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Preface to the special issue on "The why and how of integrated STEM education"

Guest Editors
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The term "STEM" originated in 2001 from Judith Ramaley, the director of the U.S. National Science Foundation's Education and Human Resources division and subsequently STEM education initiatives have been established across the world based on the argument related to STEM workforce needs. STEM policy documents across the globe (e.g., Australian Curriculum, Assessment, and Reporting Authority, 2016; European Commission, 2015; Hong, 2017; National Research Council (NRC), 2012) promote interdisciplinary or integrated instruction, commonly referred to as "integrated STEM education", rather than separate disciplinary approaches to the teaching of science, technology, engineering, and mathematics. These STEM education policies created a significant need for new approaches to curriculum and pedagogy, as well the need for providing professional learning opportunities for both preservice and inservice teachers now expected to use integrated STEM approaches in their classrooms. Thus, over the past decade there has been a growing body of research on integrated STEM education. However, disagreement on models and effective approaches for integrated STEM instruction persists (Moore et al., 2020; Roehrig et al., 2021). Thus, this special issue addresses the ongoing need to conceptualize integrated STEM and provide additional empirical support for integrated STEM approaches to teaching and learning.

These new STEM education policies require significant changes in teachers' classroom practices (e.g., Dare et al, 2018; Pleasants et al, 2021). Across the world, STEM teacher educators have responded through changes to preservice teacher programs and myriad professional development opportunities for inservice teachers (e.g., Dare et al., 2019; Du et al., 2019; Estapa & Tank, 2017; Guzey et al., 2014). Wang and Knoblach present a rubric for use in a methods course for agriculture teachers designed to help teacher educators to understand preservice teachers' understanding of integrated STEM, as well as a tool to help preservice educators to reflect on the level of integrated STEM present in their lesson plans and classroom activities. Two papers in this special issue explored the expectations that teachers have for integrated STEM professional development. Oztay and colleagues focused on the needs of chemistry teachers, while Mumcu and colleagues focused on the different needs of middle school science, mathematics, and computer science teachers. Knowledge about assessment in integrated STEM learning environments, presents a specific aspect of teachers' practice where little research has been conducted to date. Karakaya and Yılmaz present information on the different process- and outcome-oriented methods used by teachers to evaluate STEM education. They also share information about challenges related to assessment faced by teachers to guide teacher educators work to support the development of teachers' knowledge for integrated STEM. Another approach for supporting teachers' implementation of integrated STEM is the development of STEM schools. Waters and Orange explore the ways in which administrators can support the successful development of a

STEM school through the perception of elementary teachers at the STEM school about what is necessary to create a successful STEM school.

Given that STEM policy arguments are driven by STEM workforce needs (Takeuchi et al., 2020) and pressing concerns about the need to attract more students to STEM careers, 2020), there is a need within the field to better understand how to promote positive attitudes and interest in STEM for K-12 students, particularly for students traditional under-represented in the STEM fields (e.g., Wieslemann, Dare et al., 2020; Wieselmann, Kim et al., 2020). Tekbiyik and colleagues shared details about a summer robotics camp designed for 7th grade students and how this experience improved students' interest in STEM careers, particularly engineering. Timur and colleagues explored secondary students' goals toward STEM and report on gender differences, with girls expressing less interest in STEM careers compared to their male peers. Less common in the research are studies that explore the impact of integrated STEM on cognitive student outcomes. Slavit and colleagues present an analytic framework for understanding Students' Ways of Thinking in STEM learning environments, specifically related to the way in which students generate claims connected to related evidence and reasoning as they engage in addressing STEM problems. Stohlmann explores the connections between integrated STEM and the development of mindset within students through a review of the literature. In a rare study focused on mathematical student outcomes, Gündoğdu and Tunç explored the impact of STEM activities on the development of proportional reasoning skills of middle school students. Finally, addressing another less common space within the literature, Kuroda explored the perceptions of undergraduate STEM students about the importance of specific STEM competencies, and how these perceptions varied by gender and STEM major.

As a special issue, these papers add to the extant literature on integrated STEM particularly in under-researched areas within the literature such as the impact of integrated STEM on cognitive student outcomes, as well as less researched contexts such as mathematics classrooms and undergraduate programs. The papers also provide strong implications for teacher educators providing professional integrated STEM learning opportunities.

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