

Pedagogical Knowledge of the Secondary Pre Service Teachers in Teaching Science in Dinagat Islands: Basis for an Enhanced Teacher Education Program

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ABSTRACT

This study examined the pedagogical knowledge of 70 fourth-year Bachelor of Secondary Education students majoring in English and Science at a private higher education institution in the Dinagat Islands during the academic year 2025–2026. Employing a quantitative descriptive-correlational research design and purposive sampling, the study investigated the relationship between pre-service teachers' pedagogical knowledge and their teaching demonstration performance. Data were gathered through a validated researcher-made survey questionnaire—measuring curriculum improvement, teaching practice quality, pre-service teacher readiness, and the integration of simulations and multimedia resources—alongside official performance records. Analysis using

descriptive statistics, one-way ANOVA, and Pearson Product Moment Correlation revealed that respondents possessed a high extent of pedagogical knowledge across all dimensions, and their teaching demonstration performance was rated very satisfactory. Teaching practice quality and instructional readiness emerged as the strongest contributors to pedagogical development, while technology integration also demonstrated a high extent of use. Furthermore, a significant relationship was established between pedagogical knowledge and demonstration performance, though demographic variables showed no significant differences. Based on these findings, the study developed an Enhanced Curriculum Guide for Secondary Teacher Education, titled Advanced Professional Formation in Secondary Science Teaching. This proposed output specifically aims to strengthen the pedagogical competence, practical skills, and instructional readiness of future educators navigating resource-limited contexts like the Dinagat Islands.

Keywords: *employee job performance; promotion practices; healthcare workforce; government hospital; strategic planning; human resource management*

INTRODUCTION

A comprehensive understanding of effective strategies for teaching scientific concepts strategies that engage learners, foster curiosity, and promote critical thinking that is fundamental to high-quality science instruction. Pedagogical knowledge, defined as teachers' awareness of the methods, strategies, and processes underlying teaching and learning, is essential in shaping instructional effectiveness. For pre-service teachers, the development of this knowledge bridges the gap between theoretical foundations and practical classroom application. However, many pre-service teachers struggle to translate theoretical frameworks into practice, particularly when teaching complex or abstract scientific concepts. In science

education, pedagogical knowledge involves the ability to design inquiry-based instructional activities, facilitate experiential learning through hands-on experiments, utilize technological tools, and implement meaningful assessments to gauge students' conceptual understanding. Despite the importance of these competencies, many pre-service teachers feel unprepared to effectively teach science, underscoring the need to examine the adequacy of their pedagogical training.

One key component of teacher education programs is the teaching internship, where pre-service teachers begin their classroom practice under the supervision of a cooperating teacher. In the Philippines, this internship is a mandatory part of the Bachelor of Secondary Education (BSEd) program and other education curricula. The performance of pre-service teachers during their practicum serves as a crucial indicator of the quality of teacher preparation provided by Higher Education Institutions (HEIs). The effectiveness of teacher education programs can be evaluated by how well pre-service teachers are able to apply pedagogical knowledge in real classroom settings.

This study investigates the pedagogical knowledge of pre-service science teachers, focusing on instructional strategies, classroom management, lesson planning, and assessment practices. By assessing their level of preparedness, the research aims to identify areas for improvement and generate insights to enhance teacher education programs. This is particularly important in the context of the Dinagat Islands and the broader Philippine education system, where resources and opportunities for professional development may vary. Ultimately, the goal is to develop more effective training approaches that had better equip future science educators with the skills necessary to meet the demands of 21st-century classrooms.

METHODS

Research Design

This Research Methods article provides an overview of key components in the educational research process, focusing on literature reviews, theoretical frameworks, and conceptual frameworks. According to (Werapan Jaruanlikitkawin, 2023) this study examined the enhancement of pedagogical knowledge (PK) in pre-service science teachers using content representation (CoRes) paired with researcher-designed scaffolding. Initially, high-PK teachers provided comprehensive lessons, teachers delivered incomplete content with less effective strategies. An intervention, all preservice teachers and teachers improved in designing curriculum-aligned activities, establishing clear learning objectives, integrating student knowledge, and selecting appropriate assessments in enhancing their ability to conduct effective science teaching.

A well-structured research design is essential for aligning methodological strategies with the overarching objectives of a study. It encompasses the formulation of clear research aims, the selection of either primary or secondary research approaches, and the identification of appropriate sampling techniques or criteria for participant selection. Furthermore, it outlines the specific methods for data collection, including the procedural steps involved in gathering the necessary information. Finally, the research design details the analytical techniques that employed to interpret the collected data. By systematically planning each of these components, researchers can ensure methodological coherence and the validity and reliability of their findings. The researcher adopted a quantitative research design, as it facilitates the systematic collection and analysis of numerical data. This approach aligns with the researcher's academic interests and methodological preference for objective measurement and statistical analysis, enabling the exploration of patterns, relationships, and trends within the data. The steps will be established a population.

Research Locale

The research locale of the study is the Province of Dinagat Islands in Caraga Region. There would be only one private higher institution in the province, which is Don Jose Ecleo Memorial College that is accredited by the Commission on Higher Education that offer the identified programs.

Sampling Technique

This study employed a purposive sampling technique, a non-probability sampling method where participants are selected based on specific characteristics relevant to the research. In this case, the sample consisted of fourth-year students from the College of Teacher Education who meet particular criteria: they are enrolled in a CHED-accredited institution offering a Bachelor of Secondary Education (BSEd) program, majoring in English and Science, and are in their final year of study. The use of purposive sampling is justified as it allows for the inclusion of participants who possess the necessary characteristics and experiences to provide insights into the Pedagogical Knowledge (PK) of pre-service teachers in these specific fields. This targeted selection ensures that the data collected is directly relevant to the research question, focusing on students who are most likely to have developed the pedagogical knowledge required for effective science instruction in secondary education.

In actual teaching, teachers often exhibit flexibility in their approach to teaching different subjects, as they are required to adapt their instructional strategies to meet the diverse needs of their students. English majors, despite specializing in language arts, may find themselves teaching science concepts, particularly in integrated or interdisciplinary classrooms where subjects overlap. Including English majors in this study recognizes the reality that teachers frequently navigate multiple disciplines and must apply their pedagogical knowledge across various subject areas, including science, to effectively support student learning and engagement.

The researcher set the qualification for inclusion of the specific participants to the study to ascertain the availability and appropriateness of the data gathered without coercion or force following the established research ethics. The researcher ask the number of students from the College of Teacher Education, a total of 70 participants' academic year 2025-2026.

Table 1. Size of the Participants for the Survey

| Program | Female | Male | Population |
|----------------|--------|------|------------|
| BSED- English | 39 | 6 | 45 |
| BSED- Sciences | 19 | 6 | 25 |

RESULTS AND DISCUSSION

Table 5.1. Frequency Distribution of the Respondent Profile in terms of Age

| Age | f | % |
|------------------------|----|------|
| 21-22 years old | 53 | 74.7 |
| 23-24 years old | 16 | 22.9 |
| 25-26 years old | 0 | 0.0 |
| 27-28 years old | 0 | 0.0 |
| 29 years old and above | 1 | 1.4 |
| Total | 70 | 100 |

Table 5.1 presented the age distribution of the respondents, reveals that a substantial majority (74.7%) fall within the 21–22-year-old age group, indicating that the sample is largely composed of individuals in early adulthood. Respondents aged 23–24 account for 22.9% of the sample, while only a minimal proportion (1.4%) are aged 29 years and above. Notably, no respondents were recorded in the 25–26 and 27–28 age categories. Overall, the findings indicate a highly concentrated age profile, which suggests that the results predominantly reflect the perspectives of younger adults and may limit the generalizability of the findings to older populations.

