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Exploring female pre-service teachers' self-efficacy in teaching science and mathematics: a mixed-methods study

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ABSTRACT

Teacher self-efficacy is particularly relevant to the teaching of science and mathematics and affects their teaching and learning through the teachers' instructional practices. This study examines female pre-service teachers' self-efficacy in teaching science and mathematics across three domains: planning, implementation, and assessment, and examines the factors influencing its development during practicum experiences. A mixed-methods design was used, quantitative data were collected using a validated scale from 86 female pre-service teachers, while qualitative data were obtained through a semi-structured interview. Data were analyzed with descriptive statistics and thematic analyses, respectively. The results indicated consistently high levels of self-efficacy across all domains, with the highest levels in instructional implementation, followed by planning and assessment. Qualitative findings further revealed that field-based experiences, mentoring, and reflective practice enhance confidence in lesson design, classroom management, and student engagement. The study concludes that self-efficacy develops through the interaction of cognitive, emotional, and contextual factors. These findings have practical implications for improving teacher education programs by emphasizing structured practicum experiences, reflective mentorship, and targeted pedagogical training, and they provide directions for future research on subject-specific teacher development.

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1. INTRODUCTION

Teachers' beliefs about teaching and learning are largely shaped during their pre-service preparation years, a critical stage that forms the foundation of their professional identity. Among these beliefs, self-efficacy, the conviction in one's ability to organize and execute the actions required to achieve effective teaching has been recognized as a central determinant of classroom performance [1]. Recent research, however, suggests that self-efficacy beliefs can be further developed through targeted training experiences, reflective practice, and contextual teaching opportunities, particularly during the pre-service stage [2]–[5].

Persistent challenges in understanding basic mathematics and science concepts remain evident among pre-service teachers. This is particularly evident in subjects that require conceptual reasoning and problem-solving [6]–[8]. Many scholars have documented continuing difficulties experienced by pre-service teachers when dealing with introductory topics such as fractions and decimals [9]–[11], Improving these areas of difficulty will require more than an increase in cognitive content knowledge. It also requires an integrated approach to pedagogical content knowledge to enable pre-service teachers to translate disciplinary

knowledge into teaching practices [12]–16]. Developing such integrated competence strengthens teachers' confidence in their ability to teach complex material and directly contributes to the growth of their self-efficacy beliefs.

Self-efficacy is the belief that one can perform a given task in a competent manner Bandura *et al*. [17] and has also been considered to be a contextual and domain-specific construct [18], [19]. This perception depends largely on how individuals interpret task demands and anticipate challenges [13], [20]. Within educational contexts, self-efficacy is inherently domain- and context-specific. A teacher may feel confident teaching science but less assured when teaching mathematics [21]. Consequently, teaching efficacy encompasses a dynamic combination of knowledge, procedural skills, and professional attitudes that enable teachers to act effectively in specific teaching situations [22].

Within this context, it appears that teaching self-efficacy is being understood as a multidimensional construct linking knowledge, pedagogical skill, and adaptive decision-making in order for teachers to respond effectively to the varied demands of their classroom environment [23]. Achieving such professional competence requires systematic preparation in lesson planning, the formulation of measurable learning outcomes, and the selection of suitable pedagogical and assessment strategies.

Recent studies indicate that there remains a significant amount of variability regarding pre-service teachers' confidence in teaching science, technology, engineering, and mathematics (STEM) related subjects, particularly when comparing confidence levels between science and mathematics [6]–[8]. A substantial portion of the existing literature has explored teacher self-efficacy and confidence as it pertains to the general population. Much less research has been dedicated to the experiences of female pre-service teachers regarding contextual influences of their efficacy beliefs during the initial teacher preparation programs that they complete [3], [19].

In addition, most of the research that has investigated self-efficacy has utilized a largely quantitative approach. There continues to be a need for integrative approaches which would utilize both statistical analysis and qualitative analysis to provide insight into the underlying mechanisms which may be influencing the teacher's efficacy beliefs [24], [25].

Unlike previous studies conducted mainly in Western setting, this study employs a mixed methods design to examine the self-efficacy of female preservice teachers in teaching science and mathematics within an Arab educational context, therefore, this study aims to fill these gaps by investigating the self-efficacy of female pre-service teachers who are preparing to teach both science and mathematics using a mixed-methods research design, to provide a more complete understanding of both the levels of confidence and the factors that affect their teacher self-efficacy beliefs.

This study aims to examine the perceptions of pre-service teachers at the College of Educational Sciences regarding their self-efficacy in teaching science and mathematics across three core domains of teaching competence—planning, implementation, and assessment. It also seeks to explore the experiential and contextual factors that shape and reinforce these self-efficacy beliefs during their practicum training. The study was guided by the following research questions: i) what are the perceptions of primary (classroom) pre-service teachers in the college of educational sciences regarding their self-efficacy in teaching science and mathematics? and ii) how do pre-service teachers perceive the impact of their self-efficacy in teaching science and mathematics on classroom management, student engagement, and learning performance during practicum training?

