Readiness and Attitudes of Pre-Service Chemistry Teachers toward Inclusive Chemistry Education in Indonesia

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ABSTRACT

Inclusive education has become a global priority aligned with Sustainable Development Goal 4 and the UN Convention on the Rights of Persons with Disabilities (UNCRPD), emphasizing fair access and participation for all learners. In this context, chemistry, due to its abstract and experimental nature, presents unique challenges for students with disabilities and calls for teachers who are conceptually, emotionally, and pedagogically prepared. This study examines the readiness and attitudes of pre-service chemistry teachers toward inclusive chemistry education, focusing on the influence of gender, teaching experience, and institutional background. Using a quantitative survey design, data were collected from 135 pre-service chemistry teachers across four universities in Yogyakarta and Semarang, Indonesia. The instruments included a validated Likert-scale questionnaire measuring attitudes, readiness, and knowledge of inclusive education. Data analysis with the Mann–Whitney U test was employed because of the non-normal data distribution. Results showed that participants held positive attitudes and had strong conceptual knowledge of inclusive education (M = 8.50/10; 85.03%), although their level of readiness remained moderate and mainly theoretical. Gender significantly influenced attitudes, with females showing higher affective responses, while no notable differences appeared across institutions or teaching experience. Applying Self-Efficacy Theory and the Theory of Planned Behavior, the study concludes that positive attitudes and a solid conceptual understanding form a promising foundation, but practical readiness requires structured mastery experiences, reflective mentoring, and institutional support. The findings provide empirical evidence and theoretical insights into preparing inclusive science teachers, highlighting the importance of integrating inclusive pedagogy across discipline-specific curricula.

Keywords: Inclusive chemistry education; pre-service teacher readiness; teacher attitudes; self-efficacy; theory of planned behavior; inclusive pedagogy; STEM inclusion

INTRODUCTION

Aligned with Sustainable Development Goal 4 and the UN Convention on the Rights of Persons with Disabilities, inclusive education has become a global necessity for providing equitable and quality learning opportunities for all students [1]. Inclusive education in Indonesia has increasingly gained recognition as a transformative approach that promotes access, participation, and success for students with disabilities [2]. Over the past decade, awareness among parents about the importance of enrolling children with disabilities in mainstream schools has significantly increased [3]. Inclusive education offers opportunities for students with disabilities to learn and socialize alongside their peers without disabilities, fostering emotional development, confidence, and a sense of belonging [4-6]. It not only enhances educational access but also strengthens mutual understanding and social cohesion, reflecting Indonesia's broader commitment to equity and social justice in education [7, 8].

Within this inclusive framework, chemistry is one of the most conceptually challenging subjects for students with disabilities due to its abstract content and high cognitive demands [9-11]. Previous research has identified ongoing accessibility challenges in chemistry education, such as the lack of Braille materials for blind students,

limited sign language resources for deaf students, and poor accessibility during lab sessions [12, 13]. These issues often lead to low participation and independence among students with disabilities [14], emphasizing the need for teachers who are pedagogically skilled, emotionally responsive, and prepared to create inclusive chemistry learning environments.

Teachers play a key role in achieving inclusive education, especially in science subjects that require adapting materials, teaching methods, and assessment strategies [15]. Therefore, pre-service teachers must develop not only pedagogical and content knowledge but also readiness, confidence, and positive attitudes toward students with disabilities. Teacher readiness reflects an individual's willingness and ability, both physical and mental, to perform teaching duties effectively [16]. Such readiness is influenced by internal factors like motivation, knowledge, and skills, as well as external factors such as social environment, teaching experience, and institutional support [17]. Recent national reforms under the Merdeka Belajar – Kampus Merdeka framework also highlight differentiated and inclusive instruction, making it timely to examine how chemistry teacher preparation aligns with the goals of inclusive education.

