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Knowledge, Attitudes, and Practices of Pre-service Science Teachers Towards Blended Learning Modalities in Selected State Colleges in Mindanao, Philippines

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Abstract. The COVID-19 pandemic has significantly disrupted human life and created educational innovation opportunities. One of the educational innovations is the implementation of blended learning modalities to ensure continuity of education. This study aimed to assess pre-service science teachers' knowledge, attitudes, and practices toward blended learning modalities in two selected state colleges in Mindanao. A modified and adapted questionnaire was administered to a sample of 138 participants. Most of the participants were within the age bracket of 18–24 (91%), predominantly female (72%), with a medium level of technological capacity (65%), and primarily preferred a mixed-method approach (59%) to blended learning. Quantitative results revealed that most participants were knowledgeable (X=4.12, SD=0.57), had a positive attitude (X=3.54, SD=0.68), and practiced (X=3.62, SD=0.58) blended learning modalities. At a $p<0.05$ level of significance, only the learning modality ($p<0.02$) showed a significant difference in the participants' attitudes, while technological capacity ($p<0.05$) showed a significant difference in their practices. Qualitative analysis revealed ten (10) essential themes from participants' experiences and insights regarding blended learning modalities (BLM): (1) Unstable internet connectivity in online classes; (2) Technology-related difficulties in online learning; (3) Time-management as a factor in blended learning; (4) Blended learning promotes independent learning; (5) Blended learning as the most effective modality; (6) Continuity of BLM in post-pandemic education; (7) Adequate learning resources in BLM; (8) Provision of clear instructions in BLM; (9) Teaching-learning strategies utilized are doable; and (10) Learning materials available online for further learning. Further qualitative research is recommended to explore the relevant constructs of this study in greater depth. The findings may serve as a baseline for curriculum assessment in higher education programs. Implementing blended learning may be a sustainable approach to delivering quality education in the 'new normal.'

Keywords: Blended learning; Face-to-face learning; Online learning; Technological capacity.

1.0 Introduction

The COVID-19 pandemic placed the global education system in a precarious position. Despite its devastating impact, it created opportunities for educational innovation. More than a billion learners worldwide experienced disruptions due to school closures aimed at preventing virus transmission (Holme, 2020). As a result, traditional classroom learning transitioned to blended learning modalities, requiring teachers worldwide to develop

strategies to support students' learning (Bozkurt & Sharma, 2020). This shift led to the evolution of e-learning models, transforming how instructional content is delivered, learning activities are conducted, and how social networks facilitate communication (Assaf & Nehmeh, 2021). In response, UNESCO (2020) advocated for distance learning, promoting open educational resources and digital platforms to help schools and educators maintain continuity in education. This transition presents an opportunity to explore teachers' digital tools and instructional methodologies, providing deeper insights into the effectiveness of blended learning in virtual education.

The Commission on Higher Education of the Philippines released Memorandum Order Number 4, Series of 2020, outlining the implementing rules and regulations for flexible learning. The primary objective is to provide learners with the most adaptable method of acquiring knowledge regarding content, access, assessments, and the utilization of digital and non-digital resources (CHED, 2020). According to Gemin and Pape (2016), online learning is a teacher-led education approach that leverages the Internet to create an organized learning environment. In the context of the COVID-19 pandemic, technological skills and internet access have become significant challenges (Doucet et al., 2020). This has led to the development of new learning environments, such as the blended learning modality (BLM), which must be examined in comparison to traditional, conventional education methods.

Many schools have implemented various instructional technologies to adapt to the evolving educational landscape to enhance the teaching-learning process. Tools such as Moodle, Google Classroom, Virtual Labs, and Simulators have been widely used. Students must adjust to these changes and develop proficiency in using these programs to engage and contribute in class fully. According to Chua et al. (2021), while technology integration has prepared students for an increasingly digitized education system, there remains a need for a skill-based curriculum that emphasizes hands-on learning and practical application. Additionally, educational institutions are becoming overwhelmed by the rapid adoption of new learning modalities.

Online learning can be delivered in either synchronous (real-time) or asynchronous (self-paced) formats, each with different implications for access to materials, compatibility with students' schedules and learning preferences, and consistency of content (Panigrahi et al., 2018). Many instructors also adopt a blended approach, integrating in-person and online learning elements. In general, blended learning also referred to as the blended learning modality (BLM) in this study, is an instructional technique that combines traditional face-to-face teaching with structured online learning activities. It has been widely utilized in higher education for various purposes (Smith, 2019; Shorey et al., 2018). Consequently, this study aims to explore the knowledge, attitudes, and practices of pre-service science teachers from two selected state colleges in Mindanao to assess the effectiveness of BLM. By examining their level of understanding, perceptions, and actual application of BLM, the study seeks to determine how well this instructional approach supports their learning experiences.

Given this context, Figure 1 presents the conceptual framework of the study. Specifically, the study aimed to assess the knowledge, attitudes, and practices of pre-service science teachers from selected state colleges regarding blended learning modalities. It also examined differences in knowledge, attitudes, and practices based on various profile variables. Moreover, the researchers explored students' personal learning experiences using synchronous, asynchronous, and blended learning. The participants shared their insights on BLM. The researchers hoped that the findings of this study would contribute to future evaluations of pedagogical approaches, particularly in planning online classes, developing engaging online activities, and enhancing the delivery of online instructional content.

