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Unravelling STEM: Beyond the acronym of Science, Technology, Engineering, and Mathematics.

Dr. Maeve Liston

The Emergence of STEM

Governments and industry are highlighting the importance and need for a highly capable STEM population with creativity, problem solving, critical thinking, and communication skills to ensure not only economic, but also social and cultural prosperity, making the world a better place to live in.

Many research publications, reports and policies have been highlighting the importance of STEM lessons and educational experiences:

1. STEM lessons encourage children to go deeper in their understanding of important mathematics and science concepts.
2. Students become innovative critical thinkers and more able to make good decisions.
3. Students understand how to approach and solve problems.
4. Students develop a sense of ethics and social conscience.
5. Students develop good collaboration skills. STEM lessons and projects have a major emphasis on teamwork and communication.
6. Students become more technologically literate.
7. Students understand how their STEM coursework opens doors to future careers.

(Jolly, 2017).

Therefore, there have been calls to integrate STEM right across education systems and the need to prepare students with twenty-first-century skills through STEM-related teaching, especially at the grassroots at primary and second level (Roberts, 2012).

"*On its surface, "STEM" is the acronym of Science, Technology, Engineering, and Mathematics. However, when you pull that first layer away, you reveal the most elaborate puzzle in the education world. Most educators know what STEM stands for, but how many really know what it means*?"(Gerlach, 2012).

This article will focus on what STEM is? and the characteristics of truly authentic STEM learning experiences, activities and events.

What is STEM?

We once spoke about Science, Technology, Engineering and Mathematics as separate disciplines. Now we speak about STEM …….STEMmania has gripped the world. We are speaking about STEM everywhere….There are STEM events, STEM teaching resources, STEM festivals, STEM kits etc. (Sanders 2009). Everything is being labelled 'STEM' nowadays…….is a coding session STEM or just technology…….is a session on building a circuit…STEM or just Physics? ….does using an electronic whiteboard or apps during a science lesson make it a STEM lesson?

Gerlach (2012) questioned '*Can science and mathematics alone be STEM?'* There is much more to integrating STEM disciplines than simply teaching two disciplines together or using one discipline as a tool for teaching another (Bryan *et al.* 2016). STEM education isn't just one thing—it's a range of strategies that help students to build understanding apply concepts and skills from different disciplines in contexts that make connections between school, community and work in order to solve meaningful problems (Gerlach 2012; Vasquez, Comer and Sneider 2013).

> *'STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering and mathematics and integrates them into real-world, rigorous and relevant learning experiences for students'*
>
> (Vasquez, Comer, & Sneider 2013)

If true authentic STEM education is adopted during so called/labelled STEM events and initiatives, they should comprise of the following characteristics:

- Removing traditional barriers of separating the four disciplines of science, technology, engineering and mathematics (Vasquez, Comer and Sneider 2013).
- Allowing for innovation and critical thinking (Jolly 2017).
- Integrating real-world, rigorous and relevant learning experiences for students (Vasquez, Comer and Sneider 2013).
- Inspiring creativity, problem solving inquisitive thinking, and teamwork (Roberts 2012).
- Integrating and applying a deeper level knowledge and understanding of mathematics & science to create technologies and solutions for real-world problems using engineering design approach (Jolly 2017).

From my experience, 'STEM' events quite often do not possess the above characteristics of STEM but only elements of STEM therefore we need to ask ourselves should they just then be more appropriately called 'Science' events or 'Tech' events rather than 'STEM' events? If events are to be labelled 'STEM', engineering has to take centre stage during the activities. Engineering is the glue that integrates science, mathematics and technology and forces them towards workable solutions. STEM activities and lessons use the Engineering Design Process (EDP) as a systematic, orderly, open-ended way of approaching problems and designing solutions for those problems (Figure 1).

Figure. 1. Engineering Design Process (EDP) for STEM Lessons and Activities

Jolly (2017) in her book entitled '*STEM by Design: Strategies and Activities for Grades 4-8'* describes the characteristics of successful STEM activities and lessons in which students use science, mathematics, and technology to solve real-world engineering design problems (Figure 2).