The study was conducted at a public university in Jordan, within the faculty of educational sciences, which specializes in preparing classroom teachers. The pre-service primary (classroom teacher) program integrates both content, and pedagogical courses in mathematics—covering topics such as mathematical concepts, numbers and operations, geometry, and teaching methods—and in science, including biological, physical, and chemical concepts alongside their teaching methodologies.

Students in their last semester complete a four-term long field practicum providing a combined approved total of approximately 460 hours of professional experience. The practicum consists of four structured phases beginning with a 4-week observation phase that provides students with the opportunity to observe lessons being taught; interact with their mentor teachers; and understand the policies of the school in which they are working. The second phase includes assisting teachers to provide instruction in their classrooms; participating in school activities; collaborating with the teachers to complete unit plans. The third phase provides students with the opportunity for partial teaching, where students will be able to teach specific lessons under direct supervision to two or three classes while continuing to develop their own instructional strategies. Finally, during the independent teaching phase, students assume full teaching responsibilities, compile assessment portfolios, and demonstrate mastery of core teaching competencies.

2. LITERATURE REVIEW

According to Bandura's social cognitive theory [26], self-efficacy is analyzed as a self-referential dynamic system that enables individuals to evaluate their ability to perform the necessary behaviors that will result in accomplishing specific results. Moreover, Bandura makes a distinction between thinking you can do something as opposed to believing that you will accomplish something. This self-referential dynamic system is shaped by four main sources; mastery experiences, vicarious experiences, social persuasion and emotional and physiological states. These sources interact with contextual and domain specific factors in shaping self-efficacy beliefs [27], [28].

In the field of teacher education, self-efficacy extends beyond these four sources mentioned above. Self-efficacy in teacher education also includes content knowledge, pedagogy and practical experience as a cohesive whole which provide both cognitive and contextual supports [27]. Of the three components, all three are essential to achieve effective methods of teaching science and mathematics in order to implement the effective conceptual framework of science and mathematics teaching methods; that is, the alignment of conceptual understanding, instructional strategies and classroom practice.

Nevertheless, despite the theoretical advancements made by Bandura, the literature still treats his framework as universally applicable. This assumption remains underexamined, particularly in the context of non-Western societies, given the potential sociocultural and institutional barriers that can affect the development and expression of self-efficacy.

2.1. Teachers' self-efficacy and its educational implications

Research suggests that teachers with high self-efficacy demonstrate greater levels of commitment to their students, a sense of excitement for teaching, and a greater willingness to use creative methods when developing lessons; therefore, teacher self-efficacy should not simply be viewed as a correlational variable but should be viewed as a significant influence on how teachers make instructional decisions and develop adaptive classroom practices. Teachers with strong efficacy beliefs adopt student-centered pedagogies, promote learner autonomy, and maintain constructive learning environments [25]. Self-efficacy can also be thought about in terms of being an active force that influences teaching decisions rather than simply being a reflection of how teachers think about themselves as teachers. On the other hand, teachers with low levels of self-efficacy tend to use punitive methods of controlling behavior together with being primarily reliant on extrinsic sources for motivation from students. A teacher's low self-efficacy will manifest as low flexibility and lack of responsiveness to students' needs within the classroom [29], [30].

Overall, teacher self-efficacy is both an individual psychological construct and also a mechanism that may directly impact their instructional practice, classroom climate and student engagement. In addition, there is a correlation between self-efficacy and student-centered instructional approaches that meet the diverse needs of individual students and promote active involvement of students in learning on the part of pre-service teachers. This demonstrates that self-efficacy is not only developed internally as a cognitive construct, but is also developed in relation to and within the social context of the learning environment.

Higher levels of teacher self-efficacy among pre-service teachers are associated with higher levels of conceptual understanding of scientific and mathematical concepts and are associated with teachers' perceived ability to apply their theoretical knowledge in practice [24], [31], [32]. Previous educational experience, particularly exposure to effective teaching models within the classroom and exposure to supportive mentors, has been identified as having an impact on the development of self-efficacy beliefs and building teacher confidence [33].

It is also important to distinguish between self-efficacy and self-concept. While self-efficacy concerns situational judgments about performing specific tasks (can i do this?), self-concept encompasses a broader and more stable perception of the self (who am I?) [34], [35]. This distinction is crucial in teacher preparation, where the goal is to develop domain-specific confidence that directly influences instructional effectiveness.

2.2. Review of related studies

Research into teacher self-efficacy has made great advances. Traditionally most research on self-efficacy has been completed through descriptive measures; however more recently researchers have shifted to using both explanatory and contextual models to quantify teacher self-efficacy. Self-efficacy also plays a regulatory role by mediating one's cognitive, motivational, and instructional processes. For example, Perera and John [35] established that self-efficacy influences adaptive learning and persistence, suggesting that self-efficacy is not a product of one's competence, but rather a mediating factor.