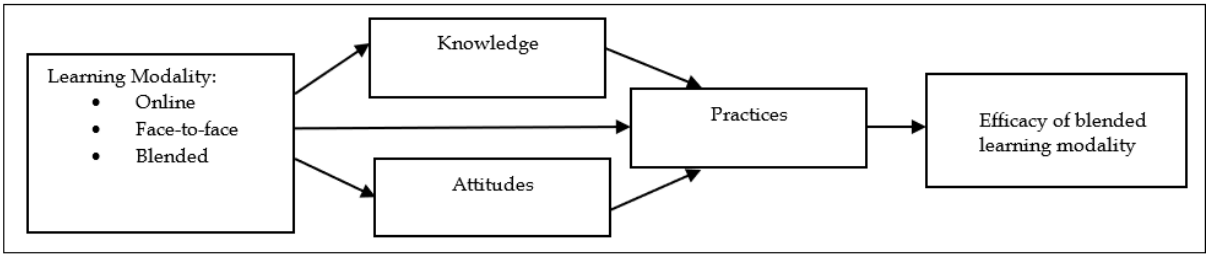

Figure 1. *Conceptual framework of the study using the KAP-O Model adopted and modified from Wan et al. (2016)*

2.0 Methodology

2.1 Research Design

This study utilized a mixed method of quantitative and qualitative analyses. A quantitative research design was employed to collect numerical data on the knowledge, attitudes, and practices related to BLM. Meanwhile, a qualitative research design explored participants' learning experiences and insights regarding implementing BLM.

2.2 Research Locale

This study was conducted in two selected state colleges in Mindanao. State College A is located in the southeastern part of Mindanao, within one of the provinces of the Davao region. It was founded in July 2010 and is considered the Philippines' youngest state-funded higher education institution. State College B is in the northeastern part of Mindanao, under the Caraga region. Both colleges offer a Bachelor of Secondary Education major in General Science program.

2.3 Research Participants

138 pre-service science teachers from two state colleges participated in the study. The sample size was determined using the Rao Soft online sample size calculator. Proportional sampling was employed to ensure a representative distribution of participants across different year levels in each state college.

2.4 Research Instrument

Quantitative data were collected using a survey questionnaire adapted from Abuhashesh et al. (2020) and administered via Google Forms, an online-based platform. The questionnaire consisted of 25 questions divided into three sections: knowledge, attitudes, and practices related to BLM. The knowledge section focused on participants' insights and perceptions regarding blended learning software and the learning platforms' operability. The attitude section examined participants' feelings and behaviors toward BLM. The practices section explored their experiences and strategies in utilizing BLM and their competency in and access to BLM materials. Interviews and focus group discussions (FGD) were conducted for qualitative data collection. The FGD session included seven questions and lasted approximately one hour, concluding with participants' final thoughts on BLM.

2.5 Data Gathering Procedure

The presidents of the two-state colleges were permitted to conduct the study. Following approval, quantitative data were collected using a questionnaire administered via Google Forms. Prior to distribution, the validity and reliability of the research instrument were assessed through expert reviews and pilot testing to ensure content and construct validity. Additionally, a reliability test was conducted, yielding a Cronbach's alpha coefficient of 0.73, indicating a high level of consistency and reliability of the research instrument. A focus group discussion (FGD) was scheduled with randomly selected participants based on their availability. Descriptive statistics were used to summarize the participants' demographic profiles, while frequency and mean were employed to present the extent of their knowledge, attitudes, and practices (KAP) toward the BLM. A normality test was conducted before data analysis, confirming that analysis of variance (ANOVA) was an appropriate statistical tool to determine significant differences in participants' KAP toward BLM when grouped according to their profile variables. The Colaizzi analysis method was applied for qualitative data, allowing key themes to emerge based on participants' responses during the FGD session.

2.6 Ethical Considerations

This study adhered to proper ethical guidelines for conducting research. Participants were required to complete an informed consent form before participating in the survey, focus group discussion (FGD), and interviews. Participation was entirely voluntary, and participants were assured of confidentiality. Personal information was strictly protected and used solely for research purposes, with no identifiable details disclosed.

3.0 Results and Discussion

3.1 Participants' Profile

The demographic profile of the participants is presented in Figure 2. 138 pre-service science teachers participated in the study, with the majority (91% or 125 participants) aged 18–24 years and predominantly female (72% or 100

participants). First-year students comprised 28% of the total participants, while the remaining year levels had a relatively equal distribution. More than half (51%) of the participants were from State College A, with the sample size proportionally representing the total number of science majors across all year levels. Regarding technological capacity, 65% (90 participants) had access to a smartphone or laptop with an internet connection. Additionally, the BLM, a combination of online and face-to-face instruction, was the most preferred learning method, chosen by 59% of the participants.

