Exploring STEM Attitudes among First-year Early Childhood and Primary Preservice Teachers: Gender and Regional Insights in Western Australia

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Abstract

Understanding how future educators approach STEM is crucial for developing effective teacher education programs. This study examined STEM attitudes among 146 first-year preservice teachers in Western Australia, comparing early childhood and primary education cohorts while considering gender and geographical location. Using an adapted T-STEM survey), results revealed that primary preservice teachers demonstrated higher efficacy in science and technology ($p < 0.01$), while their early childhood counterparts showed stronger attitudes toward STEM leadership ($p < 0.032$). Male participants reported higher mathematics efficacy ($p < 0.001$) and technology confidence ($p < 0.001$), though female participants expressed notably positive attitudes toward leadership roles. Preservice teachers residing in regional areas demonstrated more optimistic views toward STEM instruction ($p < 0.007$) compared to their urban peers. These findings suggest the need for differentiated approaches in teacher education programs, including targeted support for technical skills in early childhood education, gender-responsive strategies, and specialised resources for both urban and regional contexts.

Keywords: STEM education, preservice teachers, teacher preparation, gender differences, regional education

1. Introduction

STEM education, which includes Science, Technology, Engineering, and Mathematics, is a crucial part of modern curricula. It has significant implications for national development, economic prosperity, and technological innovation. [1]. In Australia, enhancing the quality of STEM education remains a key priority, particularly in preparing preservice teachers who will shape the future of STEM learning in early childhood and primary classrooms [2]. The attitudes and perceptions of preservice teachers toward STEM subjects are crucial in ensuring effective STEM teaching, as these attitudes directly influence classroom practices and student engagement [3].

While previous research has explored the STEM attitudes of primary preservice teachers [4], limited attention has been given to those in early childhood education [5], despite their significant role in laying the foundation for future STEM learning. Early childhood educators introduce young children to fundamental concepts in science, technology, engineering, and mathematics, making it vital to understand how first-year preservice teachers in both early childhood and primary education view these disciplines [6]. This study aims to address this gap by examining the attitudes of both early childhood and primary preservice teachers toward STEM, with a focus on gender and geographical (residing in urban location vs. residing in regional location) differences.

This study draws on the theory of planned behaviour [7] and self-efficacy theory [8]. It investigates how first-year preservice teachers' beliefs about their capabilities in STEM subjects differ between early childhood and primary education contexts. The inclusion of early childhood preservice teachers allows for a more comprehensive understanding of how attitudes toward STEM are shaped during the initial stages of teacher education [9]. Additionally, exploring gender differences in STEM attitudes continues to be relevant, given the documented disparities in STEM self-efficacy between males and females [10]. Urban and regional differences are also critical, as regional preservice teachers often face distinct challenges in accessing STEM resources and professional development opportunities [11].

To explore these aims, the following research questions were addressed:

1. Are there differences in attitudes toward STEM education between first-year early childhood and primary preservice teachers?

2. Are there gender-based differences in STEM attitudes within these two groups?

3. Are there geographical (urban vs. regional) differences in STEM attitudes among these two groups?

2. Literature Review

STEM education has been widely recognised as a cornerstone of modern educational reform efforts, contributing significantly to economic growth, innovation, and the ability to address complex global challenges [1]. In Australia, enhancing STEM education is a priority, with a growing focus on preparing preservice teachers who will be responsible for fostering STEM learning in both early childhood and primary classrooms [2]. Despite these efforts, there are notable variations in how preservice teachers, particularly those in early childhood and primary education, perceive and engage with STEM disciplines, which can have a direct impact on their teaching practices and student engagement [3, 4]. Previous research has largely focused on the STEM attitudes of primary preservice teachers, but limited attention has been given to early childhood educators [5]. Despite this emphasis on primary education, understanding early childhood educators' perspectives is crucial because they play a foundational role in shaping early STEM experiences. This study aims to fill this gap by comparing both early childhood and primary preservice teachers.

2.1. Early childhood and primary education in STEM

Early childhood educators play a critical role in introducing children to foundational STEM concepts, contributing to early development of problem-solving and critical thinking skills [5, 6]. Research suggests that positive early experiences with STEM can enhance children’s future engagement and success in these subjects [6, 7]. However, there is limited research focused on the attitudes of preservice teachers in early childhood education compared to their counterparts in primary education, even though both groups are responsible for teaching in primary settings in Australia [8]. Early childhood education is essential in establishing STEM foundations, yet preservice teachers' attitudes in this sector remain under-explored [9, 10]. This study aims to address this gap by exploring STEM attitudes across both early childhood and primary preservice teachers to better understand how these attitudes shape their effectiveness in STEM teaching.

