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Teaching self-efficacy beliefs among pre-service science teachers by academic major and level in Saudi Arabia

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ABSTRACT

Pre-service science teachers' beliefs about their own teaching capabilities shape how confidently they will eventually enter the classroom. This study surveyed 634 students at the College of Science in Saudi Arabia from five disciplines: mathematics, biology, chemistry, physics, and computer science. The aim was to examine these beliefs before they progress to postgraduate teaching diplomas. Using the Science Teaching Efficacy Belief Instrument (STEBI-B), based on Bandura's social-cognitive framework, two dimensions were measured: Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE). Both constructs were at a moderate level overall (PSTE: M = 3.19, SD = 0.44; STOE: M = 3.44, SD = 0.35). The STOE results are considered exploratory due to the borderline reliability of this subscale. Analysis of individual items showed that students reported lower confidence in laboratory and hands-on teaching, including explaining experiments, helping students overcome conceptual difficulties, and managing practical activities. PSTE differed significantly by academic level, $F(7, 626) = 4.19$, $p < .001$, $\eta^2 = .045$, indicating differences between students at different stages rather than a consistent developmental trend. In contrast, STOE showed no significant variation across academic levels, and neither construct differed by academic major. Implications for program design, institutional policy, and classroom teaching practice are discussed.

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1. Introduction

Curriculum quality and subject knowledge are not, by themselves, enough to produce effective science instruction; how teachers see their own capability matters just as much. Teaching self-efficacy in particular has emerged as one of the strongest predictors of how teachers make pedagogical decisions, how persistently they teach, and ultimately how well students learn (Bandura, 1997; Tschannen-Moran and Hoy, 2001). Bandura's (1997) original formulation frames self-efficacy as a person's belief in their own capacity to plan, organize, and carry out the actions needed to reach a given goal in a classroom; this includes drawing students into engagement with scientific ideas. Because science teaching demands abstraction, inquiry, and complex reasoning, a teacher's sense of efficacy carries unusual weight in shaping how confidently they step into instruction. The downstream effects of this confidence are well documented. Teachers who feel capable tend to favor inquiry-driven, student-centered approaches, bring laboratory work into their lessons, and keep going when students hit conceptual roadblocks (Hechter, 2011; Kazempour and Sadler, 2015); they also tend to experiment pedagogically and stay resilient under difficult conditions (Tschannen-Moran and Hoy, 2001). Teachers with weaker efficacy beliefs show close to the opposite pattern, leaning on lecture-based delivery, steering away from cognitively demanding material, and adapting less readily to what a lesson actually needs, all of which can dampen students' scientific literacy, problem-solving, and sustained interest in science. Against a backdrop of international concern over science achievement, PISA results, for instance, repeatedly tie performance gaps back to teacher quality (OECD, 2023); many countries have implemented reforms aimed at strengthening science teaching and teacher preparation. Within that agenda, cultivating robust efficacy beliefs in pre-service science teachers has become a priority, as

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early-formed beliefs tend to persist into later careers (Klassen and Tze, 2014).

Saudi Arabia's reform agenda links science education directly to Vision 2030's emphasis on economic growth and human capital. Yet restructuring curricula on paper does not automatically translate into improved teaching practice; teacher self-efficacy is a consistent predictor of instructional quality, resilience, and student achievement (Hettinger et al., 2024). That makes building strong efficacy beliefs in pre-service science teachers a particularly pressing goal within the Saudi system, especially since efficacy growth tends to stall when trainees lack hands-on, inquiry-based mastery experiences (Bandura, 1997; Lazarides and Warner, 2020; Menon and Azam, 2021). Despite the national push to strengthen science education, relatively little empirical work has examined how Saudi pre-service teachers' science teaching efficacy develops. This gap matters: tracking how these beliefs shift across academic levels and disciplinary specializations can reveal where future teachers are already strong and where additional support is needed—an issue directly relevant to reform, given the close linkage between teaching efficacy and subsequent instructional practice, professional engagement, and retention (Fackler et al., 2021; İspir and Yıldız, 2023). This study addresses that gap by examining Saudi pre-service science teachers' efficacy beliefs and their variation by academic level and disciplinary specialization, with the aim of informing the design of science teacher preparation programs in the Saudi context.