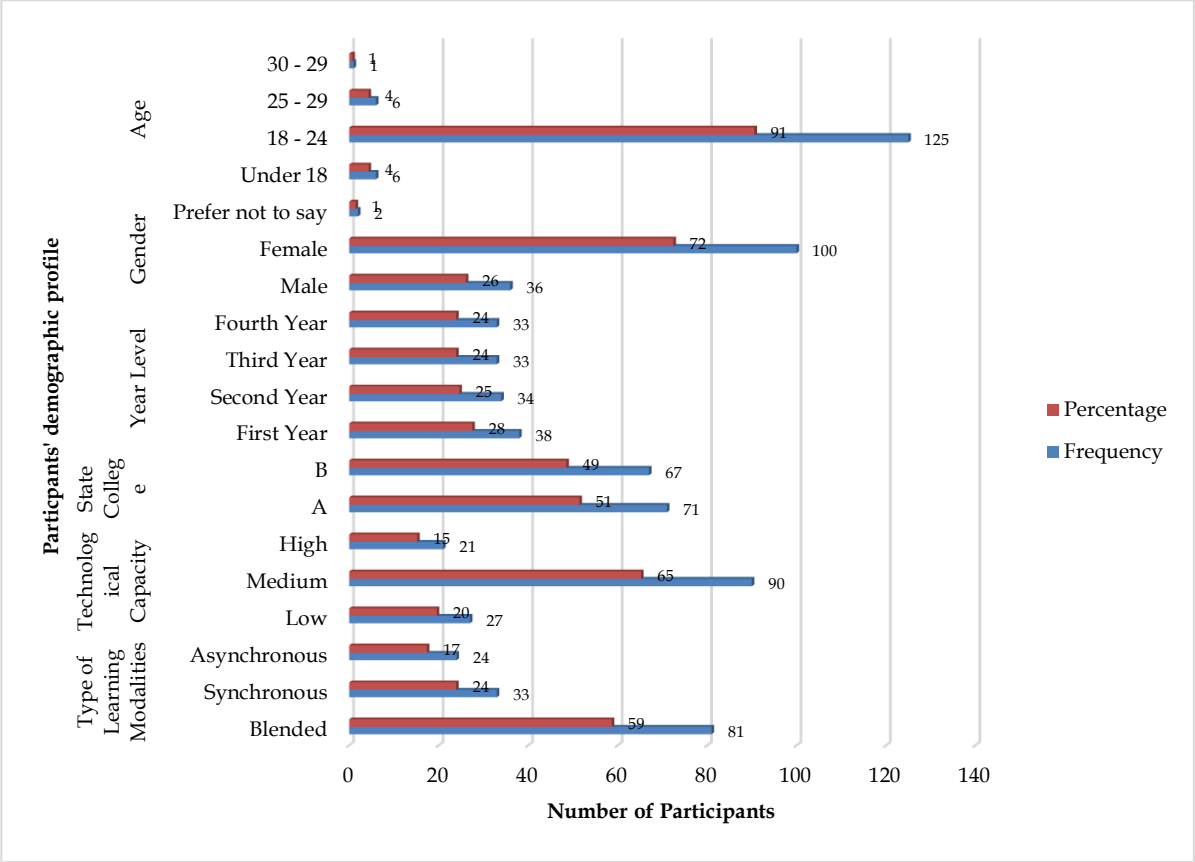

Figure 2. *Frequency and percentage of the demographic profiles of the participants of the study*

3.2 Knowledge of Pre-service Science Teachers Towards BLM

As shown in Table 1, all indicators under the knowledge category assess participants' technological proficiency in navigating online and face-to-face platforms in a blended learning environment. Indicator 7, "*I know how to troubleshoot when technical problems arise*," received the lowest mean score of 3.39, indicating uncertainty among participants. In contrast, Indicator 3, "*I know how to download and save files for study*," had the highest mean score of 4.56, signifying a high level of knowledge. The overall mean score for the knowledge category was 4.12, which is verbally interpreted as knowledgeable. The results in Table 1 highlight participants' ICT skills, including downloading files and troubleshooting technical issues that are essential for navigating online applications and overcoming the challenges of blended learning. Similarly, Baticulon et al. (2021) identified technological barriers to blended learning, such as difficulties with online platforms and a lack of technical proficiency among medical students.

Amid global economic uncertainties, the World Bank (2020) reported that many students struggle to access online learning, particularly those in areas with limited internet connectivity and other socioeconomic disadvantages. Carillo and Flores (2020) further emphasized that restricted access to technology and the internet remains a significant challenge exacerbated by lockdowns and the shift to blended learning. These disparities have not only disrupted traditional teaching and learning processes but have also deepened digital inequality, as access to

technology and levels of digital literacy continue to be shaped by social, economic, and cultural factors (Beaunoyer, Dupéré, & Guitton, 2020). This issue was echoed by Participant 6, who shared during the interview: "*Most of the time, we encounter signal issues when conducting self-directed learning or researching for additional knowledge related to our courses. This often becomes a hindrance, as it delays our course review activities*."

