Supporting Teacher Self-Efficacy for Integrated STEM Instruction: Insights from a Multi-Year Project

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Integrated science, technology, engineering, and mathematics (STEM) approaches in K-12 education aim to shift from the instruction of isolated subjects to interdisciplinary learning, thereby better preparing students for STEM careers (National Academy of Engineering & National Research Council [NAE & NRC], 2014). Notably, STEM education is critical for all students, regardless of their future career trajectories, because it prepares them to make sense of the world (National Academies of Science, Engineering, and Medicine [NASEM], 2025). The addition of engineering to standards like the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) and integrated approaches to STEM instruction present new challenges, especially for elementary teachers who often feel unprepared to teach STEM subjects (Buss, 2010; Hammack & Ivey, 2017). Both preservice and inservice opportunities to develop integrated STEM teaching skills remain lacking (Banilower et al., 2018; Luft et al., 2020; Trygstad et al., 2013). Further, science instruction is often marginalized at the elementary level, with students receiving an average of only 20 minutes of science instruction per day across the United States (Plumley, 2019). With standardized test pressures emphasizing literacy and mathematics, some students do not receive formal science instruction until the fourth or fifth grade (Rodriguez, 2015). Thus, there is an urgent need for strategic and careful attention to elementary science and STEM instruction (Larkin & Lowrie, 2022).

A key factor in effective integrated STEM instruction is teacher self-efficacy—the belief in one’s ability to carry out a series of actions to reach a desired goal (Bandura, 1986). Many elementary PSTs lack confidence in teaching science, mathematics, and engineering (Gunning & Moore Mensah, 2011; Hammack & Ivey, 2017; Knaggs & Sondergeld, 2015; Webb & LoFaro, 2020). These low self-efficacy beliefs, formed during preservice preparation, often persist into professional practice, affecting teaching effectiveness and motivation (Zeldin et al., 2008). High self-efficacy is linked to better teaching, job satisfaction, and retention in the teaching profession (Bray-Clark & Bates, 2003; Kasalak & Dagyar, 2020; Klassen & Chiu, 2011; Krieg, 2006; Muijs & Reynolds, 2002; Sehgal et al., 2017).

Bandura (1997) proposed four sources of self-efficacy: mastery experiences, vicarious experiences, verbal persuasion, and emotional arousal. Applied to teacher education, mastery experiences can be defined as involving direct teaching practice or related tasks, such as lesson planning and reflection. Vicarious experiences include observing expert teachers or instructional videos. Verbal persuasion refers to encouragement from various individuals to bolster preservice teachers' (PSTs') motivation and confidence. Emotional arousal involves managing stress and emotional states during teaching. Findings from our previous research have shown that these factors are important sources that contribute toward PSTs' self-efficacy for teaching integrated STEM (Menon et al., 2025).

However, despite growing interest, research on integrated STEM self-efficacy remains limited compared to studies on single-discipline STEM teaching. We developed the five-year Research on Integrated STEM Self-Efficacy (RISE) project, funded by the National Science Foundation (Grant Nos. 2151045, 2151056, 2151057, and 2151012). This project aims to address some of the gaps in the literature related to supporting elementary teachers' self-efficacy for teaching integrated STEM, as well as related outcomes, such as teaching practices and intent to remain in the teaching field. In this editorial, we will share key findings from the RISE project, offer several recommendations for fostering integrated STEM teaching self-efficacy among elementary PSTs, and provide considerations for professional learning design.

Key Findings from the RISE Project

At the conclusion of three years of the RISE project and with over 1,300 participants from 14 different teacher preparation programs, several key research findings have emerged. **First**, elementary PSTs' integrated STEM teaching self-efficacy increases through their experiences in science or integrated STEM methods coursework and field teaching (Menon et al., 2025). However, despite feeling more confident in planning and implementing integrated STEM lessons, elementary PSTs still perceive challenges specifically related to engineering instruction.

Second, there is a serious need for more science and engineering instructional time in elementary classrooms. This concern is shared among PSTs, inservice teachers, and program faculty, as well as prior research (e.g., Menon et al., 2024). The lack of instructional time poses particular challenges in teacher preparation, as many elementary PSTs have few opportunities to observe science or engineering instruction, let alone actually practice their STEM lessons.

Third, despite growing confidence in integrated STEM instruction, few PSTs develop a nuanced understanding of integrated STEM instruction through their science methods coursework (Wieselmann et al., 2025). For example, although they may refer to bringing STEM disciplines together, discussions of why the STEM disciplines naturally fit together or when it makes sense to integrate certain disciplines are rare among PSTs.

Recommendations for Preservice Teacher Preparation

Based on findings from the RISE project, we provide several key recommendations framed within Bandura's (1997) sources of self-efficacy. As a field, we must continue to advocate for more science and integrated STEM instructional time at the elementary level. This is foundational to enriching students' skills for engaging in sensemaking about the world (NASEM, 2025). In addition, observing integrated STEM instruction is a critical vicarious experience that can help prepare future elementary teachers for their own teaching. When this type of observational experience is not available within field experiences or practicum placements, teacher preparation programs should consider alternate opportunities for PSTs to experience integrated STEM instruction in action. This may occur through their methods courses, such as microteaching, but we also encourage programs to consider out-of-school learning contexts in which rich, integrated STEM instruction occurs on a daily basis. Strategic partnerships with these programs would allow PSTs to observe quality integrated STEM instruction and broaden their views of what STEM learning can look like.