Evidence-based research within teacher education has shown that structured pedagogical experiences that develop efficacy beliefs are present in the data [33], [36]. Pre-service teachers were able to develop their efficacy beliefs as a result of being a part of active and reflective learning environments, but these experiences varied greatly in their success based on the quality of the pre-service teacher program. Building on this perspective, Marschall *et al.* [24] and Yerdelen *et al.* [25] propose that self-efficacy is a

dynamic construct that develops through the repeated interaction of both theory and practice and supports contextual factors, which challenges the previous understanding of self-efficacy as a stable construct.

While the recent empirical studies have altered many researchers' conceptions regarding self-efficacy beliefs, there continues to be debate in the academic literature regarding the relationship between one's perception of self-efficacy and actual instructional effectiveness. Hendricks *et al.* [23] and Nousheen *et al.* [37] found that individuals with high levels of self-efficacy do not always develop effective practices, raising questions regarding self-reports as a valid measure of self-efficacy.

In a similar fashion, Akçakin and Cebesoy [38] concluded that many contextual factors (i.e., quality of instructional design, and technology integration) are influential on the development of an individual's efficacy belief, further underscoring the contextual nature of self-efficacy.

Sonsupap *et al*. [39] and Ingram *et al.* [40] have begun to frame their understanding of self-efficacy within a larger framework of educational transformation in that self-efficacy may be characterized as a skill required to support adaptability, innovation, and cross-disciplinary teaching. However, there are very few studies that have addressed the competencies associated with an individual's self-efficacy and how those competencies are formed based on the particular culture and or institutional context.

In summary, there is substantial evidence in the risk of self-efficacy literature which supports the claim that there is an evolving understanding of self-efficacy; however, there are still three key limitations regarding our understanding of self-efficacy within the literature: i) over-reliance on self-report methodologies; ii) disconnection between self-efficacy perceptions and actual performance; and iii) lack of culturally relevant research. These limitations indicate a need for research that examines self-efficacy as a multidimensional construct through the interactive relationship between context, experience, and perception; particularly related to underrepresented educational contexts.

2.3. Research gap

The notion of teacher self-efficacy has become increasingly conceptualized as a dynamic, context-sensitive construct [24], [25]. Nonetheless, scant empirical literature exists on this construct for three reasons. First, teacher self-efficacy research is dominated by Western teacher and experienced teacher samples, and therefore lacks relevance to pre-service and non-Western teaching contexts. Second, the continued reliance on self-reported data raises serious issues regarding the validity of self-efficacy as an indicator of actual teaching proficiency, with documented variability between perceived self-efficacy and actual performance, creating even greater concern [23], [37]. Third, while contextual factors have been shown to impact self-efficacy beliefs [33], [36], there remains an inadequate understanding of how self-efficacy beliefs are formed in different cultural and institutional contexts.

This study attempts to fill these gaps by investigating the beliefs of female pre-service teachers about their self-efficacy regarding teaching primary school science and mathematics, within the Jordanian context. It reconceptualizes self-efficacy as a contextually-oriented construct, and contributes to the possibility of extending current theoretical frameworks of self-efficacy beyond those found in Western contexts. Further, it provides concrete, contextually-appropriate data to better inform teacher training programs regarding how to align teachers with teaching capabilities.

3. METHOD

3.1. Research design

This study adopted a mixed-methods approach utilizing an explanatory sequential design [41]. Sequential Integration is appropriate for research studies that aim to establish a quantification of a particular phenomenon, and also to characterize its causative mechanisms as a way of improving the methodological rigor of those studies by the incorporation of complementary sources of data. The quantitative phase identified the levels of self-efficacy among female pre-service teachers in teaching science and mathematics, while the qualitative phase was designed to provide a deeper understanding of how these self-efficacy beliefs are reflected in classroom practices and outcomes during practicum training.

The integration of both phases allowed for a more comprehensive interpretation of the findings: quantitative results revealed the general trends and levels of self-efficacy, whereas qualitative data explained how these beliefs translated into actual classroom behavior and performance. Total integration using a sequential-integrated methodology will enhance the internal validity of a study through the use of triangulation of the findings from one or more data sources.

3.2. Participants

The quantitative phase included 86 female pre-service teachers, this sample represents the full accessible cohort of female pre-service teachers enrolled in the classroom teacher program during specified

semester at The Hashemite University. The data were collected by the end of participants' last semester, during their teaching practicum, and informed consent was obtained. Participants' ages ranged between 21 and 25 years. For qualitative phase of the study, eight purposively selected participants were chosen, based on their differences in grade point average (GPA) and self-efficacy score(s) to ensure variation, to participate in the qualitative study; the sample size was based on the principle of data saturation in qualitative research studies, as no new Themes were discovered after further interviews had taken place and therefore no longer needed to be conducted by this researcher. Ethical approval for the study was granted by the appropriate institutional authority at The Hashemite University, and all participants were provided with the opportunity to participate voluntarily, were provided with informed consent, and will continue to have their confidentiality and anonymity protected during the data collection and analysis phase of this research study.