Table 1. *Knowledge of pre-service science teachers towards blended learning modalities*

Indicators	Mean	SD	Interpretation
1. Our college/department has a good online infrastructure for BLM.	3.94	0.80	Knowledgeable
2. I know how to use our learning management system/platforms for BLM.	4.03	0.76	Knowledgeable
3. I know how to access files/apps used for BLM.	4.56	0.78	Highly Knowledgeable
4. I know how to upload assignments in different formats through BLM.	4.47	0.96	Knowledgeable
5. Our college allows the use of other BLM platforms for study.	4.37	0.66	Knowledgeable
6. I am well-versed in using the internet and fully aware of its functions.	4.07	0.84	Knowledgeable
7. I know how to troubleshoot when technical problems arise in BLM.	3.39	0.92	Undecided
Overall Result	**4.12**	**0.57**	**Knowledgeable**

However, despite technological challenges, Chua et al. (2021) emphasized the importance of students developing excellent technological proficiency, as it significantly influences their knowledge, attitudes, and practices in utilizing lectures, programs, and software essential for blended learning. As education continues integrating digital tools, students adept at navigating learning management systems, troubleshooting technical issues, and effectively using online resources are more likely to engage in and benefit from blended learning. Moreover, enhancing technical skills, promoting digital literacy, and improving access to the internet and necessary technological tools are crucial factors in supporting students' academic success. Digital literacy goes beyond basic computer skills. It encompasses critically evaluating online information, effectively communicating in virtual environments, and adapting to emerging technologies. Without these skills, students may struggle to fully participate in online discussions, complete digital assignments, or access essential educational materials.

As shown in Table 2, all knowledge indicators assess participants' internet-based capabilities and functions. Statistical analysis revealed no significant differences in participants' knowledge of BLM across demographic attributes at a 0.05 significance level. This indicates that age, gender, year level, state college affiliation, technological capacity, and preferred learning modality did not significantly influence their knowledge of BLM.

Table 2. *Difference in the knowledge of pre-service Science teachers towards BLM when grouped according to their profile variables*

Profile variable	Category	Mean	F – Test statistic	p-value
Age	30 – 39	4.71	0.76 (3,134)	0.52
	25 - 29	3.95		
	18 - 24	4.11		
	Under 18	4.31		
Gender	I prefer not to say	4.36	0.78 (2, 135)	0.46
	Female	4.08		
	Male	4.20		
Year Level	Fourth Year	4.09	0.46 (3, 134)	0.71
	Third Year	4.22		
	Second Year	4.10		
	First Year	4.07		
State College	B	4.07	0.73 (1, 136)	0.39
	A	4.16		
Technological Capacity	High	4.05	0.96 (2, 135)	0.39
	Medium	4.17		
	Low	4.01		
Type of Learning Modalities	Asynchronous	4.10	0.67 (2,135)	0.51
	Synchronous	4.08		
	Blended	4.22		

** p-value is less than 0.05 significance level*

These findings align with Zhan et al. (2015), who reported that gender does not influence students' learning achievement in computer-assisted collaborative learning. Similarly, Fleming et al. (2017) found that age does not significantly impact students' academic goals or satisfaction with e-learning. Ali (2020) emphasized that the effectiveness of ICT-integrated learning depends on various factors, including teacher preparedness, student confidence, accessibility, and motivation. Additionally, Sindiani et al. (2020) highlighted that the abrupt transition to blended learning, inadequate preparation, and technological challenges led to negative experiences for teachers

and students. This further reinforced the perception that virtual learning is of lower quality than traditional face-to-face instruction.

3.3 Attitude of Pre-service Science Teachers Towards BLM

Among the seven attitude indicators, Indicator 6, "*I am willing to comply with changes in teaching methods based on technology*," received the highest mean score of 3.91, indicating a positive attitude. In contrast, Indicator 3, "*I prefer online learning techniques over conventional learning methods*," had the lowest mean score of 3.33, reflecting uncertainty among participants. Participants demonstrated a generally positive attitude towards BLM, with an average mean score of 3.54. These findings highlight students' perceptions and experiences, which may influence their preferences for online learning resources and their adaptability to technology-driven educational approaches. Table 3 highlights pre-service science teachers' preference for BLM over traditional methods and their openness to adapting to technology-based teaching approaches. This finding aligns with Ali (2020), who stated that modern students are highly dependent on mobile technology and expect technology-integrated learning that allows them to study from the convenience of their homes.

Table 3. *Attitudes of pre-service science teachers toward blended learning modalities*

Indicators	Mean	SD	Interpretation
1. I like using BLM.	3.51	0.81	Positive
2. I like learning in a home-type environment.	3.43	1.01	Undecided
3. I prefer BLM to conventional learning methods.	3.33	0.93	Undecided
4. I like having online tasks for academic purposes.	3.50	0.93	Positive
5. I enjoy using BLM lectures.	3.41	0.92	Undecided
6. I am willing to comply with changes in teaching methods based on technology.	3.91	0.79	Positive
7. I like the interface of the platform our college uses for BLM.	3.69	0.84	Positive
Overall Result	**3.54**	**0.68**	**Positive**

This finding encourages academic institutions to strengthen their ICT infrastructure and student support services to create a more engaging and meaningful blended learning experience. However, students' attitudes and commitment play a crucial role in determining their level of engagement and perceived quality of blended learning (Muir et al., 2019). Carillo and Flores (2020) further emphasized that focused students who are well-prepared, self-motivated, adequately supported, and receive relevant feedback tend to learn more effectively in blended learning environments.