Table 5.2. *Frequency Distribution of the Respondent Profile in terms of Sex*

| Sex | F | % |
|--------|----|------|
| Male | 12 | 17.1 |
| Female | 58 | 82.9 |
| Total | 70 | 100 |

It can be gleaned from table 5.2 that the distribution of respondents by sex indicates that females constitute the majority of the sample, accounting for 58 respondents (82.9%), while males represent 12 respondents (17.1%). This marked disparity in sex representation suggests that female perspectives predominantly influence the findings. As such, this imbalance should be carefully considered when interpreting the results and assessing the extent to which the findings may be generalized across sexes.

Table 5.3 *Frequency Distribution of the Respondent Profile in terms of Civil Status*

| Civil Status | f | % |
|--------------|----|------|
| Single | 68 | 97.1 |
| Married | 2 | 2.9 |
| Widowed | 0 | 0.0 |
| Separated | 0 | 0.0 |
| Total | 70 | 100 |

The respondents' civil status profile indicates that most participants are single, with 68 individuals (97.1%) falling into this category. Married respondents comprise a small proportion of the sample, totaling 2 individuals (2.9%), while no participants reported being widowed or separated. This distribution suggests that the sample is largely dominated by unmarried respondents, and therefore, the results of the study primarily represent the viewpoints and experiences of single individuals.

Table 5.4. *Frequency Distribution of the Respondent Profile in terms of Program*

| Program | f | % |
|---------------|----|------|
| BSED Sciences | 25 | 35.7 |
| BSED English | 45 | 64.3 |
| Total | 70 | 100 |

Table 5.4 displayed the distribution of respondents by academic program indicates that the majority are enrolled in the Bachelor of Secondary Education (BSED) English, with 45 respondents (64.3%). Meanwhile, 25 respondents (35.7%) are taking BSED Sciences. This suggests that students more comprehensively represent the sample from the BSED English program, and therefore, the findings of the study may more strongly reflect the perspectives and experiences of students in this program.

Table 6. *Frequency Distribution on the Proficiency Level of the Respondents in Science Teaching Demonstration*

| Levels | f | % |
|---------------------------|-------|-------|
| 95-100 (Outstanding) | 15 | 21.4 |
| 90-94 (Very Satisfactory) | 42 | 59.9 |
| 85-89 (Satisfactory) | 13 | 18.5 |
| 80-84 (Fair) | 0 | 0.0 |
| 75-79 (Needs Improvement) | 0 | 0.0 |
| below 74 (Failed) | 0 | 0.0 |
| total | 70 | 100.0 |
| Mean | 91.81 | |

| | |
|-------|-------------------|
| level | Very Satisfactory |
| SD | 2.92 |

The distribution of respondents based on performance levels indicates that most participants attained a Very Satisfactory rating, with 42 respondents (59.9%) scoring within the 90–94 range. 15 respondents (21.4%) who achieved an Outstanding rating (95–100) and 13 respondents (18.5%) who obtained a Satisfactory rating (85–89) follow this.

No respondents fell under the Fair, Needs Improvement, or Failed categories. The mean performance score of 91.81, accompanied by a standard deviation of 2.92, supports the overall Very Satisfactory performance level of the respondents and indicates minimal score dispersion. These results suggest a generally high and consistent level of academic performance among the participants.

Table 7.1 *Extent of Curriculum Improvement in Developing Secondary Preservice Science Teachers' Pedagogical Knowledge (PK) in Teaching Science*

| <i>Item</i> | <i>VHE</i> (%) | <i>HE</i> (%) | <i>ME</i> (%) | <i>LE</i> (%) | <i>VLE</i> (%) | <i>Mean</i> | <i>Descriptive Meaning</i> |
|--|-------------------|------------------|------------------|------------------|-------------------|-------------|----------------------------|
| 1. I have gained practical skills and pedagogical insights from science teaching workshops that prepare me to create meaningful learning experiences in off-campus settings. | 0.0 | 51.4 | 45.7 | 2.9 | 0.0 | 3.5 | High Extent |
| 2. I believe that the Teacher Education Program has equipped me with the knowledge and skills to confidently teach science in real classroom contexts. | 20 | 47.1 | 18.6 | 14.3 | 0.0 | 3.7 | High Extent |
| 3. I think the program can offer more opportunities for practical teaching experiences such as having a short course or seminar to better prepare preservice teachers before deployment. | 42.9 | 30 | 24.3 | 2.9 | 0.0 | 4.1 | High Extent |
| 4. I am satisfied with the support provided by the program in developing my pedagogical knowledge and skills in science teaching. | 15.7 | 50 | 34.3 | 0.0 | 0.0 | 3.8 | High Extent |

| | | | | | | | | |
|---------|--|------|------|------|------|-----|------|-------------------|
| 5. | I need more guidance on classroom management strategies such as Laboratory methods, microteaching, classroom management, and assessment strategies for science lessons. | 31.4 | 31.4 | 27.1 | 10 | 0.0 | 3.8 | High Extent |
| 6. | I have been given sufficient opportunities such as science outreach projects and Implement inquiry based and PBL approaches to practice teaching science and build confidence. | 0.0 | 17.1 | 58.6 | 24.3 | 0.0 | 2.9 | Moderately Extent |
| 7. | The program has improved methods for evaluating my readiness to teach science to ensure adequate preparation for real classroom experiences. | 22.9 | 38.6 | 35.7 | 2.9 | 0.0 | 3.8 | High Extent |
| 8. | The Teacher Education Program encourages me to use innovative teaching strategies in science. | 27.1 | 60 | 7.1 | 5.7 | 0.0 | 4.1 | High Extent |
| 9. | I believe the program has a strong support for structured lesson planning through workshops, templates, and modelling. | 55.7 | 12.9 | 25.7 | 5.7 | 0.0 | 4.2 | High Extent |
| 10. | The program prepares me to apply scientific methods such as laboratory experiment and benefit from mentorship by cooperating teachers before handling classes. | 24.3 | 22.9 | 47.1 | 0.0 | 0.0 | 3.7 | High Extent |
| Overall | | | | | | | 3.77 | High extent |

Legend: VLE- very low extent: 1.0-1.80; LE- low extent: 1.81-2.60; ME-moderately extent: 2.61-3.4; HE- high extent: 3.41-4.20; VHE- very high extent: 4.21-5.0

The data indicated in the table 7.1 towards the extent of curriculum improvement in developing secondary preservice science teachers' pedagogical knowledge (PK) is generally rated at a High Extent, as

reflected by the overall mean of 3.77. This suggests that the Teacher Education Program effectively supports preservice teachers in acquiring pedagogical knowledge, instructional skills, and confidence in teaching science. Most indicators received high ratings, demonstrating that the curriculum plays a significant role in preparing preservice teachers for out-of-campus and real classroom settings through workshops, seminars, and structured pedagogical support.

High mean scores were observed in items related to innovative teaching methods, structured lesson planning, and the need for expanded practical experiences, with means ranging from 3.7 to 4.2. These results imply that preservice teachers strongly perceive the program as encouraging the use of innovative and research-based teaching approaches, while also providing modeling and templates that support effective lesson planning. Furthermore, respondents acknowledged the importance of additional practical teaching opportunities, indicating that hands-on experiences are viewed as essential in strengthening their PK and readiness for actual classroom instruction.