2.2. Gender differences in STEM attitudes

The gender gap in STEM disciplines remains a significant issue globally, with persistent disparities in self-efficacy and career aspirations between male and female students [11]. This is particularly evident in areas such as mathematics and technology, where male students often report higher levels of confidence and interest compared to their female peers [12]. Research in STEM education has consistently shown that these gender differences extend to preservice teachers, who bring their own experiences and biases into the classroom, potentially perpetuating these disparities [13]. Studies focused on preservice teachers reveal that female teachers tend to exhibit lower self-efficacy in mathematics and technology, though they may show stronger leadership in collaborative and interdisciplinary STEM approaches [14]. Understanding the gender differences in STEM attitudes among preservice teachers is crucial for exploring how these differences manifest between early childhood and primary preservice teachers, which is a key aspect of this study. This study will further explore these dynamics by examining gender differences among both early childhood and primary preservice teachers, building on existing research to understand how these differences influence their future teaching practices [15].

2.3. Geographical disparities in STEM education

Geographical location plays a role in shaping preservice teachers' attitudes toward STEM. Regional preservice teachers, particularly those from rural or remote areas, often face distinct challenges, including limited access to resources, fewer professional development opportunities, and isolation from STEM communities of practice [16]. These factors can contribute to a lower sense of efficacy in teaching STEM subjects and a reduced likelihood of incorporating innovative STEM practices into the classroom [16, 17]. Conversely, preservice teachers who reside and study in urban areas generally have more access to STEM resources, leading to higher confidence in teaching these subjects [18]. There is limited research on how these geographical differences impact preservice teachers across both early childhood and primary education sectors [19]. This study will investigate how geographical factors affect STEM attitudes among early childhood and primary preservice teachers in both urban and regional settings in Western Australia, adding to the limited body of research on this topic [20].

By synthesising existing research on gender and geographical disparities in STEM education, with a focus on early childhood education, this study aims to expand our understanding of these factors among first-year early childhood and primary preservice teachers. The literature highlights critical gaps, particularly regarding preservice teachers in both early childhood and primary education settings. Although gender differences have been studied, there is limited comparative research between these two sectors. Additionally, the influence of geographical location on shaping STEM attitudes remains underexplored. By examining these factors, this study provides insights to inform curriculum design and professional development programs, supporting the development of tailored education strategies to foster STEM engagement, particularly for underrepresented groups and regions.

3. Methodology

3.1. Research Design

This study employed a quantitative, survey-based research design to measure and compare first-year preservice teachers' attitudes toward STEM subjects. Quantitative methods were selected for their efficacy in capturing and analysing attitudinal data across large participant groups, allowing for the generalisation of results and comparison between groups [17]. The study explored gender differences, geographical location (urban versus regional), and comparisons between early childhood preservice teachers and primary preservice teachers, focusing on variations in self-efficacy, confidence in STEM instruction, and STEM leadership across these groups.

3.2. Participants

A total of 146 first-year preservice teachers participated in this study. The preservice teacher participants included 32 from early childhood education and 114 from primary education. The gender distribution were 116 females, 26 males, and 4 who preferred not to disclose their gender. The geographical distribution of preservice teachers included 83 who resided in an urban location, 59 regional, and 4 remote. All participants were enrolled in a Bachelor of Education program at a large university in Western Australia. The inclusion of both early childhood and primary preservice teachers allowed for meaningful comparisons between these educational specialisations [18].

3.3. Instrumentation

Data was collected using the Preservice STEM Teaching Attitudes Survey, adapted from the validated S-STEM survey [4]. The S-STEM survey has been widely used in education research to measure students’ and teachers' attitudes toward STEM subjects. The survey included 35 Likert scale items that measured seven key domains: Science Efficacy, Mathematics Efficacy, Technology Confidence, STEM Instruction Confidence, 21st Century Learning Skills, STEM Leadership, and STEM Careers. These domains are recognised as critical factors influencing teacher attitudes and their potential effectiveness in STEM education [11].

3.4. Procedure

A survey approach was selected over other qualitative methods due to its ability to capture a wide range of attitudinal data across a larger participant group. This was particularly important for ensuring generalisability and for identifying patterns in attitudes related to gender and geographical factors. While qualitative approaches might provide deeper insights into individual experiences, the survey method allows for more robust statistical analysis, which was crucial for addressing the research questions involving multiple independent variables [19].

