ORIGINAL PAPER

Building Pre-Service Teachers' Self-Efficacy in an Online Science Methods Course

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Abstract: This study examines the challenges facing the teaching profession in the United States, focusing on the ongoing teacher shortage and its impact on science education. The research highlights the decline in teacher education program enrollment and explores the potential of online courses to address these issues. Specifically, the study investigates the role of teacher self-efficacy in science instruction and its importance in middle school education. The article discusses strategies for designing effective online science methods courses to enhance preservice teachers' self-efficacy, including simulations, collaborative projects, and formative assessment. The research emphasizes the critical role of feedback in building self-efficacy and improving instructional practices. By addressing gaps in self-efficacy and providing comprehensive training, teacher preparation programs can better equip future educators to inspire scientific curiosity and literacy in students. The study concludes that fostering self-efficacy in preservice teachers is essential for improving science education and addressing the teacher shortage crisis.

Keywords: science education, online methods courses, teacher self-efficacy, teacher preparation programs

The teaching profession in the United States faces significant challenges, including an ongoing teacher shortage. In 2022, the National Center for Education Statistics reported that over 18% of public schools had at least one teaching vacancy, while 30% reported multiple openings (National Center for Education Statistics, 2022). North Carolina has been particularly affected, with difficulties recruiting and retaining science teachers since the 1980s due to low pay, increasing workloads, and the shift to online teaching during the COVID-19 pandemic (National Math + Science Initiative, 2022; Williams, 1983).

Compounding this issue is the significant decline in teacher education program enrollment. Nationally, teacher preparation programs have seen a nearly 30% drop in enrollment since 2010 (Partelow, 2019), and North Carolina reports a 39% decline (Granados, 2023). Contributing factors include stress and burnout, negative perceptions of teaching, limited professional growth opportunities, and political debates surrounding education (Schaeffer, 2022). In response, many

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universities have turned to alternative course formats, offering traditional face-to-face, hybrid, and online models to attract and retain preservice teachers (Kebritchi et al., 2017; Knaggs et al., 2017; Wang & Wang, 2021).

Science education faces an added challenge: fostering self-efficacy in preservice teachers. However, the potential of online courses to build self-efficacy while providing robust science instruction is a beacon of hope. Research shows that teachers with higher self-efficacy are more likely to engage students and improve classroom outcomes (Menon & Sadler, 2016; Perera et al., 2022). This potential of online courses is critical for addressing teacher shortages and enhancing science education.

Problem Statement

The COVID-19 pandemic reshaped teacher preparation programs, requiring alternative approaches to in-person field experiences. Traditionally, preservice teachers honed their skills through classroom observations and hands-on teaching experiences. However, during the pandemic, restrictions limited school access, forcing programs to adapt to virtual environments (VanLone et al., 2022). This shift highlighted existing gaps in content knowledge and teacher readiness, particularly in science education.

Preservice teachers often need more knowledge of science content to enter the profession, which erodes their confidence in teaching science (Bleicher, 2006). The pandemic exacerbated these issues, as online instruction introduced new uncertainties about effectively engaging students in science lessons (Macias et al., 2022). Many preservice teachers felt unprepared to deliver science instruction that inspires and motivates students.

Teacher Self-Efficacy

Teacher self-efficacy is a crucial determinant of teaching success. It encompasses a teacher's belief in their ability to achieve desired outcomes in student learning and engagement (Lazarides & Warner, 2020; Menon & Sadler, 2016). Teachers with high self-efficacy are more likely to embrace challenges, adopt innovative teaching strategies, and persist in difficult situations (Bandura, 1977). This confidence directly impacts their effectiveness in the classroom, particularly in content-specific areas like science.

In science education, teachers' efficacy beliefs shape their instructional practices. High-efficacy teachers are likelier to employ inquiry-based learning, problem-solving activities, and hands-on experiments that enhance students' understanding of scientific concepts (Blonder et al., 2014; Haatainen et al., 2021). These methods foster critical thinking and engagement, benefiting both teachers and students.

Preservice Teacher Self-Efficacy Toward Science Instruction

Preservice teachers develop their self-efficacy during teacher preparation programs, shaped by their prior experiences in K-12 science education and their exposure to science instruction models (Menon & Azam, 2021). These early experiences, such as the quality of hands-on learning or inquiry-based activities in their education, play a significant role in forming attitudes toward teaching science. However, many preservice teachers prioritize acquiring teaching strategies over deepening their science content knowledge (Membiela et al., 2022). This imbalance can create a perception of inadequacy, leading to anxiety and negative attitudes about teaching science effectively, further eroding their self-efficacy.

To address this issue, teacher preparation programs have increasingly emphasized redesigning science methods courses to enhance preservice teachers' confidence and competence in science instruction (Wilder et al., 2019). These redesigned courses often integrate active

learning strategies such as simulations, collaborative projects, and scaffolded inquiry-based lesson planning. Such approaches aim to provide practical teaching experiences while deepening content knowledge, fostering a greater sense of preparedness among future educators (Mikeska et al., 2022; Loach, 2021).