When students were interviewed about their perspectives on BLM, a common theme emerged: many perceived it as the most effective approach to learning. Participant 3 shared, "*Based on my experience, BLM is the most beneficial since it allows us to complete assigned tasks at our own pace. Additionally, scheduled synchronous online classes allow our teacher to explain difficult concepts*." Similarly, Participant 9 agreed, stating, "*BLM is very convenient. This modality enhances my ability to adapt to different learning environments*." These insights align with the study's findings, suggesting that students gradually adapt to the new normal and recognize the advantages of blended learning in enhancing their academic experience.

Among the profile variables considered, the learning modality ($p = 0.02$) significantly impacted pre-service science teachers' attitudes toward distance learning at the 0.05 significance level. This suggests that students' attitudes toward blended learning are influenced by the specific medium used in the teaching-learning process. For instance, students more accustomed to face-to-face instruction may struggle to adapt to online components, leading to a more cautious or uncertain attitude toward blended learning. Conversely, those comfortable with digital tools and online platforms may perceive this modality more positively. These findings highlight the importance of aligning instructional strategies with students' preferred learning environments to ensure engagement and effectiveness in blended learning settings.

The results in Table 4 highlight the rapid transition to blended learning to achieve educational goals and the increased importance of integrating technology into education. This digital transformation aligns with the evolving expectations of students deeply immersed in technology. ICT literacy has become a fundamental skill, shaping instructional methodologies and learning environments and how students engage with learning.

Table 4. *Difference in the attitude of pre-service Science teachers towards BLM when grouped according to their profile variables*

Profile variable	Category	Mean	F – Test statistic	p-value
Age	30 – 39	2.71		
	25 - 29	3.22	1.13 (3, 134)	0.34
	18 - 24	3.57		
	Under 18	3.70		
Gender	I prefer not to say	4.29	1.21 (2, 135)	0.30
	Female	3.53		
	Male	3.71		
Year Level	Fourth Year	3.64		
	Third Year	3.53	0.36 (3, 134)	0.78
	Second Year	3.47		
	First Year	3.53		
State College	B	3.58	0.53 (1, 136)	0.53
	A	3.65		
Technological Capacity	High	3.48		
	Medium	3.53	0.21 (2, 135)	0.81
	Low	3.61		
Type of Learning Modalities	Asynchronous	3.52		
	Synchronous	3.55	0.08 (2,135)	0.02*
	Blended	3.53		

** p-value is less than 0.05 significance level*

Ejdys (2021) found that students' attitudes toward e-learning play a crucial role in their willingness to adopt such platforms. Factors such as perceived usefulness and computer self-efficacy significantly influence their acceptance and engagement with e-learning technologies (Agudo-Peregrina et al., 2014; Ejdys, 2020). Moreover, ICT-integrated lessons create dynamic and interactive learning experiences, encouraging self-directed learning and fostering greater student autonomy (Ali, 2020). These findings emphasize the need for academic institutions to enhance digital literacy and provide robust technological support to maximize the benefits of blended learning.

The participants of this study also highlighted that the current learning modality has encouraged them to become more resourceful. They emphasized that the availability of learning materials has played a crucial role in helping them meet academic requirements. Participant 8 shared, "*Based on my experience, our teachers have utilized various methodologies to enhance our learning. The learning resources provided are sufficient for implementing blended learning modalities effectively, and I am satisfied with the support we have received*."

In this study, a key challenge observed in utilizing blended learning modalities is their impact on students' learning experiences, influencing their attitudes toward online education. Research highlights the advantages and limitations of blended learning, with students' perspectives varying based on their engagement and perception of these learning approaches. Asynchronous learning environments are often self-paced, student-driven, and independent of time and location constraints (Clark & Mayer, 2016; Xie et al., 2018). While these settings offer flexibility, they require students to develop strong self-regulation skills, motivation, and discipline to meet learning objectives (Harnett, 2015). Additionally, students must possess adequate digital literacy to effectively complete academic tasks and learning activities (Kim et al., 2019).

In contrast, synchronous learning environments enable real-time interaction, providing immediate feedback, fostering natural communication, enhancing student engagement, and personalizing the learning experience (Blau et al., 2017). However, they may not be as immersive or dynamic as traditional face-to-face learning. Fabriz et al. (2021) argue that synchronous learning can increase cognitive load, create communicative ambiguity, and reduce student participation due to the pressures of real-time engagement. Understanding these complexities is essential for optimizing blended learning strategies to balance flexibility, engagement, and practical knowledge acquisition.