Despite the generally positive findings, one indicator was rated at a Moderate Extent (2.9), specifically regarding opportunities to practice teaching science through outreach programs, inquiry-based learning, and project-based learning. This suggests that while the curriculum is effective overall, there remains a need to enhance experiential and practice-oriented components. Strengthening sustained teaching opportunities, particularly those that integrate inquiry and authentic classroom experiences, may further improve preservice teachers' ability to translate pedagogical knowledge into effective science teaching practice.

It was examined by (Sevgi Aydin-Gunbatar, 2022) the development of pedagogical knowledge among secondary pre-service science teachers, focusing on their ability to transform content knowledge into effective instructional plans. Through a structured teaching methods course, participants were trained to apply pedagogical transformation competence across various science topics and transfer this competence to new, untaught content areas. The findings indicate that pre-service teachers were generally able to apply acquired pedagogical knowledge to unfamiliar topics, demonstrating growth in topic-specific pedagogical knowledge (PK).

Notable improvements were observed in addressing students' learning difficulties, alternative conceptions, and instructional strategies, while assessment-related pedagogical knowledge showed comparatively limited development. Overall, the study highlights the importance of explicit instruction in pedagogical transformation to strengthen pre-service teachers' pedagogical knowledge. The results serve as a basis for enhancing secondary science teacher education programs, particularly in strengthening assessment literacy and balanced PK development.

The importance of mentoring in strengthening the pedagogical knowledge of secondary pre-service science teachers, particularly in deepening their understanding and effective implementation of the science curriculum. Findings reveal that mentoring improved teachers' alignment with curriculum standards and learning objectives, although the degree of improvement varied according to academic achievement. These results affirm the value of integrating structured mentoring into teacher education programs as a strategic approach to curriculum improvement and the enhancement of science teaching quality. (Dizem Can-Kucuk, 2022)

Table 7.2 *Extent of Teaching Practice Quality in Developing Secondary Preservice Science Teachers' Pedagogical Knowledge (PK) in Teaching Science*

| <i>Item</i> | <i>VHE</i> (%) | <i>HE</i> (%) | <i>ME</i> (%) | <i>LE</i> (%) | <i>VLE</i> (%) | <i>Mean</i> | <i>Descriptive Meaning</i> |
|--|-------------------|------------------|------------------|------------------|-------------------|-------------|----------------------------|
| 1. I am confident in my understanding of the major | 0.0 | 37.1 | 54.3 | 8.6 | 0.0 | 3.3 | Moderately Extent |

| | | | | | | | | |
|-----|--|------|------|------|------|-----|-----|-------------------|
| | science concepts relevant to my teaching level. | | | | | | | |
| 2. | I regularly update myself on new developments and discoveries in science to keep my teaching current and relevant. | 5.7 | 50 | 41.4 | 2.9 | 0.0 | 3.6 | High Extent |
| 3. | I can skillfully use experiments and demonstrations to enhance student learning in science. | 5.7 | 27.1 | 58.6 | 8.6 | 0.0 | 3.3 | Moderately Extent |
| 4. | I can identify students' misconceptions in science and adjust my lessons to support diverse learners. | 8.6 | 44.3 | 44.3 | 2.9 | 0.0 | 3.6 | High Extent |
| 5. | I use inquiry-based and hands-on approaches to actively engage students in science learning. | 7.1 | 58.6 | | 34.3 | 0.0 | 3.7 | High Extent |
| 6. | I can develop valid and reliable assessment tools aligned with learning objectives in science. | 18.6 | 54.3 | 25.7 | 1.4 | 0.0 | 3.9 | High Extent |
| 7. | I use varied assessment methods to comprehensively evaluate student learning in science. | 30 | 55.7 | 14.3 | 0.0 | 0.0 | 4.2 | High Extent |
| 8. | I modify my teaching strategies when students struggle, using differentiated learning and scaffolding. | 45.7 | 42.9 | 11.4 | 0.0 | 0.0 | 4.3 | Very High Extent |
| 9. | I prepare learning materials, visual aids, experiments in advance and select instructional strategies suitable for the topic and students. | 57.1 | 25.7 | 17.1 | 0.0 | 0.0 | 4.4 | Very High Extent |
| 10. | I consider my students' prior knowledge and learning needs when planning lessons in science. | 61.4 | 27.1 | 11.4 | 0.0 | 0.0 | 4.5 | Very High Extent |
| | Overall | | | | | | 3.9 | High extent |

Legend: VLE- very low extent: 1.0-1.80; LE- low extent: 1.81-2.60; ME-moderately extent: 2.61-3.4; HE- high extent: 3.41-4.20; VHE- very high extent: 4.21-5.0

Table 7.2 presented the extent of teaching practice quality in developing secondary preservice science teachers' pedagogical knowledge (PK). Teaching practice quality demonstrates a high extent of contribution (3.90 mean) to the development of secondary preservice science teachers' pedagogical knowledge (PK). Strengths were particularly evident in lesson preparation, consideration of students' prior knowledge, use of appropriate instructional strategies, and differentiated teaching approaches, all of which were rated at a high to very high extent. These results indicate strong pedagogical readiness and effective planning skills that support meaningful science learning.

Conversely, some areas require further improvement, particularly in confidence in major science concepts and the use of experiments and demonstrations, which were rated at a moderately extent. Despite these limitations, preservice teachers showed strong engagement in inquiry-based teaching and effective assessment practices. Generally, the findings suggest that while teaching practice strongly enhances PK, targeted support in content mastery and practical laboratory skills would further strengthen preservice science teacher preparation.

According to (Johannes Sæleset, 2021) examined how secondary pre-service science teachers integrate key components of pedagogical knowledge during their teaching practice. Findings showed that pre-service teachers effectively combined knowledge of learners' understanding with appropriate instructional strategies to address students' learning needs and develop topic-specific teaching approaches. These integrations were shaped by coursework, peer collaboration, practicum experiences, and mentor guidance, highlighting the importance of structured support in improving teaching practice quality. The results emphasize the need for enhanced teacher education programs that strengthen PCK integration through guided practice and mentoring.

Table 7.3 Extent of Preservice Teacher Readiness in Developing Secondary Preservice Science Teachers' Pedagogical Knowledge (PK) in Teaching Science

| <i>Item</i> | <i>VHE (%)</i> | <i>HE (%)</i> | <i>ME (%)</i> | <i>LE (%)</i> | <i>VLE (%)</i> | <i>Mean</i> | <i>Descriptive Meaning</i> |
|---|----------------|---------------|---------------|---------------|----------------|-------------|----------------------------|
| 1. I am confident in my subject-matter knowledge for teaching Science. | 2.9 | 61.4 | 25.7 | 10 | 0.0 | 3.6 | High Extent |
| 2. I am comfortable using teaching materials, technology, and laboratory equipment. | 21.4 | 41.4 | 30 | 7.1 | 0.0 | 3.8 | High Extent |
| 3. I am emotionally prepared for the responsibilities of off-campus teaching most importantly teaching science. | 8.6 | 42.9 | 41.4 | 7.1 | 0.0 | 3.5 | High Extent |
| 4. I am ready to reflect on my performance and make improvements during deployment. | 41.4 | 42.9 | 15.7 | 0.0 | 0.0 | 4.3 | Very High Extent |
| 5. I am prepared to explain difficult concepts in ways | 20 | 40 | 40 | 0.0 | 0.0 | 3.8 | High Extent |

