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Assessing the Level of Awareness and Readiness of Science Teachers on the Use of Virtual Laboratory: A Basis for Professional Development Program

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ABSTRACT

Virtual laboratories are becoming an increasingly valuable part of science education. They help students build a clearer understanding of scientific concepts, encourage inquiry-based learning, and provide a safe and convenient space to explore experiments that might be difficult to conduct in a traditional classroom. This study examined the level of awareness and readiness of sixteen (16) science teachers from the Emilio Aguinaldo College High School Department in using virtual laboratories in their teaching as a basis for a proposed professional development program. A quantitative descriptive-correlational research design was used, and data were gathered through a structured survey grounded in the Technological Pedagogical and Content Knowledge (TPACK) framework. The findings showed that the teachers demonstrated a very high level of awareness (M = 4.53) and a high level of readiness (M = 4.18) in using virtual laboratories. Among the indicators of readiness, content knowledge received the highest rating, while skills in technological troubleshooting received the lowest. When awareness and readiness levels were compared across age groups, teaching experience, and educational attainment, no significant differences were found. However, a strong positive correlation emerged between awareness and readiness (r = 0.698, p = 0.003), suggesting that teachers who were more aware of virtual laboratories also felt more confident to use them. Based on the findings, a professional development program titled *"Lab Beyond the Classroom: Strengthening Science Teachers' Readiness in Virtual Laboratory Integration"* was proposed to address gaps in technical troubleshooting and pedagogical design. The study concludes that sustained, context-based training is essential to fully harness the benefits of virtual laboratories in science instruction.

Keywords: virtual laboratory, TPACK, teacher awareness, teacher readiness, professional development program

INTRODUCTION

Virtual Laboratories (VLs) have evolved from experimental to widely used teaching tools over the past five years, particularly after the shift to online and blended learning during the COVID-19 pandemic (Reyes et al., 2024). Virtual laboratories offer scalable, safe, and affordable alternatives to traditional lab settings by enabling educators and students to carry out digital experiments on computers or mobile devices (Shambare & Jita, 2025). They have been effective for teaching complex and abstract science concepts, where understanding, motivation, and self-efficacy have significantly improved, like those in cell and molecular biology (Byukesenge et al., 2022; Navarro et al., 2024; Swastika et al., 2024).

Despite the pedagogical promise of VLs, research shows that the effective implementation of VL depends on the awareness and readiness of the teachers. While many science teachers appreciate their teaching value, the use of VLs remains limited due to low digital skills, inadequate training and lack of support from the institution, especially in schools with fewer resources (Kolil and Achuthan, 2022). According to Amemasor et al. (2025), hands-on professional development programs relevant to the local context that include mentoring and infrastructure lead to a higher chance of adoption than one-time workshops. However, recent literature continues to reveal a gap between teachers' acceptance of VLs and their actual integration into the teaching process, particularly in rural settings, suggesting that awareness and positive attitudes alone are not enough to ensure meaningful implementation. While much of this research focuses on rural or under-resourced schools, there is limited evidence examining whether the same gap exists in urban private institutions where access to technology may be comparatively better. This opens an important area of investigation: even when digital tools are available, are teachers sufficiently aware and ready to use them in their science teaching?

To address this gap, the present study was conducted at Emilio Aguinaldo College–High School Department, where all 16 science teachers served as respondents. The selection of this locale is grounded in the institution's ongoing commitment to enhance digital integration and improve science teaching strategies in line with 21st-century learning goals.

Specifically, this study sought to answer the following research questions:

1. What is the demographic profile of science teachers in terms of:

1.1. Age

1.2. Years of Teaching Experience

1.3. Educational Attainment

2. What is the level of awareness of science teachers on the use of virtual laboratories in terms of:

2.1. Knowledge Awareness

2.2. Pedagogical Awareness

2.3. Resource Awareness

3. What is the level of readiness of science teachers on the use of virtual laboratories based on TPACK in terms of:

3.1. Technological Knowledge

3.2. Pedagogical Knowledge

3.3. Content Knowledge

4. Is there a significant difference between the level of awareness and the level of readiness of science teachers when grouped according to their profile?
5. Is there a significant relationship between the level of awareness and the level of readiness of science teachers on the use of virtual laboratories?
6. What professional development program can be proposed based on the results of this study?

Accordingly, this study aimed to determine the level of awareness and readiness of science teachers in using virtual laboratories and, based on the results, to propose a professional development program that responds to the needs identified.

