



HYBRID TEACHING DELIVERY READINESS OF SCIENCE PRE-SERVICE TEACHERS: BASIS FOR PROPOSED TRAINING PROGRAM

Bon Joseph D. Panton ¹, Leslie Kaye M. De Guzman ¹, Daniel S. Hernandez ²,
Janine D. Millar ², Jael Caleb G. Galima ², Corina N. Samin ³

¹ De La Salle University, Manila, Philippines

² Pamantasan ng Lungsod ng Valenzuela, Valenzuela City, Philippines

³ University of the Philippines Open University, Los Baños, Laguna, Philippines

ABSTRACT

The COVID-19 pandemic has posed challenges worldwide, especially in Philippine education, prompting a shift from traditional face-to-face classes to blended and online learning. Moreover, hybrid modality has been introduced and is considered one of the best options today, as it allows students to attend classes in person or online. But this requires teachers, especially pre-service teachers, to be better equipped for this modality and aligned with the domains of the TPACK framework. This study aimed to determine the readiness of science pre-service teachers in hybrid teaching in June 2023. A descriptive statistics research design was used to assess 15 SPSTs' competencies in a hybrid teaching set-up through assessments by the SPSTs and their instructors during a hybrid teaching demonstration. Results showed that the SPSTs were competent but needed to develop in several areas, including content mastery and laboratory practicum, lesson planning, teaching methods and strategies, classroom management, and ICT skills for hybrid teaching. The researchers proposed a training program comprising a series of workshops/seminars/webinars to help the SPSTs develop their teaching competencies in a hybrid setting, covering the areas identified by this study.

Keywords: *hybrid teaching, TPACK framework, delivery readiness, training program, pre-service teachers, science education, COVID-19 pandemic*

INTRODUCTION

A virus that turned the world upside down is how people describe the coronavirus disease, or COVID-19, which was first detected in Wuhan, China. The disease had progressed dramatically, changing the lives of everyone in a blink, particularly in the education sector. As a result, many schools and universities were immediately closed, and students were not allowed to attend classes for months to minimize the spread of the virus. A United Nations Educational, Scientific, and Cultural Organization (UNESCO) (2020) article reported that at least 363 million learners worldwide from preschool to tertiary education were affected by the pandemic, with 57.8 million in higher education. In addition, almost 15 countries issued nationwide school and university closures, and 14 issued only localized closures, including Europe, the Middle East, North America, and Asia. In pursuit of continuous education, most countries have implemented distance and online learning, including the Philippines, until now.

In DepEd Order No. 012, series of 2020, the Department of Education launched the "Basic Education-Learning Continuity Plan" in response to the ongoing pandemic, aiming to keep children, teachers, and staff safe and provide quality distance learning. A blend of remote-learning options was mentioned, such as (1) online platforms, (2) educational television and radio, (3) self-learning modules, and (4) a combination. As such, the term "blended learning set-up" is introduced and widely adopted as schools formally open the new school year 2021-2022. With this, schooling over the past two years has come to every learner's home, either through online platforms such as Google Meet, Facebook Live, Educational TV, and Zoom meetings, or through self-learning modules, where parents supervise and serve as the teacher. However, learning experiences still vary, particularly in low-income households, which need more budget for preparation for the new learning setup, including technological devices and internet connectivity. In the last Social Weather Station (SWS) survey (2020), 9 out of 10 Filipino families with enrolled members believed that blended learning is more challenging than the face-to-face setup. Before, technology was only a tool for engaging students in teaching and learning. However, due to the previous health crisis, this has become a medium for continuing and transforming education.

Despite the challenges encountered during the implementation of blended learning, the pandemic accelerated the integration of technology into education and transformed teaching and learning into a new, flexible educational approach—hybrid learning. As Ngan (2022) described, "hybrid classes can be conducted with students physically present in the room, but there can also be students tuning in remotely online, with the teacher monitoring their presence on a big screen at the back." Raes (2021) further emphasized that this modality has been in use since 2017, aiming to promote pedagogical freedom to reach all learners and educators worldwide, broadening access to education while enhancing its quality. A hybrid learning setup, also known as a concurrent classroom, is one in which students in a class learn simultaneously, both online and face-to-face (Ladd, 2020).

Transitioning from traditional face-to-face to distance learning was a complete shock for students and teachers. Amid the pandemic, teachers were also labeled "frontliners" in the education sector. Expecting them to be flexible despite the challenges, such as modifying their teaching delivery, evaluating students, communicating with the learner's guardian, and investing significantly in the technological resources needed to accommodate the new normal setup. Also, this required them to attend brief training sessions and seminars to learn more about the new modality and gain sufficient technical knowledge. Though hybrid learning has been introduced in some other countries long before, the Philippines does not recognize the importance of emerging technology as essential to education. A survey by Steiner and Woo (2021) found that teachers ranked hybrid teaching as the most stressful part of their jobs, followed by remote teaching and changes in instructional style. Given these challenges, the education sector in the Philippines is still eyeing the transition to a hybrid learning set-up.

On the other hand, teachers also encounter challenges in online learning. Gurung (2021) mentioned that teachers reported that internet connectivity is one of the challenges in online learning, affecting the clarity of their voices and contributing to students losing interest and becoming unmotivated to participate in discussions. Furthermore, he emphasized that teachers spent more time preparing their instruction and discussions in online classes because they needed more technological and software knowledge. With these challenges in face-to-face classes and online learning, one must realize that, if hybrid learning is seen as one of the modalities for the new normal, especially in the country, the combination of these challenges must be considered and addressed to implement this type of learning successfully. The demands on teachers in a hybrid setup were a combination of their competency and their knowledge of technology. According to Lock (2021), there are two factors for teachers to consider to make hybrid learning successful: pedagogy and technology. She also introduced the term resilient pedagogy, which is an approach that applies activities and discussions to both face-to-face and online learners. The use, placement, and technology utilization also make hybrid learning successful. Shah (2021) stated that many teachers need the right equipment or technology to roam around the classroom among in-person students, while online students can continue to see and hear them. Furthermore, lessons had to be reinvented to make sense to both sets of learners simultaneously. As highlighted in an interview with Jason Bradshaw, a science teacher with CBC News, he mentioned how it is often an impossible task to teach in a hybrid set-up because he has to prepare his production gear, such as computer, webcam, and tablets, before the class and also keeping the students of both in-class and online students engage during the discussion all at the same time (Wong, 2021, para. 4).

In a study by Mutya and Palero (2022), the authors assessed science teachers' readiness for online learning and examined their practices, self-efficacy beliefs, and attitudes toward the shift in learning modality brought about by the pandemic. It revealed that science educators possessed the needed competencies for online learning and remote teaching. However, teachers needed help planning their lessons, preparing assessments, engaging with their families and students through technology, and designing class activities. They found that science teachers' readiness for online education was high

across all indicators, which they interpreted as evidence that they still possess competencies despite the struggles and challenges brought on by the pandemic. Moreover, Ramirez (2020) stated that pre-service teachers may be ready for their responsibilities as educators once their teaching skills have been established through teacher preparation programs and professional development. Moreover, he stressed that the facilitators of these training sessions were challenged in teaching and preparing pre-service teachers for a knowledge- and technology-driven society as they integrate content, pedagogy, and technology into their instruction. Similarly, Velasco and Cañada (2020) emphasized how proper training in teaching approaches, course delivery, and learner assistance were essential in improving the teacher's competence in an online set-up, such as being able to use Microsoft Office, a web browser, sending mail with attachments, and an online video conferencing app for online teaching to be effective. Furthermore, Bihasa (2022) noted that educators should benefit from the role technology plays in the education sector today, as it motivates students, provides new learning experiences, and enables them to achieve their full potential.

Additionally, Olurinola and Adelana (2022) stated that pre-service teachers in the Department of Science and Technology preferred either hybrid or remote learning because they had been adjusted to the changes brought by the pandemic. It implied that science and PST could be taught and learned online. Mikeska et al. (2022) reported that the pandemic has posed new challenges for teaching programs in preparing PSTs, as modalities shifted from face-to-face classes to online instruction and blended learning, and then to hybrid instruction. Morrison (2021) further argued that teaching programs must evolve, including the practice and learning of pedagogy that involves online learning to meet the demands of the new education in preparing PSTs. Moreover, the shift has affected PSTs' opportunities to engage and teach effectively, as they are accustomed to the traditional setup.