3.3. Quantitative instruments: self-efficacy questionnaires for mathematics and science teaching

Two parallel self-efficacy questionnaires were used to measure pre-service teachers' perceptions of their competence in teaching mathematics and science. The mathematics version was adapted from Al-Titi and El-Shara [42], who developed and validated a self-efficacy scale for mathematics teaching among newly graduated teachers in Jordan. Minor linguistic and contextual modifications were made to ensure alignment with the current study's objectives and target population.

Based on the mathematics instrument, a second version was developed for science teaching. Both instruments contained identical items across three core domains—planning, implementation, and evaluation—with two additional items added to the implementation domain of the science version to capture practical aspects related to laboratory work and the use of the learning-cycle model.

Each questionnaire used a five-point Likert scale ranging from (1) strongly disagree to (5) strongly agree, where higher scores indicated greater self-efficacy in the corresponding teaching domain. The instruments were reviewed by a panel of faculty experts in science and mathematics education to ensure content validity, linguistic accuracy, and contextual appropriateness. The expert review process was utilized in order to validate the content of the instruments to be used in this study; ensuring that the items included on the instruments were aligned with the constructs of the three domains (planning, implementation, and evaluation). After expert feedback and refinement, both instruments were piloted with a sample of 22 pre-service teachers from the same population but outside the main study sample.

Reliability of the instruments was evaluated by using Cronbach's alpha coefficients. All of the assessed alpha coefficients were greater than the recommended value of 0.70 indicating that there are high levels of internal reliability and consistency of measures with the use of the instruments. The alpha coefficients of the science instrument were 0.815 (planning), 0.902 (implementation), and 0.832 (evaluation), with an overall reliability of 0.943. The mathematics instrument alpha coefficients were 0.918 (planning), 0.926 (implementation), and 0.896 (evaluation), with an overall reliability of 0.969. This data indicates that the instruments have a high degree of internal reliability and are appropriate for use in this study.

3.4. Qualitative instrument: semi-structured interviews

Following the quantitative analysis, the qualitative phase was conducted to interpret the most significant quantitative results—specifically, the domains that achieved the highest mean scores of self-efficacy. The qualitative tool utilized in this study was a semi-structured interview protocol created by the authors to examine how high levels of self-efficacy are demonstrated through classroom practices. The semi-structured nature of the interviews provided the interviewer with some latitude in gathering information about the participants' experiences in a flexible and individualized manner while also maintaining similar structures among each of the interviews, thus improving the credibility of the data collected.

The purpose of the interviews was to explore how participants perceived high levels of self-efficacy, as indicated by the quantitative phase of the study, translated into observable outcomes in the classroom such as effective classroom management, high levels of student engagement, and increased student achievement.

The interview guide was sent to several members of the institution's faculty who are experts in educational assessment and teacher education for review to ensure that the language was clear and precise and conceptually accurate. Each of the interviews took between 30 and 40 minutes to complete and were held in a quiet area on the campus of the institution. To protect the trustworthiness of the qualitative information collected, multiple procedures were used, including meticulous transcription of the interviews, consistency checks of the data for themes as well as using prolonged engagement with the data; thus, enhancing the credibility and dependability of the findings. The qualitative information was also analyzed by way of a systematic coding process, accounting for initial codes, refining categories, and developing themes; thus, enhancing the analytic consistency and interpretive depth of the results.

3.5. Data analysis

Quantitative data were analyzed first and then followed up with qualitative data analysis. Data was collected through semi-structured interviews to provide context for quantitative findings about pre-service teachers' self-efficacy. Quantitative data were analyzed using descriptive statistics to compare instructor's self-efficacy teaching science and mathematics for the domains of planning, implementation and assessment. Qualitative data obtained from semi-structured interviews were analyzed to understand more about participants' perceptions of teaching self-efficacy. Thematic analysis was conducted following the development of codes from the in-depth interviews. This midway point of crystallization was incorporated into the interpretation phase where the findings from each of the methods were merged to explain the full story.

4. RESULTS

4.1. Results related to the first question, which stated the following: what are pre- service teachers' perceptions of their self-efficacy for teaching mathematics and science?

Arithmetic means, standard deviations, rank, and score were calculated for all domains of the questionnaire and the questionnaire as a whole. Table 1 shows that the arithmetic mean of pre-service teachers' perceptions of their self-efficacy for teaching mathematics and science was relatively high (above 4). Although both domains demonstrated high levels of self-efficacy, slight variations were observed between mathematics and science, particularly in the assessment domain, where mathematics consistently yielded higher mean scores than science.

The pre-service teachers' perceptions of self-efficacy in mathematics (the implementation domain) had the highest arithmetic mean, reaching (4.38), with a standard deviation of (0.45), followed by the domain of self-efficacy in planning. Finally, the domain of self-efficacy in assessment learning came, with an arithmetic mean of (4.31), with a standard deviation of (0.46). The domain of self-efficacy in implementation also had the highest arithmetic mean for perceptions of self-efficacy in science, reaching (4.35), with a standard deviation of (0.47), followed by the domain of self-efficacy in planning, with an arithmetic mean of (4.30), and a standard deviation of (0.46). Finally, the domain of self-efficacy in assessment learning came, with an arithmetic mean of (4.17), and a standard deviation of (0.57). A cross-domain comparison reveals a consistent pattern in which implementation efficacy ranks highest in both subjects; however, mathematics shows marginally higher scores across all domains, suggesting stronger perceived confidence in structured instructional contexts compared to the more inquiry-oriented nature of science teaching.

