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Editorial: A New Era with STEM Education?

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Abstract

Over the last two decades, discussions, rhetoric, recommendations have proposed numerous suggestions for the integrated STEM approach. Different approaches are based on different "interpretations" of the nature of integration, epistemological approaches and the implementation of didactic models to include engineering design. New aspects like artificial intelligence and mixed reality included in this volume can serve as STEM practices in alignment with the 21st century skills.

Keywords: K-12 STEM education, integrated STEM, computational thinking, scientific and engineering thinking

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Introduction

Mr. Andreas Schleicher, Director of OECD Directorate for Education and Skills, stresses that "Education is no longer about teaching students something alone; it is more important to be teaching them to develop a reliable compass and the navigation tools to find their own way in a world that is increasingly complex, volatile and uncertain." (As cited in OECD, 2019). STEM education seeks to develop and provide innovative solutions to global issues, in particular those directly related to the 2030 Sustainable Development Goals.

Boon Ng (2019) asserts that "[A]s Industrial Revolution 4.0 gains momentum and influences every aspect of our everyday lives, the boundaries between STEM disciplines (Science, Technology, Engineering and Maths) and also between STEM and non-STEM fields, are becoming more and more blurred."

There are various interpretations of "STEM education and STEM integration" and numerous references indicate that STEM education has been defined in different frameworks ranging from disciplinary through to transdisciplinary approaches (English, 2016)

Many researchers have work for a conceptual framework for "integrated STEM". (Sanders, et al., 2012) labeled this phenomenon "STEMmania" and encouraged the field proceed for "integrative STEM education."

Science education reform documents also make consistent references to interconnectedness of science with other disciplines (e.g., NRC, 2011a, 2011b) using terms such as 'cross-cutting,' 'interdisciplinary,' etc. Commonly invoked are also the terms 'multidisciplinary', 'transdisciplinary', 'interdisciplinary' and now 'integrated' (Mobley, 2015) used to describe the nature of "diffusion" of STEM disciplines in the integrated approach.

We present some of the numerous frameworks for STEM integration. According to Sanders and Wells (as cited in Sanders, 2015) "[I] Integrative STEM education refers to technological/engineering design-based learning approaches that intentionally integrate the concepts and practices of science and/or mathematics education with the concepts and practices of technology and/or engineering education. Integrative STEM education may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc." Scholars have proposed different forms of epistemological integration (e.g. Vasquez, 2013) where different forms of discipline boundary crossings characterize the type of integration.

Another issue in STEM integrated approach is the Inclusion of Computational Thinking (CT) in STEM integrated approach. STEM interdisciplinary content approach can encompass CT practices and computing through the of the so-called crosscutting/transversal/big ideas in the curriculum (NGSS, 2013).

CT practices (e.g. data practices, modelling and simulation, computational problem solving practices and system thinking practices) and *CT concepts* (e.g. abstraction, pattern recognition, algorithmic thinking, problem decomposition and evaluation) are considered essential for the enhancement of *Scientific and Engineering Thinking* and *STEM Education* while *coding* is an effective means for developing computational thinking (Weintrop, et al., 2016; Kong & Abelson, 2019).

Computational STEM is an approach that infuses CT practices in order to develop computational models that teach both CT-STEM practices and science content in the framework of computational science using modeling and simulation practices (Swanson, et al., 2019). CT sets a focus on computational abstractions and representations—i.e., the computational artifacts (Hoppe & Werneburg, 2019).

Other issues for the inclusion of STEM integrated approach concern the different of interrelations between the STEM disciplines in interdisciplinary approach, the practical difficulties in organizing interdisciplinary activities (Hobbs, Cripps Clark & Plant 2018) and theoretical objections relating to loss of epistemic integrity in participant subjects (Lehrer, 2016; Tytler, et al., 2019). Instead, according to (Mayes, 2019) the ability to apply mathematics within a real-world context is at the core of quantitative reasoning.

Assessment also is another issue of great concern in STEM Education (Gao et al., 2020) where emphasis is set not only on the forms of the different epistemologies applied in STEM education,

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but raises issues about the learning objectives and how teachers working in different subjects will cooperate to evaluate not only the final "product" but also the interdisciplinary or transdisciplinary process followed.

Computational reasoning and STEM use of models and modelling is of great importance in STEM integrated approach. Computational modeling produces real data which includes errors and make the computational experiment "equivalent" to physical experiment (Psycharis et al., 2020; Xenakis, et al., 2020; Psycharis, 2018; Psycharis, 2016; Yasar, et al., 2015). Physical computing plays a crucial in STEM education. The use of platforms like Arduino, Raspberry, Microbit etc. can provide the tools to develop artifacts following he engineering design process integrating Computational Thinking concepts with interdisciplinary approaches through problem solving. Integrated STEM (for Indicator descriptors you can visit the article by Bryan & Guzey, 2020) can also enhance internal motives for STEM based activities (Bryan & Guzey, 2020; Guzey, et al., 2017).

In this volume, we are happy to introduce articles related to Artificial Intelligence and Machine Learning, Robotics and Mixed Reality, as we consider they can contribute to integrated STEM through indicators like the development of 21st century skills.

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