Educators are crucial to ensuring continuous education for learners amidst the health crisis. Agayon et al. (2022) discussed how teachers need more experience in the current situation, especially the modality used for the new normal, particularly the distance and online learning setup. In addition, lesson planning, internet access, knowledge, the availability of technological applications or devices, assessment, and classroom management are among the factors that have changed the basic assumptions every teacher faces in the new normal (Mayol, 2020). As revealed in the study by Al Fajri et al. (2021), most teachers needed to be more proficient in using technology in their instruction to engage students in the teaching-learning process. With these challenges and demands, and given the transition to a hybrid learning set-up in the country, educators need to attend training, webinars, or seminars to improve their instruction as they utilize technological resources. Pre-service teachers who are expected to graduate this year and in the coming years must now possess the necessary skills, knowledge, and competencies to navigate a hybrid learning setup as the new normal in education, to prevent the challenges faced by current educators.

The Manila Standard (2022) noted the need for training programs, digital materials, and resources to enable them to conduct online classes during the pandemic. Hernando-

Malipot (2022) also mentioned that the Department of Education implemented the Digital Rise Program to provide teachers with access to technology, the materials and resources they need, and the skills for digital teaching. The DepEd also created the DepEd Commons Learning Resources Portal as a significant platform to access a wide range of self-learning modules and learning materials for every year level in junior and senior high school. Training programs for teachers are vital as they will hone and enhance teachers' skills and competencies in adjusting the teaching-learning method after the pandemic ends. In the sudden shift in teaching, teachers must strengthen their skills to retain their knowledge.

Nevertheless, since teachers were the frontliners of education, they were ready to adapt to the implemented changes. Teachers must develop ICT skills to successfully manage online education, as they will stay up to date if their skills align with the new teaching modality. As Ventayen (2018) notes, although teachers have yet to gain experience in online education, they are ready to adapt to these changes and enhance their teaching competency. She also suggested continuing online education to adapt continuously and be ready for the growth and development of education. Furthermore, science pre-service teachers may develop technological skills during their education to be fully ready for the new teaching modality. The study by Agayon et al. (2022) also found that teachers had difficulty adjusting to the new normal learning modality. It required patience as they faced various challenges, including internet connectivity, module distribution and retrieval, quality of learning transfer, and students' inquiries and difficulties. Hence, this led to the idea of measuring SPSTs' competencies in facing different challenges during their hybrid instruction.

As the education system introduces a new modality, teachers' assessments must be conducted, especially to assess their mastery of the subject content, to ensure the quality of the education they provide learners. In the study by Ekiz-Kiran et al. (2021), it was observed that the PST examined the content knowledge not only of the subject but also of the curriculum, instructional strategies, etc., and considered this important in developing their content knowledge. These were based on the SPST's self-assessment and reflection. Moreover, sufficient scientific knowledge and literacy are related to one's self-efficacy, wherein students' achievement would be the product of these two variables. Thus, it is emphasized that universities should develop programs for pre-service teachers that provide them with more learning experience in the context of science to increase their self-efficacy, thereby resulting in positive learning outcomes for their students (Catalano et al., 2019). On the other hand, addressing a student's queries not only corrects misconceptions but also shows that he or she has mastered the content beyond the textbook. An article by Bowen (2021) found that addressing student queries fostered a sense of belonging, increasing students' academic performance and motivation in the classroom. In this research, the researchers concluded that addressing students' queries enhances their engagement and academic performance in science education.

Self-efficacy among PSTs is essential, as it shows how their beliefs about teaching affect their ability to assess their teaching styles and strategies. In the study of Kartal and Dilek (2021), through time, differences in circumstances, environment, and such can affect the

self-assessment of PSTs, which might cause personal biases– it could be positive or negative towards themselves. As also presented in the study by Savec and Wisiak (2017), the instructor's perception differs from PSTs' perception of their pedagogy in classroom teaching. The mentors' comments during the evaluation of PSTs' first presentations helped them improve their pedagogy for their final presentations; however, the pre-service teachers believed that their experience and being in the actual classroom were what enabled them to improve their presentations. Subsequently, it is presented that PSTs' self-evaluations leaned towards self-esteem, whereas mentors' assessments provided a more detailed evaluation of PSTs' performance in the structure of chemistry lessons, teaching methods, student engagement, and discipline.

According to Wilichowski and Cobo (2021), teachers need to develop and cultivate their technical skills while enhancing their role in the classroom. Technical skills were specialized expertise and practical tasks involving technology and information in real-life situations. As technology is integrated into the classroom, various challenges may arise during instruction. These challenges include internet connectivity loss, glitches, and bugs. In line with this, Ghavifekr et al. (2016) suggested that teachers need to be prepared for these challenges and issues, as ICT and new technologies may create more opportunities and improve the quality of education. Formont (2020) stated that remote or hybrid learning helped teachers communicate effectively with students and reach their parents and families. Learning can still occur amid a pandemic; however, the learning experience has changed. Communication was a critical aspect of distance learning, but it also helped teachers understand how to reach their students while teaching remotely.

In addition, Will (2020) mentioned that teachers must be flexible in hybrid instruction. Teachers must know how to adjust to a new normal setup and be more creative than they used to be. A hybrid teaching setup gives students more opportunities to work independently, making them globally competitive. As targeted support and explicit instruction are the keys to hybrid learning, teachers must know how to record themselves delivering the lessons for an online school learning platform. Learner-centered approaches have been used in hybrid learning set-ups, which also help the students and teachers create a better teaching and learning experience. 21st-century education was said to be more technology- and student-centered, challenging educators to be innovative in engaging students. Oyelekan et al. (2019) emphasized that innovative strategies will lead to better student engagement and academic performance. In addition, their study found that years of teaching experience and the use of innovative teaching strategies did not interact. Therefore, this suggests that experienced or inexperienced teachers can innovate their teaching strategies to accommodate the ever-changing context of the education sector. And lastly, these strategies will make learning in science more meaningful and active. With technology, teachers can make the class more interactive and exciting. According to Sudarsana et al. (2017), teachers must be able to use and integrate technologies into the teaching-learning process. It increases learning and attracts students who want to learn. As the world changes, education is improving, and teachers must research and stay up to date on new technologies that will help them teach more efficiently and improve the quality of learning in school.

Due to the pandemic, there were changes, particularly in the education sector, as teachers integrated technology into their instruction, which led Grigsby (2021) to his study assessing the technological knowledge of elementary preservice teachers. Russo and Siko (2018) further elaborated that there was a continuous decrease in confidence for teachers with regard to the integration of technology, as it required them to acquire skills in implementing a variety of technologies in their discussions to demonstrate effective teaching that will reflect the learning outcomes of students; thus, preparation programs were implemented. In addition, Herold (2021) stressed how teachers during the pandemic tried to recreate the teaching-learning process in a traditional classroom in the online setup. He also explained that even though the younger and present PST were knowledgeable about different applications or software, such as PowerPoint Presentations and a learning management system, they were not taught how to utilize them in actual teaching since technology integration courses in the US were limited to teaching the functionality of a particular software used in an online environment. With this, Grigsby (2021) suggested that the curriculum must include technology courses that will build SPSTs' knowledge of technology and how they will implement it in their lesson plans and the discussion itself.

Correspondingly, the study by Isidro and Teichert (2021) focused on assessing pre-service teachers' experiences in online education, specifically their virtual teaching practice, which led them to teach online due to COVID-19. The subjects' narratives revealed that pre-service teachers used their traditional knowledge in teaching and later improved when needed. In practice, these pre-service teachers identify their students' needs; thus, improving their knowledge helps them become effective and efficient teachers. In addition, improving their knowledge will lead them to practice their social skills, especially by observing their students' knowledge needs.

