

# Science Teaching Efficacy and Science Outcome Expectancy Among Early Childhood Preservice Teachers: Effects of Constructivist Beliefs vs. Traditional Beliefs

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## Abstract

This study examined early childhood preservice teachers' perceived science teaching efficacy and its association with their teaching beliefs (constructivist and traditional beliefs). The participants included 181 preservice teachers enrolled in an early childhood teacher education program at a university in the Midwestern United States. Information was collected using the Science Teaching Efficacy Beliefs Instrument – Preservice (STEBI-B) and Teaching Beliefs Survey (TBS). The results revealed that the preservice teachers were efficacious about their science teaching, showing a negative relation with traditional teaching beliefs and no statistically significant relation with constructivist teaching beliefs. The results of hierarchical regression analyses revealed that the preservice teachers' traditional teaching beliefs was a significant negative predictor of their personal science teaching efficacy and of their science teaching outcomes expectancy, while there was no significant effect of constructivist beliefs on them. These results suggest that when preservice teachers adhere to traditional teaching methods, it can lower their confidence and expectations about their effectiveness in teaching science. This underscores the current trend in early childhood education towards promoting innovative, student-centered teaching practices. By moving away from traditional beliefs and embracing more constructivist and inquiry-based approaches, teacher education programs can better prepare preservice teachers to create dynamic, effective, and engaging science classrooms for young children. This approach aligns with contemporary educational practices that prioritize hands-on learning and critical thinking, laying a strong foundation for students' lifelong interest and involvement in STEM subjects.

**Keywords:** science teaching efficacy, preservice teachers, teaching beliefs, STEM, early childhood education

## 1. Introduction

Preservice teachers' science teaching efficacy is the confidence that they have the ability to teach science effectively. Science teaching efficacy beliefs may be one of the most important psychological factors of teachers that affect their science teaching practices and behaviors in class. Teaching efficacy beliefs help us to predict their motivation and choice (Bandura, 1994). Thus, preservice teachers' self-efficacy beliefs are a critically important determinant that impacts how they will teach in their future class (Cakiroglu et al., 2005; Menon et al., 2023).

Science education in early childhood is important as it lays the foundation to develop beginning skills and attitudes for students to make sense of and work with natural phenomena (National Research Council, 2012). Teachers' teaching beliefs and efficacy influence the quality and approach to teaching science (Bandura, 1997; Garbett, 2003). Pajares (1992) stated that teachers' beliefs about teaching and learning affect their instructional strategies as well as manifested classroom practices and, in turn, student outcomes.

While science teaching efficacy has been identified as a critical variable in the literature, the issue of how this efficacy develops has been an area of significant neglect, particularly for the preservice teacher of early childhood education (Forbes & Davis, 2010; Menon et al., 2023). This gap is particularly pronounced in understanding the distinct impacts of constructivist versus traditional teaching beliefs on preservice teachers' science teaching efficacy and outcome expectancy.

Empirical studies indicate that self-efficacy is a vital predictor of teachers' instructional strategies, motivation,

and classroom behaviors (Bandura, 1997; Pajares, 1992). However, the literature lacks robust investigations into how different pedagogical beliefs—such as constructivist approaches, which emphasize active learning and student-centered instruction, compared to traditional methods, which are often more teacher-directed and didactic—affect these efficacy beliefs in early childhood education contexts (Gillies & Rafter, 2020; Smetana & Nelson, 2023).

Understanding these impacts is essential for developing effective teacher education programs. For instance, studies have shown that integrated STEM approaches, which align closely with constructivist principles, can significantly enhance preservice teachers' self-efficacy and teaching outcome expectancy (Menon et al., 2023). These approaches encourage preservice teachers to adopt innovative and interdisciplinary methods, fostering a more engaging and effective learning environment for young children (Chen et al., 2021).

Addressing this gap in the literature is critical. By exploring how constructivist and traditional beliefs influence science teaching efficacy, educators and policymakers can tailor teacher preparation programs to better support the development of confident and competent early childhood science educators. This, in turn, could lead to more effective science instruction in early childhood classrooms, laying a stronger foundation for lifelong STEM engagement among students (Forbes & Davis, 2010; Gillies & Rafter, 2020).