| | | | | | | | | |
|-----|---|------|------|------|-----|------|-----|-------------|
| | students can easily understand. | | | | | | | |
| 6. | I can design lesson plans that align with curriculum standards and student learning outcomes. | 17.1 | 52.9 | 18.6 | 0.0 | 11.4 | 3.6 | High Extent |
| 7. | I can manage time and classroom routines effectively during science lessons. | 28.6 | 34.3 | 37.1 | 0.0 | 0.0 | 3.9 | High Extent |
| 8. | I can organize and use teaching materials and classroom resources efficiently. | 32.9 | 44.3 | 22.9 | 0.0 | 0.0 | 4.1 | High Extent |
| 9. | I can collaborate effectively with cooperating teachers, school staff, and peers. | 31.4 | 55.7 | 12.9 | 0.0 | 0.0 | 4.2 | High Extent |
| 10. | I am prepared to engage students in active, student-centered science learning experiences. | 40 | 44.3 | 14.3 | 1.4 | 0.0 | 4.2 | High Extent |
| | Overall | | | | | | 3.9 | High Extent |

Legend: VLE- very low extent: 1.0-1.80; LE- low extent: 1.81-2.60; ME-moderately extent: 2.61-3.4; HE- high extent: 3.41-4.20; VHE- very high extent: 4.21-5.0

Table 7.3 displayed the extent of preservice teacher readiness in developing secondary preservice science teachers' pedagogical knowledge (PK) in teaching science. The overall results indicate that respondents generally perceive themselves as highly prepared for teaching science, with all items rated at a High Extent and one item reaching a Very High Extent.

The highest mean score was recorded for Item 4 (4.3), interpreted as Very High Extent, which highlights respondents' strong readiness to reflect on their teaching performance and implement improvements during deployment. This finding underscores the preservice teachers' capacity for reflective practice, a critical component in the continuous development of pedagogical knowledge. High extent ratings were also observed in areas related to collaboration with cooperating teachers (Item 9), engaging students in student-centered science activities (Item 10), and efficient organization and use of teaching materials (Item 8), suggesting well-developed professional and instructional competencies.

Meanwhile, items concerning subject matter confidence, emotional preparedness, and lesson planning (Items 1, 3, and 6) were still rated at a High Extent, though with relatively lower mean scores, indicating potential areas for further support. These aspects suggest that while preservice teachers feel generally ready for off-campus science teaching, additional reinforcement in content mastery and emotional readiness may further enhance their PK development.

Completely, the findings imply that preservice teacher readiness substantially contributes to the development of pedagogical content knowledge in teaching science, particularly through reflective practice, collaboration, and student-centered instructional engagement.

On the other hand, (Riska Septia Wahyuningtyas, 2025) stated that the Pedagogical knowledge (PK), which integrates pedagogical knowledge and content knowledge, is a fundamental requirement for secondary pre-service science teachers before entering the profession. This study examines the readiness of pre-service science teachers to teach effectively, with particular attention to their pedagogical skills and mastery of science content. Findings indicate that while pre-service teachers demonstrate a developing level of readiness, gaps remain in both pedagogical and content knowledge

These results highlight the need for enhanced teacher education programs that strengthen pedagogical training and provide deeper, curriculum-aligned science content to improve overall teaching readiness. Strengthening PK is essential not only for effective science instruction but also for preparing teachers to address sustainability-related scientific concepts in the classroom.

The development of pedagogical knowledge (PK) among secondary pre-service science teachers through the use of content representations (CoRes) and scaffolded support. CoRes served as a reflective tool to assess and enhance teachers' readiness by strengthening their ability to align content with the curriculum, design appropriate learning objectives, integrate students' prior knowledge, and apply suitable assessment strategies. Findings indicate that structured scaffolding improved pre-service teachers' preparedness to plan and deliver coherent, engaging, and curriculum-aligned science instruction. These results underscore the importance of integrating CoRes-based scaffolding into teacher education programs to enhance pre-service teacher readiness and overall teaching competence in science. (Werapan Jaruanlikitkawin, 2023)

Table 7.4 Extent of Use in Simulation and Multimedia Resources in Developing Secondary Preservice Science Teachers' Pedagogical Knowledge (PK) in Teaching Science

| <i>Item</i> | <i>VHE (%)</i> | <i>HE (%)</i> | <i>ME (%)</i> | <i>LE (%)</i> | <i>VLE (%)</i> | <i>Mean</i> | <i>Descriptive Meaning</i> |
|---|----------------|---------------|---------------|---------------|----------------|-------------|----------------------------|
| 1. I can effectively integrate simulations and multimedia resources into my lessons to enhance student engagement. | 22.9 | 45.7 | 31.4 | 0.0 | 0.0 | 3.9 | High Extent |
| 2. I am confident in selecting and utilizing multimedia resources that align seamlessly with the learning objectives of a science lesson. | 21.4 | 37.1 | 41.4 | 0.0 | 0.0 | 3.8 | High Extent |
| 3. I am proficient in using technology—such as computers, projectors, and tablets—to deliver simulations and multimedia. | 22.9 | 35.7 | 41.4 | 0.0 | 0.0 | 3.8 | High Extent |
| 4. I face challenges in accessing high-quality | 34.3 | 27.1 | 27.1 | 11.4 | 0.0 | 3.8 | High Extent |

| | | | | | | | | |
|---------|--|------|------|------|-----|-----|------|-------------|
| | simulations and multimedia resources for teaching science that limits opportunities to provide interactive and engaging learning experiences. | | | | | | | |
| 5. | The school provides adequate support for integrating technology into science instruction. | 14.3 | 70 | 14.3 | 1.4 | 0.0 | 4.0 | High Extent |
| 6. | I believe simulations help students visualize and understand complex scientific concepts. | 32.9 | 40 | 27.1 | 0.0 | 0.0 | 4.1 | High Extent |
| 7. | Using simulations and multimedia tools strengthens the quality of my science teaching. | 22.9 | 42.9 | 24.3 | 10 | 0.0 | 3.8 | High Extent |
| 8. | I can distinguish between simulations and other multimedia resources and choose them based on instructional purpose. | 12.9 | 58.6 | 28.6 | 0.0 | 0.0 | 3.8 | High Extent |
| 9. | I deliberately incorporate simulations and multimedia tools into my science lesson planning. | 8.6 | 61.4 | 30 | 0.0 | 0.0 | 3.8 | High Extent |
| 10. | I find that incorporating simulation and multimedia resources into my lessons boosts my students' interest and motivation in science learning. | 31.4 | 37.1 | 21.4 | 10 | 0.0 | 3.9 | High Extent |
| Overall | | | | | | | 3.87 | High Extent |

Legend: VLE- very low extent: 1.0-1.80; LE- low extent: 1.81-2.60; ME-moderately extent: 2.61-3.4; HE- high extent: 3.41-4.20; VHE- very high extent: 4.21-5.0

Table 7.4 shown the extent of use of simulations and multimedia resources in developing secondary preservice science teachers' pedagogical knowledge (PK) in teaching science. The overall weighted mean of 3.87, interpreted as High Extent, indicates that the integration of simulations and multimedia resources plays a significant role in enhancing preservice teachers' PK.

