Using Literature to Teach Integrated STEM[1]

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Nations around the world certainly value and promote reading. They want citizens to develop positive reading dispositions and engage in meaningful reading behaviors. Nations also value writing, computing, investigating, and innovating. Reading helps citizens do all of these effectively and efficiently.

Reading is a useful literate behavior. Throughout life, reading helps us to acquire new knowledge and use this knowledge to solve real-life problems. Sometimes, we already know the problems. Other times, we don't. Fortunately, reading helps us discover new problems. Still other times, reading allows us to wonder about potential problems that nations, individually or collectively, might need to solve in the future. What is important is that citizens need to continually learn to write clearly, compute accurately, investigate critically, and innovate imaginatively in order to improve the quality of their lives and the lives of others. Reading literature that integrates STEM (Science, Technology, Engineering, and Mathematics) and the engineering process holds much promise to do just that.

This article introduces STEM (Science, Technology, Engineering, and Mathematics) and the engineering design process. Next, it describes the engineering design process and shares selected literature from a text set of literature to teach integrated STEM. It ends with implications and challenges for future research.

[1] This article has been published in *Kielikukko 2/2018* except **Appendix A: Text Set of Literature to Teach Integrated Stem**

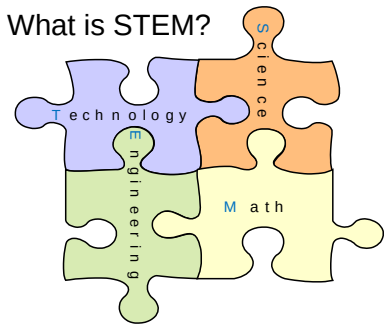
STEM

The Most Magnificent Thing (Spires 2014) is a wonderful story to introduce STEM.The story describes a little girl who decides one day to make the most magnificent thing. She knows exactly how it will look and work. With an assistant, her dog, she gathers supplies and builds it, only to discover it is just wrong. She examines, fiddles and tries again. She makes changes but it is still wrong. She gets frustrated, then angry and wants to quit. Her dog suggests a time out. Then, she looks at the first wrong thing she made, then the next, and finally notices something surprising. Parts of the wrong things are quite right. She now knows how to make the most magnificent thing. She tinkers, hammers, fiddles, glues, and paints. Finally, she looks again. It leans a little and looks heavy, but it is just what she wanted!

This story highlights the natural curiosity, imagination, and playfulness of young children. It also captures the excitement of imagining, creating, and inventing something, as well as the frustration and disappointment of discovering that sometimes the process is harder than expected. The story is a celebration of one little girl for being curious, remaining steadfast, overcoming frustration, and thinking differently.

This story is a good way to introduce STEM. Science is the study of the natural world. Technology is the "Innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs" (International Technology and Engineering Educators Association 2000). The goal of technology is to "make modifications in the world to meet human needs" (National Research Council 2012). Engineering is a field which focuses on applying knowledge to solve practical problems. Math is a way of quantifying and describing used to support the fields of science, technology, and engineering. Figure 1 illustrates the integrated concept of STEM.

Figure 1. What is STEM?



We use the following four-step procedure to introduce STEM to students with *The Most Magnificent Thing*:

Step 1: Before Reading

- Before reading the story aloud, we show the book cover and invite students to share predictions about what the story will be about;
- We pose two inquiry questions for students to consider: What do you notice? What do you wonder?

Step 2: During Reading

- During reading, we stop at strategic places in the text and invite students to spend 2–3 minutes thinking about and writing down initial responses to the two inquiry questions they posed in step 1.

Step 3: After Reading

- After reading, we invite students to take 3–5 minutes and do a Focused Quick Write. The purpose of this instructional strategy is for students to write quick responses to the text based on the two inquiry questions.
- Afterwards, students share quick writes with the entire class. The teacher guides this discussion to highlight key features of STEM thinking.

Step 4: Reflection

- As a culminating experience, we invite students to spend time reflecting and writing how this text has helped them better understand the concept of STEM.

Engineering Design Process

We also like *The Most Magnificent Thing* (Spires 2014) to introduce the engineering design process. This picture book describes how the young girl uses the engineering design process to solve a real-world problem, her own, in a real-world context, her neighborhood.

The engineering design process involves an iterative series of steps. The entry point to this process is typically defining the problem. Next, brainstorm and develop solutions, make and test a prototype or model, and reflect and redesign. The process then starts again. Students can identify the elements of this process in *The Most Magnificent Thing*.

Creating engineering design challenges is one way to engage students in the engineering design process. After reading *The Most Magnificent Thing*, student might explore such design challenges with building a cart to carry sport supplies or design a food transport system for roadless areas.

- Food deserts in the US are places where fresh produce and grocery items are difficult to find. They are often located in inner city or low income communities.
- How can you help families who live in food deserts grow fresh produce in spite of land and space restrictions?
- Design a system for growing fresh produce without soil.