The survey was administered online to accommodate participation from preservice teachers residing in urban, regional, and remote locations. The online format ensured accessibility and allowed the researchers to gather data from a geographically diverse sample. Online surveys efficiently collect data from large samples and ensure data integrity [19]. Participants completed the survey over a four-week period during their first semester. Participation was voluntary, and confidentiality was assured throughout the process, with university ethics approvals obtained.

3.5. Data analysis

The data was analysed using SPSS Version 26, which is commonly used in education research to analyse survey data [20]. Descriptive statistics were calculated to summarise the demographic characteristics of the participants and the overall attitude scores for early childhood and primary preservice teachers. Independent t-tests were used to compare attitudes between early childhood and primary preservice teachers, while analysis of variance (ANOVA) was used to examine the effects of gender and geographical location on STEM attitudes. These statistical methods were chosen for their ability to handle comparisons between multiple independent variables and measure their effects on the dependent variables [21].

3.6. Validity and reliability

The survey instrument's reliability was assessed using Cronbach’s alpha, with an overall reliability score of 0.89, indicating high internal consistency [22]. Content validity was ensured through expert review of the survey items, with adjustments made to reflect the specific context of preservice teachers in early childhood and primary education. Factor analysis was conducted to confirm that the seven domains adequately represented the intended constructs [23].

4. Results

4.1. Comparison of early childhood education and primary preservice teachers' attitudes to STEM education

The MANOVA results indicated significant differences between the early childhood and primary education cohorts, with Wilks' Lambda, $\lambda = 0.69$, $F(9, 136) = 6.77$, $p < 0.001$; Pillai's Trace, $V = 0.31$, $F(9, 136) = 6.77$, $p < 0.001$; Hotelling's Trace, $T^2 = 0.45$, $F(9, 136) = 6.77$, $p < 0.001$; and Roy's Largest Root, $\theta = 0.45$, $F(9, 136) = 6.77$, $p < 0.001$.

Welch's T-tests further supported these findings, showing significant differences in specific constructs between early childhood and primary cohorts. The T-tests revealed differences in Science Efficacy ($t = 2.60$, $p = 0.011$), Science Expectancy ($t = 2.74$, $p = 0.009$), Mathematics Expectancy ($t = 4.31$, $p < 0.001$), Technology ($t = 2.27$, $p = 0.027$), 21st Century Learning Skills ($t = 3.95$, $p < 0.001$), and STEM Leadership ($t = -2.20$, $p = 0.032$). No significant differences were found in Mathematics Efficacy ($p = 0.561$), STEM Instruction ($p = 0.971$), or STEM Careers ($p = 0.779$). The results are presented in Table 1.

Table 1. Differences in early childhood and primary preservice teachers' attitudes to STEM categories

Category	Early Childhood Mean	Primary Mean	t-Statistic	p-Value	Significant difference
Science Efficacy	3.51	3.19	2.60	0.011	Yes
Science Expectancy	4.08	3.76	2.74	0.009	Yes
Mathematics Efficacy	3.57	3.47	0.59	0.561	No
Mathematics Expectancy	4.25	3.74	4.31	<0.001	Yes
Technology	3.48	3.22	2.27	0.027	Yes
21st Century Learning Skills	4.84	4.51	3.95	<0.001	Yes
STEM Leadership	4.60	4.88	-2.20	0.032	Yes
STEM Instruction	3.80	3.78	0.04	0.971	No
STEM Careers	3.50	3.42	0.28	0.779	No

4.2. Gender differences in STEM attitudes

The analysis of gender differences among first-year preservice teachers revealed significant disparities across several STEM constructs. Independent t-tests were conducted to compare male and female scores across the following categories: Science Efficacy, Science Expectancy Values, Mathematics Efficacy, Mathematics Expectancy Values, Technology, STEM Instruction, 21st Century Learning Skills, STEM Leadership, and STEM Careers.

Male participants demonstrated significantly higher scores in Mathematics Efficacy (male mean = 4.06, female mean = 3.40, $p < 0.001$) and Technology (male mean = 3.59, female mean = 3.03, $p < 0.001$), while female participants scored higher in STEM Leadership (female mean = 4.89, male mean = 4.64, $p < 0.001$) and STEM Instruction (female mean = 3.53, male mean = 3.70, $p = 0.013$).

No significant differences were observed in Science Efficacy (male mean = 3.40, female mean = 3.34, $p = 0.527$) and Science Expectancy Values ($p = 0.053$). The results are presented in Table 2.