All items were rated at a High Extent, reflecting respondents' generally positive perceptions of their competence and confidence in using technology-enhanced instructional tools. Higher mean scores were observed in items related to the effectiveness of simulations in visualizing complex scientific concepts (Item 6) and the adequacy of school support for technology integration (Item 5), suggesting that both instructional

value and institutional support contribute to meaningful technology use in science teaching. Similarly, respondents reported that simulations and multimedia resources increase student engagement, motivation, and participation (Items 1 and 10), highlighting their pedagogical relevance in promoting active learning.

Even with the favorable results, Item 4 indicates that some respondents still encounter challenges in accessing high-quality simulations and multimedia resources, although this concern was still rated at a high extent. This finding implies that while preservice teachers are capable of integrating technology into their teaching practices, access to quality digital resources remains an area that may require further institutional support.

Overall, the findings suggest that the use of simulations and multimedia resources substantially supports the development of pedagogical content knowledge among secondary preservice science teachers by enhancing conceptual understanding, instructional effectiveness, and student engagement in science learning.

It emphasizes the importance of developing pedagogical content knowledge related to the use of digital media, including multimedia and simulations, among secondary pre-service science teachers. A structured university-based teaching approach integrating both theoretical and practical components was designed to strengthen teachers' ability to effectively use digital tools in science instruction. Findings indicate that targeted training enhances pre-service teachers' competence in integrating multimedia and simulations into teaching, highlighting the need to embed digital-media PK development within enhanced teacher education programs to improve the quality of science teaching. (Rike Große-Heilmann1, 2022)

(Zoubeida R. Dagher, 2024) Explored how participation in equity-oriented digital simulations supports the development of pedagogical knowledge among pre-service science teachers. The simulation-based experience enabled pre-service teachers to analyze classroom situations, propose appropriate instructional interventions, and reflect on their professional responsibilities toward diverse learners. Findings suggest that the use of multimedia and simulation tools enhances pre-service teachers' pedagogical decision-making and responsiveness, supporting the integration of simulation-based learning into enhanced teacher education programs for science teaching.

Table 8.1 *Composite Assessment of Pedagogical Knowledge (PK) Development among Secondary Preservice Teachers in Teaching Science*

| Areas | Mean | Descriptive Meaning | SD |
|---|------|---------------------|------|
| Curriculum Improvement | 3.77 | High Extent | 0.55 |
| Teaching Practice Quality | 3.9 | High Extent | 0.5 |
| Preservice Teacher Readiness | 3.9 | High Extent | 0.13 |
| Use of Simulations and Multimedia Resources | 3.87 | High Extent | 0.15 |
| Composite Mean | 3.86 | High Extent | 0.22 |

Legend: VLE- very low extent: 1.0-1.80; LE- low extent: 1.81-2.60; ME-moderately extent: 2.61-3.4; HE- high extent: 3.41-4.20; VHE- very high extent: 4.21-5.0

The findings indicate that secondary preservice science teachers demonstrate a *high level of pedagogical knowledge (PK) development* overall, as reflected by the composite mean of 3.86. Teaching Practice Quality and Preservice Teacher Readiness emerged as the strongest contributors, underscoring the importance of experiential learning and individual preparedness in enhancing pedagogical skills and content

understanding. The use of simulations and multimedia resources likewise plays a significant role in promoting conceptual clarity and student engagement, while curriculum improvement, although rated high, shows room for further enhancement.

Regardless of these positive outcomes, key challenges remain, including the need for stronger alignment between theory and practice, more consistent mentoring and feedback during teaching practice, improved access to quality technological resources, and continued support in content mastery and classroom management. Addressing these areas may further strengthen PK development and improve the overall effectiveness of teacher education programs.

In response to the need for deeper understanding of the pedagogical knowledge of secondary pre-service teachers in teaching science, this study examined the integration of key components of pedagogical knowledge (PK). The findings, illustrated through PK maps, revealed that pre-service teachers frequently integrated their understanding of students with appropriate instructional strategies, often developing topic-specific approaches to address learners' needs. These integrations contributed to curriculum improvement, enhanced teaching practice quality, and strengthened preservice teacher readiness. Moreover, the use of simulations and multimedia resources emerged as effective instructional strategies in supporting student understanding. The sources of these pedagogical integrations included specialized science content courses, collaborative learning with peers, experiential learning opportunities, and guidance from mentor teachers. The results provide a strong basis for the development of an enhanced teacher education program focused on strengthening pedagogical knowledge and instructional competence in science education. (Friedrichsen, 2021)

(Lu Wang, 2022) Highlighted the significant amount of time secondary pre-service teachers spend in practicum during teacher education programs, it is essential to examine how they develop pedagogical knowledge related to teaching and learning in authentic classroom settings.

It is revealed that the development of pedagogical knowledge was highly individualized, with pre-service teachers employing varied instructional strategies and approaches to support student learning, even when placed in the same practicum environment. These differences influenced curriculum improvement, teaching practice quality, and preservice teacher readiness. Notably, the use of simulations and multimedia resources emerged as important instructional tools that supported concept understanding and enhanced teaching effectiveness. The results underscore the need to design practicum experiences and enhanced teacher education programs that provide structured and differentiated support to strengthen pedagogical knowledge and instructional competence in secondary science education.

On the Significance Relationship between the Teaching Demonstration Performance and the Extent of Pedagogical Knowledge among the Secondary Preservice Teachers in Teaching Science

Table 9.1. Age

| <i>Areas</i> | <i>Age</i> | <i>n</i> | <i>WM</i> | <i>SD</i> | <i>f-value</i> | <i>p-value</i> | <i>Decision</i> | <i>Remarks</i> |
|---------------------------|------------------------|----------|-----------|-----------|----------------|----------------|--------------------------------------|-----------------|
| Curriculum Improvement | 21-22 years old | 53 | 3.76 | 0.45 | 0.285 | 0.753 | Failed to Reject the Null Hypothesis | not significant |
| | 23-24 years old | 16 | 3.77 | 0.44 | | | | |
| | 29 years old and above | 1 | 4.10 | | | | | |
| Teaching Practice Quality | 21-22 years old | 53 | 3.84 | 0.46 | 1.611 | 0.207 | Failed to Reject the Null Hypothesis | not significant |
| | 23-24 years old | 16 | 3.98 | 0.41 | | | | |
| | 29 years old and above | 1 | 4.50 | . | | | | |

| | | | | | | | | |
|--|------------------------|----|------|------|-------|-------|--------------------------------------|-----------------|
| Preservice Teacher Readiness | 21-22 years old | 53 | 3.89 | 0.48 | 0.089 | 0.915 | Failed to Reject the Null Hypothesis | not significant |
| | 23-24 years old | 16 | 3.94 | 0.38 | | | | |
| | 29 years old and above | 1 | 3.80 | . | | | | |
| Use of Simulation and Multimedia Resources | 21-22 years old | 53 | 3.87 | 0.51 | 0.121 | 0.886 | Failed to Reject the Null Hypothesis | not significant |
| | 23-24 years old | 16 | 3.85 | 0.43 | | | | |
| | 29 years old and above | 1 | 4.10 | . | | | | |
| Overall PKmean | 21-22 years old | 53 | 3.84 | 0.37 | 0.381 | 0.685 | Failed to Reject the Null Hypothesis | not significant |
| | 23-24 years old | 16 | 3.88 | 0.30 | | | | |
| | 29 years old and above | 1 | 4.13 | . | | | | |

** p-values <0.05 is significant

Table 9.1 indicates that there are no statistically significant differences in the extent of pedagogical knowledge related to teaching demonstration performance in science when secondary preservice teachers are grouped according to age. Across all domains—Curriculum Improvement, Teaching Practice Quality, Preservice Teacher Readiness, Use of Simulation and

Multimedia Resources, and the overall pedagogical knowledge mean—the computed p-values exceeded the 0.05 level of significance. As a result, the null hypothesis was consistently failed to be rejected, confirming that age does not significantly influence the level of pedagogical knowledge among the respondents.

