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Teacher Self-Efficacy and Preparedness for Integrating STEM Education Using a Project-Based Learning Approach

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Abstract: The purpose of this mixed-methods, sequential, explanatory study was to investigate elementary mathematics and/or science teachers' self-efficacy for implementing integrated science, technology, engineering, and mathematics (STEM) instruction through a project-based learning (PBL) approach to learning in the classroom. Further explored were elementary mathematics and/or science teachers' perceived barriers and needed supports for effective implementation of integrated STEM education using a PBL approach. Participants (n = 43) included elementary mathematics and/or science teachers from seven local school districts in a single southeastern state in the U.S. Quantitative data were collected using the STEM Confidence Questionnaire, and qualitative data were collected from focus group interviews and responses to open-ended questions within the questionnaire. Item-level analysis showed that teacher self-efficacy was the lowest for developing both formative and summative assessments, while teacher confidence levels in gaining students' interest and motivation in STEM and learning new and appropriate technologies were reported as the highest. Results indicated that while teachers reported confidence in implementing integrated STEM lessons, several barriers preventing them from doing so were identified. Various supports were also discussed, including administrative support, additional resources, and adequate training to aid teachers in the successful implementation of integrated STEM education using a PBL approach.

Keywords: STEM education; project-based learning; teacher self-efficacy; elementary teachers
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Introduction

The twenty-first century brings with it advancements in technology, pedagogy, and instructional design. At the Third Annual White House Science Fair in 2013, former President Barack Obama stated, "One of the things that I've been focused on as President is how do we create an all-hands-on-deck approach to science, technology, engineering, and math. We need to make this a priority to train an army of new teachers in these subject areas, and to make sure that all of us as a country are lifting up these subjects for the respect that they deserve." The practice of project-based learning (PBL) is infused with 21st century skills required for students to be successful in science, technology, engineering, and mathematics (STEM) education, and investigating the effectiveness of integrating STEM subjects while utilizing a PBL approach has been a priority in the U.S.

Approaches to implementing integrated STEM education include the following: student-centered learning, PBL, problem-based learning, place-based learning, family involvement, curriculum integration, inquiry, instructional technology, 21st century skills, and core STEM practices (Sias et al., 2017). These STEM learning experiences enhance student motivation and success and help students develop technological skills, conceptual understanding, self-confidence, life and career skills, and communication and collaboration skills (Sahin & Top, 2015). Additionally, as students are engaged in integrated STEM lessons, they are required to think creatively and critically, increasing students' higher-order thinking skills and the development of 21st century skills (e.g., problem solving, critical thinking, collaboration, and communication) (Kasim & Ahmad, 2021). Participating in integrated STEM lessons using a PBL approach increases students' STEM identity, which in turn encourages more students to pursue STEM careers (Goralnik et al., 2018).

The success of implementing a STEM initiative is reliant on teachers' attitudes towards and confidence in implementing new, innovative, teacher practices (Al Salami et al., 2017). Teachers committed to life-long learning and changing their practice, based on research, typically put forth more effort in implementing these innovative practices (Jarosaros, 2010). As teacher satisfaction is attributed to job performance, greater satisfaction may lead to increased student performance and attitudes (Shann, 1998). However, for teachers who are resistant, change may lead to a decrease in teacher satisfaction. Further, teacher satisfaction may be related to self-efficacy; those with low self-efficacy often set lower goals, avoid challenges, and do not engage in stressful or difficult tasks (Mintzes et al., 2013). Additionally, teachers may become intimidated by the integration of the STEM disciplines because of low self-efficacy related to a particular discipline or negative prior teaching experiences related to one or more of the disciplines (Mintzes et al., 2013; Novak & Wisdom, 2018).

