking, communication, collaboration, and creativity, or the 4Cs. Therefore, combining the ideas of STEM integration with the importance of recognizing 21st century skills, elementary content areas of Science, Technology, Engineering, and Mathematics can be addressed fully, purposefully, and effectively. While some educators may view each of these subjects individually, in this article ideas for integrating the STEM concepts across curricular areas, in an interdisciplinary manner, will be described as a way to encourage problem solving and communication between and among elementary students, specifically grades K-6.

The purpose of this article is to outline ideas, research, and examples of ways elementary educators can guide students to develop the outlined 21st century skills in order to prepare for future careers. While the outlined ideas could be implemented in any classroom environment, the specific focus on elementary teachers and classrooms has been highlighted in this article because K-6 education arguably builds the foundation for future interactions and learning. What is developed in K-6 classrooms will inevitably influence a students' educational career and future experiences. As stated by Innovate Public Schools (2015), "Elementary school learning is like building a house—the concepts your child learns early on will serve as the foundation for everything that comes after. Catching up later is a lot harder than keeping up" (para.1).

Elementary STEM Integration

The outlined ideas for STEM integration in elementary classrooms in this article are provided as a way to help guide teachers through the integration process. The research associated with the ideas are aimed to provide teachers reasoning behind the concepts, provide additional resources and substantiate the concepts. And finally, the examples are provided as a way for readers to "see" how the outlined ideas could be integrated in elementary classrooms. However, it should be noted that while STEM integration can be implemented in several ways, this article provides actionable items for elementary teachers. Additionally, throughout each actionable item, the following two themes are threaded: authentic or real-world problems and service learning.

Authentic learning incorporates instructional strategies that allow students to explore, discuss, and meaningfully construct concepts clearly related to real-world problems. Elementary teachers who are able to understand and incorporate authentic learning with other actionable items related to STEM integration, build a strong foundation for students in their future educational careers.

Service learning develops community partnerships as a way to fully integrate real-world scenarios and problem solving. Specifically, Joe Bandy, the Director at the Center for Teaching at Vanderbilt University (2017) defines service learning as, "combining learning goals and community service in ways that can enhance both student growth and the common good" while also teaching civic responsibility" (para. 1). Integrating service learning with STEM concepts increases students' social emotional capacity, while also developing a sense of what needs are in the community, how to collaborate with community organizations, and the processes of urban planning (Chung & McBride, 2015). Service learning "combines learning goals and community service in ways that can enhance both student growth and the common good" (Bandy, 2017, para. 1).

Hands-on

Hands-on learning specifically provides students opportunities to actively participate in a lesson verses passively listening to instruction. It has long been recognized that experiential, hands-on education provides motivation and inspiration for learning new material because it provides real-world (authentic learning) meaning to otherwise abstract knowledge (Christensen, Knezek, & Tyler-Wood, 2015; Mataric, Koenig, & Feil-Seifer, 2007; Toma & Greca, 2018). Service learning is also a way for hands-on instruction to occur related to STEM. Students and/or classrooms can engage in a wide variety of service learning partnerships with local companies such as community gardening initiatives or community restoration projects or filling potholes as it relates to the wear and tear on vehicles.

While hands-on learning can be met through authentic and service learning, there are also other examples of implementing this idea. Relating the hands-on concept back to research, the National Research Council's Framework for K-12 Science Education (2012) discusses the role of engineering as a mechanism by which students can learn meaningful, hands-on, and scientific. For example instead of reading about gravity or the mechanics of a rollercoaster, teachers could partner with local amusement parks to provide students with the learning opportunity and hands on task of building a model roller coaster to learn about the math, physics, and technology concepts involved with designing a successful theme park ride.

Learner-Centered, Student Choice

Learner-centered or student choice environments allow students to choose and feel accountable for their learning. This accountability has been shown to motivate students to take an active role in their learning (Williams, 2018). Furthermore, in learner-centered classrooms, students feel accepted and supported, feel ownership over their learning, and are more likely to be involved and willing to learn (Bransford et al. 2000; Cornelius, White & Harbaugh, 2009; McCombs & Whisler, 1997; Watson & Reigeluth, 2008).

Authentic and service learning incorporation are two methods of creating student choice or a learner centered classroom. When students are able to choose an area of their community or an organization providing services in their community to partner with, students are taking ownership of not only their learning but their community. Furthermore, students who are provided the mutual respect and autonomy to choose from a variety of structured problems, develop an increased self-esteem and enjoyment around learning (Velici, 2017).

Research supports this idea. According to the National Research Council's report (2012) "Effective STEM instruction capitalizes on students' early interest and experiences, identifies and builds on what they know, and provides them with experiences to engage them in the practices of science and sustain their interest" (p.18). Granting students a choice personalizes their learning and increases their motivation. While this may be obvious to many educators, researchers go even further to say that student-choice could make or break the success of a STEM education program/curriculum (Schmidt & Kelter, 2017).

Creativity

Encouraging creativity can be simply summarized by Ruppert (2010) who stated, "The arts both as a stand- alone and an integrated curriculum must be an integral part of the 21st century education if our students are going to succeed in a global economy" (p.2). Land (2013) echoes this sentiment by sharing how the integration of the arts into STEAM produces a unique skill set in learners that can improve creativity and innovativeness in our students. While this may be an obvious item to many educators and the general public, it is important to develop a common definition for creativity as it relates to the elementary classroom and STEM instruction specifically.