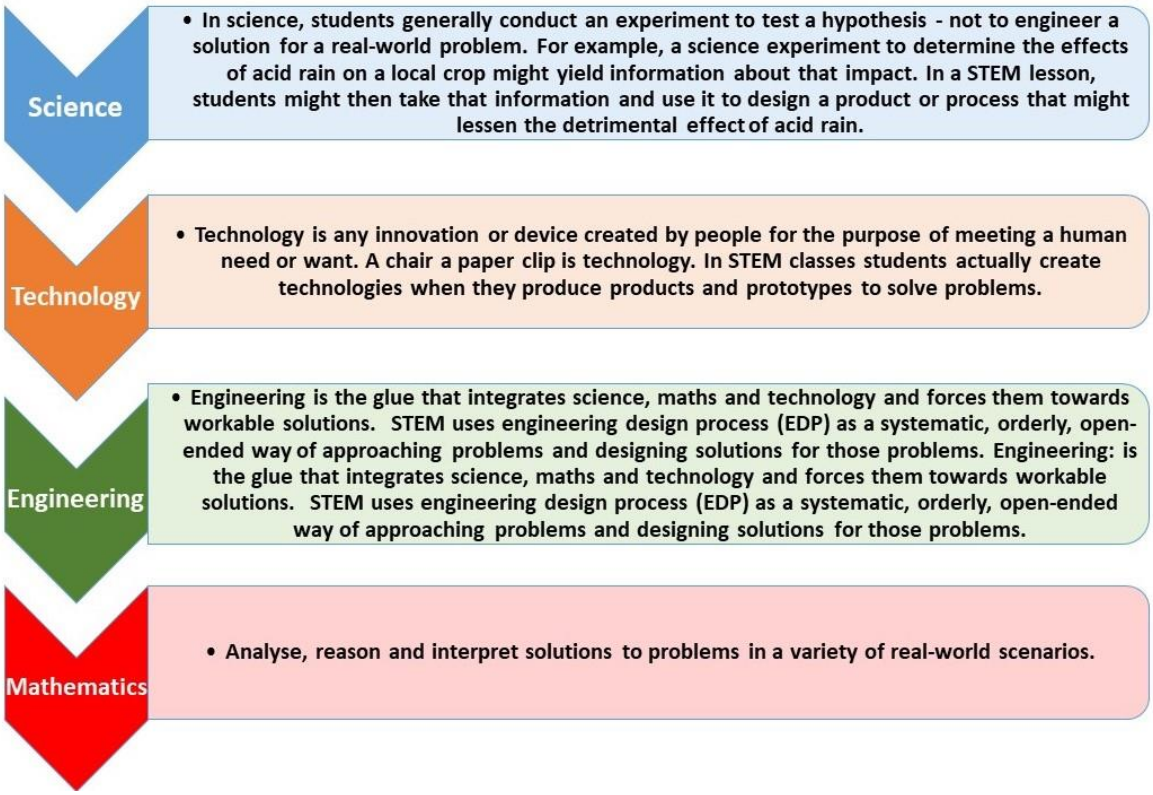

Figure 2: Successful STEM activities and lessons explained (Jolly, 2017).

Many STEM events and activities already involve inquiry-based learning and experimenting, which may incorporate technology. Does this mean that these presenters are already teaching STEM? From what has been explained in the previous sections above and in Figure 2 we would

have to say “No”. The foundation of STEM education lies in engineering and of the four letters in the acronym, the "E" is the least understood and utilised (Basham & Marino 2013).

When researching books including activities for integrating STEM into outreach activities and teaching at primary level I often find that many examples of lessons and resources available do not encompass interdisciplinary project based STEM. Many lessons are science lessons that do not incorporate any type of design, real world applications or core ideas of engineering.

The “T” of STEM Education can also be an obstacle to producing a meaningful STEM experiences. As stated in Figure 2 above a chair or a paper clip is a piece of technology as they were produced to solve a problem. Vasque (2015) describes an activity to explain the concept of STEM by using a simple pen (Figure 3).

Pick up a pen and take a close look at it.

Do you think this is a piece of technology? **If you’re like most people you probably answered no. we tend to think of technology as just things we plug in, in fact, however, technology is anything that is made by human and used to solve a problem.**

The pen certainly solves a lot of problems, and it’s very convenient. Let’s look at this pen a little closer. ***Are there different parts that make up the pen? How many would you get if you took it apart? What happens if you touch the point of the pen to your tongue?***

Do you think that ink would harm you? **(it would not as this ink has been developed and tested by biochemists who made certain the ink was non toxic).**

The physical properties of your pen (hardness, durability, and mass) and the way the parts function together result from the calculations of mathematicians and the design choices of engineers who worked in interdisciplinary teams to develop it. The humble pen in your hand is an excellent example of technology based on science, engineering and mathematics.

Figure 3. The concept of STEM: a simple pen (Vasque, 2015)

There can be quite a lot of uncertainty around the design and understanding of STEM activities. This article discussed what STEM is and the characteristics of true authentic STEM activities and lessons. It also looked at possible misunderstandings we may have about STEM. If you are at a STEM event or researching STEM resources in the future I would ask you to take a moment to analyse and reflect if the activities incorporate the characteristics of a true authentic STEM. In order for us to embrace an integrated approach to STEM which is meaningful and effective in our classrooms and as part of STEM outreach activities high quality STEM teaching and learning materials and resources are needed along with well-informed professional development. In a series of follow up articles, I will explore designing STEM lessons including

examples of STEM projects, STEM lesson specifications and criteria necessary for authentic STEM lessons.

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