Guided by the TPACK framework (Koehler & Mishra, 2006; McGraw-Hill, 2019), the main basis and primary foundation of this study, which was then applied to different theoretical models, specifically TAM and PCK. Granić and Marangunić (2019) explained the technology acceptance model as the process by which users accept or reject modern technology and form an intention to use it. On the other hand, Kultsum (2017) identified the Pedagogical Content Knowledge Model as the teacher's knowledge of the subject matter, infused with appropriate pedagogical application during the teaching and learning process, that a teacher must possess to ensure the quality of the learning the student receives. The combination of these theoretical models led to the TPACK Model, a complex interconnection among the three knowledge components: technology, content, and pedagogy. Furthermore, Kultsum (2017) distinguished the components of the PCK model necessary for developing the quality of teaching and the professionalism of teachers, namely: pedagogical competency, subject-matter knowledge, integration of pedagogy and subject-matter knowledge, and integration of pedagogical knowledge and professional competencies. These explained the proficiency of pre-service teachers in content and pedagogy, given the new normal setup.

As applied to this study, the implications of TPACK theories explained that readiness was crucial, particularly for content mastery, teaching strategies, and technological integration

by educators in a hybrid learning setup. This was applied to assess SPST readiness, which served as a basis for developing a training program, as illustrated in the study's paradigm (Figure 1).

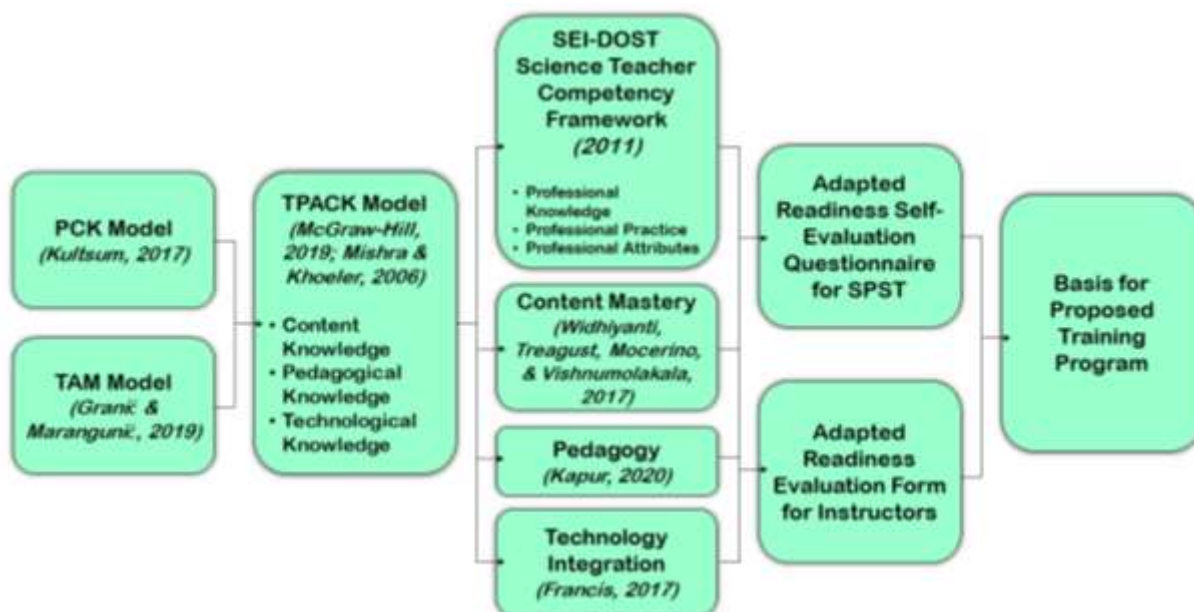


Figure 1. Paradigm of the study guided by the PCK, TAM, and TPACK model

Since essential components of TPACK were utilized in this research, the concepts of Widhiyanti et al. (2017), Kapur (2020), Francis (2017), and the science teacher education framework of the Department of Science and Technology - Science Education Institute and University of the Philippines National Institute for Science and Mathematics Education Development (2011) further helped establish the framework of this study. With their combined concepts, this research adapted a readiness questionnaire from Schmidt et al. (2009) that will be modified according to the concepts and indicators in assessing the competencies of the SPSTs, namely, content knowledge, pedagogical knowledge, and technological knowledge. Moreover, to strengthen the data gathered, the SPSTs had to conduct a teaching demonstration, during which they took their self-evaluations, and the instructors from the university's science department had to evaluate them. Based on evaluations from both SPST and instructors, the researchers assessed and compared the results, which served as a basis for the proposed training program to enhance the SPST's competency in preparation and readiness for hybrid teaching delivery.

Research Questions

This research aimed to provide a basis for developing a teacher training program to enhance SPSTs' competencies and readiness for a hybrid teaching modality. Furthermore, the researchers sought to answer the following:

1. What is the level of SPSTs' competencies as revealed by:

- a. Instructors' evaluation?
 - b. SPSTs' self-evaluation?
2. Is there a significant difference between instructors' evaluation and SPSTs' self-evaluation in terms of content knowledge?
3. Is there a significant difference between instructors' evaluation and SPSTs' self-evaluation in terms of pedagogical knowledge?
4. Is there a significant difference between instructors' evaluation and SPSTs' self-evaluation in terms of technological knowledge?

METHODOLOGY

This study used a descriptive statistics research design to identify differences in the competencies of science pre-service teachers (SPSTs) as revealed by SPST and instructor evaluation forms, providing a basis for a training program to develop their readiness for a hybrid teaching modality. Kintu et al. (2017) highlighted that a descriptive statistical research design was used to determine the significance of the variables using statistical tools. This research used a quantitative research design lens to analyze and evaluate the results. An evaluation form for both SPSTs and instructor was administered to assess the content knowledge, pedagogical knowledge, and technological knowledge of the SPSTs in defining their readiness in a hybrid teaching set-up.

This study was conducted in a public local college/university in Valenzuela City, founded in 2002. To assess the SPSTs' competencies, respondents conducted a hybrid teaching demonstration on the university's premises. Audiences included first-year students attending the in-person class, while others attended online via Google Meet to maximize the hybrid modality. Moreover, third-year science pre-service teachers conducted their teaching demonstration in a hybrid modality and evaluated themselves afterward. Since this research used a purposive sampling technique, third-year pre-service teachers enrolled in the Bachelor of Secondary Education (BSED) major in science program were selected as the sample. A total of 15 SPSTs will be the sample of this research.

This research used a four-point Likert scale to assess the SPSTs' competencies in a hybrid teaching modality. The evaluation forms used in this research were adapted from the survey questionnaire of Schmidt et al. (2009) and applied the synthesized concepts from the essential components of the TPACK model: content, pedagogy, and technological knowledge, as well as the Philippine Science Teacher Education Framework. The evaluation forms are classified into: (1) SPST's self-evaluation form, which will be given after they conduct their teaching demonstration in a hybrid modality, and (2) the instructor's evaluation form to evaluate the SPSTs' competencies in a hybrid teaching modality.

Table 1. Distribution of items and sample statements for instructors' and a self-evaluation tool for SPSTs

Competencies	Number of items	Sample statements
Content Knowledge	10	Knowledge about science concepts, principles, generalizations, theories, and laws.
Pedagogical Knowledge	10	Ability to use explicit instruction during discussions in class.
Technological Knowledge	10	Confident in using different online learning delivery modalities and knowing their functions and features.

Each survey questionnaire was composed of four parts: (1) Profile of the SPST/Instructor; (2) questions assessing the content knowledge of the SPSTs; (3) questions assessing the pedagogical knowledge of the SPSTs; and (4) questions assessing the technological knowledge of the SPSTs. Apart from the profile, each part comprises ten questions, with the following scale: 4 – strongly agree; 3 – agree; 2 – disagree; 1 – strongly disagree. Weighted means of the evaluation forms were used to determine the level of competency of the SPST and interpreted as follows:

Table 2. Weighted mean scale interpretation

Weight	Scale	Interpretation
4	3.25 - 4.00	Strongly agree
3	2.50 - 3.24	Agree
2	1.74 - 2.49	Disagree
1	1.00 - 1.74	Strongly disagree

These research instruments had undergone face and content validation by the three research instrument validators. A two-week period was allotted to assess the validity of the research instruments. Certification of the validated research instruments has been issued to the research validators for verification of their validity.