Moorehouse and Wong (2021) found that teachers integrated both asynchronous and synchronous digital technologies and instructional strategies to enhance student learning, assess progress, and maintain communication with students and parents remotely. Their study suggests that a blended approach, combining asynchronous and synchronous learning, is the most effective way to support online student learning. Similarly, this study's participants preferred a mixed learning modality, emphasizing its flexibility and effectiveness. Participant 7 noted that this approach allowed for independent learning, while Participant 8 agreed, stating, "*BLM*

is effective for me. I can learn on my own, and at the same time, teachers are available whenever we need their guidance. We can consult them about our difficulties during synchronous classes." This reinforces that a balanced combination of self-paced learning and real-time interaction enhances the learning experience.

3.4 Practices of Pre-service Science Teachers Towards BLM

In terms of practice, pre-service science teachers recorded the lowest mean score (X = 3.30) on Indicator 11, "*I do not have trouble accessing learning materials*," which was interpreted as neutral. In contrast, Indicator 9, "*I make sure to understand a topic before moving on to another topic*," received the highest mean score of 3.91, categorized as "practiced." Overall, seven out of the eleven indicators were rated as "practiced," while the remaining four were classified as "neutral" or "uncertain." These findings highlight students' engagement and competencies in blended learning, particularly their study habits and adaptability within the BLM framework.

The results in Table 5 highlight pre-service science teachers' uncertainty regarding their BLM practices, particularly in areas such as accessing learning materials online, collaborating with classmates, completing assignments, and the conduciveness of their learning environment. This neutrality does not necessarily indicate disinterest but suggests inconsistent engagement in these practices—sufficient to sustain online learning but potentially leading to suboptimal learning outcomes. These challenges reflect broader issues of digital inequality, influenced by disparities in access to technology and variations in digital literacy, which are deeply rooted in social, economic, and cultural contexts (Beaunoyer et al., 2020; Carillo & Flores, 2020). Despite these technological challenges, the findings reveal the pre-service science teachers' enthusiasm, persistence, and commitment to mastering topics before progressing to new ones. This underscores their determination and passion for learning, even within a blended learning framework.

Table 5. *Practices of pre-service science teachers towards blended learning modalities*

Indicators	Mean	SD	Interpretation
1. I have a conducive learning environment.	3.46	0.79	Undecided
2. I manage my time well when engaging with my lessons.	3.54	0.86	Practiced
3. I can use all learning materials provided online, such as class discussions or recordings.	3.84	0.83	Practiced
4. I only use online learning for passing requirements.	3.48	0.98	Undecided
5. I attend all my classes on time.	3.90	0.92	Practiced
6. I can use additional learning materials (e.g., Virtual Labs).	3.77	0.86	Practiced
7. I participate actively during online class discussions.	3.62	0.79	Practiced
8. I ask my professors questions (message privately or during online class discussions).	3.68	0.90	Practiced
9. I make sure to understand a topic first before moving to another topic.	3.91	0.77	Practiced
10. I actively study with my classmates online.	3.36	0.93	Undecided
11. I do not have trouble accessing learning materials.	3.30	1.02	Undecided
Overall Result	**3.62**	**0.58**	**Practiced**

Furthermore, Table 6 reveals that pre-service science teachers' BLM practices differ significantly based on technological capacity ($p = 0.05$). This suggests that access to and proficiency with digital tools play a vital role in shaping their engagement and effectiveness in remote learning environments. Students with stronger technological skills are more likely to navigate online platforms efficiently, utilize digital resources effectively, and participate actively in virtual discussions. In contrast, those with limited access to technology or lower digital literacy may struggle to adapt to blended learning, potentially impacting their academic performance. These findings emphasize the need to equip pre-service teachers with essential technological skills and resources to successfully integrate digital tools into their learning and future teaching practices.

Table 6 highlights technological capacity as a significant challenge in blended learning. Limited access to reliable internet, digital devices, and technological infrastructure can hinder effective learning, especially for students from underprivileged backgrounds. Carillo and Flores (2020) emphasized that contextual limitations, such as unstable internet connections, lack of appropriate learning devices, and minimal technical support, can diminish students' motivation and engagement, ultimately affecting their academic performance. Similarly, Beaunoyer et al. (2020) posited that these digital constraints continue to impact the quality of blended learning experiences, further widening the educational gap between students with sufficient technological access and those without.

Table 6. *Differences in the practices of pre-service Science teachers towards BLM when grouped according to their profile variables*

Profile Variable	Category	Mean	F – Test statistic	p-value
Age	30 – 39	3.91		
	25 - 29	3.18	1.31 (3, 134)	0.27
	18 - 24	3.64		
	Under 18	3.70		
Gender	I prefer not to say	3.68		
	Female	3.59	0.53 (2, 135)	0.59
	Male	3.71		
Year Level	Fourth Year	3.72		
	Third Year	3.69	1.39 (3, 134)	0.25
	Second Year	3.64		
	First Year	3.47		
State College	B	3.59	0.43 (1, 136)	0.51
	A	3.65		
Technological Capacity	High	3.43		
	Medium	3.67	1.13 (2, 135)	0.05*
	Low	3.62		
Type of Learning Modalities	Asynchronous	3.45		
	Synchronous	3.64	1.42 (2,135)	0.25
	Blended	3.69		

** p-value is less than 0.05 significance level*

Further, addressing these challenges requires a comprehensive approach that ensures all students have equal opportunities to succeed in a blended learning environment. There is a pressing need for a broader support network to promote equity and inclusivity in blended education. Higher education institutions may implement policies that give students access to digital tools, such as loaner laptops, subsidized internet plans, and technical assistance. Government agencies can play a crucial role by investing in digital infrastructure, expanding broadband coverage, and offering financial aid programs for students facing technological difficulties. Collaboration with non-governmental organizations and private sector stakeholders can also help bridge the digital divide by providing training programs that enhance students' digital literacy skills. By fostering a multi-sectoral effort, blended learning can become a more inclusive and effective educational approach for all students, regardless of technological capacity.