Table 1. Arithmetic means, standard deviations, ranks, and levels of self-efficacy in teaching mathematics and science

Domain number	Domain	Rank	Mathematics		Sciences		Degree of agreement
			Mean	SD	Mean	SD	
2	Efficacy in implementation	1	4.38	0.45	4.35	0.47	High
1	Efficacy in planning	2	4.36	0.43	4.30	0.46	High
3	Efficacy in learning assessment	3	4.31	0.46	4.17	0.57	High
	Total		4.35	0.41	4.27	0.41	high

4.2. Mathematics

4.2.1. Efficacy in planning

The analysis of pre-service teachers' self-efficacy in planning mathematics lessons revealed consistently high confidence levels. The overall mean for the planning domain was 4.36 (SD=0.43), with item means ranging from 4.25 to 4.48. The highest-rated item was statement (5): "I can plan to use tools and materials that support student learning" (M=4.48, SD=0.65), followed by statement (1): "I can plan a time appropriate for the class period" (M=4.45, SD=0.65).

The lowest-rated item, "I am able to take into account the logical sequence of presenting educational content in my planning for the class period" (M=4.25, SD=0.73), indicates that while participants displayed strong planning self-efficacy, they may still need more practical experience in sequencing content and pacing lessons effectively. Overall, the results demonstrate that participants exhibit high planning self-efficacy in mathematics, characterized by confidence in lesson design, preparation, and time management.

4.2.2. Efficacy in implementation

For the implementation domain, the overall mean reached 4.38 (SD=0.45), with individual item means ranging between 4.21 and 4.48. The highest-rated statement was (5): "I can take into account

individual differences among students during teaching" (M=4.48, SD=0.59), reflecting strong self-efficacy in adapting instruction to diverse learners. Conversely, the lowest-rated item was (2): "I employ technology while presenting mathematics topics in class" (M=4.21, SD=0.78), suggesting that integrating digital tools into mathematics instruction remains a relative challenge. These results indicate that pre-service teachers possess high implementation self-efficacy, particularly in motivating students and managing classroom activities, though they may benefit from enhanced training in technology integration.

4.2.3. Efficacy in learning assessment

The overall mean for the learning assessment domain in mathematics was 4.31 (SD=0.46), with item means ranging between 4.21 and 4.43. The top-rated item, (11): "I continually evaluate students' learning of the material presented to improve the learning process" (M=4.43, SD=0.67), demonstrates strong self-efficacy in using formative assessment for instructional improvement. The second-highest, (3): "I am able to correct students' misconceptions" (M=4.38, SD=0.68), highlights confidence in assessment-informed teaching.

The lowest-rated item, (9): "I conduct diagnostic tests at the beginning of each unit to identify students' problems" (M=4.21, SD=0.80), reflects limited practice with diagnostic evaluation. These findings suggest that while participants display strong assessment self-efficacy, they are still developing deeper expertise in formative and diagnostic assessment strategies.

4.3. Science

4.3.1. Efficacy in planning

For science teaching, the overall mean of the planning domain was 4.30 (SD=0.46), with item means ranging from 4.13 to 4.45. The highest-rated item was (1): "I can plan a time appropriate for the class period" (M=4.44, SD=0.66), while the lowest-rated item was (4): "I am able to determine the appropriate time for each of the specific learning outcomes" (M=4.13, SD=0.85). These findings indicate high planning self-efficacy among pre-service teachers, especially in structuring lessons and managing instructional time, though further practice in sequencing learning objectives is needed to strengthen planning depth.

4.3.2. Efficacy in Implementation

The implementation domain for science instruction yielded an overall mean of 4.35 (SD=0.47), with item means ranging between 4.19 and 4.50. The highest-rated statement was (1): "I employ various teaching strategies in teaching students" (M=4.50, SD=0.59), emphasizing strong instructional self-efficacy and pedagogical adaptability. The lowest-rated item was (2): "I employ technology while presenting science topics in class" (M=4.19, SD=0.79).

This trend mirrors the mathematics results, reflecting high teaching confidence but a relative need for improving digital instructional practices. Overall, participants demonstrated strong implementation self-efficacy, particularly in managing interactive lessons and adapting to classroom contexts.

4.3.3. Efficacy in learning assessment

In the science domain, the overall mean for learning assessment was 4.17 (SD=0.57), with item means ranging between 4.11 and 4.29. The highest-rated item was (3): "I am able to correct students' misconceptions" (M=4.29, SD=0.77), revealing confidence in formative assessment and conceptual correction.