Pre-Implementation

Before the data-gathering process, the researchers sent a request letter to the three instructors who participated in the study. The researchers had also sent a request letter to an instructor from the faculty for approval to use the course People and the Earth's Ecosystems, a general science education course with course code MST 2, as the course of discussion for the SPSTs during the conduct of their hybrid set-up teaching demonstration. Upon their approval to serve as evaluators of the hybrid set-up teaching demonstration for the SPSTs, the researchers met with the respondents and briefed them on the research and the data collection process for this study. In addition, respondents were given two weeks' preparation for their teaching demonstration in a hybrid teaching modality. First-year BSED students were invited, with their instructor's approval, to serve as the respondent's audience during the teaching demonstration. After validating the research instruments for this study, the researchers obtained approval from the dean of

the target college to conduct the study and administer the instruments to the respondents. The researchers had also secured permission from the institution's registrar, upon the recommendation of the University's service office admin, to use a room for data collection.

During Implementation

The third-year SPSTs delivered a 20-minute teaching demonstration, as shown in Figure 1, in a hybrid teaching modality to assess their competencies in this modality. The SPSTs were clustered into three batches to maximize the course duration. They had been given the topics that would be taught in the course People and the Earth's Ecosystem. The audience could attend either the in-person class in the institution or the online class via Google Meet.



Figure 2. Hybrid teaching demonstration of selected SPSTs

On the day of the teaching demonstration, the researchers distributed the evaluation form to the panel of evaluators beforehand. They were given time after each session to complete the evaluation forms. On the other hand, self-evaluation forms were given to the SPSTs after their teaching demonstration to help them reflect on their performance. The researchers collected the evaluation forms after respondents and the panel finished answering them and consolidated them afterward.

Post Implementation

After administering the hybrid set-up teaching demonstration and consolidating the data, results were processed and analyzed using statistical methods to provide the information needed to address the research questions. Two statistical treatments were used in order to analyze the data collected from the survey: weighted mean was the first statistical treatment to be used in order to determine the levels of competencies of SPSTs from both evaluation forms answered by the SPSTs, and the instructors who evaluated their performance, and paired t-test was utilized in order to determine the difference among the evaluations of instructors and SPSTs on their content, pedagogical, and technological knowledge. In this research, Microsoft Excel was utilized, and the weighted mean formula was used to determine the level of competence of the SPSTs in a hybrid teaching modality. The *AnalySTAT* statistics calculator was used to identify differences between the evaluation forms using the paired t-test.

RESULTS

The instructors' and SPSTs' self-evaluations were divided into three competencies: content knowledge, pedagogical knowledge, and technological knowledge. Each category contains 10 statements that evaluate the SPSTs' abilities and competencies during their hybrid teaching demonstration.

Content Knowledge

Table 3. SPSTs' level of content knowledge based on the instructors' and SPSTs' self-evaluation

Statements	Instructors' Evaluation		SPSTs' Self-Evaluation	
	Weighted Mean	Verbal Interpretation	Weighted Mean	Verbal Interpretation
1. Knowledge about science concepts, principles, generalizations, theories, and laws.	3.60	Strongly agree	3.33	Strongly agree
2. Relating concepts of science to real-life activities	3.65	Strongly agree	3.80	Strongly agree
3. Connecting concepts of science to other areas or disciplines.	3.24	Agree	3.40	Strongly agree
4. Updated on the recent scientific research and discoveries	3.22	Agree	3.40	Strongly agree
5. Dealing with students' queries beyond	2.87	Agree	3.20	Agree

textbooks				
6. Confident in detecting and clarifying students' science misconceptions.	2.89	Agree	3.27	Strongly agree
7. Using other references to support the concept provided by the school's textbook.	3.27	Strongly agree	3.60	Strongly agree
8. Simplifying complex topics in science.	3.44	Strongly agree	3.53	Strongly agree
9. Knowledge of experimentation and skills in laboratory equipment.	2.00	Disagree	3.07	Agree
10. Willingness to attend local and international scientific webinars/seminars.	2.56	Agree	3.53	Strongly agree
General Weighted Mean	3.06	Agree	3.41	Strongly agree

Table 4. Difference between instructors' evaluation and SPSTs' self-evaluation based on content knowledge

Variable	Mean	Variance	Computed t-value	Critical t-value	Decision	Interpretation
Instructors	3.06	0.05	2.93	2.14	Reject H_0	Significant
Self	3.41	0.16				

Pedagogical Knowledge

Table 5. SPSTs' level of pedagogical knowledge based on the instructors' and SPSTs' self-evaluation

Statements	Instructors' Evaluation		SPSTs' Self-Evaluation	
	Weighted Mean	Verbal Interpretation	Weighted Mean	Verbal Interpretation
1. Ability to write and design lesson plans.	3.00	Agree	3.47	Strongly agree
2. Ability to use different materials and resources.	3.11	Agree	3.67	Strongly agree
3. Ability to apply his/her knowledge gained from	2.76	Agree	3.40	Strongly agree

training programs, educational lectures, seminars/webinars they have attended.				
4. Ability to use explicit instruction during discussions in class.	3.16	Agree	3.27	Strongly agree
5. Ability to set objectives and plans before lessons to track their progress.	2.91	Agree	3.47	Strongly agree
6. Ability to pay attention to the students' suggestions throughout class discussions to enhance their learning.	3.27	Strongly agree	3.73	Strongly agree
7. Ability to adapt teaching methods easily offered by technology that allows students to reach their full potential by giving them an alternative explanation or demonstration.	3.22	Agree	3.60	Strongly agree
8. Ability to carry out a variety of teaching techniques successfully that must be established and used in a school setting.	3.07	Agree	3.00	Strongly agree
9. Ability to adapt to new teaching methods and approaches to increase students' competency and performance in the classroom.	3.24	Agree	3.27	Strongly agree
10. Ability to establish a classroom management system that can accommodate the essential needs of the learners.	3.20	Agree	3.33	Strongly agree
General Weighted Mean	3.10	Agree	3.42	Strongly agree

Table 6. Difference between instructors' evaluation and SPSTs' self-evaluation based on pedagogical knowledge

Variable	Mean	Variance	Computed t-value	Critical t-value	Decision	Interpretation
Instructors	3.09	0.03	2.82	2.14	Reject H_0	Significant
Self	3.42	0.14				

Technological Knowledge

Table 7. SPSTs' level of technological knowledge based on the instructors' and SPSTs' self-evaluation

Statements	Instructors' Evaluation		SPSTs' Self-Evaluation	
	Weighted Mean	Verbal Interpretation	Weighted Mean	Verbal Interpretation
1. Confident in solving technical problems such as device errors, internet problems, and others.	2.93	Agree	3.33	Strongly agree
2. Learn easily by using technologies in a short period of time.	3.22	Agree	3.60	Strongly agree
3. Keeping up with new technologies.	3.07	Agree	3.47	Strongly agree
4. Exploring the features of the technologies they use.	3.13	Agree	3.53	Strongly agree
5. Knowledge of different kinds of technology.	3.16	Agree	3.33	Strongly agree
6. Possess technical skills in using technology.	3.20	Agree	3.33	Strongly agree
7. Make time to research the different technologies that are released and widely used nowadays.	2.51	Agree	3.13	Agree
8. Confident in using different online learning delivery modalities and knowing their functions and features.	3.16	Agree	3.33	Strongly agree
9. Accessible to different reliable sources on the internet.	3.27	Strongly agree	3.33	Strongly agree

10. Incorporating different online applications in many aspects.	3.13	Agree	3.33	Strongly agree
General Weighted Mean	3.08	Agree	3.37	Strongly agree

Table 8. Difference between instructors' evaluation and SPSTs' self-evaluation based on technological knowledge

Variable	Mean	Variance	Computed t-value	Critical t-value	Decision	Interpretation
Instructors	3.08	0.01	2.43	2.14	Reject H_0	Significant
Self	3.37	0.23				

DISCUSSION

Content Knowledge

Table 3 presents the instructors' evaluations and SPSTs' self-evaluations of SPSTs' content knowledge during the hybrid teaching demonstration. As can be gleaned from this table, the instructors and SPSTs both strongly agreed that SPSTs had knowledge about science concepts, principles, generalizations, theories, and laws; where at the same time, SPSTs were able to apply science concepts in real-life, simplify related topics, and were all supported by different references coming from textbooks and the internet during the teaching demonstration. Based on the data gathered, the instructors commented that most of the SPSTs could confidently deliver the topic, as they had mastered the content of the discussion, which was presented thoroughly, concisely, and in a relevant manner and connected to real-life situations.