For the purposes of this study, the term pre-service teacher refers specifically to university students enrolled in a science major who have not yet undertaken formal pedagogical training. This reflects a common pathway in teacher preparation, whereby students first complete a subject-specific degree and subsequently enroll in a separate professional education diploma covering pedagogy and classroom practice. The participants here, therefore, are students currently registered in a science specialization who have neither pursued nor completed that educational diploma and thus have not yet received formal instruction in educational theory, teaching methodology, or classroom management.

2. Literature review

2.1. Theoretical perspective

Bandura's (1997) social cognitive theory anchors this study's account of how teaching efficacy beliefs take shape among pre-service science teachers. Rather than treating self-efficacy as something fixed in a person, Bandura (1997) frames it as a belief system that shifts depending on the interplay between a person's own traits, their behavior, and the environment around them. Bandura (1997) identifies four sources – mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states – with mastery experiences carrying the greatest weight because they derive from direct performance and provide the firmest basis for judging one's capability (Usher and Pajares, 2008). Applied to teacher education, this implies that pre-service teachers develop more durable efficacy beliefs when they have authentic opportunities to teach, observe effective instruction modeled, receive actionable feedback, and reflect on their performance in classroom-like settings (Tschannen-Moran et al., 1998; Tschannen-Moran and Hoy, 2001).

Science teaching is a demanding test of this framework, as it requires confidence not only in subject matter but also in inquiry-based instruction, laboratory work, facilitation of problem solving, and the explanation of concepts that are often abstract or conceptually dense (Menon and Sadler, 2018). From a social-cognitive perspective, building science teaching efficacy is therefore not solely a function of how much science a person knows; it also depends on whether the preparation program creates the right conditions: authentic laboratory exposure, opportunities to practice inquiry-based teaching, structured field placements, and mentorship paired with guided reflection (Chichekian and Shore, 2016; Mulholland and Wallace, 2001). Without these conditions, efficacy can stall even in students who are otherwise strong in their subject (Moulding et al., 2014), which may partly explain why some new teachers default to lecture-based delivery rather than inquiry-driven teaching once they enter the classroom (Chichekian and Shore, 2016; Perera et al., 2022).

2.2. Empirical research on science teaching efficacy

Following Bandura's (1997) social cognitive theory, this study defines science teaching efficacy as a pre-service teacher's own judgment of how well they can teach science. This judgment is not fixed; it develops through mastery experiences, observing others, and social encouragement during teacher preparation, and it matters because it shapes how confidently a future teacher enters a science lesson and how capable they feel in drawing students into genuine inquiry. The link between this confidence and both instructional quality and student engagement is well established (Boz and Cetin-Dindar, 2023; Lazarides and Warner, 2020). Less settled is which elements of teacher preparation contribute most to its development. Some studies point to structured fieldwork, scaffolded instruction, and guided reflection as key drivers (Fackler et al., 2021; İspir and Yıldız, 2023).

Researchers do not fully agree on where the emphasis should fall; however, Fackler et al. (2021), for instance, foreground institutional support and program design, whereas İspir and Yıldız (2023) placed more weight on how personally engaged trainees are with the teaching tasks themselves.

These differences likely reflect analytical emphasis rather than substantive disagreement.