As the gap in the literature denotes, there exists a series of needs related to the development and effect of preservice teachers' science teaching efficacy beliefs. The sooner the better, then. This study was conducted to explore the association between the science teaching efficacy perceptions of early childhood preservice teachers and their teaching beliefs and, at the same time, to investigate this difference between the constructivist and traditional ones. Therefore, research into this association provides an understanding about how preservice teachers perceive their efficiency in the aspect of teaching science as a part of their teaching that affects their practices.

There are three main motives for acquiring information about the science teaching efficacy beliefs of preservice teachers. First, it also offers an insight into how these may be encouraged and developed in teacher education programs because changes in self-efficacy beliefs are seldom made once they have been established (Bandura, 1977, 1982). Developing these beliefs early in their preparation is likely to inspire preservice teachers to more effectively engage in science teaching, resulting in improved young children's scientific problem solving and positive attitudes towards science. The more specific the belief structures of preservice teachers are linked to the instructional strategies and student outcomes addressed in this study, the more valuable the research to the general educational psychology literature (Brown, 2005; Pajares, 1992). This will allow forms of teacher preparation that are highly specific to be developed to adequately equip preservice teachers with the capacities needed to be science teachers who can be effective translators of theory into practice in early childhood science classrooms.

## **2. Literature Review**

### *2.1 Theoretical Framework: Bandura's Self-Efficacy Theory*

This study is grounded on Bandura's self-efficacy theory (1977, 1982), which posits that individuals' beliefs in their capabilities to produce designated levels of performance that exercise influence over events that affect their lives. In the context of education, teachers' self-efficacy may be particularly dependent on the teaching situation, such as science education. Bandura (1982) emphasized that teachers' efficacy beliefs significantly influence their attitudes, motivation, and behaviors, which in turn, affect their teaching practices and student outcomes. Preservice teachers develop a generalized expectancy concerning action-outcome contingencies based on their teaching-related experiences, shaping their expectations about teaching science through their engagement in teacher education programs (Bandura, 1997; Pajares, 1992).

Simsar and Jones (2021) found that the practical experiences and interactive mentorship within the teacher education program greatly affect the self-confidence of science teachers. Their research demonstrates that active involvement in field experiences and engaging with mentors plays a crucial role in building self-confidence. Through these hands-on clinical experiences, aspiring teachers are able to apply their theoretical knowledge in real-world situations, ultimately enhancing their confidence and effectiveness in teaching science (Menon et al., 2023).

Gunning and Mensah. (2020) examined the development of preservice elementary teachers' science teaching self-efficacy through reflective practices in a science methods course. The mixed-methods approach revealed that engaging in reflective practices significantly enhanced self-efficacy. The integration of these practices into method courses helped preservice teachers reflect on their teaching experiences, leading to increased confidence

and science teaching efficacy.

In a science methods course, preservice elementary teachers' self-efficacy in science teaching was examined by Gunning and Mensah (2020) through reflective practices. Using a mixed-methods approach, it was found that practicing reflection greatly increased self-efficacy. Preservice teachers' confidence in the effectiveness of their science instruction increased as a result of the practices' incorporation into method courses, which encouraged them to reflect on their own teaching experiences.

Kazempour and Sadler (2015) examined the relationship between science content knowledge and self-efficacy. Results showed that higher science content knowledge was significantly correlated with higher science teaching self-efficacy. The findings suggest that a strong foundation in science content is essential for developing preservice teachers' confidence in teaching science (Smetana & Nelson, 2023).

The development of the Science Teaching Efficacy Belief Instrument (STEBI) and its preservice version (STEBI-B) by Enochs and Riggs (1990) marked a significant advancement in measuring science teaching self-efficacy. These instruments, comprising scales for personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE), have facilitated research into preservice teachers' efficacy beliefs in teaching science. Personal teaching efficacy reflects the belief in one's ability to teach effectively, while teaching outcomes expectancy concerns the belief that effective teaching will positively impact student learning.

### *2.2 Constructivist vs. Traditional Teaching Beliefs*

Recent studies continue to underline the importance of self-efficacy in the educational context, echoing Bandura's foundational work. The evolving educational landscape, with its new pedagogical approaches and technological advancements, necessitates a reevaluation of existing instruments like the Science Teaching Efficacy Belief Instrument (STEBI). Research indicates a significant correlation between preservice teachers' constructivist beliefs and their science teaching self-efficacy, suggesting that aligning teaching beliefs with constructivist principles may enhance teachers' confidence and effectiveness in science teaching (Hansen & Olson, 2021; Zhao et al., 2022). Moreover, practical teaching experiences and professional development have been shown to positively impact preservice teachers' science teaching efficacy and outcome expectancy, emphasizing the importance of targeted professional development (Hechter, 2011; Lakshmanan et al., 2011; Liang & Richardson, 2009).