Mastery experiences, in which PSTs teach integrated STEM themselves, must be part of teacher preparation. Although teacher preparation programs include field experiences and student teaching, this does not guarantee that PSTs will actually get to teach STEM lessons, particularly because of the lack of instructional time dedicated to science and engineering. Programs may need to be creative to ensure that PSTs get the opportunity to teach integrated STEM. This may require leveraging relationships with partner schools to ensure such teaching opportunities exist or expanding school partnerships to include schools with more of a STEM focus. In addition, peer teaching models, while not entirely realistic representations of elementary classrooms, can provide opportunities for feedback, practice teaching, and reflection on their integrated STEM lessons.

Feedback during planning sessions and on STEM teaching experiences is crucial for PSTs' professional growth. This verbal persuasion can help increase their self-efficacy for integrated STEM teaching while also prompting reflection on their teaching practices. Participants in the RISE project expressed a desire for constructive feedback that highlights specific changes that would improve their teaching. While a comment of "good job" can feel good in the moment, PSTs are aware that there is always room for improvement as a teacher. Thus, a lack of constructive feedback can actually lead PSTs to question the authenticity of such feedback.

Finally, emotional arousal is a central element of self-efficacy. Supporting PSTs in reflecting on their teaching experiences and making sense of their emotions is critical. In addition to celebrating teaching successes, it is also important to name and normalize the struggles PSTs face when implementing integrated STEM instruction. Recognition that challenges are part of the learning process can help reframe potentially negative experiences by emphasizing the learning opportunities that emerge. Structured reflection and debriefing discussions can help PSTs develop solidarity and support networks that include their instructors and peers.

While these recommendations focus on fostering integrated STEM teaching self-efficacy among PSTs, there is also a need for ongoing support as they enter the teaching field. In the following section, we describe our approach to designing online professional learning workshops to meet the ongoing need for support in designing and implementing integrated STEM lessons and units.

Professional Learning Considerations

Our project has featured online professional learning (PL) workshops each summer. Online PL is particularly beneficial for geographically dispersed participants (Wong et al., 2022), which is characteristic of our project. While the PL topics differ from year to year, we have maintained a coherent focus on integrated STEM education and a professional learning design that is anchored in research in STEM self-efficacy as well as online learning environments.

Effective PL programs promote evidence-based strategies that enhance teachers' content knowledge, pedagogical content knowledge, and teaching practices to meet students' instructional needs (Desimone, 2009; Wong et al., 2022). The summer PL incorporated features of effective PL identified by various researchers, including content focus, active learning, coherence, duration, collective participation, modeling effective teaching practices, and time for reflection (e.g., Darling-Hammond et al., 2017; Desimone, 2009; Johnson et al., 2017; Zhou et al., 2020). A meta-analysis by Estrella et al. (2018) found that PL programs lasting over 15 hours had more positive effects than shorter ones. Our PL program adhered to this recommendation, offering both synchronous and asynchronous sessions. Participants also had ongoing access to facilitators and a Canvas learning management system page with additional resources.

Through our PL design, we have highlighted a variety of opportunities for teachers to bring integrated STEM education into their existing lessons and curricula. Given the limited time allocated for elementary science instruction (Plumley, 2019), this is particularly important. For example, we modeled the engineering design process (EDP) through activities anchored with picture books, integrating engineering with English Language Arts for a meaningful cross-curricular learning experience. Further, the PL centered on picture books that represented female STEM role models from around the world to encourage STEM participation among diverse students (see Asim et al., 2025 for more details). Leveraging existing instructional schedules and structures is imperative when supporting elementary teachers in implementing integrated STEM instruction.

Given technological advances, it is also critical for PL to remain current with new technologies. One of our summer institutes focused on artificial intelligence (AI) resources to support integrated STEM education. This included hands-on exploration of AI tools related to personalized learning, curriculum design, and lesson planning, as well as opportunities to reflect on potential uses and challenges of AI. As the role of AI continues to evolve, staying at the forefront of education will require PL programs to consider uses of AI to help shape equitable, innovative, and effective STEM learning experiences.

Over 50 preservice and inservice teachers have participated in these PL sessions, reporting in anonymous evaluations that they have been particularly beneficial because of the recognition of the challenges, such as a lack of preparation in implementing integrated STEM lessons and a clear focus on strategies for overcoming these challenges. Further, by focusing on innovations and technological advances, the sessions have been beneficial to teachers with a wide range of experience. It is critical for PL providers to contextualize integrated STEM PL sessions within the current needs and demands of the ever-changing society.

Conclusion

At the conclusion of three project years, we have gained valuable insights into supporting current and future elementary teachers as they plan and implement integrated STEM instruction. However, additional research is also needed. For example, while the finding that integrated STEM teaching self-efficacy increases through methods coursework, there is limited evidence about whether these increases are sustained over time; thus, longitudinal studies are needed (e.g., Menon et al., 2024). In addition, additional information about the specific experiences and factors that impact self-efficacy can provide greater insight into how integrated STEM teaching self-efficacy develops in similar and different ways from self-efficacy for teaching science, mathematics, or engineering as distinct subjects. Finally, while improving teacher self-efficacy is a meaningful goal in itself, research on whether self-efficacy is associated with sustained teaching practices and student outcomes is also needed. While our project will aim to address some of these gaps in the literature in the coming years, we also call on other STEM education researchers to further investigate these important questions.

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