20 Strategies *for* STEM Instruction

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INTRODUCTION

STEM, an acronym for science, technologies, engineering and mathematics, represents one of the most effective instructional perspectives in schools today (Myers & Berkowicz, 2015; Slavin, 2014). Over the last decade, STEM instruction has been sweeping schools throughout the United States, Great Britain, Canada, Australia and most of the rest of the world, as educators increasingly choose to emphasise more rigorous instruction in these "hard science" subjects (Jolly, 2014; Markham, 2011; Myers & Berkowicz, 2015; National Science Board, 2012). The primary rationale for increasing the rigour of instruction in these topics in particular has been based on research showing that the United States and other Western nations are falling behind certain other countries in the areas of science and mathematics (Jolly, 2014; National Science Board, 2012; US Department of Education, 2011; Venkataraman, Riordan & Olson, 2010).

While that rationale is both comprehensive and compelling, it is not the focus of this book. Here we will not spend a great deal of time on comparing US school performance to that of other nations or describing how other nations instruct students. Rather, this book is intended for educators seeking practical instructional strategies that help foster STEM instruction in the classroom, and I intend to present the latest STEM instructional trends and specific teaching techniques.

Parameters of STEM

As with most innovative instructional perspectives, proponents do not always agree on the definition or parameters of STEM (Myers & Berkowicz, 2015; Zubrzycki, 2015). For some educators, STEM represents merely a restructuring of instruction in the four subject areas of science, technologies, engineering and mathematics, while stressing 21st century technology tools for teaching and student learning. Other educators suggest that all school subjects become STEM focused, while still others argue that STEM represents nothing less than a fundamental restructuring of the instructional process in all subjects. The latter group proposes to focus on constructing understandings by cooperatively solving real-world problems while exposing students to content as needed within that solution process. Myers and Berkowicz (2015) summarise this comprehensive view of STEM as follows:

> The STEM shift encourages reimagining schools from kindergarten through the 12th grade, including the way curriculum is designed, organized, and delivered. (p. 8)

As shown by this quote, some STEM proponents see STEM as a profound reorganisation of schools, a complete restructuring, which they believe is required by the demands of the global marketplace. In fact, there is a rationale for this view of STEM. As most educators realise, our current school curriculum has not been fundamentally restructured since the work of John Dewey in the early 1900s (see https://en.wikipedia.org/wiki/John_Dewey for a discussion of Dewey's work).

Dewey advocated for what he referred to as a vocational curriculum focused on maths, science, history and English, rather than the classics-based curriculum of the day – a historical curriculum utilised in the colonial period, which emphasised the great works of history and philosophy, as well as Greek and/or Latin studies. Dewey's version of the vocational curriculum has been the main thrust of how schooling has been conducted since the 1920s or so, and we've structured our current school courses around those practical application topics emphasised by Dewey, including maths, science, history and language as our core studies. While a technologies course, a course in home economics, or a course or two specialising in automotive or other vocational skills (*vocational* as used herein reflects the current meaning of that term) may have been added, we are, in general terms, still teaching using Dewey's course structure.

In contrast to these subject-defined curricula, some of the more extreme proponents of STEM education advocate something quite different – a complete restructuring of schools to emphasise the STEM process in all areas (Bender, 2012; Myers & Berkowicz, 2015). In this view, STEM involves student-driven, scientifically grounded instruction based on real-world problems to be solved by students working in teams and using the scientific method. Such a reorganisation may do away with daily lesson plans, units of instruction or even our current course structures (Myers & Berkowicz, 2015).

STEM involves student-driven, scientifically grounded instruction based on real-world problems to be solved by students working in teams and using the scientific method.

Here is an example. The Minnesota New Country High School has been restructured based on student-initiated research projects that are not tied to specific courses. Students are provided with the required educational standards, and they must negotiate with the staff to complete a series of STEM projects to address all of the standards. Students may work individually or in groups and are required to regularly present their various projects to a staff committee, describing how their work should earn them the required credits (ten credits per year are required). In this successful school, students are studying content within their own interest areas but must show how they are meeting the required curricular standards while completing the ten credits. This usually translates to between eight and twelve projects each year. To better understand this STEM example, I'd encourage all educators to view the following video: https://www.youtube.com/watch?v=ovkW8M8vD5o.

While this is one of the most extreme examples of school restructuring based on project-based instruction in STEM, it is quite impressive to consider that in the Minnesota New Country School, students rather than teachers are responsible for documenting their mastery of the content. Further, documentary evidence presented in the video shows that students are doing well on state and national assessments.

In terms of legislation, the definition of STEM is a bit more restricted but was expanded in October of 2015. Federal legislation on STEM funding includes computer science, in addition to the four original areas of science, technologies, engineering and mathematics (Zubrzycki, 2015).

As one might expect, these widely divergent visions of STEM represent part of the difficulty in discussing STEM. Definitions of STEM range from those that are overly focused on a few courses to those that are expansively broad, such as the example above, which exemplifies fundamental restructuring of both the curriculum and the school organisation.

At this point, let me reassure you that the expansive definition of STEM does not represent the vast majority of STEM instruction. While that example can provide for a challenging reflection for educators, the strategies provided within this book will not require such a major rebuilding of school structures. For our purposes, we'll focus on strategies that can be applied by a single teacher working alone in their science, mathematics, technologies or engineering classroom. We'll use a definition of STEM that is somewhat toward the centre of these extreme examples. STEM can best be understood as a concerted, systematic effort to increase the instructional rigour in science, technologies, engineering, mathematics and other classes, utilising the scientific method to solve real-world problems as the basis for instruction in order to position our students to better compete with other students in a world economy (National Science Board, 2012; US Department of Education, 2011). As this definition suggests, STEM is broader than merely a new way to teach mathematics or science, and STEM should certainly impact all courses in the school. Throughout this book, I will discuss strategies for the hard sciences of STEM classes, as well as STEM approaches to instruction in other subject areas, in an effort to provide a vision of what a STEM-based school might look like.

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But educators moving into STEM instruction should not plan on rebuilding schools from the ground up; rather, they should move more tentatively and explore the strategies presented herein that seem to best fit within their current teaching assignments. As those are shown to be successful in the classroom, teachers may choose to explore more innovative approaches and/or school restructuring options for STEM instruction.

With this definition of STEM in mind, I should again point out that broad discussions of the implementation of STEM at the school level or of research supporting the STEM movement are not the primary emphasis of this book. Rather, this book is intended to provide specific instructional practices for teachers in science, mathematics, technologies, engineering and other classes across the year levels. Further, in addition to providing detail on the best practices for STEM classes, this book will give teachers specific instruction on how to effectively implement these strategies in a manner consistent with the expectations of STEM instruction.