To guide this study, the following null hypotheses were formulated and tested at a 0.05 significant level:

- H_{01}: There is no significant difference in the level of awareness and level of readiness of virtual labs among teachers when grouped according to their profile.
- H_{02}: There is no significant relationship between the level of awareness and the

level of readiness of science teachers on the use of virtual laboratories.

LITERATURE REVIEW

Virtual Laboratory in Science Education

Virtual laboratories (VLs) function as interactive computer applications which enable students to perform actual laboratory work through online interfaces. Students can perform experiments while modifying variables and obtain data results through digital experimentation. Science education benefits from these virtual laboratories because they enable students to practice scientific inquiry through practical activities which address traditional laboratory constraints (Abdelmoneim et al., 2022; Reyes et al., 2024).

Virtual laboratories enable science education to reach more students because they operate without requiring physical laboratory spaces or safety equipment. The system offers students digital access to safe and affordable laboratory experiences through digital devices without requiring expensive laboratory equipment purchases (Byukesenge et al., 2022).

Teachers can implement innovative teaching approaches through virtual laboratories because they support flipped learning and problem-based learning and group work activities. The research by Alhashem and Alfailakawi (2023) demonstrated that pre-service teachers who created virtual lab activities developed their technology competencies while gaining assurance in teaching inquiry-based lessons. The educational value of virtual laboratories extends to student learning while simultaneously helping teachers develop digital competencies for creating enhanced educational materials.

Research evidence demonstrates virtual laboratories in science education serve as more than a temporary educational trend. The educational approach now focuses on student involvement through interactive learning experiences, which provide equal access to all students. The combination of simulation technology with hands-on experimentation and feedback systems in virtual laboratories transformed student learning methods while enhancing science education accessibility.

Effectiveness of Virtual Laboratory in Student Learning

The effectiveness of VLs in promoting student learning outcomes is well-documented. Byukesenge et al. (2022) found that VLs are especially useful in teaching complex and abstract concepts, such as those in cell biology and molecular structures. Through visual simulations, students are able to conceptualize processes that are otherwise difficult to observe in a traditional classroom setting. Ajayan and Eichler (2025) further highlighted that the use of simulation models helps strengthen students' comprehension by making scientific concepts more concrete and accessible.

Research findings show that Virtual Laboratories create substantial effects on student achievement results. The knowledge gain of undergraduate biology students who used virtual molecular cloning laboratories reached 75.93 ($SD = 10.25$) which was significantly higher than the traditional group at 50.93 ($SD = 9.76$) with a large effect size of $d = 1.46$ ($p = .001$) (Sari et al., 2022).

VLs are particularly valuable in contexts where experiments are costly, hazardous, or logistically difficult to perform. In a study of pre-service chemistry teachers, the integration of virtual laboratory tools significantly improved learners' conceptual understanding and engagement compared with conventional methods (Alhashem and Alfailakawi, 2023). The findings indicated that students exposed to VL simulations showed stronger practical reasoning and self-efficacy when later performing physical experiments.

Overall, the literature confirms that virtual laboratories not only support cognitive development but also foster positive attitudes, engagement, and inquiry-based learning behaviors (Abdelmoneim et al., 2022; Byukesenge et al., 2022). These studies underscore that the effectiveness of VLs lies in their ability to combine accessibility with interactivity—allowing students to build scientific understanding through exploration, reflection, and active experimentation.

Teachers' Awareness of Using Virtual Laboratory

Teacher awareness plays a vital role in the effective implementation of new instructional technologies. According to Tabassum (2023) that a lot of teachers, especially in those developing countries, barely knew about virtual labs even before the pandemic. However, once introduced to these platforms, teachers perceived them as intuitive and highly beneficial for teaching complex scientific topics at the secondary level. In a survey involving 142 secondary science teachers, 67% reported that they had heard of or seen a VL demonstration, yet only 24% had actually used one in teaching practice (Kolil and Achuthan, 2022). This discrepancy underscores the difference between awareness and practical application, revealing that knowledge of VLs does not automatically translate into implementation.

Shambare and Jita (2025) observed that teachers' awareness often determines whether VLs are perceived merely as supplementary tools or as integral components of science instruction. The more teachers are informed about the potential of VLs to foster inquiry, collaboration, and critical thinking, the more likely they are to integrate them meaningfully into teaching practices. Nonetheless, the literature also indicates that awareness alone is insufficient—without readiness and institutional support, awareness may not lead to sustained adoption.