From a theoretical perspective, teacher readiness can be analyzed using Bandura's (1997) Self-Efficacy Theory [18], which suggests that individuals' beliefs in their abilities influence their effort, resilience, and achievement. [19] Theory of Planned Behavior (TPB) further explains that attitudes toward behavior, subjective norms, and perceived behavioral control shape intentions to act. In inclusive education, positive attitudes and perceived competence related to teaching diverse learners predict greater readiness and engagement. Similarly, the Attitude–Behavior Consistency Theory [20] highlights that strong, positive attitudes are more likely to lead to consistent inclusive teaching behavior.

Globally, evidence shows that pre-service teachers often express positive attitudes toward inclusion but have limited readiness to implement inclusive practices. [21] found that pre-service teachers in Canada and the UK reported positive attitudes toward inclusion, with primary-level teachers being more open than secondary-level teachers. [22] demonstrated that empathy significantly predicts inclusive teaching motivation, efficacy, and attitudes among pre-service teachers. However, [23] observed that pre-service teachers in Malaysia, despite holding favorable attitudes, still lacked the readiness to teach inclusively. In Europe, the project Teaching Chemistry Inclusively – Are We Prepared? concluded that pre-service chemistry teachers need stronger inclusive pedagogical and emotional skills [24]. These studies collectively indicate that while attitudes are generally positive, actual readiness remains inconsistent and depends on the context.

In chemistry education, where abstract concepts and laboratory work dominate, inclusive pedagogy requires teachers to create accessible and engaging learning experiences that support all learners. Cavicchi and McDonald (2022) highlight that effective inclusive chemistry teaching goes beyond technical adjustments and promotes inquiry-based, collaborative, and empathetic learning environments. Similarly, [25] argue that inclusive practice should shift from "specialist adjustment" toward "shared responsibility" among all teachers. [26] also note that developing inclusive pedagogical values must become a core part of teacher education programs, integrated through coursework and practicum experiences.

Although the global conversation on inclusive education is expanding, limited attention has been paid to pre-service chemistry teachers, especially in emerging educational contexts like Indonesia. Most existing research focuses on general teacher training or elementary-level inclusion, leaving gaps specific to STEM subjects. This area is crucial because chemistry education presents unique conceptual and procedural challenges that require specialized inclusive strategies. However, there is still a lack of research on how pre-service chemistry teachers integrate inclusive principles into their teaching preparation, particularly within the Indonesian context.

Therefore, this study aims to examine the readiness and attitudes of pre-service chemistry teachers toward teaching students with disabilities, focusing on how gender, teaching experience, and institutional background affect these factors. Specifically, the study addresses the following questions:

1. To what extent are pre-service chemistry teachers prepared to instruct students with disabilities?

2. How do gender, teaching experience, and institutional background affect their readiness and attitudes?

By combining Self-Efficacy and Theory of Planned Behavior frameworks, this study offers both empirical evidence from Indonesia and theoretical insights into inclusive pedagogy in subject-specific teacher education. The findings aim to guide curriculum development and professional growth initiatives that enhance inclusive chemistry teaching skills among future teachers.

METHODS

Research Design

This study used a quantitative research design with a survey method. The survey was chosen because it enables data collection from a large number of respondents in a short period, making it ideal for studying trends in teachers' attitudes and readiness [27]. The main aim of this research was to gather accurate and generalizable data about pre-service chemistry teachers' attitudes and preparedness for teaching chemistry to students with disabilities.

Population and Sample

The study population included students enrolled in the Chemistry Education Study Program at universities in Yogyakarta (UIN Sunan Kalijaga and Universitas Negeri Yogyakarta) and Semarang (UIN Walisongo and Universitas Negeri Semarang). These institutions were chosen because they are leading teacher education universities that offer inclusive education courses in their curriculum. Participants were selected from the fourth and sixth semesters, as students at this level usually have completed coursework in inclusive education and pedagogy.

A total of 135 students participated in the study, selected through purposive sampling based on inclusion criteria: (1) enrollment in a chemistry education program and (2) completion of at least one course in inclusive education. Purposive sampling was chosen to ensure that respondents had relevant exposure and knowledge regarding inclusive education [28]. According to [29],purposive sampling allows researchers to identify respondents who meet specific criteria related to the research objectives.