Table 2. Gender differences in STEM categories

Category	Male Mean	Female Mean	t-Statistic	P-Value	Significant difference
Mathematics Efficacy	4.06	3.4	8.212	< 0.001	Yes
Mathematics Expectancy	3.76	3.78	-0.295	0.768	No
Science Efficacy	3.4	3.34	0.634	0.527	No
Science Expectancy Values	3.68	3.82	-1.941	0.053	No
Technology	3.59	3.03	5.883	< 0.001	Yes
STEM Instruction	3.7	3.53	2.489	0.013	Yes
21st Century Learning	4.13	4.28	-2.493	0.013	Yes
STEM Leadership	4.64	4.89	-4.221	< 0.001	Yes
STEM Careers	3.68	3.45	1.475	0.142	No

4.2.1. Gender differences in early childhood educators' STEM attitudes. The MANOVA results indicated no significant overall differences between male and female early childhood preservice teachers across the measured STEM constructs. Wilks' Lambda, $\lambda = 0.64$, $F(6, 11) = 1.04$, $p = 0.45$; Pillai's Trace, $V = 0.36$, $F(6, 11) = 1.04$, $p = 0.45$; Hotelling's Trace, $T^2 = 0.57$, $F(6, 11) = 1.04$, $p = 0.45$; and Roy's Largest Root, $\theta = 0.57$, $F(6, 11) = 1.04$, $p = 0.45$.

One specific comparison yielded significant differences: Wilks' Lambda, $\lambda = 0.12$, $F(6, 11) = 13.48$, $p < 0.01$; Pillai's Trace, $V = 0.88$, $F(6, 11) = 13.48$, $p < 0.01$; Hotelling's Trace, $T^2 = 7.35$, $F(6, 11) = 13.48$, $p < 0.01$; and Roy's Largest Root, $\theta = 7.35$, $F(6, 11) = 13.48$, $p < 0.01$. While most tests did not indicate significant overall differences across all constructs, Roy's Largest Root suggests a pronounced difference in one specific construct.

The analysis of gender differences among early childhood preservice teachers revealed significant disparities across several STEM constructs. Independent t-tests were conducted to compare male and female scores across the following categories: Science Efficacy, Science Expectancy Values, Mathematics Efficacy, Mathematics Expectancy Values, Technology, STEM Instruction, STEM Leadership, and STEM Careers.

Male preservice teachers demonstrated significantly higher scores in Technology (male mean = 4.09, female mean = 3.20, $p < 0.001$), while no significant differences were observed in Mathematics Efficacy ($p = 0.419$), Science Efficacy ($p = 0.107$), Mathematics Expectancy Values ($p = 0.402$), 21st Century learning skills ($p = 0.223$) and STEM Leadership ($p = 0.247$). The results are presented in Table 3.

Table 3. Gender differences in early childhood education preservice teachers' STEM attitudes

Category	Male Mean	Female Mean	t-Statistic	P-Value	Significant difference
Mathematics Efficacy	4.00	3.85	0.81	0.419	No
Mathematics Expectancy	3.75	3.80	-0.86	0.402	No
Science Efficacy	3.45	3.88	-1.64	0.107	No
Science Expectancy Values	3.72	3.80	-1.41	0.161	No
Technology	4.09	3.20	3.77	< 0.001	Yes
STEM Instruction	3.55	3.63	-0.47	0.643	No
21st Century Skills	4.10	4.20	1.24	0.223	No
STEM Leadership	4.45	4.71	-1.17	0.247	No
STEM Careers	3.68	3.55	1.27	0.215	No

4.2.2 Gender differences in primary education preservice teacher's STEM attitudes. The MANOVA results indicated significant overall differences between male and female primary preservice teachers across the measured STEM constructs:

Wilks' Lambda, $\lambda = 0.72$, $F(9, 155) = 6.77$, $p < 0.001$;

Pillai's Trace, $V = 0.28$, $F(9, 155) = 6.77$, $p < 0.001$;

Hotelling's Trace, $T^2 = 0.39$, $F(9, 155) = 6.77$, $p < 0.001$;

Roy's Largest Root, $\theta = 0.39$, $F(9, 155) = 6.77$, $p < 0.001$.

These results indicate significant overall differences between genders in several STEM constructs.