In early childhood education, constructivist beliefs emphasize developmentally appropriate practices based on children's active engagement and exploration. This approach is contrasted with traditional teaching models, which often involve more passive learning and teacher-directed instruction. Constructivist approaches are supported by a substantial body of research advocating for practices that foster active learning and critical thinking in young children (Copple & Bredekamp, 2009; Fisher et al., 2013; Hirsh-Pasek et al., 2020; Weisberg et al., 2013)

Research suggests that constructivist teaching beliefs significantly enhance preservice teachers' self-efficacy. Hansen and Olson (2021) found that preservice teachers with constructivist beliefs are more confident in their ability to teach science effectively. This is because constructivist approaches align well with strategies that engage students actively, thus boosting the teachers' confidence in managing and facilitating learning environments (Zhao et al., 2022).

Traditional teaching beliefs, characterized by teacher-centered instruction and passive learning, have been less effective in fostering high levels of self-efficacy among preservice teachers. Traditional methods may not provide the same level of engagement or hands-on experience that constructivist approaches offer, potentially leading to lower self-confidence in teaching abilities (Jones & Carter, 2021).

The role of practical teaching experiences and professional development cannot be overstated. Recent studies highlight that targeted professional development programs significantly improve preservice teachers' self-efficacy. For instance, a study by Hill, Harshbarger, and Keshwani (2024) demonstrated professional development workshops combined with practical implementation of lesson plans in a school garden setting notably increased preservice teachers' personal science teaching efficacy and science teaching outcome expectancy (STOE).

Additionally, another study by Menon et al. (2023) found that preservice elementary teachers experienced significant gains in integrated STEM teaching self-efficacy through a redesigned STEM semester involving concurrent methods courses focused on science, engineering, mathematics, and technology. Furthermore, a research study by Menon and Azam (2021) emphasized the importance of reflective practices and mentorship in developing science teaching self-efficacy among preservice teachers, showing that reflective practices within a

supportive learning environment greatly enhanced preservice teachers' confidence and competence in science teaching.

These programs often include workshops, mentorship, and hands-on teaching experiences that are crucial for building confidence and competence in teaching science.

Despite the prevalence of studies supporting constructivist approaches across all subject matters, research focusing on early childhood preservice teachers' beliefs, especially concerning science and its teaching, remains limited. More empirical evidence is needed to understand the relationship between preservice teachers' science teaching efficacy beliefs and their pedagogical beliefs. Addressing this gap could help in designing more effective teacher education programs that align with best practices in early childhood education (Lee & Ginsburg, 2022; Smith et al., 2023).

### *2.3 Summary and Research Gap*

Literature indicates that constructivist beliefs strongly outshine traditional beliefs among early childhood preservice teachers. Such beliefs significantly predict their personal efficacy regarding science teaching and positive predictions of successful science teaching outcomes. It strongly suggests that constructivist teaching beliefs are important for the manifestation of confidence and efficacy of preservice teachers regarding science education. There is also significant need for research in developing strategies for improving these efficacy beliefs. This research is relevant to the science teaching practices in early childhood education and contributes to the vast subject of educational psychology through the nature of subject-specific teaching efficacy attributed to the domain of influence on instructional practices and student learning outcomes.

Of particular importance is that inquiry into constructivist and traditional teaching beliefs, the impact on science teaching efficacy, and the influences professional development plays on the shaping of these beliefs underlie an important line of inquiry into early childhood education. This not only retraces the basic thrust of Bandura's early work but also documents the changing nature of educational research in the light of new pedagogical challenges and opportunities. The dynamic interplay between pre-service teachers' self-efficacy beliefs and their pedagogical orientations points to a complex process through which future educators conceptualize and approach science teaching. Of all reasons, the fact that the pivotal role which these play in instructional strategies and classroom practices is quite pronounced, warrants an in-depth inquiry into how the factors relate to one another in the context of early childhood education.