To increase teacher self-efficacy and preparedness to implement integrated STEM education in the classroom, professional development related to effective implementation of integrated STEM education is needed (Nadelson et al., 2013). It is important for teachers to share the difficulties they encounter in teaching integrated STEM in their classrooms to target the needed professional development (Claesgens et al., 2013). As professional development contributes to a significant positive influence on teacher confidence towards integrated STEM education, hands-on learning and exposure to the integrated STEM curriculum are important components of professional development that are relevant and beneficial to teachers in all stages of their careers (Nadelson et al., 2013).

When implementing effective integrated STEM education in the elementary classroom, challenges have been identified by teachers, including insufficient time for the planning and implementation of lessons, a lack of an integrated curriculum, inept content knowledge and skills, overpopulated classrooms, and inadequate resources and assessments (Byrd et al., 2022; Johnson et al., 2021). Teacher beliefs, confidence, efficacy, and the overwhelming focus on literacy and numeracy are also great challenges (Al Salami et al., 2017; Aydin, 2020; Byrd et al., 2022; Johnson et al., 2021; Nadelson et al., 2013). Thus, it is important that professional development consider the cognitive, dynamic, and affective characteristics of teachers in relation to integrated STEM education (Asiroglu & Akran, 2018). Thus, the purpose of this study was to investigate elementary teachers' self-efficacy towards implementing integrated STEM education and to identify barriers and needed supports for effective implementation of integrated STEM education in the classroom using a PBL approach.

Literature Review

Definition of STEM Education

STEM education is defined as the teaching and learning of content, context, and practices of mathematics and science through the integration of engineering design and relevant, accessible technologies (Moore et al., 2015). Integrated

STEM education is an effective way to teach interdisciplinary lessons between mathematics and science that are often taught independently. As outlined by Radloff and Guzey (2016), STEM instruction can be distinguished by five primary characteristics: (1) one or more content practices from mathematics and science guide the instruction to accomplish the final goal, (2) the integration of either engineering practices or the engineering design of technologies, (3) the justification of the engineering design or practices through scientific and mathematical concepts, (4) the development of 21st century skills, and (5) encouraging collaboration and teamwork is required to solve real-world problems. An additional and major component of the STEM education curriculum is inquiry, as it raises student motivation towards STEM education (Silm et al., 2017; Voet & De Wever, 2017).

When implementing effective STEM education, students take control of their learning, developing necessary 21st century skills that will ultimately guide them in their pursuits when choosing to enter a STEM related career field (Bell, 2010). STEM education is relevant due to the naturally occurring science and mathematical concepts that students encounter in their everyday lives, thus providing support outside of the classroom to make rational and critical decisions regarding problems they may face (Capraro et al., 2013). Research also indicates that productive STEM lessons could be designed by educators to increase student engagement levels and develop essential skills for students (Tseng et al., 2013).

Definition of PBL

According to Sias et al. (2017), PBL is an innovative approach to integrating STEM teaching and learning in the classroom. PBL is defined as a constructivist approach to learning that allows students to investigate real-world problems through a hands-on, collaborative, student-centered environment and is defined by five characteristics (Kokotsaki et al., 2016). First, the project itself is structured around the required curriculum; the project should be the centralized focus of the lesson. Second, students should be engaged, must take control of their learning, and should be involved in productive struggle in order to gain a conceptual understanding of the content guided by a driving question (Kokotsaki et al., 2016). Productive struggle involves students "delving more deeply" into the comprehension of and relationships among ideas rather than just focusing on the correct solution (National Council of Teachers of Mathematics [NCTM], 2014, p. 48). Third, as students are creating investigations linked to the driving question, they need to be developing their knowledge, inquiry, and problem-solving skills. Fourth, the PBL approach is not pre-packaged; students should be given the opportunity to drive their own instruction and investigate issues that they find relevant throughout the project. Teachers should allow the lesson to go "off book." Fifth, projects are authentic since no two projects will be the same due to the direction in which students take the project (Kokotsaki et al., 2016).