Male primary preservice teachers demonstrated significantly higher scores in Mathematics Efficacy (male mean = 4.06, female mean = 3.40, $p < 0.001$) and Technology (male mean = 3.59, female mean = 3.03, $p < 0.001$), while their female counterparts scored higher in STEM Leadership (female mean = 4.89, male mean = 4.64, $p < 0.001$), STEM Instruction (female mean = 3.53, male mean = 3.70, $p = 0.013$) and 21st Century learning skills (female mean = 4.40, male mean = 4.15, P= <0.001)

No significant differences were observed in Science Efficacy (male mean = 3.40, female mean = 3.34, $p = 0.527$) and Science Expectancy Values ($p = 0.053$). The results are presented in Table 4.

Table 4. Gender differences in primary preservice teachers' STEM attitudes

Category	Male Mean	Female Mean	t-Statistic	P-Value	Significant difference
Mathematics Efficacy	4.06	3.40	8.21	< 0.001	Yes
Mathematics Expectancy	3.76	3.78	-0.30	0.768	No
Science Efficacy	3.40	3.34	0.63	0.527	No
Science Expectancy Values	3.68	3.82	-1.94	0.053	No
Technology	3.59	3.03	5.88	< 0.001	Yes
STEM Instruction	3.70	3.53	2.49	0.013	Yes
21st Century Skills	4.15	4.40	3.71	<0.001	Yes
STEM Leadership	4.64	4.89	-4.22	< 0.001	Yes
STEM Careers	3.68	3.45	1.48	0.142	No

4.3 Geographical differences in preservice teachers' STEM attitudes

The analysis of geographical differences (Urban vs. Regional) among first-year preservice teachers revealed significant disparities across several STEM constructs. Independent t-tests were conducted to compare urban and regional scores across the following categories: Science Efficacy, Science Expectancy Values, Mathematics Efficacy, Mathematics Expectancy Values, Technology, STEM Instruction, 21st Century Learning Skills, STEM Leadership, and STEM Careers.

The MANOVA results indicated significant overall differences between preservice teachers residing in urban and regional across the measured STEM constructs:

Wilks' Lambda, $\lambda = 0.64$, $F(9, 118) = 4.72$, $p < 0.001$;

Pillai's Trace, $V = 0.36$, $F(9, 118) = 4.72$, $p < 0.001$;

Hotelling's Trace, $T^2 = 0.57$, $F(9, 118) = 4.72$, $p < 0.001$;

Roy's Largest Root, $\theta = 0.57$, $F(9, 118) = 4.72$, $p < 0.001$.

These results suggest significant overall differences between urban and regional preservice teachers across several STEM constructs.

Significant differences were observed in Science Efficacy (urban mean = 3.27, regional mean = 4.13, $p < 0.0001$), Science Expectancy Values (urban mean = 3.41, regional mean = 4.18, $p < 0.0001$), Mathematics Expectancy Values (urban mean = 3.66, regional mean = 4.31, $p < 0.0001$), and STEM Careers (urban mean = 3.09, regional mean = 3.46, $p = 0.0394$).

No significant differences were found in Mathematics Efficacy ($p = 0.0858$), Technology (p =

0.0810), STEM Instruction (p = 0.4805), 21st Century Learning Skills (p = 0.1705), or STEM Leadership (p = 0.1840). The results are presented in Table 5.

Table 5. Geographical differences in STEM categories

Category	Urban Mean	Regional Mean	t-Statistic	p-Value	Significant difference
Science Efficacy	3.27	4.13	-6.79	< 0.0001	Yes
Science Expectancy Values	3.41	4.18	-4.42	< 0.0001	Yes
Mathematics Efficacy	3.50	3.82	-1.77	0.0858	No
Mathematics Expectancy Values	3.66	4.31	-4.18	< 0.0001	Yes
Technology	3.37	3.05	1.77	0.0810	No
STEM Instruction	3.91	3.79	0.71	0.4805	No
21st Century Learning Skills	4.38	4.51	-1.39	0.1705	No
STEM Leadership	4.46	4.62	-1.34	0.1840	No
STEM Careers	3.09	3.46	-2.10	0.0394	Yes

4.3.1 Geographical differences in early childhood students. The MANOVA results indicated significant overall differences between early childhood preservice teachers residing in urban locations and those residing in regional locations across the measured STEM constructs:

Wilks' Lambda, $\lambda = 0.01$, $F(9, 22) = 225.50$, $p < 0.001$;

Pillai's Trace, $V = 0.99$, $F(9, 22) = 225.50$, $p < 0.001$;

Hotelling's Trace, $T^2 = 92.25$, $F(9, 22) = 225.50$, $p < 0.001$;

Roy's Largest Root, $\theta = 92.25$, $F(9, 22) = 225.50$, $p < 0.001$.