Improving preservice teachers' self-efficacy has a cascading effect. Studies indicate that higher self-efficacy in science teaching leads to more engaging classroom practices, including experiments and inquiry-based learning, which, in turn, enhances student achievement and interest in science (Perera et al., 2022; Menon & Azam, 2021). Moreover, fostering self-efficacy equips preservice teachers to overcome challenges and adopt reflective practices, improving their instructional methods continually (Blonder et al., 2014; Haatainen et al., 2021).

Preparation programs must combine theoretical knowledge with practice-oriented approaches to further strengthen self-efficacy. These programs can bridge content mastery and effective pedagogical strategies by aligning methods courses with the challenges preservice teachers will face in the classroom and offering structured feedback. Such efforts build confidence in teaching science and instill a sense of responsibility and enthusiasm for cultivating scientific literacy in future generations.

Feedback and Its Role in Building Self-Efficacy

Feedback is a cornerstone in building self-efficacy. Constructive feedback is a powerful tool that aids preservice teachers in identifying their strengths and areas for improvement, fostering growth, and bolstering confidence. Feedback is particularly crucial in online learning in fostering connections between students and instructors (Straub, 2024).

A recent study found that feedback from professors and peers significantly influenced preservice teachers' perceptions of their learning and their confidence in teaching science (Rhew, 2024). Feedback on assignments, lesson plans, and teaching demonstrations allowed candidates to reflect on their practices, identify areas for growth, and develop their instructional skills. This process strengthened their belief in their ability to teach science effectively.

Designing Effective Online Science Methods Courses

Creating engaging and effective online courses is crucial for preparing preservice teachers. Online science methods courses must incorporate critical elements of in-person instruction, including interactive content, collaborative projects, and hands-on experiences (Mahmood, 2020; McMahon, 2021).

Strategies for building self-efficacy in online science methods courses include:

1. **Simulations and Virtual Labs:** Research into the effectiveness of virtual environments in science teaching supports tools such as PhET Interactive Simulations and Labster for immersive virtual experiments (Mikeska et al., 2022).
2. **Collaborative Projects:** Research on collaborative and inquiry-based teaching methods supports assignments encouraging group work and peer feedback to foster cooperative learning environments (Haatainen et al., 2021).
3. **Modeling Effective Instruction:** Video demonstrations and virtual classroom observations were beneficial for showing preservice teachers how to adopt best practices and refine their teaching in virtual settings (Chiu et al., 2021).
4. **Formative Assessment and Feedback:** Straub (2024) highlights the role of specific, actionable feedback in refining

teaching practices and building confidence.

5. **Scaffolded Lesson Planning:** Guided lesson planning and iterative feedback have been recognized as effective for building preservice teachers' skills in creating structured and engaging lessons (Membiela et al., 2022).
6. **Addressing Science Anxiety:** Studies on building confidence through content knowledge and hands-on activities have explored strategies to demystify science concepts and help preservice teachers overcome anxiety about science teaching (Loach, 2021).

Connecting Self-Efficacy to Middle School Science Teaching

Middle school is a critical developmental stage where students' interest in science can flourish or falter, making it a critical period for fostering scientific curiosity and literacy. Teachers who possess high self-efficacy—the belief in their capacity to influence student outcomes—are more effective in implementing inquiry-based, hands-on learning approaches that promote active engagement, critical thinking, and a deeper understanding of scientific concepts (Blonder et al., 2014; Haatainen et al., 2021). Research has shown that teachers with high self-efficacy are not only more adept at creating dynamic, student-centered learning environments but are also more likely to persist in the face of challenges, adjust their teaching strategies, and inspire a growth mindset in their students (Bandura, 1997; Tschannen-Moran & Hoy, 2001). Moreover, preservice teachers who cultivate strong self-efficacy during their teacher preparation programs are more inclined to integrate these effective instructional practices into their teaching once they enter the classroom, positively impacting student engagement and achievement in science (Lazarides & Warner, 2020; Tschannen-Moran et al., 1998). Studies have also emphasized that self-efficacy in teaching can be nurtured through formal training and reflective practice, further enhancing the likelihood of future success in fostering scientific literacy and interest among middle school students (Zeldin et al., 2008; Woolfolk et al., 2005).

Conclusion

Teacher self-efficacy plays a defining role in shaping instructional practices, student engagement, and learning outcomes (Menon & Azam, 2021). Building self-efficacy is essential for preservice teachers, particularly those preparing to teach science. Online science methods courses emphasizing interactive content, regular feedback, and opportunities for hands-on learning can effectively prepare future educators. By addressing gaps in self-efficacy and providing robust training, teacher preparation programs can equip preservice teachers to inspire the next generation of scientists.

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