Within science education, hands-on laboratory and inquiry experiences repeatedly emerge as major drivers of teaching efficacy (Menon and Sadler, 2018), though the evidence comes largely from well-resourced North American settings, leaving open the question of whether comparable opportunities exist, or are prioritized, in other regions such as the Middle East. Efficacy is not purely psychological; the institutional environment also carries substantial weight. The coherence of coursework, the availability of mentorship, and the connection of theory to practice all shape how pre-service teachers absorb their training experiences (Fackler et al., 2021; Ma et al., 2022; Velthuis et al., 2014). A further methodological consideration concerns how this body of work is measured. Much of the literature relies on self-report, which captures perceived confidence effectively but provides limited insight into actual classroom ability. This issue is also relevant here, as the field's dominant instrument, the Science Teaching Efficacy Belief Instrument (STEBI), developed by Enochs and Riggs (1990), is itself self-reported. As a result, the literature offers substantial insight into how capable pre-service teachers perceive themselves to be, but comparatively less into how capable they are in practice once teaching. In this sense, institutions differ not only in the resources they provide, but also in the extent to which those resources translate into pre-service teachers' confidence to teach science effectively (Lazarides and Warner, 2020).

Globally, science teacher preparation has drawn growing research attention, but the Middle East remains comparatively under-studied, particularly when it comes to science-specific efficacy in pre-service populations (Alasmari, 2023; Al Sultan, 2020). Existing regional work tends to focus on in-service teachers or on general teacher efficacy, rather than on how science-specific efficacy forms during initial training (Alasmari, 2023; Alnahdi and Schwab, 2021). Alasmari (2023), for example, examined general teaching efficacy among Saudi teachers without addressing science-specific beliefs or pre-service samples, and Alnahdi and Schwab (2021) investigated teacher efficacy in inclusive-education settings rather than science teaching. Both studies are referenced here to map the existing boundaries of regional research, general and inclusive-education contexts, and to mark out the gap this study is positioned to fill, rather than as direct points of comparison with the present sample or focus. None of this work speaks to how science teaching efficacy shifts across academic levels within a science-oriented preparation program, which is a notable gap given how strongly efficacy formed during training carries into later practice, persistence, and professional engagement (Bandura, 1997; Klassen and Tze, 2014). The gap carries particular weight in Saudi Arabia, where Vision 2030's reforms place heavy emphasis on STEM and, by extension, on the quality of science teacher preparation (Alharbi and Albidewi, 2024). Closing this gap matters both for the regional literature and for providing teacher-education institutions and policymakers with actionable guidance when designing programs intended to build strong science teaching efficacy before teachers enter the classroom (Alasmari, 2023; Fackler et al., 2021). The present study is aimed at both of these needs at once: the regional research gap and the practical need within Saudi science teacher education.

To address the study objectives, three research questions were formulated concerning pre-service science teachers' Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE), with a focus on differences across academic levels and majors:

RQ1: What are the levels of Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) among pre-service science teachers in the College of Science in Saudi Arabia?
RQ2: Do Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) differ significantly across academic levels (the first through the fourth year)?
RQ3: Do Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) differ significantly across academic majors (mathematics, biology, chemistry, physics, and computer science)?

3. Methodology

3.1. Research design

A cross-sectional quantitative survey was employed to assess science teaching self-efficacy beliefs among pre-service science teachers in the College of Science at a public Saudi university. This design suited the study's purpose, allowing statistical comparisons of efficacy beliefs across academic levels and disciplinary specializations at a single point in time. In addition to subscale-level analyses, individual item responses were examined to provide a more fine-grained indication of areas of greater and lesser confidence in science teaching.

3.2. Participants and context

A total of 634 pre-service science teachers, all enrolled in the College of Science at a public Saudi university, participated in the study. Participants represented five disciplinary specializations: chemistry (n = 253), physics (n = 126), biology (n = 116), mathematics (n = 64), and computer science (n = 75) (Table 1). Students were distributed across eight academic levels (levels 1–8), which reflect the university-based progression structure, with two levels corresponding to each academic year. In terms of gender, the sample comprised 537 females (84.7%) and 97 males (15.3%). This distribution

reflects the gender-segregated structure of Saudi higher education, in which male and female students are taught in separate sections within the same institution. Data collection was coordinated primarily through the female section of the College of Science, where the researcher had more direct access to student groups and communication channels. As the survey was administered online and circulated through student networks, it may have reached some male students despite this institutional separation. Although both groups follow the same academic program and are assessed through unified final examinations, the predominantly female composition of the sample means that the findings cannot be readily generalized to male pre-service science teachers, a point discussed further in the Limitations section. Participation was voluntary, institutional ethical approval was obtained prior to data collection, and all responses were anonymized to ensure confidentiality.