Empirical evidence also suggests that awareness is closely linked to teachers' professional exposure and training. In a quasi-experimental PD intervention involving 60 science teachers, those who participated in a virtual lab orientation workshop reported a 46% increase in confidence and a 38% increase in self-rated awareness of pedagogical uses of VLs compared to those who received only informational materials (Amemasor et al., 2025). These findings imply that structured professional learning opportunities can transform teachers' perceptions of VLs from optional add-ons to integral components of science instruction.

Nevertheless, awareness alone is not sufficient to guarantee long-term integration. Without sustained support, infrastructure, and school-level policies promoting digital innovation, awareness tends to remain superficial (Kolil and Achuthan, 2022; Shambare and Jita, 2025). This highlights the need for continuous capacity-building programs and institutional strategies that go beyond introducing technology, focusing instead on cultivating teachers' digital competence, confidence, and pedagogical understanding.

Teachers' Readiness on Using Virtual Laboratory Based on TPACK Framework

Teachers' readiness refers to their preparedness, technically, pedagogically, and attitudinally, to integrate virtual laboratories (VLs) into instruction. Within the TPACK framework, readiness involves effectively combining technological, pedagogical, and content knowledge to design meaningful science lessons (Mishra and Koehler, 2006, as cited in Amemasor et al., 2025). A ready teacher is confident in using digital tools, skilled in planning inquiry-based learning, and competent in guiding students' conceptual understanding.

Studies show that while many science teachers view VLs positively, their readiness depends on factors such as prior training, access to resources, institutional support, and self-confidence (Tabassum, 2023). Higher TPACK competence is linked to greater VL integration: science teachers with strong TPACK are significantly more likely to use VLs (Shambare and Jita, 2024), and hands-on digital pedagogy training has been found to increase readiness levels (Amemasor et al., 2025).

Personal and professional characteristics also influence readiness. Mane (2025) noted that teachers' age, educational background, and length of service affect how they develop and apply technological, pedagogical, and content knowledge. These differences may shape teachers' confidence, adaptability, and openness to using emerging digital tools.

Overall, readiness is influenced by both individual competence and the support available within the school environment. Strengthening all components of TPACK through targeted professional development can enhance meaningful and sustained VL integration in science classrooms.

Gaps in Acceptance and Professional Development

Although the benefits of VLs are widely recognized, gaps remain in their acceptance and usage. Shambare and Jita (2025) identified a discrepancy between teachers' acceptance of VLs and their actual use in classrooms, particularly in rural and resource-constrained schools. Teachers acknowledged the usefulness of VLs but seldom integrated them due to infrastructural barriers, lack of training, and limited institutional facilitation. This gap highlights the need for targeted interventions that address not just attitudes but also practical challenges of adoption.

Professional development (PD) emerges as a critical solution. Amemasor et al., (2025) emphasized that PD programs designed for technology integration are most effective when they are context-specific, hands-on, sustained, and supported by school leadership. Short-term workshops tend to raise awareness but do not necessarily translate into readiness or long-term use. Instead, comprehensive training that builds teachers' technical competence, pedagogical confidence, and access to peer support networks is more likely to sustain VL adoption.

MATERIALS & METHODS

A quantitative descriptive-correlational research design was employed in this study to identify the level of awareness and readiness of science teachers in utilizing virtual laboratories, as well as the relationship between them. All 16 science teachers in the High School Department were sampled using total enumeration, thus everyone in this population was accommodated.

Data were collected through a structured survey instrument that was developed from the existing well-tested instruments on technology integration and teacher digital competency. The instrument included three parts: (1) demographic profile; (2) level of awareness on the use of virtual laboratory measured in terms of knowledge, pedagogical and resource awareness, and (3) level of readiness based on the Technological Pedagogical Content Knowledge (TPACK), which assessed the technological, pedagogical, content aspects. All items were rated on a 5-point Likert scale, where the tested respondents, at the end of reading the questions, checked one of the five options that best fit their situation and the options were: "Strongly Disagree", "Disagree", "Neutral", "Agree", and "Strongly Disagree". In the statistics, 1, 2, 3, 4 and 5 points are assigned to each of the five options, and the student's scores for each of the five options are added up to calculate the total score, with the higher the total score, indicates a higher level of awareness and higher level of readiness.