3.5 Experiences and Insights of Pre-service Science Teachers in BLM

The study participants were also asked specific questions about their experiences and insights regarding implementing the blended learning modality. Their responses provided valuable perspectives on this learning approach's effectiveness, challenges, and overall impact. Through a thorough qualitative analysis of their feedback, ten (10) essential themes emerged, as summarized in Table 7.

Table 7. Essential themes on the experiences and insights of pre-service Science teachers in BLM

	Essential Themes
Pre-service Science Teachers' Experiences in BLM	*Unstable internet connectivity in online classes*
	Technology-related difficulties in online learning
	Time management as a factor in blended learning
	Blended learning promotes independent learning
	Blended learning is the most effective modality
	Continuity of BLM in post-pandemic education
	Adequate learning resources in BLM
	Provision of clear instructions in BLM
	The teaching-learning strategies utilized are doable
	Learning materials available online for further learning

Pre-service Science Teachers' Experiences in BLM

Unstable Internet Connectivity in Online Classes

Most participants emphasized the challenge of unstable internet connectivity when attending online classes. They sometimes wanted to participate actively, but internet-related issues prevented them. This also made accessing the online materials needed for their coursework difficult. As shared by P3, "*The bad thing is that technology-related*

too. Although I was willing to be very attentive in class, the signal does not cooperate, and there's difficulty sometimes in accessing online materials."

Technology-related Difficulties in Online Learning
During the interview, the participants shared their experiences with asynchronous activities, highlighting technology-related challenges. Many struggled to download and submit exercises or assignments due to poor internet connectivity. P6 expressed a similar concern: "Most of the time, we encounter signal issues when we conduct our self-learning process when we do research for more ideas or knowledge related to our courses. And it becomes a *hindrance sometimes because it delays our course review activities*."

Time Management as a Factor in Online Learning
The current learning setup presents significant challenges for students. While some activities are completed asynchronously, students must effectively manage their time to maintain the quality of their work and meet academic deadlines. Several participants emphasized that time management is crucial, especially when learning from home, as they also have household responsibilities to fulfill. P8 also agreed that time management is a significant challenge, explaining, " *Time management in home-based learning is hard. Making asynchronous learning tiring. In my experience, I have to be a daughter and a student simultaneously*."

Blended Learning Promotes Independent Learning
Participants who experienced both synchronous and asynchronous learning identified several advantages. Asynchronous learning, in particular, allowed them to manage their time effectively and provided opportunities to research complex concepts for better comprehension. As shared by P4, "*I used to make things easy and simple as the learning is mixed. The learning is also enough to sustain my understanding of the topic*."

As discussed above, participants shared their experiences with the learning modalities implemented by their schools. While the transition has not been easy, they continue to adapt and strive to keep up with their studies. Jacintos et al. (2021) highlighted that maintaining their attention is one of the main challenges students face in physical and online lectures. Some instructors incorporate real-life scenarios relevant to the course to create engaging synchronous online lectures. In contrast, others use entertaining content to help students feel more comfortable and capable of learning.

Pre-service Science Teachers' Insights on BLM

Blended Learning is the Most Effective Modality
For most participants, the blended learning modality is the most effective approach. Combining online and in-person activities allows students to maintain a balanced learning process. Online classes, in particular, allow teachers to explain complex concepts that students may struggle to learn independently. As P3 shared, "*Based on my own experience, the blended learning modality is most effective because the student can have a time or a choice when or where we will answer the activities. Moreover, of course, there is a scheduled online class to help students understand a specific subject better, especially the specialized subject that needs guidance and ideas from the instructors*."

Continuity of BLM in Post-Pandemic Education
The blended learning modality has become increasingly prominent since the pandemic. The students in this study believe that BLM should continue as part of the educational system due to its various benefits. Additionally, they find the asynchronous learning mode particularly effective, especially for accessing assignments online. As P9 stated, "*It is convenient for students who can access their assignment or task via online. This is equally essential to teachers as they can easily access lesson materials online*."

Adequate Learning Resources in BLM
There are numerous resources available to support the learning process. With the implementation of the blended learning modality, students can browse various online references to assist them in completing their assigned tasks. Most participants shared the same perspective, stating that blended learning provides adequate learning resources. Additionally, using learning applications and other digital tools plays a significant role in supporting BLM. Regarding resource availability, P8 explained, "*Learning resources were adequate in implementing the blended*

learning modalities. Based on my experience at the institution where I study. Professors always have many ways to nourish students learning. I am satisfied with how I have been treated. This only means resources were sufficient."