Table 1: Demographic distribution of participants by specialization and gender

Specialization	Female	Male	Total	Percentage
Chemistry	234	19	253	39.9%
Physics	123	3	126	19.9%
Biology	57	59	116	18.3%
Mathematics	61	3	64	10.1%
Computer science	62	13	75	11.8%
Total	537	97	634	100%

3.3. Instrument adaptation and reliability

3.3.1. Science teaching efficacy belief instrument (STEBI-B)

The Science Teaching Efficacy Belief Instrument (STEBI-B), originally developed by Enochs and Riggs (1990), measures two theoretically grounded constructs. Personal Science Teaching Efficacy (PSTE): confidence in one's ability to teach science effectively. Science Teaching Outcome Expectancy (STOE): beliefs about the extent to which effective teaching can positively influence student learning.

STEBI-B has a well-documented record of acceptable reliability and construct validity across a range of educational settings (Bleicher, 2007; Enochs and Riggs, 1990). For this study, the instrument underwent minor contextual adaptation: selected items were reworded so they would read naturally for science undergraduates in the local curriculum who may go on to teach. These were surface-level wording changes only; the conceptual content and structure of the original instrument were preserved, and all modifications were reviewed by subject-matter specialists for clarity and contextual fit.

Internal consistency reliability was evaluated using Cronbach's alpha. In the present sample, the values were the following:

- PSTE: $\alpha = 0.72$ (indicating modest internal consistency)
- STOE: $\alpha = 0.76$.

Both values fall within the conventionally acceptable range ($\alpha \geq 0.70$). Because the instrument was adapted through contextual rewording of selected items, the factorial validity of the adapted version has not yet been independently confirmed for this sample. Accordingly, findings related to the STOE construct are interpreted as exploratory rather than confirmatory, and conclusions regarding outcome expectancy should be treated with appropriate caution. Future research should subject the adapted STEBI-B items to confirmatory factor analysis.

3.4. Data preparation and analysis

Differences in PSTE and STOE across academic levels and disciplinary specializations were tested using one-way ANOVA. Where the ANOVA for PSTE across levels was significant, Tukey's HSD post hoc tests were conducted to identify which pairs of levels differed. Means and standard deviations were computed to summarize PSTE and STOE. All analyses were conducted in SPSS, with statistical significance set at $\alpha = 0.05$. Effect sizes were reported alongside these results to convey the magnitude, not merely the presence, of any differences (Lakens, 2013). Before the inferential tests were run, assumptions of normality and homogeneity of variance were checked and found to be within the range required for ANOVA.

4. Results

The results are organized and reported in alignment with the study's research questions. Descriptive analyses were conducted to assess overall levels of science teaching efficacy among participants. The results indicated moderate efficacy levels on both dimensions of the STEBI-B instrument. The mean score for Personal Science Teaching Efficacy (PSTE) was 3.19 (SD = 0.44), reflecting a moderate level of confidence in the ability to teach science effectively. Similarly, the mean score for Science Teaching Outcome Expectancy (STOE) was 3.44 (SD = 0.35), indicating moderate beliefs regarding the extent to which effective teaching can positively influence student learning (Table 2). As noted in Section 3.3.1, STOE results are interpreted as exploratory given the subscale's reliability. To provide more details, item-level descriptive statistics were calculated for PSTE and STOE (Tables 3 and 4).