### *2.4 The Present Study*

In view of this, the objective of the present study is to fill the gap that past studies have pointed to by focusing on initiative and impact of science teaching efficacy beliefs among early childhood preservice teachers. Within this context, in studying the nature of how these teachers perceive their ability to teach science and to what extent their teaching beliefs have influenced their conceptions, this research intends to provide insight into the way that effective science educators are prepared. The nature of these relationships needs to be understood for appropriate designing of teacher education programs that increase pre-service teachers' self-efficacy and provide them with the necessary pedagogical tools for developing child-friendly, interesting, and science-rich learning environments for young learners.

Therefore, guided by the theoretical framework and the gaps identified in the existing literature, this study is poised to address the following specific research questions:

1. By answering these questions, the study aims to illuminate the intricate relationships How do early childhood preservice teachers perceive their science teaching efficacy, including both personal science teaching efficacy and science teaching outcome expectancy?
2. How does preservice teachers' science teaching efficacy relate to their teaching beliefs, specifically constructivist beliefs and traditional beliefs?
3. To what extent do teachers' teaching beliefs explain their science teaching efficacy and their science teaching outcome expectancy?

By answering these questions, the study aims to illuminate the intricate relationships between preservice teachers' efficacy beliefs, their pedagogical beliefs, and the implications of these relationships for early childhood science education. The findings are expected to offer empirical evidence that can inform the development of targeted interventions and strategies within teacher education programs, ultimately contributing to the broader goal of enhancing science teaching and learning in early childhood settings.

### 3. Method

#### 3.1 Sample

The present study was conducted with a total of 181 preservice teachers enrolled in an early childhood education program and elementary education program (primary grades) at a state university located in the Midwest region of the United States. These participants were at the junior and senior academic levels, having been fully admitted into the professional education program, thereby attaining the status of official teacher candidates as per the program's criteria. These preservice teachers, enrolled in both early childhood education and elementary education programs, were specifically interested in teaching early childhood (PreK- 3). They were recruited with the approval of program coordinators and the assistance of course instructors during class meetings. The demographic profile of the sample revealed an average age of 21.43 years ( $SD = .92$ ), with an age range spanning from 20 to 24 years. The majority of the participants, constituting 93.9%, identified as Caucasian White, with the remainder comprising 4 individuals of Asian descent and 7 Native Americans. Regarding marital status, 80.5% of the sample were single.

#### 3.2 Instruments

##### 3.2.1 Science Teaching Efficacy Beliefs

To assess the science teaching efficacy beliefs of preservice teachers, this study employed the Science Teaching Efficacy Belief Instrument - Preservice (STEBI-B), originally developed by Enochs and Riggs (1990). This instrument is widely recognized and validated within the field of educational research for its ability to accurately measure the construct of science teaching efficacy beliefs among preservice educators. The STEBI-B is comprised of two distinct sub-constructs: Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE), which are represented through 13 and 12 items, respectively (see Table 1 for detailed reliability statistics).

Table 1. Items in Science Teaching Efficacy

Construct	Items	<i>M</i>	<i>SD</i>
Personal science teaching efficacy (13 items; $a = .91$ )	I am continually finding better ways to teach science.	3.42	1.64
	Even when I try very hard, I don't teach science as well as I do most subjects.*	5.20	1.19
	I know the steps necessary to teach science concepts effectively.	3.36	1.49
	I am not very effective in monitoring science experiments.*	5.23	1.30
	I generally teach science ineffectively.*	5.16	1.30
	I understand science concepts well enough to be effective in teaching elementary science.	3.33	1.46
	I find it difficult to explain to students why science experiments work.*	5.01	1.32
	I am typically able to answer students' science questions.	3.37	1.46
	I wonder if I have the necessary skills to teach science.*	5.18	1.31
	Given a choice, I would not invite the principal to evaluate my science teaching.*	5.22	1.31
	When a student has difficulty understanding a science concept, I am usually at a loss as to how to help the student understand it better.*	5.20	1.33
	When teaching science, I usually welcome student questions.*	3.40	1.79
	I don't know what to do to turn students on to science.*	5.17	1.36
Science teaching outcome expectancy (8 items; $a = .76$ )	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	3.08	1.12
	When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	3.19	1.24
	If students are underachieving in science, it is most likely due to ineffective science teaching.	3.24	1.20
	The inadequacy of a student's science background can be overcome by good	3.18	1.42

teaching.		
The low science achievement of students cannot generally be blamed on their teachers.*	5.02	.99
When a low achieving child progresses in science, it is usually due to extra attention given by the teacher.	3.11	1.25
Increased effort in science teaching produces little change in students' science achievement.*	5.12	1.17
The teacher is generally responsible for the achievement of students in science.	3.28	1.19
Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	3.15	1.18
If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.	3.17	1.00
Effectiveness in science teaching has little influence on the achievement of students with low motivation.*	5.26	1.19
Even teachers with good science teaching abilities cannot help some kinds learn science.*	4.88	1.25