Barriers and Needed Supports

Despite the need for effective implementation of STEM education in the classroom, teachers face challenges that must be overcome in order for authentic STEM education to be realized (Dabney et al.,2020) As teachers often note a negative experience as an elementary school learner, they may lack interest in and motivation towards planning effective and relevant integrated STEM lessons. Further, teachers noted that attention to elementary science instruction was diminished by the focus on mathematics and language arts. Another barrier identified was the lack of resources provided for teachers to engage students in hands-on learning through science experiments (Dabney et al., 2020). Time and flexibility with schedules in the classroom have also been identified as barriers alongside the effective infusion of technology (Byrd et al., 2022; Marksbury, 2016). Teachers also note that state standardized testing may pose a challenge in teaching integrated STEM lessons, as the administrative directives focus on teaching the individual disciplines of mathematics and science to prepare students for the high-stakes, end of year state testing (Qablan, 2021).

According to Margot and Kettler (2019), teachers often have the knowledge and professional experience to successfully teach integrated STEM lessons. However, they may lack the necessary ability to implement the needed skills in the classroom, thus requiring additional support (Margot & Kettler, 2019). Teachers also indicated a need for additional supports related to professional development, teaching and curriculum resources, mentoring, and sufficient time to effectively engage learners in integrated STEM lessons (Amran et al., 2021). Likewise, Qablan (2021) noted that teachers need not only time for collaboration with colleagues, more high-quality professional development, and an integrated curriculum, but they also need additional administrative and technological support.

Theoretical Framework

The theoretical framework for this study was grounded in Bandura's (1977) theory of self-efficacy. Personal efficacy is comprised of four major sources: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal. Increasing one's self-efficacy results in a change in their behavior, which ultimately leads to their expected outcomes (Bandura, 1977). However, teachers who have a low sense of instructional efficacy spend more time on non-academic pastimes, readily give up on students who do not achieve quick results and criticize them for their failures. Alternatively, teachers who have a high sense of instructional efficacy create mastery experiences for their students (Bandura, 1993). According to Tschannen-Moran et al. (1998), teacher self-efficacy is not measured by the level of actual competence but rather by self-perceived competence. Once efficacy beliefs in teachers are established, they can become resistant to change, though exposure to vicarious learning experiences and practice can contribute to the increase of teacher efficacy. Teachers who have high self-efficacy are more open-minded and likely to experiment with new teaching methods.

Teacher confidence in teaching integrated STEM lessons is essential to the effective implementation of this practice. Shann (1998) noted, ''Teacher satisfaction is a pivotal link in the chain of education reform. Teacher satisfaction also influences job performance, attrition, and ultimately, student performance'' (p. 68). Teacher satisfaction is attributed to an increase in teacher self-efficacy as teachers who are highly satisfied often feel as though they are making a positive impact on their students, which in turn increases teacher self-efficacy. Teacher self-efficacy may be positively influenced through purposeful and long-term professional development related to the identified support teachers need in order to effectively implement integrated STEM education (Velasco et al., 2022).

Methods

Research Design

The purpose of this study was to investigate elementary teachers' self-efficacy towards implementing integrated STEM education and to identify barriers and needed supports for effective implementation of integrated STEM education in the classroom using a PBL approach. A mixed-methods, sequential, explanatory design was used to answer the research questions (Creswell & Plano Clark, 2007). This allows quantitative data to be collected, followed by qualitative data that will explain and extend the quantitative data. Data collected in the quantitative phase of the study were used to measure teacher self-efficacy towards and preparedness for implementing integrated STEM education. Data collected in the qualitative phase of the study allowed teachers to explain in more detail their level of preparedness related to barriers and needed supports for effective implementation of integrated STEM education using a PBL approach.

This mixed-methods study was guided by the following research questions:

RQ1: What are elementary teachers' perceived levels of self-efficacy towards implementing integrated STEM in the classroom?

RQ2: What do elementary teachers identify as barriers to effective implementation of integrated STEM education using a PBL approach in the classroom?

RQ3: What do elementary teachers identify as needed supports for effective implementation of integrated STEM education using a PBL approach in the classroom?