In line with this, Rafi (2022) found that one of the greatest problems encountered by science teachers was the use of online laboratory experiments. It was emphasized that the student's knowledge and skills with laboratory equipment were crucial to succeeding in future laboratory activities, as they can reduce accidents during the laboratory practicum. With this, it was expected that a science educator who could impart adequate knowledge and skills about laboratory equipment would increase students' success in performing laboratory experiments and enable them to experience the concepts encountered (Djukri & Restiana, 2021). Moreover, SPSTs must be confident in answering students' queries about concepts beyond the textbook, as this not only demonstrates mastery of the content but also fosters a sense of belonging that can increase students' academic success and motivation (Bowen, 2021). Therefore, the ability to handle queries and impart knowledge, as well as the skill in using laboratory equipment, were as important as having a quality science education, which the SPSTs need to further improve.

Comments from the instructor's evaluation during the teaching demonstration were included to support the gathered data. First, it was noted that the SPSTs demonstrated complete mastery of the lesson by providing detailed, clear, and concise explanations of the concepts, which allowed some of them to show their confidence in delivering the lesson. Second, some of the SPSTs inject personal biases during the discussion, disregarding the facts that must be applied in science education, thus suggesting that they are neutral. Lastly, the SPSTs simplified complex concepts and connected them to real-life situations, making science learning relevant to students and supported by varied references, including a video presentation during the discussion.

The content knowledge of SPSTs is essential for delivering quality education to learners. This research found a significant difference between instructors' and self-evaluations of SPSTs' content knowledge in a hybrid teaching modality, as presented in Table 4. Traditional knowledge was insufficient for pre-service teachers to meet their students' needs in online education; thus, developing their content mastery is essential for effective and efficient teaching practice. Although it was revealed that the SPSTs had sufficient knowledge of the topic they discussed in a hybrid setting, instructors still saw room for improvement.

Pedagogical Knowledge

Table 5 presents the instructors' and self-evaluations of the SPSTs' pedagogical knowledge during the hybrid teaching demonstration. The instructors and SPSTs both strongly agreed that SPSTs paid attention to students' suggestions throughout the class discussion, thereby enhancing learning.

In the instructor's evaluation, they agree that SPSTs adapted new teaching methods, approaches, and technology-based methods to help their students reach their full potential. The instructors also agreed that the SPSTs were able to establish classroom management, use explicit instructions, use different materials and resources in teaching, carry out a variety of teaching techniques, write and design a lesson plan, set objectives and plans, and apply their knowledge gained from training programs, educational lectures, seminars, and webinars they had attended. The SPSTs' self-evaluation strongly agreed on the remaining areas, in which they were able to use different materials and resources and adapt new teaching methods and approaches offered by technology to help their students reach their full potential. The SPSTs also strongly agreed that they were able to write and design lesson plans, set objectives, and plan lessons in advance to track their progress. Furthermore, they strongly agreed that they could apply the knowledge gained from training programs, educational lectures, seminars, and webinars they had attended; establish classroom management practices to accommodate all their students across different modalities; adapt new teaching methods; and use explicit instruction during class discussions.

According to the instructors' comments supporting this data, some SPSTs were able to manage the class both online and face-to-face, but others struggled to provide equal attention and opportunity, especially for the online team. Moreover, instructors noticed

that some were good at classroom management and awareness by simply asking students for their understanding from time to time and checking whether they were still listening to the class, even during technical difficulties. Most SPSTs received comments about their energy and rapport with students. Also, they received multiple pieces of advice, especially on how to ask students questions using the Socratic Method or rephrase them so they would be easier for students to understand.

This implied that SPSTs, during their hybrid demonstration, demonstrated pedagogical competence, such as creating lesson plans and using a variety of teaching techniques in the classroom. Similarly, the study by Agayon et al. (2022) indicated that teachers experienced difficulty during the current pandemic, particularly in the online teaching modality, including preparing lesson plans and developing teaching strategies in an online environment. Although SPSTs were competent according to the instructors' observations, they should pay close attention to the students during the discussion. This suggested that the SPSTs believed that they had pedagogical competence in several aspects of science education in a hybrid demonstration, including the use of a wide range of teaching strategies in the classroom. Therefore, for effective science education that enables students to clearly understand the fundamentals of science, a variety of teaching techniques will be needed to successfully execute the teaching-learning process in this modality.

Regarding the data gathered, the instructor's evaluation comments indicated that most SPSTs needed help in providing equal attention and opportunities to students in both online and face-to-face settings during activities and recitations. It was also repeatedly noted and suggested that the SPST must be time-conscious within the allotted time, as most of the allotted time was exceeded during the teaching demonstration. Additionally, body language was observed, including energy, eye contact, mannerisms, poise, and hand gestures, with or without technical difficulties. Some SPST were commended, and some were advised to improve these aspects. The activities were all engaging and highly commended, as most were able to connect them to the discussion. Some allowed interaction between the two setups, but others did not. Moreover, in regular face-to-face classes, teachers would begin with preliminary activities. However, only a few were able to do things such as introduce themselves, state the objectives, pray, and the attendance portion. Also, it was observed that some SPSTs leveraged students' higher-order thinking skills, aligning with 21st-century education, which is student-centered, but the comments also stated that the SPSTs were becoming teacher-centered over time.

Pedagogical knowledge in teaching, particularly in hybrid delivery, plays a vital role in providing learners with teaching styles and strategies tailored to their learning styles. The data gathered showed that SPSTs' self-evaluation of their pedagogical knowledge was significantly higher than the mean score in the instructors' evaluations, indicating a gap between the two. Moreover, the pre-service teachers were found to be stricter in their pedagogy, as perceived by their instructor, with differences including greater self-reliance in lesson planning, more student interaction in class, and greater application of content knowledge in discussion. Furthermore, PSTs' self-evaluations vary as they progress in their teaching practice, leading to significant differences in how mentors and PSTs assess

their pedagogical knowledge, as shown in Table 6. Nevertheless, pre-service teachers might be ready for their responsibilities as educators once their teaching skills have been established through teacher preparation programs and professional development, as well as through the term "resilient pedagogy," which applies activities and discussions to both face-to-face and online learners.

Technological Knowledge

Table 7 presents the instructors' evaluations and SPSTs' self-evaluations of SPSTs' technological knowledge during the hybrid teaching demonstration. The instructors and SPSTs both strongly agreed that SPSTs could access a variety of reliable sources on the internet. Both also agreed that SPSTs made time to research different recent technologies.

Furthermore, based on the SPSTs' self-evaluations, they strongly agreed that they were able to learn to use technologies quickly, explore the features of the technologies they used, and keep up with new technologies. However, the instructors only agreed on these. Similarly, the instructors have agreed that the SPSTs have demonstrated confidence in solving technical problems, knowledge of various technologies, technical skills, confidence in using various online learning methods, and the ability to incorporate different online applications.

Comments from the instructors' evaluation form were retrieved and used to support the data presented. The SPSTs, in terms of their technological knowledge, received positive comments such as introducing new applications to spice up the discussion; the animation and transitions were appropriate; and the presentation was made available online to be seen by the face-to-face team. However, there were also suggestions to improve the text size, text preferences, and color combinations on the slides. This implies that SPSTs are knowledgeable about using technology in teaching and can access reliable sources. However, they need to be more confident in their ability to find solutions to various technical problems during presentations. Incorporating new technology into the teaching-learning process made students active and engaged during the discussion, which can only happen if the teacher continues to research and update their knowledge of new technologies for classroom use. Although teachers have no experience with different kinds of technology in teaching, they were ready to adapt to these changes and upgrade their competencies to teach in this new learning environment.

In a hybrid learning setup, strong technological knowledge is essential. According to the instructor's evaluation, a few items were noted, some commended, and others needed improvement. First is the PowerPoint Presentation; most comments suggest the following: improving the font size, text preferences, and color combination for the design and text; maximizing space on every slide; and improving the video and picture quality, as some were blurry. Nonetheless, some SPST were commended for their choice of animation and transitions that emphasized the words in the discussion. The second was using different applications to project their presentation and the students' online setup. Some were commended for how the SPSTs can present PowerPoint and for the online

team, allowing the face-to-face classes to see and still interact with them. There were also suggestions regarding the applications used, such as maximizing the use of multiple applications so that students, both face-to-face and online, can see the activity. The application of technological knowledge in online education is vital, as it embodies the modality that teachers and pre-service teachers use in teaching. This research then identified a significant difference between instructors' evaluations and SPSTs' self-evaluations of their technological knowledge for teaching in a hybrid modality, as presented in Table 8. Even though the self-evaluation revealed that the SPSTs strongly agreed they possess high competence in their technological knowledge, the instructors mostly agreed they were competent enough to apply their technological knowledge in hybrid teaching. However, the means themselves showed little difference across the evaluations.