Table 2: Descriptive statistics for PSTE and STOE

Variable	M	SD
PSTE	3.19	0.44
STOE	3.44	0.35

4.1. Personal science teaching efficacy (PSTE)

A clear pattern stands out in Table 3. The three highest-rated items were item 2, on continually finding better ways to teach science (M = 4.14, SD =

0.85), item 23, on welcoming student questions (M = 4.10, SD = 0.88), and item 5, on knowing the steps needed to teach science concepts effectively (M = 4.05, SD = 0.89). At the lower end were item 6, 'I am not very effective in monitoring science experiments' (M = 2.78, SD = 1.18), item 8, 'I generally teach science ineffectively' (M = 3.14, SD = 1.25), and item 17, 'I find it difficult to explain to students why science experiments work' (M = 3.20, SD = 1.11). Overall, participants expressed greater confidence in general teaching tasks than in managing hands-on experimentation and explaining underlying concepts.

4.2. Science teaching outcome expectancy (STOE)

Given the exploratory status of the STOE subscale (see Section 3.3.1), the following item-level patterns should be interpreted as indicative rather than confirmatory. Table 4 shows a comparable pattern. The highest-rated items were item 4, 'When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach' (M = 4.30, SD = 0.86), item 1, 'When a student does better than usual in science, it is often because the teacher exerted a little extra effort' (M = 4.13, SD = 0.95) and item 9, 'The inadequacy of a student's science background can be overcome by good teaching' (M = 4.07, SD = 0.84). At the lower end were item 25, 'Even teachers with good science teaching abilities cannot help some kids learn science' (M = 3.44, SD = 1.14), item 20, 'Effectiveness in science teaching has little influence on the achievement of students with low motivation' (M = 3.53, SD = 1.02), and item 11, 'When a low achieving child progresses in science, it is usually due to extra attention given by the teacher' (M = 3.68, SD = 1.04). Taken together, participants generally believed that effective teaching could improve student outcomes, although this confidence appeared to soften in more challenging learning contexts.

4.3. Descriptive statistics by academic level

Table 5 breaks PSTE and STOE down by academic level (1 through 8). PSTE varied modestly, from 2.97 to 3.35, with level 1 highest and level 6 lowest; standard deviations were relatively consistent across levels (0.37–0.52), indicating comparable dispersion. STOE varied little; means ranged from 3.39 to 3.50, peaking at level 3 and lowest at level 1, and its standard deviations (0.30–0.40) indicated even less variability. Across the full sample (N = 634), the overall pattern remained moderate: M = 3.19 (SD = 0.44) for PSTE and M = 3.44 (SD = 0.35) for STOE.

Table 3: Item-level descriptive statistics for PSTE

Item	Item statement	Mean	SD	Order
2	I am continually finding better ways to teach science.	4.14	0.85	1
23	When teaching science, I usually welcome student questions.	4.10	0.88	2
5	I know the steps necessary to teach science concepts effectively.	4.05	0.89	3
12	I understand science concepts well enough to be effective in teaching elementary science.	4.00	0.92	4
19	I wonder if I have the necessary skills to teach science.	3.79	0.94	5
18	I am typically able to answer students' science questions.	3.74	0.98	6
22	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.	3.66	1.05	7
21	Given a choice, I would not invite the principal to evaluate my science teaching.	3.39	1.16	8
3	Even when I try very hard, I don't teach science as well as I do most subjects.	3.32	1.19	9
24	I don't know what to do to turn students on to science.	3.23	1.14	10
17	I find it difficult to explain to students why science experiments work.	3.20	1.11	11
8	I generally teach science ineffectively.	3.14	1.25	12
6	I am not very effective in monitoring science experiments.	2.78	1.18	13