Participants

Participants included 43 elementary teachers from seven local school districts in the southeastern United States with mathematics and/or science teaching experience varying from 1-16+ years. Researchers contacted local elementary school principals via email with a description of the study and a request to disseminate the STEM Confidence Questionnaire to their teachers who teach mathematics. Principals then sent a link to the questionnaire via email, asking teachers for voluntary participation in the study. Upon completion of the questionnaire, the respondents were offered the opportunity to participate in an online, follow-up focus group. Subsequently, the focus group consisted of one fifth-grade, one second-grade, and two fourth-grade mathematics and/or science teachers, all female and Caucasian. The semi-structured interviews allowed participants to elaborate on their responses to the questionnaire as well as provide insight on barriers and needed supports for successful implementation of integrated STEM education using a PBL approach.

Instruments

Quantitative Data

The STEM Confidence Questionnaire, adapted from the Self-Efficacy to Teach Science in an Integrated STEM Framework (SETIS) instrument (Mobley, 2015), was used to measure participants' self-efficacy to teach science and mathematics in an integrated STEM framework. The questionnaire included a 4-point Likert scale ranging from 1 = *Cannot do this at all* to 4 = *Very confident I can do this* and consisted of 19 questions assessing teachers' confidence levels with respect to the social, personal, and material factors. The social confidence factor, measured with items 1-10). relates to teachers' confidence in their ability to teach science and mathematics within an integrated STEM framework based on elements outside of their control, (e.g., assessments, evaluations, student motivation, access to resources). The personal confidence factor relates to teachers' ability to teach science and mathematics within an integrated STEM framework based on elements that are within their control and are not easily influenced by others, such as understanding the STEM framework and acquiring new knowledge for successful implementation (Items 11-15). The material confidence factor relates to teachers' confidence in the ability to teach science and mathematics within an integrated STEM framework based on elements that are outside of personal and social control such as access to technology and resources (Items 16-19).

Qualitative Data

Qualitative data were collected through open-ended responses to four free response questions in the questionnaire related to barriers and needed supports for implementation of integrated STEM using a PBL approach in the classroom as well as opportunities for professional development related to STEM education. Upon analysis of the quantitative data, research-based questions for the focus group interview protocol were developed to support the findings of the quantitative data, including questions such as, “How is the integration of STEM incorporated into your lessons?” and, “How prepared do you feel teaching integrated STEM lessons while utilizing effective student collaboration?” They were designed to allow participants to further describe teachers’ barriers and needed supports for successful implementation of integrated STEM lessons using a PBL approach.

Data Collection and Analysis

Quantitative Data

Participants were emailed a link to complete the questionnaire within two weeks of the dissemination date, and 43 responses were recorded. To convey teachers' perceived efficacy in teaching science and mathematics within an integrated STEM framework, the means and standard deviations of item responses on the STEM Confidence Questionnaire were computed.

Qualitative Data

Upon completion of the questionnaire, responses to the four open-ended questions were analyzed in accordance with the quantitative data to develop the interview protocol for the focus group. The audio file from the focus group interview was transcribed. The written responses to the open-ended questions, along with the verbal interview responses, were coded to indicate any emerging themes across the data. The coding process was initially very broad, revealing 18 codes that included administrative support, lack of resources, state-testing, and barriers to student/teacher collaboration. The data were then condensed and grouped to create very specific themes that correlated with the research questions (Saldaña, 2021).

Results

Quantitative Results

The reliability coefficients for the three factors (Social, Personal, Material) within the STEM Confidence Questionnaire were 0.92, 0.92, and 0.89, respectively, as supported by the prior analyses in the development of the original SETIS instrument (Mobley, 2015). The overall mean and standard deviation of the responses were *M* = 3.20, *SD* = 0.64 indicating consistent confidence scores for each factor among participants. Table 1 shows the mean and standard deviation for each factor on a scale of 1-4.