The survey was administered via Google Forms following administrative approval and an orientation with the participants. Descriptive statistics (mean and standard deviation) were used to describe the teachers' levels of awareness and readiness. One-way ANOVA was employed to determine differences across demographic groups, while Pearson's correlation was used to examine the relationship between awareness and readiness, with a significance level of 0.05.

STATISTICAL ANALYSIS

The data collected were analyzed using both descriptive and inferential statistical methods to address the research questions and test the hypotheses. Descriptive statistics, including frequency and percentage, summarized the demographic characteristics of science teachers, such as age, years of teaching experience, and educational attainment. Levels of awareness and readiness regarding virtual laboratories were assessed using weighted means. Responses on the 5-point Likert scale were assigned numerical values from 1 (Strongly Disagree) to 5 (Strongly Agree), with higher mean scores reflecting greater awareness or readiness. To determine significant differences in awareness and readiness across demographic groups, one-way analysis of variance (ANOVA) was applied. The relationship between awareness and readiness was examined using Pearson's r correlation coefficient. Hypotheses were tested at a 0.05 level of significance; p-values less than 0.05 indicated a significant difference or relationship, while p-values greater than 0.05 indicated no significant difference or relationship. This statistical approach facilitated a comprehensive understanding of teachers' awareness and readiness levels and provided a valid foundation for designing a professional development program responsive to their needs.

RESULT

Result Related to SOP 1: What is the demographic profile of the respondents in terms of? In order to provide an answer to this question, a descriptive using mean distribution analysis was employed. This enabled the researchers to establish the most represented groups and capture the general composition of the science teachers.

Table 1. Profile of the Respondents

Profile N-16	Frequency	Percentage
Age		
21-30 years old	8	50.0
31-40 years old	6	37.5
41-50 years old	2	12.5
Total	**16**	**100%**
Years of Teaching Experience		
1-10 years	12	75.0
11-20 years	4	25.0
Total	**16**	**100%**
Educational Attainment		
Bachelor's Degree	10	62.5
With Master's Units	5	31.25
Master's Degree	1	6.25
Total	**16**	**100%**

Table 1 presents that the respondents in the study was 16 science teachers. Findings show that half of the science teachers (50%) were between 21 and 30 years old, 37.5% were aged 31–40, and only 12.5% were in the 41–50 age group. Most of them were also relatively new to the profession: 75% had 1–10 years of teaching experience, while the remaining 25% had been teaching for 11–20 years. In terms of educational background, 62.5% held a bachelor's degree, 31.25% had completed master's units, and only 6.25% had finished a full master's degree.

These figures suggest that the teaching workforce is largely composed of young and early-career educators. As noted by Weiselmann and Crotty (2022), teachers early in their careers may be more open to adopting new instructional strategies, resources, or digital tools. The small proportion of teachers with completed master's degrees also highlights the need for ongoing professional development to strengthen both pedagogical and technological competencies. Overall, the profile of respondents provides a clear picture of the teaching force in the study. Mane (2025) noted that teachers' age, educational background, and length of service are demographic factors that affect the technology integration of teachers, specifically in teaching science education.

Result Related to SOP 2: What is the level of awareness of science teachers on the use of virtual laboratories in terms of? To provide an answer to this question, researchers used descriptive analysis to compute the means and standard deviations for each indicator of the level of awareness. Respondents rated each statement on a 5-point Likert scale ranging from Strongly Disagree to Strongly Agree, and the average scores were used to determine the levels of Knowledge Awareness, Pedagogical Awareness, and Resource Awareness. By identifying which indicators yielded the highest and lowest mean scores, the researchers were able to infer the areas where teachers demonstrated the strongest awareness and where gaps were most evident. All interpretations were drawn directly from the numerical patterns generated from the survey.

2.1. Knowledge Awareness

Table 2. Assessment on the Level of Awareness of Science Teachers on the Use of Virtual Laboratories in terms of Knowledge Awareness

Indicators	Mean	Standard Deviation	Description	Interpretation
I have heard about the use of virtual laboratories in science education.	4.75	0.58	Strongly Agree	Very High
I know that virtual laboratories simulate real-life experiments using computers or mobile devices.	4.81	0.54	Strongly Agree	Very High
I am aware that virtual laboratories can be accessed online through specific platforms.	4.81	0.40	Strongly Agree	Very High
Overall	4.79	0.45	Strongly Agree	Very High

Table 2 indicates that the highest mean (4.81) was reported on the awareness that teachers gained regarding virtual laboratories simulate real experiments and can be accessed through the internet. This signifies that those teachers are well-informed that virtual laboratories serve as digital platforms that simulate experimental procedures and science concepts interactively. This suggests familiarity not only with the existence of virtual laboratories but also with their functional role in supporting experimental learning.