Table 4: Item-level descriptive statistics for STOE

Item	Item statement	Mean	SD	Order
4	When the science grades of students improve, it is most often due to their teacher having found a more effective teaching approach.	4.30	0.86	1
1	When a student does better than usual in science, it is often because the teacher exerted a little extra effort.	4.13	0.95	2
9	The inadequacy of a student's science background can be overcome by good teaching.	4.07	0.84	3
16	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.	4.07	0.91	4
15	Students' achievement in science is directly related to their teacher's effectiveness in science teaching.	4.06	0.95	5
14	The teacher is generally responsible for the achievement of students in science.	3.89	1.00	6
13	Increased effort in science teaching produces little change in some students' science achievement.	3.85	0.99	7
10	The low science achievement of some students cannot generally be blamed on their teachers.	3.75	1.01	8
7	If students are underachieving in science, it is most likely due to ineffective science teaching.	3.70	1.11	9
11	When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.	3.68	1.04	10
20	Effectiveness in science teaching has little influence on the achievement of students with low motivation.	3.53	1.02	11
25	Even teachers with good science teaching abilities cannot help some kids learn science.	3.44	1.14	12

4.4. Differences across academic levels

A one-way ANOVA was conducted to examine whether PSTE and STOE differed by academic level. The analysis revealed significant differences in PSTE: $F(7, 626) = 4.19$, $p < 0.001$ (Table 6). This indicates that personal science teaching efficacy varies across academic levels. Post-hoc Tukey HSD comparisons showed that level 1 students had significantly higher PSTE than students in levels 3, 5, and 6 (Table 7). Although differences were present, they did not follow a strictly linear pattern; therefore, they are

interpreted as cross-sectional differences by level rather than evidence of developmental change. In contrast, no significant differences were identified in STOE across academic levels, F(7, 626) = 0.88, p = 0.520, indicating that beliefs about the impact of teaching on learning remained relatively stable. This finding should, however, be interpreted in light of the exploratory status of the STOE subscale.

Table 5: Descriptive statistics for PSTE and STOE across academic levels (1-8)

Academic level	N	PSTE (M)	PSTE (SD)	STOE (M)	STOE (SD)
1	107	3.35	0.46	3.42	0.40
2	63	3.22	0.46	3.39	0.36
3	135	3.11	0.40	3.50	0.33
4	99	3.20	0.37	3.45	0.33
5	96	3.15	0.42	3.43	0.32
6	23	2.97	0.44	3.45	0.30
7	70	3.17	0.45	3.47	0.38
8	41	3.31	0.52	3.41	0.31
Total	634	3.19	0.44	3.44	0.35

Table 6: One-way ANOVA results for PSTE and STOE across academic levels

Variable	df	F	p
PSTE	7,626	4.19	< 0.001
STOE	7,626	0.88	0.520

Table 7: Mean PSTE scores across academic levels

Academic level	M	SD	n
Level 1	3.35	0.46	107
Level 2	3.22	0.46	63
Level 3	3.11	0.40	135
Level 4	3.20	0.37	99
Level 5	3.15	0.42	96
Level 6	2.97	0.44	23
Level 7	3.17	0.45	70
Level 8	3.31	0.52	41

4.5. Differences across academic majors

A second one-way ANOVA examined differences across academic majors. Although some variation in means was observed, the ANOVA results showed no statistically significant differences in either dimension: PSTE: F (4, 629) = 1.76, p = 0.135 and STOE: F (4, 629) = 1.31, p = 0.263 (Table 8). This indicates that science teaching efficacy beliefs were broadly consistent across the five scientific majors included in this study.

Table 8: ANOVA results for PSTE and STOE across academic majors

Variable	F	df	p
PSTE	1.76	4,629	0.135
STOE	1.31	4,629	0.263

5. Discussion

This study set out to map the science teaching self-efficacy beliefs of pre-service science teachers in a Saudi College of Science and indicates moderate confidence on both PSTE and STOE (STOE results, as noted in Section 3.3.1, are treated as exploratory given the subscale's reliability). Participants' beliefs about their own ability to teach science are generally positive but not yet at the level associated with strong instructional readiness—a pattern consistent with prior work showing that pre-service teachers' efficacy beliefs are still taking shape before they have had much authentic teaching exposure (Bleicher, 2007; Enochs and Riggs, 1990; Menon and Azam, 2021). This accords with the broader literature on early-career efficacy, which similarly describes confidence as still developing at this stage, particularly where authentic practice opportunities are scarce. Recent evidence suggests that what matters is not subject knowledge alone but the deliberate integration of opportunities to apply that knowledge, receive feedback, and reflect on practice. Interpreted in this light, the present results resemble a snapshot of students with reasonably solid science knowledge who have not yet accumulated the mastery experiences needed to translate that knowledge into stronger teaching efficacy, and recent studies support this interpretation, showing that well-designed instructional opportunities, not coursework alone, advance efficacy and outcome expectancy (Hammack et al., 2024; Menon et al., 2025; Ribeirinha and Correia, 2025).