*Note.* \* = reversely coded; *a* = Cronbach's Alpha

The Personal Science Teaching Efficacy (PSTE) construct measures the confidence that preservice teachers have in their ability to effectively teach science. It reflects their personal belief in their capabilities to facilitate science learning in their future classrooms. Sample items include "I know the steps necessary to teach science concepts effectively" and "When a student does better than usual in science, it is often because I exerted a little extra effort." Science Teaching Outcome Expectancy construct assesses the preservice teachers' beliefs about the outcomes of effective science teaching, specifically whether they believe that their teaching efforts can positively affect students' science learning outcomes. Sample items in this construct include "When the science grades of students improve, it is often due to their teacher's effective teaching" and "If students are underachieving in science, it is most likely due to ineffective science teaching." For this study, the STEBI-B with a 7-point Likert scale was employed to provide a more nuanced measurement of preservice teachers' self-efficacy beliefs and outcome expectancies, allowing for a better understanding of their confidence and perceived impact on student learning outcomes.

The reliability of the STEBI-B instrument, as applied in this study, was confirmed through the calculation of Cronbach's alpha coefficients, which yielded values of .96 for the PSTE subscale and .86 for the STOES subscale. These coefficients indicate a high level of internal consistency within each of the subscales, underscoring the instrument's robustness in evaluating the targeted efficacy beliefs.

### 3.2.2 Teacher Beliefs Survey

To explore the teaching beliefs of early childhood preservice teachers, the study utilized the Teacher Beliefs Survey (TBS), as developed by Woolley, Benjamin, and Woolley (2004). This survey is designed to assess participants' orientations towards teaching methodologies, specifically distinguishing between constructivist and traditional pedagogical beliefs. The TBS is structured around two primary sub-constructs: Constructivist Teaching Beliefs and Traditional Teaching Beliefs, with each construct being evaluated through 12 distinct items. Responses to these items were captured using a 7-point Likert scale, where 1 represents "strongly disagree" and 7 signifies "strongly agree." The reliability of the TBS was assessed through the computation of Cronbach's alpha, resulting in values of .84 for the Constructivist Teaching Beliefs subscale and .87 for the Traditional Teaching Beliefs subscale. These values indicate a commendable level of internal consistency for each subscale, affirming the survey's efficacy in measuring the intended constructs.

### 3.3 Data Analysis

The analytical approach of this study was structured to methodically address the posed research questions through the application of statistical techniques. Initially, descriptive statistics were employed to provide a foundational understanding of the sample characteristics and the distribution of responses across the various measures. This step was crucial for establishing the context within which the efficacy and teaching beliefs of preservice teachers were examined.

Subsequently, Pearson's correlation analysis was conducted to explore the relationships between preservice teachers' science teaching efficacy beliefs (both personal science teaching efficacy and science teaching outcome expectancy) and their teaching beliefs (constructivist and traditional). This analysis aimed to identify any significant associations that might exist between these constructs, thereby offering preliminary insights into the interplay between teachers' efficacy beliefs and their pedagogical orientations.

Building upon the correlational findings, hierarchical regression analyses were performed as a more sophisticated statistical procedure to delve deeper into the dynamics of these relationships. Specifically, these analyses sought to determine the extent to which teaching beliefs (constructivist and traditional) could explain variations in science teaching efficacy and outcome expectancy among early childhood preservice teachers. By employing this analytical strategy, the study aimed to uncover the predictive power of teaching beliefs on efficacy beliefs, thereby contributing to a nuanced understanding of how these factors interact to shape preservice teachers' readiness and confidence in teaching science.

## 4. Results

### 4.1 Descriptive Statistics

The descriptive statistics of personal science teaching efficacy showed that the preservice teachers believed that they were efficacious on all 13 items. Among them, item 8 (reverse items), "I will generally teach mathematics ineffectively", was the highest score of 5.99 out of 7 points ( $SD = 1.32$ ). Item specific descriptive statistics are available in Table 1 above.

Table 2 provides a comprehensive overview of the descriptive statistics and correlations between science teaching efficacy and teaching beliefs.