Instrumentation

Data were gathered using a structured questionnaire with closed-ended questions designed to measure three main constructs: (1) attitudes toward students with disabilities, (2) readiness to teach chemistry to students with disabilities, and (3) knowledge and understanding of disability and inclusive education. The questionnaire employed a five-point Likert scale from Strongly Agree (5) to Strongly Disagree (1), alongside true/false items to assess factual knowledge.

The questionnaire items were adapted from several established instruments on teachers' attitudes and readiness toward inclusive education, including the Multidimensional Attitudes toward Inclusive Education Scale (MATIES) developed by Mahat [30] and the Teacher Efficacy for Inclusive Practices (TEIP) Scale by Sharma, et al. [31]. Both instruments have been widely used to assess cognitive, affective, and behavioral components of teacher attitudes and perceived efficacy in inclusive settings. The items were further modified and contextualized to reflect the field of chemistry education and the Indonesian higher education context. Additional indicators were generated through a review of recent literature on inclusive science and chemistry teacher preparation [21, 24, 25, 32].

The adaptation process involved translation, expert review for content equivalence, and refinement to ensure cultural and disciplinary relevance. This approach ensured that the instrument maintained theoretical alignment with global inclusive education frameworks while addressing the specific demands of chemistry teacher education in Indonesia.

Table 1. Questionnaire Blueprint

No	Indicator	Item Numbers	Number of Items
1	Attitudes toward students with disabilities	1–11	11
2	Readiness to teach chemistry inclusively	12–20	9
3	Knowledge and understanding of disability and inclusive education	21–30	10

The categorization of knowledge levels was based on percentage scores ranging from 0–100%. Respondents who obtained scores of 80–100% were classified as having "High Understanding," those with scores of 60–79% were categorized as "Moderate," and those scoring below 60% were categorized as having "Low Understanding." The results showed that 82.96% of participants fell into the "High Understanding" category, 13.33% into the "Moderate" category, and 3.70% into the "Low Understanding" category, with an overall average score of 85.03%, indicating a generally high level of understanding of inclusive education concepts.

Validity and Reliability

Instrument validity was confirmed through content validity, which involved expert review by specialists in chemistry education and inclusive pedagogy. Content validity ensured that each item accurately reflected the intended construct. Experts evaluated the questionnaire's clarity, relevance, and comprehensiveness. Revisions were made based on expert feedback until full agreement was reached, confirming that the instrument adequately represented the targeted constructs.

Reliability analysis was conducted using Cronbach's alpha to assess internal consistency for each subscale. The results indicated acceptable reliability for all constructs: attitudes ($\alpha = 0.82$), readiness ($\alpha = 0.90$), and knowledge ($\alpha = 0.73$). All coefficients exceeded the recommended threshold of 0.70, demonstrating that the items consistently measured their respective constructs. The reliability values are consistent with prior research on inclusive teacher attitude scales, indicating stable internal structure.

Data Analysis

The data were analyzed with SPSS version 26. Initial analyses involved tests of normality and homogeneity to assess the appropriateness of parametric tests.

1. Normality Test: The Shapiro–Wilk test was used to assess whether the data followed a normal distribution. A significance value (p) greater than 0.05 indicated a normal distribution.

2. Homogeneity Test: Levene's test was applied to determine the equality of variances across groups. Data were considered homogeneous when $p > 0.05$ [33] .

3. Because several data groups did not meet the normality assumptions, as assessed by the Shapiro–Wilk test, group comparisons were mainly performed using the nonparametric Mann–Whitney U test. This test was used to examine differences in readiness and attitudes across independent variables (gender, teaching experience, and university origin). Levene's test was also used to assess variance homogeneity to aid interpretation.

Ethical Considerations

Ethical approval for this research was obtained from the institutional ethics committee of UIN Sunan Kalijaga Yogyakarta. Participation was voluntary, and respondents were informed of their right to withdraw at any time without penalty. All data were collected anonymously and used solely for academic purposes.