Generally, creativity is defined as using one's imagination. However, in the field of education, the definition goes deeper to focus on creativity as it relates to solving problems by thinking outside of the box when a challenge is presented and to finding various solutions to a problem. This is known as creative education and can be directly related to STEM integration (Kanematsu & Barry, 2016).

Creativity and STEM also can be linked to service and authentic learning because part of the creative education concept focuses on students being provided problems that move away from rote memorization or prescriptive teaching to encourage innovative approaches to problem solving (Honey & Kanter, 2013). As with many of the other ideas, classrooms could partner with community agencies to provide a service or needed task in the community that is hard to solve. Allowing students to think outside of the box for a needed problem in their community not only provides an avenue for creativity related to STEM concepts, but it also nurtures the social skills of empathy.

It is important to note, however, that a partnership with any organization is great, but will not necessarily build on STEM concepts. Some ideas for agencies to partner with that may provide creative problems and link to STEM concepts include, but are not limited to: waste management, city works (water, sewage), street cleaners, park districts, nursing

homes, retirement communities or food pantries/soup kitchens (i.e. how many tubs of food do we need, how are we going to transport it or keep it at a healthy temperature, etc.).

Cooperative Learning and Inquiry

Often individuals use the terms cooperative and collaboration interchangeably, however they are different. Collaboration is basically working with one or more people in order to accomplish a shared goal or produce something. While collaboration is an important concept in elementary classroom, the idea of cooperative learning, as it relates to STEM and problem-solving, is more applicable. Specifically, cooperative learning focuses on teachers consciously placing students in small teams or groups with the added benefit of every students entering the group at different ability levels (Perez, 2015). Providing experiences for students to engage with each other in cooperative learning teams allows students to learn from each other and teach each other. Additionally, in cooperative learning teams students are able to build on each other's strengths, while helping each other strengthen areas of weakness. As part of the cooperative learning environment, students are able to build relationships and develop emotional processes, which impact how the students' learn. Therefore, incorporating collaborative learning teams in elementary classrooms positively impacts students' educational careers in the present and future (Elias, Wang, Weissberg, & Zins, 2002).

As with the other ideas, service and authentic learning can be incorporated into cooperative learning in much the same way. However, another example of incorporating cooperative learning into an elementary classroom involves a discovery jar. Leading up to a new unit, specifically focused on a STEM concept, students can place questions in the discovery jar about the new unit. When the new unit arrives, each cooperative learning team is provided one of the questions to research, solve, and/or discover through group interactions and working together.

Some readers may ask, "Isn't this collaboration and not cooperative learning?" The answer is 'Yes'. Once students are placed in cooperative learning teams based on ability levels, the real-world problem the team is researching and/or solving together because a common goal, therefore a collaboration. This movement from collaborative learning teams to cooperation is minimal and fluid, hence why the words are often used interchangeably.

The discovery jar example leads into the corresponding concept of inquiry. Inquiry is the act of asking for information. Incorporating inquiry methods into an elementary classroom allows students to discuss and explore various ways to solve a problem. It also promotes the use of critical questions rather than just question answering. This in turn encourages inquiry based thinking.

In the inquiry classroom the teacher's' role becomes less involved with direct teaching and more involved with modeling, guiding, facilitating, and continually assessing student work. STEM based instruction should embrace an inquiry-based philosophy that encourages student to pose questions, experiment, and develop ideas, rather than simply memorizing information and knowledge (Regalla, 2016). Teachers in inquiry classrooms must constantly adjust levels of instruction to the information gathered by the assessment, whether informal or formal (Oliveira, 2010). However, the constant assessment aids in the development of cooperative learning teams and benefits the students' learning.

Discussion

This article provides ideas for teachers on how to successfully integrate STEM concepts into all elementary grade levels (K-6). Each idea was supported by research and examples, while also focusing on the core mathematical practice of relating to real world problems. According to Tsupros, Kohler, and Hellinen (2009) STEM integration can provide

students with one of the best opportunities to experience learning in the real world, rather than learning STEM subjects in isolation. There is a natural overlap between the science, technology, engineering and math concepts that provide a perfect opportunity for students to apply their knowledge to real-world situations, which strengthen their understanding and motivation to learn. If students know that what they are learning applies to their future understanding of how the world works, their interest increases, as does their ability to apply the knowledge to new settings.

Due to the national initiative to integrate STEM into schools, teachers are interested in learning strategies for making the cross curricular infusion of science, technology, engineering and math. STEM is not only an important aspect of the education field but also to the development of our future innovative thinkers. Using STEM infused curriculum, students can be inspired to become creative artists, scientists, engineers, and mathematicians. Interacting and learning in classrooms that fully and integrate STEM interdisciplinary creates learners that are able to work collaboratively. Through the integration of a hands-on authentic STEM curriculum, teachers become creators with the students, observers, reflectors, and guides in a student-centered classroom. As STEM curriculum continues to flourish in education, students benefit and are becoming prepared to live, work, and function in a future world; a world with problems to solve and innovations that are the machines of the future.

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