Whereas the lowest mean (4.75) was on the awareness that they had heard about VLs in science education, indicating that the respondents are already exposed to discussions or information about virtual laboratories, either through professional development, academic literature, or peer interactions, although variation in exposure is slightly more noticeable than in the other two items.

Overall, the findings suggest that the respondents possess a very high level of awareness regarding virtual laboratories. This high awareness level may serve as a positive foundation for integration and implementation, as familiarity often influences acceptance and willingness to adopt educational innovations. The results imply that efforts toward training, capacity building, and utilization of virtual laboratories may be well-supported among the teaching group.

2.2. Pedagogical Awareness

Table 3 presents the level of pedagogical awareness of science teachers regarding the use of virtual laboratories. The overall mean of 4.69 with a standard deviation of 0.69 indicates that the respondents strongly agree with the statements, reflecting a very high level of pedagogical awareness on the instructional benefits of virtual laboratories.

Table 3. Assessment on the Level of Awareness of Science Teachers on the Use of Virtual Laboratories in terms of Pedagogical Awareness

Indicators	Mean	Standard Deviation	Description	Interpretation
I am aware that virtual laboratories can enhance students' understanding of abstract scientific concepts.	4.69	0.79	Strongly Agree	Very High
I am aware that virtual laboratories can be effectively integrated into science lessons to support inquiry-based learning.	4.69	0.79	Strongly Agree	Very High
I am aware that virtual laboratories can create avenues for interactive and immersive teaching and learning process.	4.69	0.60	Strongly Agree	Very High
Overall	4.69	0.69	Strongly Agree	Very High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

All three indicators obtained equal mean values, suggesting a consistent agreement among the respondents regarding the pedagogical value of virtual laboratories.

Overall, the results demonstrate that teachers are not only aware of the technical existence of virtual laboratories but also possess a high level of pedagogical insight into how these tools can enhance learning outcomes. This strong awareness may contribute to greater willingness and readiness to use virtual laboratory tools in classroom practice, especially in promoting conceptual understanding, inquiry-based, and interactive learning.

2.3. Resource Awareness

Table 4 shows that the highest mean (4.75) pertains to teachers' awareness of the equipment needed for virtual laboratories, indicating that teachers are well aware of the basic technological requirements needed to run virtual laboratory activities. This reflects a strong consistency among the respondents, suggesting shared understanding and familiarity with classroom technology.

Meanwhile the lowest mean (3.44) concerns awareness of training opportunities. Limited or unequal access to training programs may be a contributing factor. This disparity suggests that although teachers understand the technical requirements, they lack exposure to institutional training or resource support.

With these findings, the results indicate that while teachers are highly aware of the technological requirements needed to implement virtual laboratories, there is less consistent awareness of available platforms and training opportunities. This suggests the need for the school to provide more structured training and workshops about the use of virtual laboratories.

Table 4. Assessment on the Level of Awareness of Science Teachers on the Use of Virtual Laboratories in terms of Resource Awareness

Indicators	Mean	Standard Deviation	Description	Interpretation
I know websites or institutions that provide virtual laboratory simulations.	4.19	0.98	Agree	High
I know what equipment (computers, projectors, and internet connection) is needed to operate a virtual laboratory.	4.75	0.58	Strongly Agree	Very High
I am aware of some training workshops that focus on using virtual laboratories in science teaching.	3.44	1.15	Agree	High
Overall	4.13	0.69	Agree	High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

Table 5. Summary on the Assessment of the Level of Awareness of Science Teachers on the Use of Virtual Laboratories

Level of Awareness of Science Teachers on the Use of Virtual Laboratories in terms of:	Mean	Standard Deviation	Description	Interpretation
Knowledge Awareness	4.79	0.45	Strongly Agree	Very High
Pedagogical Awareness	4.69	0.69	Strongly Agree	Very High
Resource Awareness	4.13	0.69	Agree	High
Overall	4.53	0.46	Strongly Agree	Very High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

Table 5 shows that the highest awareness is in knowledge (4.79), while the lowest is in resource awareness (4.13). This imbalance implies that while teachers are conceptually and pedagogically ready, they lack consistent knowledge of where and how to access VL tools and training

In summary, science teachers are highly aware of the importance and instructional benefits of virtual laboratories, but there is a need to strengthen resource support, especially in terms of training and access to established virtual laboratory platforms. This indicates that institutional provision and capacity-building programs may further enhance teachers' readiness and confidence to effectively integrate virtual laboratories in teaching science.