RESULTS

Demographic Characteristics of Participants

A total of 135 pre-service chemistry teachers took part in this study. Table 2 shows the distribution of respondents by gender, teaching experience with students with disabilities, and university background.

Variable	Category	n	%
Gender	Male	13	9.6
	Female	122	90.4
Teaching experience with students with disabilities	Yes	56	41.5
	No	79	58.5
University origin	Yogyakarta	89	65.9
	Semarang	46	34.1

Table 2. Demographic profile of respondents

The sample mainly consists of female participants and students from universities in Yogyakarta. A large portion of respondents (58.5%) reported having no previous experience teaching students with disabilities, which is important for understanding their readiness and attitudes.

Gender Differences in Attitudes and Readiness

Normality tests using the Shapiro–Wilk statistic showed that the distributions of attitude and readiness scores were not normal across gender groups ($p < 0.05$). Therefore, the Mann–Whitney U test was employed to compare differences between male and female respondents. Regarding attitudes toward students with disabilities, the analysis showed a statistically significant gender difference ($U = 476.000$, $p = 0.018$). Female pre-service teachers had a higher average attitude score ($M = 46.21$) compared to male pre-service teachers ($M = 42.39$), indicating that female respondents held more positive attitudes. No statistically significant difference was found between male and female pre-service teachers in readiness to teach chemistry to students with disabilities ($U = 544.500$, $p = 0.064$). Mean readiness scores were fairly similar, indicating that perceived preparedness to teach inclusively does not heavily depend on gender. These results show that gender is linked to the affective dimension (attitudes), but not to perceived readiness to implement inclusive chemistry teaching.

Differences by University Origin

Because of deviations from normality in some subgroups, the Mann–Whitney U test was also used to assess differences by university origin (Yogyakarta vs. Semarang). Regarding attitudes, there was no significant difference between respondents from Yogyakarta and Semarang ($U = 2213.000$, $p = 0.441$). The average scores were very similar ($M = 45.93$ for Yogyakarta; $M = 45.65$ for Semarang). For readiness, no significant difference was observed ($U = 2153.000$, $p = 0.624$), with mean scores again closely aligned ($M = 33.34$ for Yogyakarta; $M = 32.94$ for Semarang). These findings suggest that both groups of institutions provide similar academic environments and exposure to inclusive education, resulting in comparable attitudes and preparedness among their pre-service chemistry teachers.

Differences by Teaching Experience with Students with Disabilities

To assess whether direct exposure to teaching students with disabilities influences attitudes and readiness, respondents were categorized based on previous teaching experience (yes vs. no). Since some variables did not

follow a normal distribution, the Mann–Whitney U test was employed. For attitudes, the test revealed no significant difference between those with experience and those without (U = 2219.500, p = 0.932). Mean scores were very close (M = 45.71 for no prior experience; M = 46.02 for prior experience). Regarding readiness, the Mann–Whitney U test also showed no significant difference (U = 2160.500, p = 0.861), with mean scores again being very similar (M = 33.19 vs. M = 33.22). These findings indicate that limited or incidental exposure to students with disabilities, without structured guidance or reflective support, may not be sufficient to significantly influence pre-service teachers' inclusive attitudes or readiness.

Knowledge and Understanding of Disability and Inclusive Education

Knowledge was evaluated with 10 true–false questions on disability and inclusive education. The highest achievable score was 10. The average total score was M = 8.50, corresponding to an average correct response rate of 85.03%. Categorization of knowledge levels showed that:

- 112 respondents (82.96%) were in the "high understanding" category,
- 18 respondents (13.33%) in the "moderate understanding" category,
- 5 respondents (3.70%) in the "low understanding" category.

Overall, these results show that most pre-service chemistry teachers have a solid understanding of disability and inclusive education principles.

DISCUSSION

Overall Positive Attitudes and High Conceptual Knowledge

The findings show that pre-service chemistry teachers generally have positive attitudes toward students with disabilities and possess a strong understanding of inclusive education concepts.