Table 2. Descriptive Statistics and Correlations between Science Teaching Efficacy and Teaching Beliefs

Items	n	<i>M</i>	<i>SD</i>	1	2	3	4
1. Personal science teaching efficacy beliefs (PSTEB)	180	4.48	1.15	1	.73**	-.07	-.24**
2. Science teaching outcome expectancy (STOE)	180	3.81	.74		1	-.03	-.29**
3. Constructivist beliefs	181	5.72	.81			1	-.21**
4. Traditional beliefs	181	3.03	.88				1

Note. \*\*  $p < .01$  (2-tailed).

On the 7-point scale, our preservice teachers showed moderately higher scores on science teaching efficacy and relatively lower scores on science teaching outcome expectancy than on their teaching efficacy. The mean score for personal science teaching efficacy beliefs (PSTEB) was 4.48 ( $SD = 1.15$ ), indicating a moderate level of confidence among preservice teachers in their science teaching abilities. The science teaching outcome expectancy (STOE) had a mean score of 3.81 ( $SD = .74$ ), reflecting a slightly lower expectancy regarding the outcomes of their science teaching efforts.

Constructivist beliefs were strongly endorsed by the preservice teachers, with a mean score of 5.72 ( $SD = .81$ ), suggesting a high inclination towards constructivist teaching methods. In contrast, traditional beliefs scored lower, with a mean of 3.03 ( $SD = .88$ ), indicating a lesser preference for traditional teaching approaches.

### 4.2 Correlation Between Science Teaching Efficacy and Teaching Beliefs

The results of Pearson's correlation showed that both personal science teaching efficacy ( $r = -.24, p < .01$ ) and teaching outcome expectancy ( $r = -.29, p < .01$ ) were negatively related with traditional teaching beliefs, but there was no correlation with constructivist beliefs. The more efficacious their personal science teaching was and the higher the science teaching expectancy the preservice teachers had, the weaker the traditional teaching beliefs the preservice teachers had (see Table 2).

These results demonstrate that preservice teachers are less likely to support traditional teaching views and more likely to adopt constructivist teaching approaches when they have greater confidence in their ability to teach science. The moderate to high scores on science teaching efficacy and the strong inclination towards constructivist beliefs suggest a readiness among preservice teachers to implement active learning and critical thinking strategies in their future classrooms.

### 4.3 The Impact of Teaching Beliefs on Science Teaching Efficacy

To see the changes in the predictability of constructivist and traditional beliefs in both personal teaching efficacy and teaching outcome expectancy, this study performed two separate hierarchical linear regression analyses by entering constructivist teaching beliefs at the first step, followed by traditional teaching beliefs at the second step.

The results of the hierarchical regression analysis showed that about 7.3% of the variability was explained by teaching beliefs. At the first step ( $F = .895, p > .05$ ), when we entered constructivist teaching beliefs ( $\beta = -.071, t = -.946, p > .05$ ), the model was not statistically significant, with an  $R^2$  of .005. However the entry of traditional teaching beliefs ( $\beta = -.25, t = -3.09, p < .01$ ) at the second step resulted in an increase in  $R^2$  by 0.68, showing an overall  $R^2$  of 0.073 ( $F = 7.002, p < .001$ ). In turn, traditional teaching beliefs added 6.8% of the variability, resulting in 7.3% of predictability in the preservice teachers' science efficacy (see Table 3).

Table 3. Predictability of Teaching Beliefs on Personal Science Teaching Efficacy Beliefs

Step	Predictors	$\beta$	$t$	VIF	$F$	$R^2(\Delta)$
1	Constructivist beliefs	-.071	-.946	1.000	.895	.005
2	Constructive beliefs	-.125	-1.695	1.919	7.002***	.073
	Traditional beliefs	-.267	-3.612***	1.749	(.068)	

Note. \*\*\* $p < .001$ .  $R^2(\Delta)$  = changes in  $R^2$ ; VIF = variance inflation factor.

The results of the hierarchical regression analysis showed that the science teaching outcome expectancy was explained by teaching beliefs for about 9.2 %. The two-level model was not statistically significant at the first step ( $F = .895, p > .05$ ), but the entry of traditional teaching beliefs resulted in an increase in  $R^2$  by .091, showing an overall  $R^2$  of .092. Overall, constructivist teaching beliefs ( $\beta = -.095, t = -1.294, p > .05$ ) was not a statistically significant predictor while traditional teaching beliefs ( $\beta = -.307, t = -4.200, p < .001$ ) was a significant predictor. In turn, traditional teaching beliefs was the major predictor in explaining the preservice teachers' science teaching outcome expectancy (see Table 4).