Result Related to SOP 3: What is the level of readiness of science teachers on the use of virtual laboratories in terms of? To provide an answer to this question, researchers used descriptive analysis to compute the means and standard deviations for each indicator of the level of awareness. Respondents rated each statement on a 5-point Likert scale ranging from Strongly Disagree to Strongly Agree, and the average scores were used to determine the levels of Technological Knowledge, Pedagogical Knowledge and Content Knowledge. This enables the researchers to establish the extent of preparedness of the teachers to integrate virtual laboratories. The highest and lowest means gave information on what area teachers were more or less confident in. The overall readiness score was obtained by averaging all readiness-related items.

3.1. Technological Knowledge

Table 6. Assessment on the Level of Readiness of Science Teachers on the Use of Virtual Laboratories in terms of Technological Knowledge

Indicators	Mean	Standard Deviation	Description	Interpretation
I understand the basic functions and features of virtual laboratory platforms (e.g., simulation controls, data tools, and activity modules).	4.19	0.66	Agree	High
I can troubleshoot basic or common technical problems when using virtual labs.	3.56	1.15	Agree	High
I have the necessary digital skills to operate virtual laboratories.	4.13	0.72	Agree	High
Overall	3.96	0.64	Agree	High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

Table 6 shows that the highest mean (4.19) refers to understanding VL platform functions, while the lowest mean (3.56) is in troubleshooting. This indicates that teachers can operate VLs but lack confidence in resolving technical issues independently, which may inhibit spontaneous use during lessons.

Overall, the findings point to a teaching group that has strong foundational digital competencies but may require additional technical support and training, particularly in managing troubleshooting challenges

3.2. Pedagogical Knowledge

The table 7 shows that assessing student performance using VLs has the highest mean (4.31), while designing VL-integrated lessons has the lowest (4.06). The computed overall mean score of 4.19 which indicates that the respondents agree with the statements, signifying a high level of pedagogical knowledge on the use of virtual laboratories.

Table 7. Assessment on the Level of Readiness of Science Teachers on the Use of Virtual Laboratories in terms of Pedagogical Knowledge

Indicators	Mean	Standard Deviation	Description	Interpretation
I can design learning activities that integrate virtual laboratories.	4.06	1.00	Agree	High
I can facilitate student learning successfully through virtual laboratory activities.	4.19	0.98	Agree	High
I can assess students' performance in virtual laboratory activities.	4.31	0.60	Strongly Agree	Very High
Overall	4.19	0.73	Agree	High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

Overall, the findings reveal that teachers are generally ready to implement VLs, particularly in assessment, although designing and facilitating activities may require further support and training.

3.3. Content Knowledge

Table 8. Assessment on the Level of Readiness of Science Teachers on the Use of Virtual Laboratories in terms of Content Knowledge

Indicators	Mean	Standard Deviation	Description	Interpretation
I can align virtual laboratory tasks with the learning competencies in the science curriculum.	4.5	0.52	Strongly Agree	Very High
I understand which science concepts are best taught using virtual laboratories.	4.31	0.70	Strongly Agree	Very High
I can explain scientific concepts more effectively with the help of virtual labs.	4.38	0.62	Strongly Agree	Very High
Overall	4.40	0.56	Strongly Agree	Very High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

Table 8 shows that the highest mean (4.50) relates to aligning VL tasks with curriculum standards, while the lowest (4.31) concerns identifying which concepts best suit VL instruction. The computed overall mean score of 4.40 indicates that the respondents strongly agree with the statements, signifying a very high level of content knowledge related to virtual laboratory use.

Overall, the findings point to a teaching group that possesses very strong content knowledge and conceptual understanding of science concepts suitable for virtual laboratory integration. Teachers are well-prepared to use VLs to enhance explanation and understanding of scientific concepts, aligning learning activities with curriculum objectives, though some continued support in selecting the most suitable concepts may further strengthen readiness.