Moreover, teachers needed to be more confident in integrating technology into their discussions, as it requires them to learn technical skills to become effective teachers. In this sense, acquiring the skill to integrate technology in a teaching-learning environment takes time to develop and become effective. Although instructors' evaluations of SPSTs' technological knowledge indicated that they were competent, there was room for improvement in developing ICT skills.

Table 9. SPSTs' level of technological knowledge based on instructors' and self-evaluation

Competencies	Instructors' Evaluation		SPSTs' Self-Evaluation	
	Weighted Mean	Verbal Interpretation	Weighted Mean	Verbal Interpretation
Content Knowledge	3.06	Agree	3.41	Strongly agree
Pedagogical Knowledge	3.09	Agree	3.42	Strongly agree
Technological Knowledge	3.08	Agree	3.37	Strongly agree
Overall Weighted Mean	3.08	Agree	3.40	Strongly agree

Table 9 presents a summary of SPSTs' competency levels based on the instructors' evaluations. As shown in the table above, the instructors agreed that the SPSTs were competent across all three competencies—pedagogical, technological, and content knowledge. Furthermore, the SPSTs strongly agreed that they were knowledgeable in pedagogical, content, and technological competencies. This imparted that they know for themselves that they were ready and knowledgeable to teach in a hybrid learning situation.

Conclusions

As today's learners are active, participative, and involved, they will be more engaged in class interactions through tasks, discussions, and individual or group activities, especially in a hybrid teaching modality. SPSTs shall develop their teaching styles and strategies for both online and face-to-face settings and learn to provide balanced attention to both settings to engage their students in discussion during activities and recitations. Accordingly, content mastery and pedagogy are two significant aspects that make the learning process more engaging and create a light, inviting atmosphere in students' learning spaces, making them more accessible, involved, and connected to the teacher and their classmates. As learners and teaching modalities evolve, SPSTs' content mastery must be developed to support 21st-century learners' learning processes. Furthermore, content is the foundation of learning because it is what students must acquire, and it must be continually updated, re-equipped, and rationalized; thus, it must be continuously developed and improved. Moreover, integrating technology into students' learning through software, online simulations, and applications makes the learning environment more engaging.

The competencies of future science educators should continually evolve as learners and the education system evolves. As there is a gap in the specific skills in each knowledge, which are content knowledge, pedagogical knowledge, and technological knowledge, this shows that SPSTs are still lacking, and there are aspects that they must improve. Therefore, the researchers proposed a training program to enhance SPSTs' skills in setting objectives and designing lesson plans, acquiring new teaching methods and strategies, and establishing classroom management. Additionally, the proposed training program's main objective is to help SPSTs gain knowledge and skills they can apply as science educators. In this sense, the training program will be the tool to prepare SPSTs for hybrid teaching delivery. Furthermore, the proposed training program can address the significant difference between SPSTs' self-evaluations and instructors' evaluations across all competencies. Wherefore, it will not only benefit the SPSTs but also support the development of quality education for 21st-century learners and help the government produce competent, efficient, and effective future educators who provide students with meaningful learning and skills.

Recommendations

Proposed Training Program

For the content knowledge, the instructors' evaluation showed the three lowest means for content knowledge, which were observed during the hybrid teaching demonstration, namely, (1) knowledge in experimentation and skills in laboratory equipment, (2) willingness to attend local and international scientific webinars/seminars, and (3) dealing with students' queries beyond a textbook. The SPSTs evaluation, on the other hand, in Table 6 displayed a different set of statements based on the three lowest means, and these were: (1) knowledge in experimentation and skills in laboratory equipment, (2) dealing with student queries beyond the textbook, and (3) detecting and clarifying

students' misconceptions. Moreover, the data, as the basis for the proposed training program, focuses on maximizing the SPST's knowledge not only in scientific concepts but also in the skills involved in the laboratory practicum, which will help them address students' queries and clarify misconceptions about fundamental science concepts. Thus, laboratory skills, practicum, and content mastery to answer students' queries and debunk science misconceptions needed to be enhanced through training programs to develop the SPSTs' content knowledge.

Since there are two different areas to be enhanced, elective subjects will be conducted with a focus on laboratory practicum, skills, and content mastery through a series of workshops, seminars/webinars. Lecturers who have earned degrees in these areas shall be invited to train the SPSTs in these areas. Since it dealt with content mastery, four special lectures can be done to cover the branches of science. In addition, those lectures that require laboratory experiments, especially in Biology, Chemistry, and Physics, shall be conducted on separate days, with a maximum of three hours for the lecture and an additional six hours for the laboratory to cover all the required lectures.

For pedagogical knowledge, although the instructors' evaluations were the lowest, the instructors agreed that the SPSTs could apply knowledge gained from workshops, set objectives and plans before lessons, and write and design lesson plans. On the other hand, the SPSTs agreed they could use various teaching techniques. They also strongly agreed that they could discuss explicitly, adapt new teaching methods and approaches, and establish a classroom management system. Moreover, the two evaluations differed significantly. Although they differed, both evaluations revealed that the three lowest means across both variables focused on lesson planning, teaching methods and strategies, and classroom management systems. These three areas need to be developed by the SPSTs to enhance their pedagogical competence in hybrid-modality teaching; thus, training programs should highlight them. 21st-century educators are adaptable and can learn new skills to improve their practice, especially in hybrid teaching delivery. Therefore, seminars/webinars about the improvement of the knowledge and skills of SPSTs were essential to bridge the gap in the said competencies so that they will be able to improve their competency in setting the objectives and designing lesson plans, and provide appropriate teaching methods and classroom management based on the knowledge and skills they will learn in the proposed seminar/webinar.

These three pedagogical content areas differ from one another. To accommodate all these areas, three separate workshops or seminars/webinars shall be conducted. Three proficient, experienced speakers will be invited to speak on these areas. These three separate discussions can be held in a single day, with a maximum of 2 hours per workshop, seminar/webinar.

Regarding technological knowledge, although both instructors' and self-evaluations differed significantly, they conveyed the same idea: SPSTs must focus on researching and keeping up with new technologies, as well as developing solutions to technical problems. These areas of technological knowledge are interconnected and fall under the main topic of Information and Communication Technology (ICT) integration. In line with

these areas, only one seminar/webinar shall be conducted to hone professional development and technical skills and to improve their knowledge of technological integration in teaching. One speaker shall be invited who has mastered ICT skills, is up to date and knowledgeable about recent technologies, and is proficient at solving technical problems with these newly released technologies. This workshop, seminar/webinar can be held in a single day, with a maximum of 2 hours. Since the study had already identified the areas that needed to be developed by the SPSTs to be ready for hybrid teaching, the researchers used these areas to propose a training program to enhance the SPSTs' competencies for teaching in a hybrid set-up. The hybrid setup training program proposal is stated in Table 10.

Table 10. Areas to cover during the training program

Competencies	Areas	Duration
Content Knowledge	Content Mastery for Biology	3 hours lecture; 6 hours laboratory
	Content Mastery for Chemistry	3 hours lecture; 6 hours laboratory
	Content Mastery for Physics	3 hours lecture; 3 hours laboratory
	Content Mastery for Earth Science	3 hours
Pedagogical Knowledge	Lesson Planning	2 hours
	Teaching Methods and Strategies	2 hours
	Classroom Management	2 hours
Technological Knowledge	ICT for Hybrid Setup	2 hours

This study used the core competencies of teaching: content, pedagogy, and technology, in assessing the third-year SPSTs in a hybrid teaching modality. Since this research has the potential to explore the competencies of the SPSTs and PSTs in teaching in a hybrid set-up, the researchers recommend the following: Since one of the founding frameworks used in this study is the TPACK model and used the primary domains, which were the content, pedagogical, and technological knowledges, it is therefore recommended to use and explore the remaining four components: (1) pedagogical content knowledge, (2) technological content knowledge, (3) technological pedagogical knowledge, and (4) technological pedagogical content knowledge. The data-gathering process lasted three days, and the respondents were divided into three groups. During these days, the instructors who evaluated the SPSTs' performances varied from day to day. To ensure the fairness of the scores, it is recommended to collect data for a day or two consecutively. Moreover, it is recommended to administer the SPST self-evaluation form after the post-conference to gather feedback on their performance and minimize bias.