Provision of Clear Instructions in BLM

Participants also observed that clear instructions were provided for completing their synchronous, asynchronous, and face-to-face tasks. With proper guidance, they were able to meet the requirements effectively. P8 shared their experience regarding their instructor's clarity in giving instructions: "*Instructions given through the modalities were clear because if not, I may not be able to comply with all the tasks after all*."

Teaching-learning Strategies Utilized Are Doable

Teaching-learning strategies play a crucial role in effectively conveying knowledge from teachers to students. Participants shared that their teachers were supportive and provided encouragement, especially when completing tasks. Many students were motivated to participate because most tasks were manageable. As P7 stated, "*It is doable on my part as teaching-learning strategies such as discussions, quizzes, and oral recitation are prevalent strategies and is doable for any students to participate. Furthermore, topic reports are also doable*."

Learning Materials Available Online for Further Learning

Online learning materials are highly beneficial for students in understanding complex concepts. A wide range of resources can be accessed online, supporting independent learning. P6 shared the experience, stating, "*Learning materials are accessible, and it helps me gain more knowledge in my courses. They provide easy access for reviewing discussions as those learning materials can be shared through phones. Moreover, it is more convenient because those software-based learning resources can be stored on our phones or laptops, making it less necessary to print hard copies*."

Based on the participants' responses, most found the BLM beneficial. It provides flexibility and promotes independent learning. However, internet connectivity occasionally hinders learning, affecting students' ability to engage fully with online resources and activities. Despite these challenges, BLM remains a promising and inclusive approach to higher education, integrating technology to enhance the teaching-learning experience. The continued implementation of BLM requires educators' adequate support and guidance to help students navigate digital learning environments effectively. Teachers play a crucial role in structuring lessons, providing clear instructions, and offering assistance to ensure students maximize the benefits of synchronous and asynchronous learning. Additionally, students emphasized that improved communication between instructors and learners significantly eased their transition into this new mode of education. Clear expectations, timely feedback, and accessible learning materials made the shift to blended learning more manageable and effective. As higher education institutions increasingly adopt BLM, it is essential to address existing challenges by enhancing digital infrastructure, providing technological support, and fostering digital literacy among students and educators. With the right support systems, BLM can serve as a sustainable and equitable learning approach that prepares students for the demands of an evolving educational landscape (Colfer et al., 2021).

4.0 Conclusions

Based on the findings of this study, the overall mean of all knowledge indicators suggests that participants can be characterized as knowledgeable. This indicates that, despite the challenges encountered in BLM, students could still utilize technology effectively. Their ability to adapt may be attributed to the necessity of adjusting to new learning environments, which, in turn, fosters digital literacy and helps them navigate the evolving educational landscape. Furthermore, none of the participants' demographic attributes significantly influenced their knowledge of BLM at the 0.05 significance level. Age, gender, year level, state college, technological capacity, and type of distance learning modality did not create substantial differences in their understanding or familiarity with blended learning. This means that regardless of background or personal circumstances, students could develop technological proficiency and engage with the blended learning framework effectively.

In terms of attitudes, pre-service science students demonstrated a positive outlook BLM, indicating their ability to quickly adapt to the new learning system. This indicates that pre-service science students generally prefer online learning over traditional methods. At the 0.05 level of significance, the type of blended learning modality had a significant impact on pre-service science teachers' attitudes toward distance learning. This suggests that their attitudes toward blended learning vary depending on the specific medium used in the teaching-learning process.

The pre-service science students' practices indicate that they make a conscious effort to thoroughly understand each subject before progressing to the next, demonstrating their effectiveness in the blended learning environment. Their BLM practices varied significantly based on their technological capacity. This suggests that access to and proficiency with technological tools play a crucial role in shaping students' distance learning experiences and engagement.

The qualitative findings provided valuable insights from pre-service science education students, highlighting their experiences and perspectives on BLM. The emerging themes revealed that most of their challenges stemmed from technological and internet connectivity issues. However, these difficulties did not prevent them from making efforts to adapt to the evolving educational landscape. They expressed that BLM is effective in promoting learning independence and enabling them to manage their time efficiently. The researchers recommend addressing the key findings, particularly the indicators where pre-service science teachers expressed indecisiveness. To gain deeper insights into these areas, further qualitative research is suggested to explore the underlying factors more comprehensively. Additionally, the findings of this study can serve as a valuable basis for curriculum assessment in higher education programs, guiding the effective implementation of BLM. In the post-pandemic era, where AI-driven technologies are becoming more prevalent in education, these insights can help refine instructional strategies and contribute to the delivery of high-quality, technology-integrated learning experiences.

5.0 Contributions of Authors

This paper is a product of collaborative efforts by the authors. LSD conceptualized the study, designed, and implemented the methodology for quantitative data collection, and analyzed and discussed the quantitative findings. RSM developed the abstract and introduction, analyzed and discussed the qualitative data, and formulated the conclusion. Both authors reviewed and approved the final manuscript.

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7.0 Conflict of Interests

The authors declare no conflicts of interest regarding the publication of this paper.

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