Table 9. Summary on the Assessment of the Level of Readiness of Science Teachers on the Use of Virtual Laboratories

Level of Readiness on the Use of Virtual Laboratory in terms of	Mean	Standard Deviation	Description	Interpretation
Technological Knowledge	3.96	0.64	Agree	High
Pedagogical Knowledge	4.19	0.73	Agree	High
Content Knowledge	4.40	0.56	Strongly Agree	Very High
Overall	4.18	0.52	Agree	High

Legend: 4.21-5.00 Strongly Agree, 3.41-4.20 Agree, 2.61-3.40 Neutral, 1.81-2.60 Disagree, 1.00-1.80 Strongly Disagree

Table 9 presents the overall level of readiness of science teachers in using virtual laboratories across technological, pedagogical, and content knowledge aspects. The computed overall mean score of 4.18 with a standard deviation of 0.52 indicates that the respondents agree with the statements, signifying a high level of readiness in integrating virtual laboratories into their teaching practices, with the highest in content knowledge (4.40) and the lowest in technological knowledge (3.96).

These results mirror global trends showing that teachers' digital competence often lags behind their content and pedagogical strength (Mane, 2025). Therefore, bridging this gap through sustained professional development can translate readiness into effective implementation

Result Related to SOP 4: Is there a significant difference between the level of awareness and the level of readiness of science teachers when grouped according to their profile?

To address this question, One-Way ANOVA was used to compare the level of awareness level of readiness when grouped according to age, years of teaching experience, and educational attainment. ANOVA determined the level of statistical significance of these differences. Researchers found that there was no significant demographic factor that contributed to the awareness or readiness of teachers since all the p-values were more than 0.05. These calculated p-values were the basis on which the decision to not reject the null hypothesis was made.

Table 10 displays the comparison of the respondents' assessment of the level of awareness and level of readiness of science teachers when they are grouped according to their age.

4.1. Grouped According to Age

Table 10. Comparison of the Respondents' Level of Awareness and Level of Readiness when grouped according to their Age

Items Considered	Age	Mean	SD	F-value	p-value	Interpretation	Decision on H_0
Level of Awareness	21-30 years old	4.72	0.30	1.791	0.206	Not Significant	Failed to reject H_0
	31-40 years old	4.28	0.59				
	41-50 years old	4.55	0.32				
Level of Readiness	21-30 years old	4.26	0.52	0.442	0.652	Not Significant	Failed to reject H_0
	31-40 years old	4.02	0.62				
	41-50 years old	4.33	0.00				

Based on the results, the highest awareness (4.72) and readiness (4.26) appear among teachers aged 21–30, while the lowest awareness (4.28) and readiness (4.02) appear among those aged 31–40. These two variables when grouped according to age did not exhibit significant differences, hence the null hypothesis was failed to reject, indicating that age has no significant effect on the level of awareness and level of readiness of science teachers regarding virtual laboratory use.

This finding indicates that age is not a determinant of preparedness to use VLs. It supports Mane (2025), who noted that digital competence depends more on professional exposure than on age. Both young and older teachers can be equally capable if provided with adequate training opportunities.

4.2. Grouped According to Years of Teaching Experience

Table 11. Comparison of the Respondents' Level of Awareness and Level of Readiness when grouped according to their Years of Teaching Experience

Items Considered	Years of Teaching Experience	Mean	SD	F-value	p-value	Interpretation	Decision on H_0
Level of Awareness	1-10 years	4.62	0.43	1.780	0.203	Not Significant	Failed to reject H_0
	11-20 years	4.23	0.52				
Level of Readiness	1-10 years	4.27	0.52	1.428	0.252	Not Significant	Failed to reject H_0
	11-20 years	3.92	0.48				

Table 11 displays the comparison of the respondents' level of awareness and level of readiness in using virtual laboratories when grouped according to their years of teaching experience. Based on the results, the teachers with 1–10 years of experience have the highest awareness (4.62) and readiness (4.27), while those with 11–20 years have the lowest awareness (4.23) and readiness (3.92). Despite these numerical differences, results indicate no significant effects.

These findings suggest that both awareness and readiness of science teachers in using virtual laboratories are generally high, regardless of teaching experience. This implies that professional development, exposure to digital tools, and engagement in technology-mediated teaching strategies are likely more critical factors in shaping teachers' preparedness than the length of their teaching experience.