A positive attitude among prospective chemistry teachers toward inclusive education is essential, as chemistry learning is abstract and complex, relying heavily on visual and symbolic representations and laboratory activities. These challenges demand that teachers be willing, caring, and mentally prepared to make various adaptations for students with disabilities. For instance, in topics such as atomic structure or molecular shape, teachers need to provide tactile three-dimensional models so that blind students can better understand electron configurations and molecular shapes. For topics such as chemical reactions or state changes, teachers can prepare videos with subtitles and sign language for deaf students, since many concepts require visualizing the process. In the laboratory, teachers must be able to adapt practical activities to ensure safety and accessibility, such as providing digital measuring tools that emit audible signals for students with low vision or replacing labs involving high-risk materials with PhET simulations for students with motor disabilities.

Additionally, for students with intellectual disabilities, teachers should simplify lab procedures into clear, step-by-step instructions, use visual instruction cards, or provide scaffolded versions of worksheets. These concrete examples show that prospective teachers' positive attitudes, such as empathy, a willingness to help, and a commitment to diversity, significantly influence their willingness to adapt chemistry instruction for inclusion. Therefore, the attitude analysis in this study reflects not only their perceptions of inclusion but also their emotional and pedagogical readiness to face the real challenges of teaching chemistry in diverse classrooms. The high average score of 85.03% suggests that inclusive education in teacher training programs effectively introduces key ideas about disability rights, inclusive teaching methods, and accessible education.

This aligns with previous studies showing that coursework on inclusion leads to more positive attitudes toward inclusive education [25, 34]. It also supports the argument by [35] and [36] that understanding concepts is essential for implementing inclusive practices. From the perspective of the Theory of Planned Behavior [19], these knowledge and attitude profiles suggest a strong foundation for forming intentions to teach inclusively.

However, high levels of knowledge and positive attitudes should be interpreted carefully. According to Attitude–Behavior Consistency Theory [37], strong and accessible attitudes are more likely to predict behavior when supported by supportive environments and skills. The current results highlight an important tension: while attitudes and knowledge are encouraging, other aspects of readiness may still need targeted improvement through practical and reflective experiences.

Gender Differences: Higher Affective Orientation among Female Pre-service Teachers

The notable gender difference in attitudes, with female pre-service teachers showing more positive views toward students with disabilities, aligns with earlier research indicating that female teachers generally report greater empathy and support for inclusion [21, 38]. This trend may reflect wider socialization patterns in which women are often encouraged to take on more nurturing and relational roles, influencing their attitudes toward diverse learners.

From a Self-Efficacy perspective [18], positive attitudes among female pre-service teachers may enhance their inclusive teaching efficacy, particularly in relational and emotional aspects of classroom practice. However, the lack of significant gender differences in readiness scores indicates that both male and female pre-service teachers view themselves as equally prepared in terms of skills and strategies.

This combination is significant. It shows that, although female respondents may be more emotionally inclined toward inclusion, structural and curricular experiences seem to offer similar opportunities for both genders to develop a basic sense of readiness. Regarding Attitude–Behavior Consistency, one implication is that male pre-service teachers with less positive attitudes could benefit from targeted interventions that foster empathy, reflective practice, and direct positive contact with students with disabilities, thereby promoting a stronger link between attitudes and inclusive behaviors.

The highly uneven gender distribution in this study—with 90.4% female and only 9.6% male participants—can be explained by the fact that teacher education programs, including Chemistry Education, are nationally dominated by women. This aligns with findings by [21], who note that the teaching profession is more frequently chosen by women due to sociocultural expectations that associate teaching with nurturing, empathy, and emotional connectedness. Similarly, [38] report that female pre-service teachers tend to display higher social sensitivity and empathy toward students with disabilities, which increases their interest in inclusive education. Furthermore, studies such as [39] highlight that male students are more likely to choose pure science or engineering fields rather than education-related majors, resulting in a naturally lower male representation in Chemistry Education programs. Therefore, the gender distribution observed in this study reflects the actual population characteristics of teacher education programs rather than sampling bias.