Text Set of Literature to Teach Integrated STEM

The Most Magnificent Thing (Spires 2014) is one book from a text set of literature that can be used by teachers to teach integrated STEM (see Appendix A). A text set is a collection of literature that is connected in some way, e.g. theme, topic, genre, author, illustrator, etc. (Short, Harste, & Burke 1995). For example, *Anything is Possible* (Belloni 2011) is a delightful story of a sheep who invited a wolf to build a flying machine. They designed plans and collected materials. On the first test flight, the machine fell to the ground because the fabric was not strong enough. Next, they tried balloons, but birds popped the balloons and the machine once again fell to the ground. Sheep had a new idea and it worked! They were flying.

Para's Mechanical Fish (Fleming 2013) is fictional account but it is based on the life of an eccentric inventor named Lodner Phillips. In the 19th century Phillips dreamed of designing, building, and operating a submarine. His first prototype sank, but he persevered. He made different design improvements and in 1851 he built the *Whitefish*. This unique submarine was equipped with an innovative steering system and air-purifying system, and a steam boiler to power the engine.

Mr. Ferris and his Wheel (Gibbs-Davis 2014), *The Fantastic Ferris Wheel* (Kraft 2015), and *George Ferris: What a Wheel* (Lowell 2014) are all fascinating true accounts of an eccentric inventor and mechanical engineer named George Ferris. As part of a nationwide contest for inventions to be presented at the 1893 Chicago World's Fair, Ferris designed and submitted a proposal to build a physical structure that would not only dazzle the world, but actually *move*! Although many judges were skeptical and others actually scoffed, Ferris finally received permission but received no financial support. Nevertheless, work proceeded at a rapid pace. Two huge steel towers were placed in the

earth, bolted to crossbars of steel, and cemented all around. Then, a seventy-ton axle with fittings was lowered into the ground to anchor the giant invention. Next, an enormous circle was constructed and fitted with huge passenger cars. Finally, on June 21, 1893 his amazing invention was displayed on the world stage. George Ferris had successfully invented what would become the world's most magical ride of all time -- a Ferris Wheel.

The Boy Who Harnessed the Wind (Kamkwamba & Mealer 2012) is a truly inspiring, real-life story about a young boy named William. He lived in the Republic of Malawi, in Africa, and at the time it was experiencing a severe drought. Fortunately, since birth, William was always interested in mechanical things, especially how machines work. At the age of 14 he designed and built out of junkyard scraps a functioning windmill that brought electricity to his home and later life-saving water to his village.

These texts, and others in the text set, can be used with instructional strategies to help students learn about STEM and the engineering process.

Implications and Challenges for Future Research

Teaching integrated STEM has interesting and promising implications for future research. Two implications on STEM thinking include: How does engineering design impact the global economy? How does engineering design shape our image of the world? Teaching STEM also poses challenges for both teachers and teacher educators with respect to curriculum, instruction, assessment and teacher preparation. For example, how do we move from a disciplinary-based (individual content areas) to an interdisciplinary-based (integrated content areas)? How do we move from a transmission model of teaching to an inquiry-based model? How do we move from standardized testing to authentic assessment? How do we prepare pre-service and in-service teachers? We hope

these questions with start new conversations about the power and potential of teaching integrated STEM.

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Appendix A: Text Set of Literature to Teach Integrated Stem

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INTRODUCTION Need for Integrated STEM In recent years, the importance of providing students with a strong education in Science, Technology, Engineering and Mathematics (STEM) has been stressed.Â STEM-literacy, i.e. the awareness of the nature of science, technology, engineering, and mathematics and the familiarity with some of the fundamental concepts from each discipline, should be an educational priority for all students (Bybee, 2010; National Academy of Engineering and National Research Council, 2014). A promising approach in this regard, is the use of an integrated STEM curriculum, which provides opportunities for â€˜more relevant, less fragmented, and more stimulating experiences for learnersâ€™ (Furner and Kumar, 2007, p.186). Stem education integrated science, technology, engineering, & mathematics education. INTEGRATED STEM â€¢ Authentic, engaging, hands-on learning â€¢ Developing thinking skills: How to think vs. what to think â€¢ Project-based learning â€¢ Curiosity, imagination, technological literacy â€¢ Exploiting technology to foster creativity â€¢ Treating effective teamwork as an outcome â€¢ Learning transfer: Basic skillsâ€”applicationâ€”synthesis â€¢ Building a STEM mental warehouse!Â Big Ideas â€¢ Attributes of shapes used in structures â€¢ Properties of materials â€¢ Use of the engineering design loop â€¢ Ability to clearly demonstrate and present final project. Solve the ProblemUsing the design loop! How is disciplinary content delivered in STEM?