The lowest-rated items were (6), (5), and (7)—related to using varied assessment tools and developing remedial and enrichment plans—each with a mean of 4.11 (SDs=0.76-0.80). These findings indicate emerging assessment self-efficacy that would benefit from additional field-based practice and feedback on assessment design.

4.4. Summary

A cross-sectional analysis indicates that implementation efficacy indicates the same pattern of maximum to minimum levels across disciplines. Mathematics has been reported as slightly higher than science in implementation efficacy for all three levels of self-efficacy assessment in the implementation domain. This suggests that there may be greater confidence perceived in the implementation of instruction within clear, structured environments when comparing to those of a more inquiry-based experience in science. While their strongest self-efficacy appeared in instructional delivery and lesson organization, both groups exhibited a developmental need to enhance assessment literacy and the effective integration of technology into teaching practice. These findings provide evidence that self-efficacy is not simply a general belief about teaching but is dependent upon the particular context that exists in conjunction with the epistemological and pedagogical demands that exist in each subject area.

Higher self-efficacy for teaching mathematics may be attributed to the straightforward nature of the content, as well as the highly predictable nature of instructional sequences, whereas science lessons

continuously involve open-ended exploration, experimentation, and, therefore, may not provide the pre-service teacher with as much confidence in their teaching abilities. The availability of laboratory space and hands-on practice in a practicum may also impact the differences in perceived self-efficacy between the two subjects. The comparative data provided here contributes to a more nuanced understanding of how pre-service teachers develop self-efficacy beliefs based on the specific context of each subject area. Table 2 provides objective item-level data for each domain and provides a detailed comparison of pre-service teachers' self-efficacy in mathematics and science. The results in Table 2 demonstrate that a high level of self-efficacy is displayed across nearly all survey items for both subjects and scores appear to be slightly higher in mathematics than in other topics, most noticeably for questions concerning assessment practices; matching previously found domain level differences.

Table 2. Arithmetic means, standard deviations, and degree of agreement for the items arranged in descending order for each domain

Rank	Items number	Domain of efficacy in planning Items	Mathematics Mean	Mathematics SD	Sciences Mean	Sciences SD
1	5	I can plan to use tools and materials that support student learning.	4.48	0.65	4.45	0.65
2	1	I can plan a time that suits the class period.	4.45	0.65	4.44	0.66
3	8	I can plan to use a variety of learning resources necessary to support student learning.	4.42	0.60	4.20	0.79
4	6	I design educational situations appropriate to the learning outcomes.	4.41	0.54	4.29	0.68
5	9	I can design educational situations that suit students' abilities.	4.35	0.68	4.22	0.62
6	2	I can consider achieving vertical and horizontal integration in the planning process.	4.33	0.63	4.36	0.61
7	4	I can determine the appropriate time for each of my learning outcomes.	4.29	0.69	4.13	0.85
8	7	I take into account students' learning styles when planning the educational situation.	4.29	0.75	4.24	0.65
9	3	I can consider the logical sequence of presenting educational content in my planning of the class period.	4.25	0.73	4.34	0.66
		Total	4.36	0.43	4.30	0.46
		Domain of efficacy in Implementation in descending order				
1	5	I can take into account individual differences among students while teaching.	4.48	0.59	4.30	0.78
2	1	I employ a variety of teaching strategies in educating students.	4.47	0.55	4.50	0.59
3	3	I can give examples in mathematics/science that relate to the student's daily life.	4.36	0.75	4.36	0.8
4	4	I motivate and inspire students to participate during class.	4.42	0.66	4.37	0.63
5	9	I can use a variety of teaching methods to explain mathematics/science topics.	4.41	0.71	4.45	0.66
6	7	I can connect mathematics/science topics with other topics during explanation.	4.41	0.74	4.34	0.68
7	6	I give the students the opportunity to express their ideas in mathematics/science.	4.38	0.66	4.33	0.73
8	10	I can employ diverse learning resources to support student learning	4.36	0.71	4.43	0.64
9	8	I pay attention to explaining and modeling mathematics/science concepts in different ways	4.26	0.74	4.31	0.76
10	2	I use technology while presenting mathematics/science topics in class	4.21	0.78	4.19	0.79
		I can employ a teaching strategy based on the learning cycle approach			4.35	0.72
		I can employ active learning experiences			4.22	0.82
		Total	4.38	0.45	4.35	0.47
		Domain of Efficacy in learning assessment rank in descending order				
1	11	I continuously assess students' learning of the material presented to improve the learning process.	4.43	0.67	4.27	0.76
2	3	I can correct students' misconceptions.	4.38	0.68	4.29	0.77
3	10	Test the pre-learning required for the new lesson before starting the class.	4.36	0.71	4.16	0.75
4	4	I use assessment strategies that are appropriate to learning outcomes.	4.35	0.66	4.15	0.68
5	5	I use a variety of assessment tools in mathematics class.	4.30	0.69	4.15	0.800
6	2	I can provide feedback on students' answers.	4.29	0.74	4.20	0.67
7	1	I use different types of homework assignments.	4.29	0.76	4.19	0.79
8	7	I use assessment results to develop treatment and enrichment plans.	4.28	0.69	4.11	0.80
9	6	I diversify assessment strategies to take into account student levels	4.27	0.72	4.11	0.76
10	8	I analyze students' test results to identify their strengths and weaknesses.	4.25	0.68	4.20	0.72
11	9	I conduct diagnostic tests at the beginning of each unit to identify students' problems.	4.21	0.80	4.21	0.87
		Total	4.31	0.46	4.17	0.57