Institutional Context: Converging Practices between Yogyakarta and Semarang

The lack of notable differences in attitudes and preparedness between universities in Yogyakarta and Semarang indicates a growing alignment in how inclusive education is integrated into chemistry teacher training programs. This is a positive sign, showing that efforts to promote inclusive education are spreading beyond a single institution or area and are starting to become more widespread.

This pattern differs from some international research that documents significant institutional variability in exposure to and support for inclusive education [26]. In this study, the similarity in outcomes might reflect shared national policy influences, especially the emphasis on inclusion in Indonesian regulations and the Merdeka Belajar framework. From the perspective of the Theory of Planned Behavior, consistent institutional norms and expectations across universities could contribute to similar subjective norms, thereby shaping relatively uniform attitudes and readiness profiles.

However, the lack of major institutional differences should not be seen as proof that current provisions are enough. Rather, it indicates a basic level of inclusion-focused curriculum that now needs to be enhanced through more comprehensive, practice-based, and discipline-specific experiences in chemistry education.

Teaching Experience Without Structured Support: Limited Impact on Readiness

One of the most notable findings is that prior experience teaching students with disabilities did not significantly affect attitudes or readiness. The mean scores for both groups were nearly the same.

This result differs from studies indicating that direct contact with students with disabilities can enhance teachers' attitudes and efficacy when such experiences are well-structured, supported, and reflective [25, 26]. In this study, the absence of a difference suggests that many reported experiences may have been brief, incidental, or unsupported, and therefore insufficient to change beliefs or skills.

Interpreted through Self-Efficacy Theory, this suggests that mastery experiences and vicarious experiences related to inclusive teaching have not yet been systematically developed. Without guided reflection, mentoring, or explicit modeling of inclusive practices, contact alone may not increase perceived control or readiness. Similarly, from a TPB perspective, behavioral control beliefs may stay the same if institutional and pedagogical supports are limited.

These findings emphasize the importance of structured practicum opportunities where pre-service chemistry teachers work directly with students with disabilities in inclusive classrooms or laboratories, with supervision, feedback, and clear links to inclusive pedagogy.

High Knowledge but Emerging Practice: Implications for Inclusive Chemistry Education

The extensive knowledge about disability and inclusive education is a key strength and aligns with international efforts to incorporate inclusion into teacher education curricula [8]. However, the lack of strong differentiating effects based on gender (for readiness), university origin, or prior experience raises important questions about how this knowledge is being put into practice.

The findings indicate that pre-service chemistry teachers are conceptually prepared but might not yet be fully equipped with the practical tools, adaptive strategies, and confidence necessary to implement inclusive chemistry teaching. This aligns with the conclusions of [24] and Cavicchi and McDonald (2022), who highlight that subject-specific inclusive pedagogy in chemistry remains underdeveloped.

In this context, integrating Self-Efficacy and TPB as guiding frameworks is especially relevant. Improving inclusive chemistry education involves not only sharing knowledge and fostering positive attitudes but also intentionally designing learning experiences that:

1. Provide mastery experiences in adapting experiments, representations, and assessments for diverse learners.
2. Offer indirect experiences through mentors and exemplars of inclusive STEM teaching.
3. Reinforce supportive social norms that position inclusion as a professional and ethical standard.
4. Enhance perceived behavioral control by equipping pre-service teachers with concrete tools, resources, and institutional backing.

Overall, the study's findings are partly in line with earlier research. They confirm that pre-service teachers can have positive attitudes and strong knowledge of inclusion [21, 34], but also reflect concerns that such attitudes do not automatically lead to solid readiness for inclusive practice [24, 39]. The readiness of prospective chemistry teachers to implement inclusive education depends not only on theoretical knowledge of inclusion but also on their ability to adapt to the unique characteristics of chemistry learning. As a subject rich in abstract concepts, symbolic representations, and laboratory activities, chemistry learning demands a much greater level of pedagogical and technical readiness. For example, on topics such as molecular structure or chemical bonding, teachers need to be prepared to provide alternative representations, such as tactile 3D molecular models for blind students or animated sign language videos for deaf students. In laboratory activities, teachers must be prepared to modify practical work, such as using digital measuring instruments with sound for low-vision students, adjusting work durations for students with motor impairments, or replacing high-risk experiments with PhET