Table 4 illustrates the regression analysis results, emphasizing the statistical significance of traditional teaching beliefs as a predictor for science teaching outcome expectancy. The variance inflation factor (VIF) values indicate no multicollinearity issues among the predictors. The  $F$  values and  $R^2$  changes provide a clear depiction of the model's explanatory power at each step.

Table 4. Correlations between Science Teaching Efficacy and Teaching Beliefs

Items	n	$M$	$SD$	1	2	3	4
1. Personal science teaching efficacy beliefs (PSTEB)	180	4.48	1.15	1	.73*	-.07	-.24**
2. Science teaching outcome expectancy (STOE)	180	3.81	.74		1	-.03	-.29**
3. Constructivist beliefs	181	5.72	.81			1	-.21**
4. Traditional beliefs	181	3.03	.88				1

Note. \*\* $p < .01$  (2-tailed).

## 5. Discussion

The purpose of this study was to understand preservice teachers' perceptions about their science teaching efficacy beliefs and its association with their teaching beliefs during advanced years in the teacher education program. Using self-reported survey questionnaires, this study collected data from a total of 181 preservice teachers enrolled in a Midwestern US university. This study specifically aimed to understand how these beliefs correlate with both personal science teaching efficacy and science teaching outcome expectancy. The study



findings provide several empirical evidence that could inform the development of targeted interventions within teacher education programs to enhance science teaching efficacy in early childhood settings.

First, the results revealed that early childhood preservice teachers generally perceived themselves as moderately efficacious in science teaching, with higher scores on personal science teaching efficacy compared to science teaching outcome expectancy. This finding is consistent with previous studies, which have demonstrated that preservice teachers often exhibit greater confidence in their general teaching abilities compared to specific outcome expectations (Gunning & Mensah, 2020; Simsar & Jones, 2021). The moderately higher efficacy scores suggest that while preservice teachers feel somewhat confident in their ability to teach science, they are less certain about the positive outcomes of their teaching efforts. This disparity underscores the need for teacher education programs to bolster preservice teachers' confidence in achieving successful teaching outcomes (Kazempour & Sadler, 2015).

Second, the results from correlation analysis showed significant negative relationships between traditional teaching beliefs and both personal science teaching efficacy and science teaching outcome expectancy. These results align with research indicating that traditional pedagogical beliefs can hinder the development of teaching efficacy (Hill et al., 2024). Preservice teachers with stronger traditional teaching beliefs were found to have lower confidence and expectations regarding their science teaching capabilities. Conversely, the absence of significant correlations between constructivist beliefs and science teaching efficacy suggests that merely holding constructivist beliefs does not automatically translate into higher teaching efficacy. This highlights the complexity of teaching efficacy and suggests the need for practical applications and support to effectively enhance teaching efficacy (Hansen & Olson, 2021; Zhao et al., 2022).

Lastly, the hierarchical regression analyses provided further insights into the impact of teaching beliefs on science teaching efficacy and outcome expectancy. Traditional teaching beliefs emerged as significant predictors for both personal science teaching efficacy and science teaching outcome expectancy. These findings are in line with studies that emphasize the critical role of traditional beliefs in shaping teachers' expectations and confidence (Gunning & Mensah, 2020). The substantial influence of traditional beliefs suggests that addressing and modifying these beliefs could be pivotal in enhancing preservice teachers' science teaching efficacy. This is particularly relevant considering that traditional beliefs often align with less effective, teacher-centered instructional practices, which may not support the development of robust science teaching efficacy (Menon et al., 2023).

The findings of this study have significant implications for early childhood teacher education programs. Given the substantial impact of traditional teaching beliefs on science teaching efficacy and outcome expectancy, it is essential for teacher education programs to explicitly address these beliefs. Professional development programs that incorporate reflective practices, practical teaching experiences, and interactive mentorship could be particularly effective in reshaping traditional beliefs and enhancing preservice teachers' science teaching efficacy (Simsar & Jones, 2021).