These results suggest significant overall differences between early childhood preservice teachers in urban and regional residing locations across several STEM constructs.

Significant differences were observed in Mathematics Efficacy (urban mean = 4.11, regional mean = 2.67, p < 0.001), Science Expectancy Values (urban mean = 4.24, regional mean = 3.81, p = 0.038), STEM Instruction (urban mean = 3.21, regional mean = 4.26, p = 0.007), and STEM Careers (urban mean = 3.50, regional mean = 2.88, p = 0.022). No significant differences were found in Science Efficacy (p = 0.133), Mathematics Expectancy Values (p = 0.832), Technology (p = 0.070), 21st Century Learning Skills (p = 0.491), or STEM Leadership (p = 0.767). The results are presented in Table 6.

Table 6. Geographical differences in early childhood preservice teachers attitudes to STEM categories

Category	Urban Mean	Regional Mean	t-Statistic	p-Value	Significant difference
Mathematics Efficacy	4.11	2.67	8.81	< 0.001	Yes
Mathematics Expectancy Values	4.27	4.22	0.21	0.832	No
Science Efficacy	3.62	3.33	1.56	0.133	No
Science Expectancy Values	4.24	3.81	2.18	0.038	Yes
Technology	3.33	3.72	-1.94	0.070	No
STEM Instruction	3.21	4.26	-3.03	0.007	Yes
21st Century Learning Skills	4.85	4.83	0.70	0.491	No
STEM Leadership	4.73	4.76	-0.30	0.767	No
STEM Careers	3.50	2.88	2.41	0.022	Yes

4.3.2 Geographical differences in primary education preservice teachers' STEM attitudes. The MANOVA results indicated significant differences between primary preservice teachers residing in urban locations and those residing in regional locations with:

Wilks' Lambda, $\lambda = 0.64$, $F(9, 272) = 17.28$, $p < 0.001$;

Pillai's Trace, $V = 0.36$, $F(9, 272) = 17.28$, $p < 0.001$;

Hotelling's Trace, $T^2 = 0.57$, $F(9, 272) = 17.28$, $p < 0.001$;

Roy's Largest Root, $\theta = 0.57$, $F(9, 272) = 17.28$, $p < 0.001$.

Welch's T-tests further supported these findings, showing significant differences in specific constructs between primary preservice teachers in urban and regional residing locations.

The T-tests revealed differences in Mathematics Efficacy (t = 8.81, p < 0.001), Science Expectancy Values (t = 2.18, p = 0.038), STEM Instruction (t = -3.03, p = 0.007), and STEM Careers (t = 2.41, p = 0.022). No significant differences were found in Science Efficacy (p = 0.133), Mathematics Expectancy Values (p = 0.832), Technology (p = 0.070), 21st Century Learning Skills (p = 0.491), or STEM Leadership (p = 0.767). The results are presented in Table 7.

Table 7. Geographical differences in primary preservice teachers' attitudes to STEM categories

Category	Urban Mean	Regional Mean	t-Statistic	p-Value	Significant difference
Mathematics Efficacy	4.11	2.67	8.81	< 0.001	Yes
Mathematics Expectancy Values	4.27	4.22	0.21	0.832	No
Science Efficacy	3.62	3.33	1.56	0.133	No
Science Expectancy Values	4.24	3.81	2.18	0.038	Yes
Technology	3.33	3.72	-1.94	0.070	No
STEM Instruction	3.21	4.26	-3.03	0.007	Yes
21st Century Learning Skills	4.85	4.83	0.70	0.491	No
STEM Leadership	4.73	4.76	-0.30	0.767	No
STEM Careers	3.50	2.88	2.41	0.022	Yes

In summary, the results reveal notable differences in attitudes toward STEM between early childhood and primary preservice teachers, with clear distinctions based on gender and geographical location. These variations underscore key areas of divergence and convergence, providing a foundation for further analysis in the discussion section.

5. Discussion

This study aimed to explore differences in STEM attitudes between first-year early childhood and primary education preservice teachers and examine whether gender and geographical location contribute to these differences. The findings offer insights into how these variables shape STEM attitudes and have important implications for teacher education programs. This section discusses these findings in the context of existing literature.

