Kelley, T. R. & Knowles, J. G. 2016, 'A conceptual framework for integrated STEM education', *International Journal of STEM Education, 3*(11). Retrieved from: https://doi.org/10.1186/s40594-016-0046-z

Summary

This article explores ways of building integrated STEM programs so that students have opportunities to make connections to crosscutting concepts and real-world problems. This is proposed through the lens of a framework. The article also explores some reasons why STEM programs are not always successful.

Analysis

The authors contend that in the US, student motivation and interest in STEM programs has declined (as at 2016), and that there is still some uncertainty regarding the nature and development of STEM proficiencies.

The authors question the ability of most teachers to design and implement effective STEM programs, though they acknowledge the complexity of this task. They contend that teachers need to teach STEM content explicitly so that students understand how STEM knowledge is applied to real-world problems. They also argue that students struggle with an interdisciplinary approach because they don't have sufficient understanding of the relevant concepts/ideas in each of the individual disciplines.

Kelley and Knowles suggest that while there is a perception that STEM programs are innovative, in reality many are not as they are just a collection of disconnected subjects.

The authors argue that some STEM programs are compromised by the lack of a strategic approach to implementation, and that a conceptual framework will assist in implementation.

Kennedy and Odell (2014) in Kelley and Knowles proffer that high-quality STEM programs are characterised by:

- rigorous curriculum instruction and assessment
- the integration of technology and engineering into the science and mathematics curriculum
- the inclusion of scientific inquiry and the engineering design process.

Kelley and Knowles posit that when teachers have a strong domain pedagogical knowledge base, then their teaching is enhanced in STEM programs. They contend that teachers do not have to be abreast of all domains; however, they should have a strong understanding of the relationship between the domains. Student outcomes are also enhanced by integrated

programs that show connections between STEM subjects rather than students trying to find the connections themselves.

The authors contend that a STEM program could include a learning area outside the ‘STEM’ boundary (one STEM subject and one other), indicating a broader interpretation of STEM than other literature, without changing the acronym, for example, STEAM. The authors define an integrated STEM program as ‘the approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within authentic context for the purpose of connecting these subjects to enhance student learning’.

The framework proposed by the authors connects situated learning, engineering design, scientific inquiry, technological literacy and mathematical thinking. The authors warn that the ‘T’ in STEM is often lost because it fails to move beyond ‘the use of educational technology to enhance STEM learning experiences’.

An interesting opinion expressed by the authors is that ‘technologists, more than engineers, deal with human needs as well as economic, social, cultural or environmental aspects of problem-solving and new product development’.

The authors conclude by calling on teachers to provide more evidence as to how they design and implement STEM programs – that clear outcomes need to be identified and measured regarding how STEM education promotes learning, thinking and interest. They contend that a key to preparing STEM educators, as distinct from STEM programs, is to develop their key learning theories, pedagogical approaches and build awareness of the research findings of current secondary STEM educational initiatives’.

Reflection

These authors challenge STEM education on several fronts, namely the composition of the programs and the capacity of teachers to construct and implement such programs. The intent of a STEM program is generally accepted by other researchers; however, the authors have highlighted flaws in the successful implementation of STEM programs.