Furthermore, this study gathered comments and feedback from the instructors who evaluated the SPSTs' teaching demonstrations and used them to support the results. To minimize bias, it is recommended to gather narratives from the SPSTs and to pursue a mixed-methods research design. During the hybrid setup, the instructors who evaluated their competencies were present in the in-person class. It is then recommended that instructors who will evaluate the respondents' competencies be present in the online class. As this research focused on third-year SPSTs, other year levels may participate as respondents to examine the competencies that have been molded in them over the years.

Compliance with Ethical Standards

Several ethical considerations were addressed throughout the planning, execution, and reporting of this study to uphold the highest standards of research integrity and protect respondents. Prior to the data collection, an information sheet was presented on the first page of the questionnaire and checklists, and participants provided informed consent by checking the box labeled *"I have read and understood the information above, and I voluntarily agree to participate in this study"* before participating. Participation was voluntary; no minors or vulnerable participants were involved. No identifying personal information was collected; responses were anonymized, stored in secure folders, and reported in accordance with the Data Privacy Act of 2012 of the Republic of the Philippines. Plagiarism was strictly avoided through rigorous original writing and proper attribution of all sources, and findings were analyzed and interpreted objectively to eliminate bias. All collected data and results were utilized purely for research purposes.

The authors acknowledge that this paper was proofread and edited with the assistance of Grammarly Pro (Version 1.2 as of August 2026) to enhance clarity and coherence in its presentation of ideas. The human authors critically assessed and validated the content to maintain academic rigor. The authors also assessed and addressed potential biases inherent in the AI-generated content. The final version of the paper is the sole responsibility of the human authors. The authors have no competing interests to declare.

Acknowledgments

The authors would like to express their sincere gratitude to all the participants who willingly took part in this study and shared their time, effort, and experiences throughout the research process. Their cooperation and participation made this study possible. The authors also extend their appreciation to the faculty members, research adviser, panelists, and the institution for their guidance, support, and valuable insights in completing this research. Special thanks are likewise given to family, friends, and colleagues for their encouragement, understanding, and unwavering support throughout the study.

REFERENCES

- Agayon, A. J., Agayon, A. K., & Pentang, J. (2022). Teachers in the new normal: challenges and coping mechanisms in secondary schools. *Journal of Humanities and Education Development*, 4(1), 67-75. <https://doi.org/10.22161/jhed.4.1.8>
- Al Fajri, T. A., Andarwulan, T., & Damayanti, G. (2021). Elementary teachers' readiness toward the online learning policy in the new normal era during COVID-19. *International Journal of Instruction*, 14(3), 771-786. <https://doi.org/10.29333/iji.2021.14345a>
- Bihasa, D. (2022). The preparedness of pre-service teachers on the required programs to meet standards. *PUPIL: International Journal of Teaching, Education, and Learning*, 5(3), 220-237. <https://doi.org/10.20319/pijtel.2022.53.220237>
- Bowen, J. (2021, October 21). Why is it important for students to feel a sense of belonging at school? 'Students choose to be in environments that make them feel a sense of fit,' says associate professor DeLeon Gray. *College of Education News*. <https://ced.ncsu.edu/news/2021/10/21/why-is-itimportant-for-students-to-feel-a-sense-of-belonging-at-school-studentschoose-to-be-in-environments-that-make-them-feel-a-sense-of-fit-saysassociate-professor-deleon-gra>
- Catalano, A., Asselta, L., & Durkin, A. (2019). Exploring the relationship between science content knowledge and science teaching self-efficacy among elementary teachers. *IAFOR Journal of Education*, 7(1), 57-70. <https://files.eric.ed.gov/fulltext/EJ1217961.pdf>
- Department of Education. (2020). Adoption of the basic education learning continuity plan for school year 2020-2021 in light of the COVID-19 public health emergency [DepEd Order No. 012, s. 2020]. https://www.deped.gov.ph/wpcontent/uploads/2020/06/DO_s2020_012.pdf
- Department of Science and Technology – Science Education Institute and University of the Philippines National Institute for Science and Mathematics Education Development. (2011). Framework for Philippine science teacher education. https://sei.dost.gov.ph/images/downloads/publ/sei_sciteach.pdf
- Djukri, & Restiana. (2021). Students' level of knowledge of laboratory equipment and materials. *Journal of Physics: Conference Series*, 1842(2021) 1-9. doi:10.1088/1742-6596/1842/1/012022
- Ekiz-Kiran, B., Boz, Y., & Oztay, E. S. (2021). Development of pre-service teachers' pedagogical content knowledge through a PCK-based school experience course. *Chemistry Education Research and Practice*, 22(2), 415-430. <https://doi.org/10.1039/D0RP00225A>
- Formont, S. (2022, June 9). "It made the smallest thing matter more". Touro College: Graduate School of Education. <https://gse.touro.edu/news/stories/it-made-the-smallest-thing-mattermore.php>
- Francis, J. (2017). The effects of technology on student motivation and engagement in classroom-based learning. *All Theses and Dissertations*, 121(1), 1-55. <https://dune.une.edu/cgi/viewcontent.cgi?article=1120&context=theses>
- Ghavifekr, S., Kunjappan, T., Ramasamy, L., & Anthony, A. (2016). Teaching and learning with ICT tools: Issues and challenges from teachers' perceptions. *Malaysian Online Journal of Educational Technology*, 4(2), 38-57. <https://eric.ed.gov/?id=EJ1096028>
- Granić, A. Marangunić, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology*, 50(5), 2572-2593. <https://doi.org/10.1111/bjet.12864>
- Kartal, T., Dilek, I. (2021). Developing pre-service elementary science teachers' science teaching efficacy beliefs through microteaching by promoting efficacy sources.

- International Journal on Social and Education Sciences (IJonSES), 3(4), 710-731.
<https://doi.org/10.46328/ijonSES.124>
- Kultsum, U. (2017, August). The concept of pedagogical content knowledge (PCK): Recognizing the English teachers' competencies in Indonesia. *Advances in Social Science, Education and Human Research*, 134, 55-59. <https://doi.org/10.2991/icirad-17.2017.11>
- Grigsby, C. N. (2021). Exploring elementary pre-service teachers' technological knowledge for teaching literacy: A phenomenological study (Doctoral dissertation). Columbus State University. https://csuepress.columbusstate.edu/theses_dissertations/454
- Gurung, S. (2021). Challenges faced by teachers in online teaching during the COVID-19 pandemic. *The Online Journal of Distance Education and e-Learning*, 9(1), 8-18.
<https://orcid.org/0000-0002-2734-2268>
- Hernando-Malipot, M. (2022, May 13). DepEd's digital rise program a key player to address challenges in educational quality. *Manila Bulletin*. <https://mb.com.ph/2022/05/13/depeds-digital-rise-program-a-key-playerto-address-challenges-in-education-quality/>
- Herold, B. (2021, May 18). Remote learning is changing schools: Teacher preparation programs have to adjust. *EducationWeek*. <https://www.edweek.org/teaching-learning/remote-learning-is-changing-schools-teacher-preparation-programs-have-to-adjust/2021/05>
- Isidro, E., & Teichert, L. (2021). Towards socially just literacy teaching in virtual spaces. *Journal of Curriculum Studies Research*, 3(1), 21-41. <https://doi.org/10.46303/jcsr.2021.6>
- Kapur, R. (2020). Understanding the meaning and significance of pedagogy.
https://www.researchgate.net/publication/345156519_Understanding_the_Meaning_and_Significance_of_Pedagogy
- Kintu, M. J., Zhu, C., & Kagambe, E. (2017). Blended learning effectiveness: The relationship between student characteristics, design features and outcomes. *International Journal of Educational Technology in Higher Education*, 14(7), 1-20.
<https://doi.org/10.1186/s41239-017-0043-4>
- Koehler, M., & Mishra, P. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054. doi: 10.1111/j.1467-9620.2006.00684.x
- Ladd, T. (2020, June 19). Optimizing concurrent classrooms: Teaching students in the room and online simultaneously. *Forbes*.
<https://www.forbes.com/sites/tedladd/2020/06/19/optimizing-concurrentclassrooms-teaching-students-in-the-room-and-onlinesimultaneously/?sh=32d8787c3451>
- Lock, D. M. (2021, February 25). How to make hybrid learning successful. *Schoolyard*.
<https://blog.schoolspecialty.com/how-to-make-hybrid-learning-successful/>
- Mayol, P. A. (2020, October 5). The paradigm shift for teachers' challenges in the new normal. *Cebu Finest*. <https://cebu finest.com/paradigm-shift-teacherschallenges-new-normal/>
- McGraw-Hill. (2019, April 16). What is TPACK theory and how can it be used in the classroom?
<https://www.mheducation.ca/blog/what-is-tpack-theoryand-how-can-it-be-used-in-the-classroom/>
- Mikeska, J., Howell, H., & Kinsey, D. (2022). Examining the usability and viability of using a simulated classroom environment to prepare preservice science teachers during and after the COVID-19 pandemic. *Disciplinary and Interdisciplinary Science Education Research*, 4(23), 1-20. <https://doi.org/10.1186/s43031-022-00054-1>
- Morrison, L. (2021). Online teacher education during COVID: Emerging futures for pre-service teacher education (Unpublished doctoral dissertation). University of Calgary.
<http://dx.doi.org/10.11575/PRISM/39322>
- Mutya, R., & Palero, M. (2022). Teachers readiness towards online distance learning in science teaching in the new normal. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, 63(1), 132-154.
<https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/14272>