5.1. Differences between early childhood and primary education preservice teachers

The first research question sought to determine whether there are differences in STEM attitudes between first-year early childhood and primary education preservice teachers. Significant differences were found in several constructs, including Science Efficacy, Mathematics Expectancy, Technology, 21st Century Learning Skills, and STEM Leadership. Primary preservice teachers exhibited higher efficacy in science and technology. This likely reflects the greater emphasis on STEM subjects in primary curricula, while early childhood programs tend to focus more on broader developmental goals [1, 3, 6].

Research has suggested that primary school teachers may feel more responsible for preparing students for STEM-related skills, given the increasing importance of STEM in education policy and curriculum frameworks [24]. Moreover, these results align with previous studies showing how teaching specialisation and curriculum structure can influence teacher efficacy [25].

In contrast, early childhood preservice teachers scored higher in constructs such as STEM Leadership and 21st Century Learning Skills, suggesting that while these students may feel less confident in technical STEM skills, they place greater value on collaborative, leadership-oriented aspects of STEM education. Research indicates that leadership and collaborative skills are often emphasised in early childhood education, potentially explaining these results [26].

Furthermore, Diekman et al. [13] suggest that communal and leadership roles can play a significant part in shaping attitudes toward STEM, especially for teachers working with younger children. These differences highlight the need for teacher education programs to address cohort-specific strengths and areas for development, ensuring that both groups receive the support necessary to develop well-rounded STEM competencies [27].

5.2. Gender differences in STEM attitudes

The second research question explored whether gender differences exist in STEM attitudes among first-year preservice teachers. Consistent with previous research, this study found significant gender disparities in Mathematics Efficacy, Technology, and STEM Leadership [11, 12]. Male preservice teachers reported higher efficacy in mathematics and technology, reflecting persistent gender stereotypes that position these fields as male-dominated [19, 20]. These findings align with research from Cheryan et al. [12] and Wang and Degol [11], who point to the enduring influence of societal expectations and the underrepresentation of women in certain STEM fields. A study by Charles and Bradley [28] also suggests that cultural factors can influence gender disparities in STEM participation, further reinforcing these trends. The observed gender differences in self-efficacy align with Bandura's self-efficacy theory, which suggests that individuals' beliefs in their capabilities can significantly affect their engagement and performance. In this context, the lower self-efficacy reported by female preservice teachers may reflect the ongoing influence of societal stereotypes in STEM fields [11, 12].

Female preservice teachers exhibited stronger attitudes toward STEM education leadership. This challenges traditional gender roles and reflects a broader shift in societal structures and norms regarding women's roles within STEM fields, highlighting an evolving acceptance of women as leaders in these domains [13, 29]. These results support the work of Diekman et al. [13], who argue that emphasising communal and leadership goals can increase women's engagement and sense of belonging in STEM. In this context, teacher education programs should be proactive in addressing gender-specific barriers and promoting inclusive strategies that encourage both male and female preservice teachers to engage fully with STEM subjects [30]. This could include reshaping the curriculum to emphasise collaborative learning and leadership, which have been shown to positively impact female engagement in STEM [13, 31].

5.3. Urban and regional differences in STEM attitudes

The third research question focused on geographical differences in STEM attitudes, specifically whether there are disparities among first-year preservice teachers residing in urban and regional locations. The results indicate significant differences between preservice teachers in urban and regional locations in Science Expectancy Values, Mathematics Expectancy Values, STEM Instruction, and STEM Careers. Regional preservice teachers scored higher in these constructs, which may reflect differences in the availability of educational resources, community support, and access to STEM professionals in urban versus regional settings [14, 23, 32]. Previous research by Lyons et al. [33] highlights the challenges that urban schools face in providing high-quality STEM instruction, often due to larger class sizes and limited resources. By contrast, regional schools may benefit from more direct community involvement, potentially explaining the higher scores among regional preservice teachers [14, 33].

The significant difference in attitudes to STEM Instruction suggests that regional preservice teachers may have a more positive perception of the quality and approachability of STEM subjects compared to their urban counterparts. For example, teacher training programs could incorporate specific workshops aimed at boosting technological confidence among female preservice teachers, using targeted activities such as coding exercises or simulations to reduce anxiety and increase familiarity [28] The National Science Board [23] notes that rural and regional schools often emphasise personalised teaching approaches, which can lead to more positive attitudes toward STEM. Addressing these disparities will require teacher education programs to focus on developing region-specific strategies, such as increasing access to resources and providing targeted professional development opportunities for teachers in both urban and regional areas [34].