The PSTE differences found across academic levels add a further complication: level 1 students scored significantly higher than those in levels 3, 5, and 6, but the pattern was not linear, pointing to cross-sectional differences between groups rather than any longitudinal trend. This aligns with Bandura's (1997) social cognitive theory, which locates the primary driver of self-efficacy in mastery experience rather than accumulated theory. An inconsistent, non-linear pattern of this kind suggests that discipline coursework alone is insufficient; efficacy instead tracks the extent of genuine, teaching-related engagement built into a program. Other work on science programs that emphasize content over pedagogical practice points in the same direction: content alone does not reliably build instructional confidence (Menon et al., 2024; Yerdelen et al., 2024).

A finer-grained look at the item-level results tells a consistent story: confidence drops specifically around laboratory-based, practical, and inquiry-oriented teaching, even where content understanding remains strong. Participants reported difficulty explaining how experiments work, uncertainty when a student struggles conceptually, challenges in sustaining students' attention, and hesitation in managing hands-on activities. These findings align with prior work underscoring how central authentic teaching experience, hands-on practice, and guided reflection are to building this kind of efficacy (Fackler and Malmberg, 2016; Hußner et al., 2023). The gap between feeling

confident about content and feeling confident about teaching it indicates that subject knowledge on its own is insufficient, particularly once instruction moves into inquiry-based territory.

Bandura's (1997) four sources of self-efficacy offer a useful lens on why confidence dipped specifically around laboratory-based teaching tasks. Chief among these is mastery experience, the strongest source, and these participants had little of it: with no formal teacher training yet and limited classroom exposure, they had few opportunities to lead students through inquiry-based learning. Limited vicarious experience, sparse social persuasion and feedback, and the anxiety that often accompanies hands-on instruction likely compounded this effect. The flat result across majors is also telling: students from mathematics, physics, chemistry, and computer science reported much the same efficacy levels, suggesting that at this early stage, shared program conditions and common pedagogical opportunities matter more than disciplinary affiliation. This pattern is consistent with recent syntheses of the science teaching efficacy literature, which identify practice opportunities, theory–practice alignment, and implementation support as the real levers of efficacy growth, though work in more domain-specific fields shows that background can matter more when the teaching goals themselves are tightly tied to a discipline. One interpretation of the present null result, then, is that what STEBI-B is capturing here is a general orientation toward science teaching efficacy rather than discipline-specific competence (Kruskopf et al., 2024; Menon et al., 2024).

Another possibility is that the adapted STEBI-B is not fine-grained enough to detect major-specific differences, given that it was built to measure general science teaching efficacy rather than discipline-specific skill; future work using more tailored items could test this directly. Taken together, a consistent pattern emerges: strong confidence in content knowledge, weaker confidence in applying that knowledge in practice; no clear upward trend across academic levels; and no meaningful split across majors, pointing to efficacy patterns that are broadly shared across disciplines. The clearest implication is that science teacher preparation programs need more structured, practice-oriented pedagogical experience built in, rather than relying on disciplinary coursework alone (Menon et al., 2024; Toma et al., 2025; Yerdelen et al., 2024).