Table 1

STEM Confidence Questionnaire Results by Factors

Component	***M***	***SD***
Social	3.14	0.68
Personal	3.18	0.61
Material	3.28	0.62
Total	3.20	0.64

Items 1-10 assessed teachers' social confidence level. The mean within these items ranged from a high of 3.40 (*SD* = 0.58) for the ability to "get students to experience excitement, interest, and motivation to learn about phenomena in the natural world" to a low of 2.95 (*SD* = 0.82) for the ability to "develop formative assessments to measure student learning of discipline-specific content while teaching integrated STEM." Items 11-15 assessed teachers' personal confidence. The mean within these items ranged from a high of 3.21 (*SD* = 0.60) for the ability to "use my teaching experience to teach science and mathematics effectively from within an integrated STEM framework" to a low of 3.12 (*SD* = 0.63) for the ability to "use my understanding of integrated STEM in a way that allows me to teach science and mathematics effectively." Items 16-19 assessed teachers' material confidence. The mean within these items ranged from a high of 3.37 (*SD* = 0.54) for the ability to "learn new technologies that will enable me to teach from within an integrated STEM framework" to a low of 3.21 (*SD* = 0.64) for the ability to "use currently available resources to provide my students with technology to engage in learning within an integrated STEM framework." Table 2 shows the mean and standard deviation results of the STEM Confidence Questionnaire for each question.

Table 2

STEM Confidence Questionnaire Results

Item	*M*	*SD*
Connect science concepts to those of engineering, mathematics, and technology	3.26	0.58
Promote students’ grade-level appropriate acquisition of core engineering knowledge	3.12	0.63
Develop summative assessments to measure students' integrated knowledge of STEM at the end of an instructional unit	3.00	0.66
Develop formative assessments to measure student learning of discipline-specific content while teaching integrated STEM	2.95	0.82
Earn acceptable teacher-evaluation/performance scores while teaching science and mathematics in an integrated STEM framework	3.07	0.74
Access resources necessary to teach science and math within an integrated STEM framework	3.21	0.68
Obtain the materials necessary to teach science and mathematics through STEM in an integrated way	3.12	0.68
Get students to experience excitement, interest, and motivation to learn about phenomena in the natural world	3.40	0.58
Use currently available resources to provide my students with technology to engage in learning within an integrated STEM framework	3.23	0.68
Meet evaluation requirements while teaching integrated STEM	3.07	0.70
Use my teaching experience to teach science and mathematics effectively from within an integrated STEM framework	3.21	0.60
Teach my content within an integrated STEM framework	3.19	0.55
Use current knowledge and skills to teach science and mathematics within an integrated STEM framework	3.12	0.66
Use my understanding of integrated STEM in a way that allows me to teach science and mathematics effectively	3.12	0.63

Table 2 continued

Develop new knowledge and skills necessary to teach science and mathematics within an integrated STEM framework	3.26	0.62
Learn new technologies that will enable me to teach from within an integrated STEM framework	3.37	0.54
Adapt to new teaching situations such as those necessary to teach science and mathematics from within an integrated STEM framework	3.26	0.62
Use currently available resources to provide my students with technology to engage in learning within an integrated STEM framework	3.21	0.64
Access technology to teach science and mathematics from within an integrated STEM framework	3.26	0.69

Qualitative Results

Analysis of the qualitative data resulted in three major themes associated with the teachers' experiences that influenced their confidence in implementing integrated STEM lessons: needed teacher supports, student/teacher collaboration, and content integration.

Needed Teacher Supports

Upon analysis of the qualitative data, barriers to effective implementation of integrated STEM lessons were noted. Barriers included misaligned assessments, lack of resources, sufficient time for planning and teaching, state-testing requirements, and insufficient teacher training. Related to assessments, a participant asked, "What do they look like?" Participants agreed that no assessment exists related to measuring the impact of integrated STEM lessons of student achievement. In relation to implementing PBL, one participant stated, "If I had the resources, I would do it." When participants were asked about the support needed to effectively implement STEM lessons in their classrooms using a PBL approach one participant remarked, "that requires a lot of administrative support," specifically, more "flexibility" and "less testing." Teachers reported that at the elementary level they are required to post eight grades per quarter in mathematics and six per quarter in science. When asked if they had the administrative support they needed, one participant responded by saying:

> I think that they like to tell us they're supportive of it and they like to be able to see it, but they are not. I think because they're bombarding us with all of these other requirements that take away time from that.