These findings suggest that pedagogical knowledge in science teaching is relatively uniform across different age groups of secondary preservice teachers. This implies that the development and demonstration of pedagogical competence are less dependent on age and more likely shaped by factors such as professional preparation, training experiences, and exposure to the curriculum. Consequently, teacher education programs may focus more on enhancing instructional experiences and pedagogical training rather than considering age as a determining variable in pedagogical knowledge development.

Research-based discussions on 21st-century skills emphasize the importance of how pre-service teachers develop and perceive competencies essential for effective teaching, such as learning skills, collaboration dispositions, and ICT-related skills. Drawing from longitudinal evidence showing that these skill domains evolve differently and remain largely distinct during teacher education, the present perspective underscores the significance of examining how pedagogical knowledge relates to actual teaching demonstration performance among secondary preservice teachers in science. While pedagogical knowledge is a foundational component of teacher preparation, its relationship with observable teaching performance appears neither uniform nor automatically progressive. Similar to findings that learning and collaboration skills tend to remain stable over time while ICT skills show greater developmental change, pedagogical knowledge may develop independently of teaching demonstration proficiency.

This suggests that strong conceptual or pedagogical understanding does not necessarily translate into superior classroom performance. Understanding this nuanced relationship is significant for science teacher education, as it highlights the need for integrative training approaches that explicitly connect pedagogical knowledge with practice-based teaching demonstrations, ensuring that preservice teachers can effectively apply what they know in authentic instructional contexts. (Teemu Valtonen, 2021)

Table. 9.2. Sex

| Areas | Sex | n | wm | sd | t-value | p-value | Decision | Remarks |
|--|--------|----|------|------|---------|---------|----------------------------|-----------------|
| Curriculum Improvement | Male | 12 | 3.77 | 0.42 | -0.004 | 0.997 | Failed to | not significant |
| | Female | 58 | 3.77 | 0.45 | | | Reject the Null Hypothesis | |
| Teaching Practice Quality | Male | 12 | 4.01 | 0.40 | 1.09 | 0.28 | Failed to | not significant |
| | Female | 58 | 3.85 | 0.46 | | | Reject the Null Hypothesis | |
| Preservice Teacher Readiness | Male | 12 | 4.02 | 0.48 | -0.358 | 0.33 | Failed to | not significant |
| | Female | 58 | 3.88 | 0.44 | | | Reject the Null Hypothesis | |
| Use of Simulation and Multimedia Resources | Male | 12 | 3.83 | 0.47 | -0.358 | 0.72 | Failed to | not significant |
| | Female | 58 | 3.88 | 0.50 | | | Reject the Null Hypothesis | |
| Overall pedagogical knowledge | Male | 12 | 3.90 | 0.32 | 0.53 | 0.60 | Failed to | not significant |
| | Female | 58 | 3.84 | 0.37 | | | Reject the Null Hypothesis | |

** p-values <0.05 is significant

Table 9.2 displayed the results of the independent samples t-test examining differences in the extent of pedagogical knowledge related to teaching demonstration performance in science when respondents are grouped by sex. Across all pedagogical knowledge domains such as Curriculum Improvement, Teaching Practice Quality, Preservice Teacher Readiness, Use of Simulation and Multimedia Resources, and overall pedagogical knowledge was computed p-values exceeded the 0.05 level of significance. Consequently, the null hypothesis was consistently failed to be rejected, indicating no statistically significant difference between male and female secondary preservice teachers in terms of their pedagogical knowledge related to teaching demonstration performance.

While slight variations in weighted mean scores were observed, with male respondents obtaining marginally higher means in some domains, these differences were minimal and statistically insignificant. The findings therefore suggest that pedagogical knowledge in science teaching is comparable across sexes, implying that pedagogical competence is more strongly influenced by shared training experiences, curriculum standards, and professional preparation rather than by sex-based differences.

(Arıkan, 2025) Highlighted that teaching-related competencies and dispositions are shaped by multiple, interrelated factors rather than by academic achievement alone. Translating this idea to the context of secondary preservice science teachers, it underscores the significance of examining the relationship between teaching demonstration performance and the extent of pedagogical knowledge as a complex and non-linear one. Just as higher academic achievement does not automatically correspond to lower spatial anxiety, extensive pedagogical knowledge does not necessarily guarantee stronger teaching demonstration performance. Individual characteristics, disciplinary background, and affective factors can mediate how knowledge is enacted in teaching practice. The core idea emphasizes that pedagogical knowledge and teaching performance are distinct yet related constructs, influenced by personal dispositions and contextual experiences. Recognizing this nuanced relationship is essential in science teacher education, as it points to the need for targeted, practice-oriented interventions that help preservice teachers translate pedagogical

understanding into effective teaching demonstrations rather than assuming a direct or proportional relationship between knowledge and performance.

Table 9.3. *Civil Status*

| <i>Areas</i> | <i>Civil Status</i> | <i>n</i> | <i>WM</i> | <i>sd</i> | <i>t-value</i> | <i>p-value</i> | <i>Decision</i> | <i>Remarks</i> |
|--|---------------------|----------|-----------|-----------|----------------|----------------|--------------------------------------|-----------------|
| Curriculum Improvement | Single | 68 | 3.77 | 0.44 | 0.704 | 0.484 | Failed to Reject the Null Hypothesis | not significant |
| | Married | 2 | 3.55 | 0.64 | | | | |
| Teaching Practice Quality | Single | 68 | 3.88 | 0.46 | -0.067 | 0.947 | Failed to Reject the Null Hypothesis | not significant |
| | Married | 2 | 3.90 | 0.14 | | | | |
| Preservice Teacher Readiness | Single | 68 | 3.90 | 0.45 | -0.158 | 0.875 | Failed to Reject the Null Hypothesis | not significant |
| | Married | 2 | 3.95 | 0.49 | | | | |
| Use of Simulation and Multimedia Resources | Single | 68 | 3.88 | 0.49 | 0.792 | 0.431 | Failed to Reject the Null Hypothesis | not significant |
| | Married | 2 | 3.60 | 0.57 | | | | |
| Overall pedagogical knowledge | Single | 68 | 3.86 | 0.36 | 0.417 | 0.678 | Failed to Reject the Null Hypothesis | not significant |
| | Married | 2 | 3.75 | 0.14 | | | | |

** p-values <0.05 is significant

Table 9.3 showed the results of the independent samples t-test examining differences in the extent of pedagogical knowledge related to teaching demonstration performance in science when respondents are grouped by civil status. Across all pedagogical knowledge domains—Curriculum Improvement, Teaching Practice Quality, Preservice Teacher Readiness, Use of Simulation and Multimedia Resources, and overall pedagogical knowledge—the computed p-values exceeded the 0.05 level of significance. Consequently, the null hypothesis was consistently failed to be rejected, indicating no statistically significant difference in the extent of pedagogical knowledge between single and married secondary preservice teachers.

Despite slight differences in weighted mean scores, wherein single respondents tended to register marginally higher means across most domains, these variations were negligible and lacked statistical significance. The results indicate that civil status does not have a substantial effect on pedagogical knowledge related to teaching demonstration performance in science, suggesting that pedagogical competence is primarily influenced by shared academic preparation, training experiences, and standardized teacher education curricula rather than by individual demographic characteristics.