simulations for students with certain special needs. Furthermore, in chemical calculation materials such as stoichiometry, teachers need to be prepared to provide simplified visual worksheets for students with intellectual disabilities or learning difficulties. These concrete examples demonstrate that readiness encompasses not only understanding but also the ability to apply safe, accessible, and inclusive strategies in real-life chemistry learning contexts. Thus, the analysis of readiness in this study is important to describe the extent to which prospective chemistry teachers are able to translate inclusive knowledge into chemistry learning practices that are adaptive and responsive to the needs of all students. Unlike some studies that report significant institutional or experiential effects, this study suggests that in the examined context, these factors have limited distinguishing power, likely due to relatively similar curricular exposure and the unstructured nature of practical experiences. This highlights the importance of moving beyond symbolic inclusion toward intentionally designed, discipline-specific, and practice-oriented inclusive teacher education.

CONCLUSION

This study examined the readiness and attitudes of pre-service chemistry teachers toward instructing students with disabilities, highlighting how gender, teaching experience, and institutional background influence these factors. The findings show that while pre-service teachers generally hold positive attitudes and possess a solid understanding of inclusive education, their preparedness to teach chemistry inclusively remains inconsistent and mostly theoretical. These results emphasize the gap between understanding the concept of inclusion and being prepared to implement it effectively in specific subject areas.

From a quantitative perspective, gender influenced attitudes but not readiness, with female pre-service teachers showing a stronger affective orientation toward inclusion. However, both male and female participants reported similar levels of practical readiness, indicating that chemistry teacher education programs currently offer relatively equal exposure to inclusive education regardless of gender.

Institutional background and previous experience teaching students with disabilities did not lead to notable differences in either attitudes or preparedness. This pattern indicates that inclusive education principles are fairly consistent across universities, yet the limited impact of teaching experience highlights a gap between exposure and reflective learning. Without structured mentoring and guided reflection, teaching experience alone might not increase the readiness or confidence needed for inclusive teaching.

Overall, the findings highlight that positive attitudes and conceptual knowledge are essential but not enough for inclusive practice. Turning these into effective teaching behaviors requires intentional opportunities for mastery experiences, modeling of inclusive strategies, and ongoing feedback within supportive institutional environments. Developing readiness for inclusive chemistry teaching depends not only on what pre-service teachers know and believe but also on how their learning environments encourage practice, reflection, and professional confidence.

Implications

The findings underscore the urgent need for teacher education institutions to close the gap between conceptual understanding and pedagogical practice in inclusive chemistry education. To do this, teacher preparation programs must go beyond just theoretical instruction and incorporate inclusive strategies into their professional training. First, curricula should include structured practicum experiences that allow pre-service teachers to practice inclusive methods directly in chemistry classrooms and labs. These experiences help turn theoretical knowledge into real teaching skills. Second, inclusive pedagogy should be integrated across discipline-specific courses, rather than being limited to separate inclusive education modules, so that inclusivity becomes a natural part of chemistry teaching rather than an additional feature. Additionally, programs should create mentorship systems, peer reflection sessions, and feedback cycles to build self-confidence and reflective skills among pre-service teachers. Lastly, gender-sensitive and experience-based interventions are vital to foster empathy, resilience, and inclusive values for all teacher candidates, helping them address the diverse learning needs of students with disabilities effectively. Collectively, these steps would enhance the professional, emotional, and ethical foundations of inclusive chemistry teacher education, bringing it closer to the transformative goals outlined in global inclusion frameworks like SDG 4 and the UNCRPD.

Future Research

Future studies should employ mixed-methods or longitudinal designs to trace how attitudes and readiness evolve during and after pre-service education. Cross-institutional and cross-national comparisons could provide deeper insights into how cultural, institutional, and disciplinary contexts mediate the development of inclusive competencies. Additionally, observational and qualitative studies focusing on actual inclusive teaching practices in chemistry classrooms would enrich understanding of how conceptual readiness translates into professional action.

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