4.5. Qualitative part results

To expand upon the quantitative findings and provide an in-depth understanding of how the self-efficacy of pre-service teachers is experienced and demonstrated throughout their practicum experience, qualitative results will be discussed in this section. Thus, providing a complementary viewpoint based upon subject participants' reflections and personal experiences.

In response to the second research question: how do pre-service teachers perceive the impact of their self-efficacy in teaching science and mathematics on classroom management, student engagement, and learning performance during practicum training? The qualitative phase aimed to provide a deeper interpretation of the quantitative findings through thematic analysis aligned with Bandura's self-efficacy framework.

Using multiple perspectives and connecting those perspectives helped pre-service teachers understand how they developed, maintained and experienced self-efficacy in their practical teaching experiences. Based on the analysis, there were seven common themes emerging from participant responses.

First, the participants expressed the development of a professional identity and career commitment in that they all demonstrated strong intrinsic motivation for the act of teaching because they believed it was an important societal role and had significant personal value. The motivation for a sense of purpose helped to build confidence and commitment toward being effective teachers as (T1) stated "*I see myself as a successful teacher, and I will produce future leaders*." This theme reflects emotional and social dimensions of self-efficacy, where professional purpose reinforces persistence and confidence.

Second, the theme related to developing confidence in academic planning is an area where the participants expressed confidence in developing lesson plans due to establishing a structured process for the development of a lesson plan, having strong time management skills, and having support from a mentor. The advance development of high-quality lesson plans helps provide the teacher with greater control over the instructional process as (T2) stated "*I broke down the lesson into time slots based on the needs of my students*." This theme aligns with mastery experiences and social persuasion, demonstrating how guided practice and feedback contribute to developing planning.

The third theme related to the consideration of individual differences was that the participants demonstrated their awareness of the various types of diversity within their students and that their instruction needed to be adapted to the differing types of diversity. The ability of teachers to recognize individual learner differences helped to enhance their developing self-efficacy in meeting the many needs of their students as (T4) said "*My knowledge of the developmental characteristics of the children helped me to assist me in meeting the needs of my students*." This theme reflects cognitive efficacy, where understanding learner variability enhances teachers' confidence in addressing diverse learning needs.

The fourth theme related to the teachers' adaptability of teaching practices through their ability to be flexible through using different and innovative teaching strategies and technologies. Participants built confidence through a combination of trying out different methods of teaching and engaging in self-directed and collaborative learning with other professionals as (T4) stated "*I adapted to a new teaching method using research via the internet*." This theme represents adaptive efficacy, indicating that self-efficacy evolves through engagement with new challenges and reflective practice.

The fifth theme was related to the correction of misconceptions among students. Participants expressed how they had confidence to teach students who hold misconceptions about learning through using different instructional tools and an evidence-based approach to assist students in eliminating misconceptions about the content as (T6) mentioned "*I use different instructional strategies to clarify the conceptual understanding. For example, I provide students with problem-solving strategies*." This theme reflects metacognitive and instructional efficacy, where the ability to diagnose and address misconceptions strengthens confidence in facilitating conceptual learning.

The sixth theme related to classroom management and a climate for learning; participants believed that effective classroom management was a critical component of being a self-efficacious teacher. Members from the study expressed various strategies used to create a positive classroom climate through managing student behavior as (T2) said "*I have established a reward system for students to improve positive behavior*." This theme reflects behavioral and emotional regulation, highlighting how classroom management contributes to teachers' perceived effectiveness.

The seventh theme discussed the confidence of participants in their teaching effectiveness and how it will positively impact the learning of students. Participants believed that their teaching effectiveness would positively impact how much students will learn, demonstrating a high degree of professional commitment to their teaching effectiveness as (T4) stated "*I would change my methods and/or instructional tools if my students were not making improvements*." This theme represents outcome expectancy, where teachers' beliefs about their impact on students reinforce their commitment to continuous improvement. Overall, the seven themes illustrate how an interactive process of developing a teacher's professional identity, engaging in

practical training and reflecting on their practice contribute to developing self-efficacy, which is consistent with Bandura's theory on the development of self-efficacy in teachers [26].

5. DISCUSSION

The results of this study indicate that the self-efficacy of pre-service teachers is both high in terms of strength and varied across areas of practice. The area with the highest level of self-efficacy was for Instructional Implementation, while the lowest levels of self-efficacy recorded were found in Assessment, especially with regard to the use of diagnostic assessments and the use of alternative assessments, suggesting uneven development of pedagogical competencies across domains. This finding provides evidence that self-efficacy is best viewed as a construct that is specific to the domain of teaching [2], as the demands of the cognitive and practical requirements of teaching are different when compared to other domains of knowledge.