5.1. Implications for teacher preparation

The results underscore the importance of strengthening practice-based components within science teacher preparation in Saudi Arabia. Enhancing teaching efficacy may be achieved through:

- Structured job-shadowing opportunities with experienced science teachers
- Inquiry-based laboratory experiences that simulate real teaching scenarios
- Microteaching and guided pedagogical reflection sessions that help students connect theory to practice
- Early and repeated exposure to school environments

These implications are particularly relevant for educational systems seeking to strengthen the quality of science instruction and improve student learning outcomes through reforms that emphasize active learning, inquiry, and scientific reasoning.

6. Conclusion

This study examined science teaching self-efficacy beliefs among pre-service science teachers in Saudi Arabia, focusing on differences across academic levels and disciplinary majors. Participants reported moderate levels of both personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE), indicating a foundational, though not yet fully established, confidence in teaching science. As noted in Section 3.3.1, the STOE findings, in particular, are interpreted as exploratory given the subscale's reliability. PSTE differed across academic levels, though not in a linear pattern, suggesting that progression through coursework alone does not consistently strengthen efficacy. At the item level, students expressed greater confidence in their content knowledge than in applying it in practical, inquiry-based teaching contexts, pointing to a gap between subject-matter confidence and pedagogical readiness.

These findings highlight the importance of structured, practice-oriented experiences—such as laboratory engagement, microteaching, and guided pedagogical reflection in supporting the development of science teaching efficacy. Strengthening these components within teacher preparation programs may help future science educators move beyond content knowledge toward confident, inquiry-driven instructional practice, in line with the broader goals of STEM education reform in Saudi Arabia.

Several limitations should be considered when interpreting the results of this study. First, the study was conducted within a single institutional context, which may limit the generalizability of the findings to other teacher preparation programs or universities with different structures, resources or pedagogical approaches. Future studies that include multiple institutions may help establish broader external validity. Second, the study relied on self-reported survey data, which may introduce response bias. Participants' perceptions of their own abilities may not accurately reflect their actual teaching competence, particularly in practical or classroom-based settings. Observational or performance-based measures would provide a more comprehensive basis for assessment in future research.

Third, the cross-sectional design captures teaching efficacy beliefs at a single point in time. Future studies should employ longitudinal designs that follow the same pre-service teachers across multiple stages of their preparation programs to provide stronger evidence regarding how efficacy beliefs change over time.

Fourth, data collection was coordinated primarily through the female section of the College of Science, resulting in a predominantly female sample (84.7%). Although male and female students follow the same academic program and are assessed through unified final examinations, the findings cannot be readily generalized to male pre-service science teachers. Future research should include male participants to allow for broader conclusions across both groups.

Fifth, the distribution of participants across academic levels was uneven, ranging from 23 students at Level 6 to 135 at Level 3. Although ANOVA assumptions were evaluated and met, such disparities in group size can still affect the stability of variance estimates and the robustness of the F-test; the PSTE differences across levels should therefore be interpreted with some caution.

Sixth, the STOE subscale reliability ($\alpha = 0.76$) was at the lower end of the conventionally acceptable range, and the adapted items have not undergone confirmatory factor analysis. STOE findings are therefore interpreted as exploratory, and further psychometric validation is recommended before treating these results as confirmatory.

List of abbreviations

α	Significance level
ANOVA	Analysis of variance
df	Degrees of freedom
F	F-statistic
HSD	Honestly significant difference
M	Mean
n	Sample size within a subgroup
N	Total sample size
OECD	Organisation for Economic Co-operation and Development
p	p-value
PISA	Programme for International Student Assessment
PSTE	Personal Science Teaching Efficacy
RQ	Research question
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
STEBI	Science Teaching Efficacy Belief Instrument
STEBI-B	Science Teaching Efficacy Belief Instrument (preservice version)
STEM	Science, technology, engineering and mathematics
STOE	Science teaching outcome expectancy
η^2	Eta-squared (effect size)

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Compliance with ethical standards

Ethical considerations

This study involved human participants. Institutional ethical approval was obtained from the Institutional Review Board (IRB), University of Hail, Saudi Arabia (Approval No. 138), prior to data collection. Participation was voluntary and based on informed consent, and all responses were anonymized to ensure confidentiality.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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