Participants also felt that they lacked adequate training required to successfully implement integrated STEM lessons in the elementary classroom. Participants shared that typically only one person within the grade level attends professional development meetings, returning to share with others in the grade level/department what they have learned: "I'm not only going to be the learner, I'm also going to be a presenter on something that I've really not been thoroughly trained on and I'm uncomfortable with that." Participants agreed that engaging in professional development with grade level teachers that teach the same subjects and having the opportunity to collaborate and plan and reflect on lesson implementation would be more beneficial.

Collaboration as a 21st Century Skill

Focus group participants expressed the need for student and teacher collaboration. As noted by a participant, in a PBL setting, "Communication and attention is a real big concern." Participants discussed that students need to be taught how to collaborate at lower grade levels and build on those social skills as they advance through the grades. If not, participants stated, "We're not really going to see that in-depth talk that we're wanting with the project-based learning." For this to happen, participants discussed the need for teacher collaboration across all grade levels to properly prepare their students for proper engagement with this teaching and learning approach. One participant stated, "As much as the kids like to work in groups, we do too. I feed off other people's needs." As teachers are departmentalized, participants stated that there are insufficient opportunities for teacher collaboration during the school day.

Content Integration

In regard to integrating mathematics and science, participants noted that they are often unsuccessful as the curriculum is not structured in a way that allows for authentic and meaningful integration. When asked if they integrate mathematics and science, they responded, "No. We incorporate the language arts into it for the grammar and punctuation." Participants noted that they would definitely implement integrated STEM lessons if the curriculum was structured in a way that was more cohesive. One participant, who has taught over 15 years, said that she has only seen PBL implemented in the classroom during her internship semester She stated that the lesson was focused around a centralized theme such as marine life, and, while still teaching the required standard for the grade level, every subject focused on content related to the theme.

Discussions

Results from this study indicate that teachers' effective implementation of integrated STEM lessons may be influenced by many factors that impact their self-efficacy. Teachers are often reluctant to implement integrated STEM lessons in the classroom due to the lack of assessments that align with the integrated content. Related to the "social" factor, participants reported the lowest confidence scores. While confident in their ability to motivate students to learn about real-world phenomena and use technology to engage students, they often found it difficult to create an appropriate assessment that accurately tested student mathematics and science content knowledge sufficiently meeting evaluation requirements (Johnson et al., 2021). This is interesting in knowing that students are excited and motivated to learn the science curriculum, though teachers are not comfortable assessing the students appropriately based on the knowledge gained (Johnson et al., 2021). This may be due to teachers' thoughts that the instruction provided is not relayed in a way that ensures high student success rates or an issue of administrative support in meeting evaluation requirements.

The “personal” factor results are similar to those conducted in a study by Johnson et al. (2021), indicating that while teachers may possess the knowledge needed to teach integrated STEM lessons, they are not confident in their ability to use that knowledge to effectively implement these STEM lessons. This suggests that teachers may understand the definition of integrated STEM education but do not possess the appropriate pedagogical practices related to STEM education and may benefit from professional development targeting successful implementation strategies (Johnson et al., 2021). Likewise, according to the “material” factor results, participants were confident in their ability to acquire the technological knowledge needed to teach integrated STEM lessons but were not confident in implementing STEM lessons using appropriate technology. This may be due to the novelty of the 1-1 student/device ratio in the classroom, and teachers may not be informed of new technological advancements, leading to a low self-efficacy in implementing appropriate technology (Nadelson et al., 2013).