6. Conclusion

This study sought to answer three key research questions: (1) Are there differences in STEM attitudes between first-year early childhood education and primary education preservice teachers? (2) Are there gender-based differences in STEM attitudes within these groups? and (3) Are there geographical differences (urban residing location vs. regional residing location) in STEM attitudes across these groups?

In addressing the first research question, the results revealed significant differences between early childhood and primary preservice teachers. Primary preservice teachers displayed higher efficacy in science and technology, likely reflecting the structure of their curricula and professional expectations [1, 3, 6]. Conversely, early childhood preservice teachers exhibited stronger leadership skills and a greater emphasis on collaborative learning, highlighting the need for tailored support in both cohorts to ensure all preservice teachers are adequately prepared to teach STEM subjects [25]. The identification of these specific cohort differences is a novel contribution to the literature, particularly the recognition that leadership and collaborative learning are emphasised in early childhood preservice teachers STEM attitudes. Research suggests that interdisciplinary and hands-on approaches can greatly enhance preservice teachers confidence in teaching STEM subjects, particularly for early childhood educators who may lack confidence in more technical STEM skills [35]. To strengthen STEM confidence among early childhood preservice teachers, teacher education programs should consider the inclusion of dedicated STEM modules that emphasise hands-on, interdisciplinary approaches, allowing preservice teachers to see the connection between STEM and other subjects they are familiar with [24, 27]. Additionally, peer mentoring programs that link early childhood preservice teachers with primary preservice teachers or experienced STEM educators can build confidence and facilitate knowledge sharing [15]; [25]. This data uniquely suggests the benefits of cross-cohort mentoring to bridge gaps in STEM competency.

For the second research question, the study found notable gender-based disparities. Male preservice teachers demonstrated higher efficacy in mathematics and technology, while female preservice teachers excelled in leadership and 21st-century learning skills [11, 12]. These findings reinforce the need for gender-inclusive practices in teacher education programs that actively dismantle stereotypes and create equitable opportunities for all preservice teachers to engage confidently with STEM education [28, 29]. The novel finding here is the strength of female preservice teachers leadership attitudes, which challenges existing narratives about gender imbalances in STEM fields. Gender-related differences in STEM self-efficacy and engagement have been well documented in the literature [36], with studies showing that reshaping curricula to focus on collaboration and leadership may help close this gap [13, 37]. Teacher education programs should also create leadership opportunities for women in STEM, encouraging them to take on STEM-related projects and roles during their practical placements [30].

In response to the third research question, geographical differences were identified between preservice teachers residing in urban and regional locations. Regional preservice teachers reported more positive attitudes toward STEM Instruction and STEM Careers, suggesting that resource access, community support, and educational experiences can shape preservice teachers engagement with STEM [14, 23, 33]. This study provides novel evidence that regional preservice teachers may perceive a higher quality of STEM instruction, potentially due to closer community-school relationships. Previous research has shown that STEM engagement in regional areas is often supported by stronger community involvement and school networks, which could explain the higher levels of confidence reported by regional preservice teachers [38]. Urban preservice teachers, who may face challenges related to larger class sizes and limited resources, would benefit from improved access to STEM materials and professional development programs specifically tailored to overcoming these obstacles [25]. Partnerships between urban schools and local STEM industries or universities can provide preservice teachers with real-world STEM experiences, helping them to better understand the practical applications of STEM education [32]. Meanwhile, the positive engagement seen in regional preservice teachers could be leveraged by developing community-driven STEM initiatives, which have been shown to enhance perceptions of STEM teaching and careers [33, 34].

Overall, this study contributes to our understanding of how demographic factors—such as educational level, gender, and location—affect STEM attitudes in preservice teachers. These findings suggest several actionable recommendations. Teacher education programs should focus on developing context-specific support for preservice teachers, integrating STEM-focused practical placements, and creating professional networks that promote ongoing collaboration on STEM teaching methods [25, 32]. Addressing the identified gaps will better equip future teachers to foster STEM engagement and competency in their students, ultimately ensuring a more equitable and inclusive STEM education landscape [6, 32]. The novel insights presented in this research offer a foundation for further studies aimed at exploring how demographic factors can be addressed to foster more inclusive and effective STEM education across different cohorts. Future research should consider longitudinal studies to assess the impact of targeted interventions on gender-specific self-efficacy and geographical disparities over time. Such research will help identify whether the interventions suggested are effective in fostering more equitable attitudes towards STEM among preservice teachers. Ultimately, these findings provide actionable insights for developing targeted teacher education programs that focus on reducing gender disparities and addressing regional challenges, thereby contributing to a more equitable STEM education landscape.

7. References

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