The combination of the quantitative and qualitative data provides deeper insight into how these beliefs are developed. The quantitative data produced strong overall confidence; however, the qualitative data produced an understanding that this confidence is primarily derived from successful practicum experiences, having a mentor's support, and the ability to reflect on those practices. These findings align with Bandura's conceptualization of self-efficacy and the significance of mastery experiences and extend previous research (e.g., Velthuis *et al*. [22]) that demonstrates that not all of the domains of teaching receive equal benefits from the practicum [17].

The participants showed a high level of self-efficacy through successful planning and implementing lessons, through the use of lesson outlines during the planning process and having successive opportunities to practice their lessons in the classroom. There appeared to be a limited degree of continuity in teacher candidates' competencies related to assessment, particularly with regard to diagnostic assessments and the use of alternative assessments. This lack of balance indicates that the teacher education programs are likely placing greater emphasis on developing the ability of the teacher candidate to implement instruction as opposed to developing the ability of the teacher candidate to use evaluative reasoning and respond to diverse student characteristics, thus limiting the development of an assessment literate professional.

The qualitative evidence provided additional insights into the importance of adaptive teaching and how it relates to building self-efficacy. The participants demonstrated the ability to adapt to student needs, implement new strategies and address students' learning difficulties, which is indicative of a more flexible and problem-solving approach to self-efficacy. Studies by Palmer *et al*. [14] and Koutsianou and Emvalotis [43] have shown that the ability to develop an adaptive teaching competency result in greater confidence and greater effectiveness in implementing instruction.

In addition, the findings identified the role of professional identity in the development of self-efficacy. The participants' beliefs in the positive impact of the profession of teaching on society created an intrinsic motivation that fostered their confidence and commitment to the teaching profession. This implies that the development of self-efficacy is not a purely performance-based concept, and includes components that are value-based and emotionally driven.

At the broadest level, this study indicated that the establishment of self-efficacy is the result of combining the academic preparation received in a structured academic setting with the experiences gained in a practical classroom environment, and through the ongoing reflection upon those experiences. Although the current preparation model appears to be successful in developing self-efficacy for instruction, it is possible that the model needs to be expanded in the areas of assessment literacy and technology integration, in order to develop a more comprehensive and balanced professional development of teacher candidates [44].

5.1. Limitations

There are limitations associated with the findings of this study, which should be considered in the interpretation of these findings. The first limitation was that the sample, although it reflects the full cohort within this program, remain specific to this institutional context, as it was drawn from a single cohort of female pre-service teachers at a single public university in Jordan. This limits the generalizability of the findings to other contexts and populations as well. Secondly, while the instrument used in the present study has demonstrated adequate reliability, its reliance on self-developed instruments makes them less directly comparable to results obtained through the use of standardized measures used in previous studies.

The study design utilized in this research was cross-sectional in nature, preventing any causal inferences to be made regarding the development of self-efficacy at different stages of teacher training. Future research that uses longitudinal designs to examine the evolution of self-efficacy at different stages of teacher preparation would provide much needed information on the process of self-efficacy development.

5.2. Implications and recommendations

The findings from this study provide many important implications for teacher education programs. First, the noted variation in self-efficacy across the various domains indicates the need for programs to strengthen their assessment literacy, particularly for diagnostic and diversified evaluation practices. Teacher education programs should place more emphasis on the development of evaluative reasoning skills in addition to providing instruction on how to effectively teach. Second, participants expressed relatively lower levels of confidence regarding using technology in the classroom. Therefore, there is an urgent need for teacher education programs to provide systematic training in the use of technology to enhance instructional practices. To help bridge the gap between teaching practice and technology use, the development of technology-enhanced learning opportunities should be incorporated into practicum experiences. Third, the findings of this study demonstrated the critical role that structured practicum experiences and mentoring can have in the development of self-efficacy. Teacher education programs must provide their candidates with ongoing opportunities for guided practice, reflection, and feedback as they develop the ability to teach adaptively. Future research should examine the development of self-efficacy over time across various educational settings, as well as the impact of the length of the practicum experience, the quality of mentoring provided, and the support provided by the institution on the development of self-efficacy.

6. CONCLUSION

Pre-service teachers have multidimensional and context dependent constructs of self-efficacy that are established through their instructional experiences and the development of their professional identities. Overall, it was noted that pre-service teachers had high levels of confidence, especially in the implementation of instruction; however, the existence of gaps in the assessment competencies of pre-service teachers suggests there is a need to have a more balanced approach to preparing teachers. Pre-service teachers can develop more comprehensive and enduring self-efficacy through modifications to the practicum, increased focus on the training of assessments within the program, and the promotion of reflective and adaptable teaching practices.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
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O : Writing - **O**riginal Draft
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Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The study was conducted in accordance with institutional ethical guidelines at The Hashemite University

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [SS], upon reasonable request.

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