- Ngan, M. (2022, February). Hybrid learning has the potential to equip millions of students about to enter the workforce – if its challenges are addressed immediately. Ed Uy.
https://www.wheriseduy.com/addressing-the-disconnect-between-students-and-educators-is-key-to-protectingtomorrowsworkforce/?utm_source=rss&utm_medium=rss&utm_campaign=addressin-g-the-disconnect-between-students-and-educators-is-key-to-protectingtomorrows-workforce
- Olurinola, O. D., Adelana, O. P. (2022). Pre-service teachers' perceptions of remote and hybrid modes of instructions: Implication for learning preferences. *Evaluation Studies in Social Sciences*, 1(1) 26-41. <https://doi.org/10.37134/esss.vol3.1.3.2022>
- Oyelekan, O. S., Igbokwe, E. F., Olorundare, A. S. (2017). Science teachers' utilisation of innovative strategies for teaching senior school science in Ilorin, Nigeria. *Malaysian Online Journal of Educational Sciences*, 5(2) 49-65.
<https://files.eric.ed.gov/fulltext/EJ1142454.pdf>
- Raes, A. (2021, November 3). Exploring student and teacher experiences in hybrid learning environments: does presence matter? *Postdigital Science and Education*, 1(4), 138-159.
<https://doi.org/10.1007/s42438-021-00274-0>
- Rafi, F. (2022). Teaching science through online education during the COVID-19 pandemic: Science teachers' practices, self-efficacy beliefs, and attitudes toward the change [Master's thesis. University of Saskatchewan]. Harvest.
<https://hdl.handle.net/10388/13956>
- Ramirez, I. A. (2020). Teaching preparedness of pre-service teachers: Perception to practice. *International Journal of Studies in Education and Science*, 1(1), 15-35.
<https://ijses.net/index.php/ijses/article/download/6/pdf>
- Russo, T., & Siko, J. (2018). The effect of personal learning network exposure on pre-service teacher's digital resource search habits. *I-manager's Journal on School Educational Technology*, 14(2), 12-23. <http://files.eric.ed.gov/fulltext/EJ1208766.pdf>
- Savec, V., & Wissiak, K. (2017). Development of chemistry pre-service teachers during practical pedagogical training: Self-evaluation vs. evaluation by school mentors. *Acta Chimica Slovenica*, [S.I.], 64(1), 63-72. <https://doi.org/10.17344/acsi.2016.2821>
- Schmidt, D., Baran, E., Thompson, A., Mishra, P., Koehler, M., & Shin, T. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, 42(2), 123-149. <http://dx.doi.org/10.1080/15391523.2009.10782544>
- Shah, N. (2021, December 29). 'I feel half as successful': Teachers push to ban hybrid instruction, but districts want to keep it. *Politico*.
<https://www.politico.com/news/agenda/2021/12/29/teachers-districtshybrid-education-526214?fbclid=IwAR2egB6VWvosTh1xh5ZPssKeVcf4xiEHFAMNlyiwOX5rNqYfJl-8aHSvck>
- Social Weather Stations. (2021, May 13). Fourth quarter 2020 social weather survey on learning delivery modalities (Part 4): 89% of families with enrolled school-age members say the current 'blended learning system' is more difficult than past face-to-face (F2F) learning.
<http://www.sws.org.ph/swsmain/artclisppage/?artcsyscode=ART20210313193538>
- Sudarsana, I. K., Nakayanti, A. R., Sapta, A., Haimah, Satria, E., Saddhono, K., Daengs, GS. A., Putut, E., Helda, T., & Mursalin, M. (2019). Technology application in education and learning process. *Journal of Physics: Conference Series*, 1363(2019) 1-6.
[doi:10.1088/1742-6596/1363/1/012061](https://doi.org/10.1088/1742-6596/1363/1/012061)
- Steiner, E., & Woo, A. (2021). Job-related stress threatens the teacher supply: Key findings from the 2021 state of the U.S. teacher survey. RAND Corporation.
<https://doi.org/10.7249/RR1108-1>

- The Manila Standard. (2022, February 12). Improving access to education in PH through innovation. <https://manilastandard.net/tech/314206915/improvingaccess-to-education-in-ph-through-innovation.html>
- United Nations Educational, Scientific, and Cultural Organization. (2020, October 3). With one in five learners kept out of school, UNESCO mobilizes education ministers to face the COVID-19 crisis. <https://en.unesco.org/news/one-five-learners-kept-out-school-unescomobilizes-education-ministers-face-covid-19-crisis>
- Velasco, C., & Cañada, M. C. (2020). Online teaching readiness of the faculty of Aurora State College of Technology, Baler, Aurora, Philippines. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, 54(5), 34-44. <https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/download/11949/5833/>
- Ventayen, R. J. (2018). Teachers' readiness in online teaching environment: A case of Department of Education teachers. *PSU Journal of Education, Management, and Social Sciences*, 2(1), 94-106. https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3385389_code2959552.pdf?abstractid=3331115&mirid=1
- Wilichowski, T., & Cobo, C. (2021, June 2). Transforming how teachers use technology. *World Bank Blogs*. <https://blogs.worldbank.org/education/transforming-how-teachers-use-technology>
- Will, M. (2020, November 4). 6 lessons learned about better teaching during the pandemic. *EducationWeek*. <https://www.edweek.org/technology/6-lessonslearned-about-better-teaching-during-the-pandemic/2020/11>
- Widhiyanti, T., Treagust, D., Mocerino, M., & Vishnumolakala, V. (2017). Content knowledge development in a chemistry teacher preparation program: A current potentials and challenges. *AIP Conference Proceedings*, 1868(1), 1-14. <https://doi.org/10.1063/1.4995115>
- Wong, J. (2021, October 24). High schoolers, educators decry split focus of hybrid learning model. *CBC News*. https://www.cbc.ca/news/canada/hybridlearning-high-school-1.6217868?fbclid=IwAR1-_j3KtALbZzoflBUilz7nrIDtPi8ZAN30kSWKXRISyS0YHrYcTNGhrg

APA Citation:

Panton, B. J. D., De Guzman, L. K. M., Hernandez, D. S., Millar, J. D., Galima, J. C. G. & Samin, C. N. (2026). HYBRID TEACHING DELIVERY READINESS OF SCIENCE PRE-SERVICE TEACHERS: BASIS FOR PROPOSED TRAINING PROGRAM. *Ignatian International Journal for Multidisciplinary Research*, 4(8), 1009–1036. <https://doi.org/10.5281/zenodo.21978371>

Corresponding author: *bon_panton@dlsu.edu.ph*