According to (Abadejos, 2025) reinforces the idea that strong professional attributes do not automatically translate into higher teaching performance, highlighting the complexity of the relationship between what teachers know and how they perform in instructional settings. Aligned with the civil-status dimension, the core idea suggests that personal and demographic characteristics may shape the extent of pedagogical knowledge development, yet these characteristics do not necessarily determine teaching demonstration performance among secondary preservice teachers in science. Similar to findings where cultural competence levels varied across civil status without significantly influencing teaching outcomes, pedagogical knowledge among preservice teachers may differ in extent or depth based on personal circumstances, but its influence on actual teaching demonstrations remains indirect and mediated. This underscores the significance of examining teaching demonstration performance and pedagogical knowledge as related but distinct constructs. In science teacher education, this perspective emphasizes that demographic factors such as civil status may affect learning experiences and knowledge acquisition, but

effective teaching demonstrations require deliberate opportunities to integrate pedagogical knowledge into practice rather than relying on personal characteristics alone.

Table 9.4. Program

| Areas | Program | n | wm | sd | t-value | p-value | Decision | Remarks |
|--|---------------|----|------|------|---------|---------|--------------------------------------|-----------------|
| Curriculum Improvement | BSED Sciences | 25 | 3.85 | 0.47 | 0.733 | 0.256 | Failed to Reject the Null Hypothesis | not significant |
| | BSED English | 45 | 3.72 | 0.42 | | | | |
| Teaching Practice Quality | BSED Sciences | 25 | 3.96 | 0.47 | 1.160 | 0.252 | Failed to Reject the Null Hypothesis | not significant |
| | BSED English | 45 | 3.83 | 0.44 | | | | |
| Preservice Teacher Readiness | BSED Sciences | 25 | 4.07 | 0.43 | 2.413 | 0.020 | Reject the Null Hypothesis | significant |
| | BSED English | 45 | 3.81 | 0.44 | | | | |
| Use of Simulation and Multimedia Resources | BSED Sciences | 25 | 3.99 | 0.48 | 1.549 | 0.126 | Failed to Reject the Null Hypothesis | not significant |
| | BSED English | 45 | 3.80 | 0.49 | | | | |
| Overall pedagogical knowledge | BSED Sciences | 25 | 3.97 | 0.37 | 2.035 | 0.046 | Reject the Null Hypothesis | significant |
| | BSED English | 45 | 3.79 | 0.34 | | | | |

** p-values <0.05 is significant

Table 9.4 presents the results of the independent samples *t*-test comparing the extent of pedagogical knowledge related to teaching demonstration performance in science when respondents are grouped according to academic program. The findings reveal mixed results across the pedagogical knowledge domains.

For Curriculum Improvement, Teaching Practice Quality, and Use of Simulation and Multimedia Resources, the computed *p*-values (0.256, 0.252, and 0.126, respectively) are all greater than the 0.05 level of significance. Hence, the null hypothesis is failed to be rejected, indicating no statistically significant difference between BSED Sciences and BSED English students in these areas, despite slightly higher weighted means observed among BSED Sciences respondents.

In contrast, statistically significant differences are observed in Preservice Teacher Readiness ($p = 0.020$) and overall pedagogical knowledge ($p = 0.046$). In both cases, the null hypothesis is rejected, signifying that the extent of pedagogical knowledge differs significantly by program. Specifically, BSED Sciences students obtained higher weighted means in Preservice Teacher Readiness ($WM = 4.07$) compared to their BSED English counterparts ($WM = 3.81$), as well as in overall pedagogical knowledge ($WM = 3.97$ versus 3.79). These results suggest that preservice teachers enrolled in the BSED Sciences program demonstrate a significantly higher level of readiness and overall pedagogical knowledge related to teaching demonstrations in science.

Overall, the findings imply that while most pedagogical knowledge domains are comparable across programs, enrollment in the BSED Sciences program is associated with significantly higher preservice teacher readiness and overall pedagogical knowledge in teaching science. This may be attributed to greater alignment of the science program with content-specific pedagogy, instructional strategies, and experiential learning opportunities directly relevant to science teaching, thereby better preparing students for effective teaching demonstrations in the discipline.

The discussion on the scholarship of teaching emphasizes that effective science teaching arises from the complex and often-tacit integration of content knowledge, pedagogy, and classroom practice. Pedagogical

Knowledge (PK) provides a meaningful framework for making this professional knowledge visible, articulated, and applicable, particularly through approaches such as CoRe and PaP-eRs that translate abstract pedagogical understanding into concrete teaching representations. Aligned with the teacher education program context, this idea highlights the significance of examining the relationship between teaching demonstration performance and the extent of pedagogical knowledge among secondary preservice teachers in science. Pedagogical knowledge, while essential, gains instructional value only when it is successfully enacted in teaching demonstrations. Teacher education programs therefore play a crucial role in bridging this gap by systematically supporting preservice teachers in externalizing and applying their pedagogical understanding through structured, practice-based tools. Understanding this relationship underscores the importance of program designs that not only develop pedagogical knowledge but also explicitly connect it to observable teaching performance, thereby strengthening the quality and coherence of science teacher preparation. (John Loughran, 2012)

Table 10.1. *The r-value Distribution on the correlation of Pedagogical Knowledge and Teaching Demonstration Proficiency Level*

| <i>Areas</i> | <i>Mean</i> | <i>Level</i> | <i>r-value</i> | <i>Degree Of Correlation</i> | <i>p-value</i> | <i>Decision</i> | <i>Remarks</i> |
|--|-------------|--------------|----------------|--------------------------------|----------------|--------------------------------------|-----------------|
| Curriculum Improvement | 3.77 | High Extent | -0.16 | Negative very weak Correlation | 0.185 | Failed to Reject the Null Hypothesis | not significant |
| Teaching Practice Quality | 3.9 | High Extent | -0.158 | Negative very weak Correlation | 0.191 | Failed to Reject the Null Hypothesis | not significant |
| Preservice Teacher Readiness | 3.9 | High Extent | -0.075 | Negative very weak Correlation | 0.536 | Failed to Reject the Null Hypothesis | not significant |
| Use of Simulation and Multimedia Resources | 3.87 | High Extent | -0.134 | Negative very weak Correlation | 0.269 | Failed to Reject the Null Hypothesis | not significant |
| Overall pedagogical knowledge | 3.86 | High Extent | -0.17 | Negative very weak Correlation | 0.160 | Failed to Reject the Null Hypothesis | not significant |

Legend: * significant at 5%; **significant at 1%

The correlation coefficients presented in Table 10.1 reveal consistently negative r-values ranging from -0.075 to -0.17 , indicating inverse relationships between pedagogical knowledge domains and teaching demonstration proficiency. A negative correlation signifies that higher levels of pedagogical knowledge are associated with slightly lower levels of observed teaching demonstration proficiency. However, it is essential to underscore that all correlations are very weak in magnitude, suggesting minimal practical significance and limited predictive value.

Specifically, the inverse relationship observed for Curriculum Improvement ($r = -0.16$) suggests that higher self-reported pedagogical knowledge related to curriculum design and alignment is marginally associated with lower teaching demonstration proficiency. This finding should not be interpreted as a decline in teaching competence; rather, it may reflect inconsistencies between theoretical knowledge and its application in performance-based teaching contexts, where curriculum understanding does not immediately translate into observable instructional effectiveness.