Additionally, aligning teacher training with constructivist principles and providing opportunities for preservice teachers to apply these principles in real-world teaching contexts could further support the development of science teaching efficacy (Gunning & Mensah, 2020). Lawrent (2022) found that different course formats, including online and hybrid models, affected preservice teachers' self-efficacy in distinct ways, with mastery experiences being particularly influential. This suggests that teacher education programs should consider incorporating diverse and flexible course modalities that offer ample opportunities for mastery experiences to improve preservice teachers' self-efficacy.

Furthermore, Shorman, Cox, and Thomas (2023) demonstrated that participation in redesigned STEM courses led to significant positive gains in self-efficacy. The integrated approach helped preservice teachers develop a cohesive understanding of STEM disciplines, improving their confidence and efficacy in teaching these subjects. Therefore, integrating STEM courses in teacher education programs can significantly enhance preservice teachers' confidence and efficacy in teaching STEM subjects.

## **6. Conclusion**

### *6.1 Educational Implications*

From the findings of this study, this study suggests the teacher education program should facilitate preservice teachers' science efficacy through guiding them to use well developed-science activities and science oriented-teaching practices during their field experiences and practicums. In that way, preservice teachers would be more motivated to improve their content knowledge and enhance their practical use of science in their

teaching practices and ultimately enhance their teaching quality to improve their science teaching efficacy.

Preservice teachers should accept the most important idea that regardless of teachers' knowledge and efficacy in teaching science-related activities, the most effective teaching and learning occur when a teacher begins where the child is. Therefore, the teacher education program should enhance preservice teachers' capacity to assess students' developmental and learning status in order to apply relevant levels of science learning tasks and developmentally appropriate science practices.

In addition, teacher education programs should teach preservice teachers to apply an integrated curriculum (i.e., music to science) in science teaching and learning. Effective science teaching should incorporate fun and playful science learning experiences for young learners, fostering a love for science from an early age.

The educational implications suggest a need for teacher education programs that promote innovative, student-centered teaching practices to enhance science education for children in their early school years. By focusing on reducing traditional teaching beliefs and encouraging contemporary, research-based teaching methods, teacher education programs can better prepare preservice teachers to create dynamic, effective, and enjoyable science learning environments.

### 6.2 Limitations of the Study and Future Directions

Despite this study's important educational implications for early childhood teacher preparation programs, this study also has limitations. First, the use of self-reported survey questionnaires may introduce response bias, as participants might overestimate or underestimate their teaching efficacy and beliefs. Future research could employ a mixed-methods approach, combining quantitative surveys with qualitative interviews or observations to gain a more comprehensive understanding of preservice teachers' science teaching efficacy and their teaching beliefs.

Second, the sample for this study is limited to preservice teachers from a single Midwestern US university, which may affect the generalizability of the findings. Further research should include a more diverse sample from multiple programs and institutions across different grade levels and regions respectively to enhance the external validity of the results.

Third, the cross-sectional design of the study captures preservice teachers' perceptions at a single point in time, which may not reflect changes over time. Longitudinal studies are needed to examine how preservice teachers' science teaching efficacy beliefs evolve throughout their teacher education programs and into their early teaching careers. These studies will depict transformative nature of preservice teachers' beliefs and practices in teaching.

Future studies could explore the impact of specific interventions, such as professional development programs that incorporate reflective practices, practical teaching experiences, and interactive mentorship through both virtual and face-to-face approaches, on preservice teachers' science teaching efficacy. Additionally, research could investigate the effectiveness of integrating STEM courses in teacher education programs to enhance preservice teachers' confidence and efficacy in teaching STEM subjects.

Furthermore, examining the role of different course formats, including online and hybrid models, in shaping preservice teachers' self-efficacy could provide insights into how to design more effective teacher education programs, including for those who are already in the early childhood care and education workforce and completing their degree and teaching certificate through online degree programs. Finally, future research should consider the influence of various demographic factors, such as gender, age, and prior teaching experience, on preservice teachers' science teaching efficacy beliefs.

In conclusion, addressing and modifying traditional teaching beliefs, providing opportunities for mastery experiences, and incorporating innovative, student-centered teaching practices are essential for enhancing preservice teachers' science teaching efficacy. Teacher education programs should prioritize these areas to better equip preservice teachers with the skills and confidence in science content knowledge needed to foster effective science learning. By embracing reflective practices, practical teaching experiences, and interactive mentorship, these programs can further help preservice teachers develop robust science teaching strategies. Ultimately, focusing on these elements will enable teacher education programs to prepare preservice teachers to create dynamic, effective, and enjoyable science learning environments that meet the needs of young learners in the digital and global era.

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