Written responses to the open-ended questions provided great insight into barriers and needed supports for the successful implementation of integrated STEM education. Participants discussed that they were unable to teach STEM education due to a lack of supports and resources (Byrd et al., 2022; Johnson et al., 2021). Many participants noted the need for an integrated curriculum to support their instruction within the classroom while teaching the practices of mathematics and science through the integration of engineering design and technologies (Moore et al., 2015). As participants mentioned, curriculum guidelines set limitations on student learning (Byrd et al., 2022; Johnson et al., 2021).

Results of this study are supported by Amran et al. (2021) and Qablan (2021) in that teachers need support from administration, effective professional development, quality resources, and the ability to collaborate with colleagues. In regard to implementing a PBL approach, findings indicate that teachers are often unable to do so in a hands-on, collaborative, student-centered environment (Kokotsaki et al., 2016). Teachers also do not have the time and flexibility required to teach integrated mathematics and science in an integrated STEM framework, as also supported in the literature (Byrd et al., 2022; Johnson et al., 2021; Marksbury, 2016).

In order to effectively implement integrated STEM education using a PBL approach in the classroom, teachers need on-going feedback and an opportunity to collaborate with colleagues to guarantee success. It is equally important that students take control of their learning through the completion of the project while teachers facilitate this learning process (Silm et al., 2017). Participants agreed that they would benefit from professional development opportunities, followed by putting what they have learned into practice, and then collaboratively discussing what worked well and what could be improved with other teachers on their grade level.

Conclusion and Limitations

Findings from this study revealed the necessary components for successfully implementing integrated STEM education using a PBL approach in the elementary classroom. While confidence levels proved higher than anticipated, likely due to self-reporting, teachers are still lacking the key essentials that allow them the opportunity to engage students in this research-based teaching practice. With adequate administrative support, time for planning and implementation, collaboration with fellow grade-level teachers that teach mathematics and science, and adequate resources, teachers may feel more equipped to utilize a PBL approach while teaching mathematics and science in an integrated STEM framework.

Results of this study may provide insight for school administrators into the challenges that teachers face, leading to the provision of additional teacher resources and support. Findings may also encourage administrators to collaborate with teachers to identify and resolve challenges they face. Benefits for middle and high school teachers to understand the challenges elementary teachers encounter when implementing integrated STEM education using a PBL approach may lead to collaboration across grade levels to better prepare students and teachers for successful integration of STEM education. Further, district and state level leaders may consider the results of this study as they develop and provide sustaining professional development for elementary mathematics and science teachers, increasing the likelihood and opportunities to effectively implement this practice in the classroom (Byrd et al., 2022). The results of this study may also provide additional insight into how elementary mathematics and science educators at all levels perceive their self-efficacy and preparedness to effectively implement integrated STEM education using a PBL approach in the classroom. This knowledge may assist teachers in identifying areas for improvement and may encourage teachers to ask questions and seek assistance from school leaders and administrators.

Although the findings of this study contribute to the literature informing the practice of teaching integrated STEM lessons using a PBL approach, some limitations have been identified. One limitation was the minimal diversity of the focus group participants. Although they varied in the number of years of teaching experience, all participants were female and Caucasian. A larger, more diverse focus group may provide more insight into the needed support and barriers that teachers face (Dabney et al., 2020). Another limitation was that participants responding to the questionnaire were from only seven local school districts in the same region of a single state, which may limit the generalizability of the results of the study. Further, disseminating the questionnaire via email, while efficient, does not ensure or relay any information to the researchers that the teachers received the email; the email can easily get lost or overlooked among other emails.

Recommendations for future research include broadening the sample, as integrated STEM teaching practices in the classroom may vary across districts and states. Exploring the impact of STEM education-related professional development on participating teachers’ self-efficacy may also warrant investigation. It may also be beneficial to measure the impact on teachers’ self-efficacy of implementing integrated STEM lessons after receiving on-going feedback from mathematics and science mentor teachers and curriculum specialists. Finally, future research should include the investigation of authentic assessment techniques appropriate for measuring student success related to integrated STEM education using a PBL approach (Nadelson & Seifert, 2017).

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