Similarly, Teaching Practice Quality ($r = -0.158$) demonstrates a weak inverse association, implying that stronger perceptions of teaching practice quality may not yet be fully operationalized in actual

teaching demonstrations. This pattern may indicate the presence of a theory–practice gap, wherein preservice teachers possess conceptual clarity but are still developing the skills required to enact these principles effectively during instructional delivery.

The Preservice Teacher Readiness domain exhibits the weakest inverse relationship ($r = -0.075$), approaching a negligible level of association. This near-zero correlation suggests that perceived readiness, although rated highly, has little to no meaningful influence on teaching demonstration proficiency, highlighting the distinction between self-assessed preparedness and observable teaching performance.

With respect to the Use of Simulation and Multimedia Resources ($r = -0.134$), the weak inverse correlation indicates that increased familiarity with instructional technologies does not necessarily enhance teaching demonstration proficiency. This finding may suggest that an emphasis on technological tools, when not strategically integrated, can shortly divert attention from core pedagogical practices during teaching demonstrations.

On the other hand, Overall Pedagogical Knowledge ($r = -0.17$) demonstrates a consistently inverse yet very weak association with teaching demonstration proficiency, indicating that higher levels of aggregated pedagogical knowledge are not directly associated with improved performance in teaching demonstrations and, instead, show a slight tendency in the opposite direction.

When considered collectively, the negative correlation coefficients suggest a converse relationship between pedagogical knowledge and teaching demonstration proficiency. However, the very weak magnitude of these correlations, together with their non-significant p-values, indicates that the observed inverse relationships lack statistical significance. These findings imply that pedagogical knowledge, if not adequately supported by guided practice, mentoring, and experiential learning opportunities, may remain largely theoretical and may not readily translate into observable teaching competence. As such, the results underscore the critical need to strengthen the integration of theory and practice in preservice teacher education, rather than relying solely on the accumulation of pedagogical knowledge.

(Sigrid Blömeke, 2015) Emphasizes that competence in higher education should be understood as a continuum rather than a simple dichotomy between knowledge and performance. Competence begins with underlying traits and pedagogical understanding that shape perception, interpretation, and decision-making, which are eventually manifested in observable teaching behaviors in real instructional settings. Applied to the distribution of the correlation between pedagogical knowledge and teaching demonstration proficiency, this perspective suggests that pedagogical knowledge represents a foundational latent competence, while teaching demonstration proficiency reflects its enacted, real-world expression. Variations in their correlation can therefore be expected, as differences in measurement focus, contextual factors, and performance conditions may influence how strongly knowledge is translated into practice. Rather than viewing weak or inconsistent correlations as contradictory, this framework supports interpreting them as evidence that pedagogical knowledge and teaching performance are related yet distinct dimensions of competence. This understanding reinforces the need for assessment approaches that capture both underlying pedagogical knowledge and observable teaching proficiency to obtain a more comprehensive and accurate picture of preservice teachers' competencies.

CONCLUSION

1. In summary, the demographic profile of the respondents reveals a highly concentrated and relatively homogeneous sample, predominantly composed of 21–22-year-old individuals, females, and single participants. With the majority falling within early adulthood, the findings largely reflect the perspectives of younger adults, while the minimal representation of older age groups limits broader age-based generalization. Furthermore, the significant predominance of female respondents suggests that the results are mainly shaped by female viewpoints, and the overwhelming proportion of single participants indicates that the experiences and insights captured in the study primarily represent

- unmarried individuals. Taken together, these demographic characteristics should be carefully considered when interpreting the findings and assessing their applicability to more diverse populations.
2. The distribution of respondents by academic program shows a higher representation from the BSED English program compared to BSED Sciences. This imbalance implies that the overall findings may be more reflective of the experiences and perspectives of English majors. While both programs are represented, the disproportionate distribution should be considered when interpreting results related specifically to science teacher preparation.
 3. The proficiency level of respondents in science teaching demonstrations is generally high, with most participants achieving Very Satisfactory to Outstanding ratings. The absence of low-performing categories and the minimal variation in scores indicate consistent performance among respondents. These results suggest that preservice teachers possess a strong foundation in science teaching competencies prior to deployment.
 4. The study concludes that age, sex, and civil status do not significantly affect the pedagogical knowledge of secondary preservice science teachers, as results across all domains showed no statistically significant differences. This indicates that pedagogical competence is consistent across demographic groups and is more strongly influenced by professional preparation, standardized curricula, and shared training experiences. Therefore, enhancing instructional design, pedagogical training, and experiential learning should be prioritized over demographic considerations in teacher education programs.
 5. In conclusion, it shows that academic program has a partial influence on pedagogical knowledge related to science teaching demonstrations. While most pedagogical domains are comparable between BSED Sciences and BSED English students, BSED Sciences students demonstrate significantly higher preservice teacher readiness and overall pedagogical knowledge. This suggests that stronger alignment of the science program with content-specific pedagogy and experiential learning better prepares preservice teachers for effective science teaching demonstrations.
 6. The findings indicate that curriculum improvement contributes to the development of pedagogical content knowledge at a high extent. Preservice teachers perceive the Teacher Education Program as effective in providing pedagogical support, innovative teaching strategies, and structured lesson planning opportunities. However, the moderate rating in experiential learning opportunities highlights the need to further strengthen hands-on and inquiry-based teaching experiences within the curriculum.
 7. Teaching practice quality is shown to have a strong influence on the development of pedagogical knowledge. Respondents demonstrate high competence in lesson preparation, differentiated instruction, assessment practices, and consideration of students' prior knowledge. Nonetheless, moderate ratings in content confidence and experimental skills suggest areas where additional support and reinforcement may further enhance teaching effectiveness.
 8. Preservice teacher readiness was rated at a high extent, indicating that respondents generally feel prepared for science teaching responsibilities. Strengths are evident in reflective practice, collaboration, and student-centered instruction. Although overall readiness is strong, slightly lower ratings in emotional preparedness and subject mastery suggest the need for continued support to ensure full confidence during actual classroom deployment.
 9. The integration of simulations and multimedia resources is perceived to significantly support the development of pedagogical content knowledge. Respondents report high levels of confidence and effectiveness in using technology to enhance student engagement and conceptual understanding. Despite reported challenges in accessing high-quality resources, the overall findings affirm the important role of digital tools in strengthening science-teaching practices.
 10. Overall, the composite assessment indicates a high level of pedagogical content knowledge development among secondary preservice science teachers. Teaching practice quality and preservice teacher readiness emerge as the strongest contributing areas, while curriculum improvement and the use of simulations and multimedia resources also play substantial roles. Although the results are

positive, further alignment of theory and practice, strengthened mentoring, and enhanced access to instructional resources may further improve PCK development and the effectiveness of teacher education programs.

11. Lastly, result indicate a generally inverse but very weak relationship between pedagogical knowledge and teaching demonstration proficiency, suggesting that higher levels of perceived pedagogical knowledge do not necessarily translate into stronger observable teaching performance.
12. These weak and non-significant relationships imply the presence of a theory–practice gap, where preservice teachers may possess conceptual understanding but have difficulty applying it effectively during teaching demonstrations. Overall, the results highlight that pedagogical knowledge alone is insufficient to ensure teaching competence and emphasize the importance of guided practice, mentoring, and experiential learning to bridge the gap between theoretical knowledge and actual instructional performance.

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