4.3. Grouped According to Years of Teaching Experience

Table 12. Comparison of the Respondents' Level of Awareness and Level of Readiness when grouped according to their Educational Attainment

Items Considered	Years of Teaching Experience	Mean	SD	F-value	p-value	Interpretation	Decision on H_0
Level of Awareness	Bachelor's Degree	4.64	0.47	0.543	0.594	Not Significant	Failed to reject H_0
	With Master's Units	4.40	0.52				
	Master's Degree	4.39	0.08				
Level of Readiness	Bachelor's Degree	4.33	0.45	1.129	0.353	Not Significant	Failed to reject H_0
	With Master's Units	4.06	0.66				
	Master's Degree	3.78	0.31				

Table 12 displays the comparison of the respondents' level of awareness and level of readiness in using virtual laboratories when grouped according to their educational attainment. Based on the results, bachelor's degree holders have the highest awareness (4.64) and readiness (4.33), whereas teachers with master's degrees have the lowest awareness (4.39) and readiness (3.78). The level of awareness and readiness did not exhibit significant differences across the groups; hence the null hypothesis was failed to reject.

Overall, the findings indicate that both awareness and readiness of science teachers are generally high across all levels of educational attainment. This implies that factors such as training, professional development, and practical experience with virtual laboratories may have a greater impact on preparedness than formal academic qualifications alone.

Result Related to SOP 5: Is there a significant relationship between the level of awareness and level of readiness of science teachers on the use of virtual laboratories? To provide an answer to this question, researchers used Pearson's r correlation coefficient to examine the relationship between the level of awareness and the level of readiness.

Table 13. Relationship between the level of awareness and level of readiness of science teachers on the use of virtual laboratories

Level of awareness in relation to:	Computed r	Sig	Decision on H_0	Interpretation
Level of Readiness	0.698	0.003	Significant	Reject H_0

Table 13 shows the relationship between the level of awareness and the level of readiness of science teachers in using virtual laboratories, which was examined using Pearson's correlation coefficient. As shown in the table, the computed correlation coefficient (r = 0.698, p = 0.003) indicates a significant positive relationship between the two variables. This result leads to the rejection of the null hypothesis (H_0), suggesting that a higher level of awareness is associated with a higher level of readiness to integrate virtual laboratories in instruction.

The findings imply that efforts to increase teachers' awareness about virtual laboratories, such as training sessions, workshops, and exposure to digital teaching resources, can directly enhance their readiness and confidence in implementing these tools. This aligns with prior studies highlighting that awareness and familiarity with educational technologies are key determinants of successful technology integration in teaching (Paraskeva et al., 2008; Amemasor et al., 2025).

Result Related to SOP 6: What professional development program can be proposed based on the results of this study? To provide an answer to this question, researchers inferred from SOPs 2, 3, 4, and 5 to identify which areas had the lowest mean scores and which areas showed greater need for intervention. Hence, this program was developed through a Needs Analysis from the statistical findings of this study.

A. Rationale

The study shows that science teachers have very high content knowledge, high pedagogical knowledge and high technological knowledge on the use of VLs. This suggests that teachers possess a strong foundation in science concepts, understand the instructional benefits of virtual laboratories, and are generally capable of navigating digital tools for teaching. However, the results also revealed specific areas for improvement, particularly in troubleshooting technological issues and in designing and facilitating effective pedagogical activities using VLs. Addressing these gaps is essential to ensure seamless integration of virtual laboratories into science instruction.

Furthermore, the study established a significant positive correlation between the level of awareness and the level of readiness of teachers to use virtual laboratories (r = 0.698, p = 0.003). This implies that increasing teachers' awareness of VL platforms directly enhances their readiness and confidence to integrate these tools effectively in the classroom.

By addressing these needs, the professional development program aims to empower science teachers to deliver lessons that are more interactive, conceptually rich, and digitally enhanced, ultimately promoting student engagement, deeper understanding of scientific concepts, and the development of 21st-century skills.

The title of the proposed program is: *"Lab Beyond the Classroom: Strengthening Science Teachers' Readiness in Virtual Laboratory Integration"*.

B. General Objective

The findings of this study reveal that while science teachers possess a high level of awareness of virtual laboratories, they are not fully ready to integrate these tools consistently and effectively into science instruction. Although teachers demonstrate strong content knowledge and a good level of familiarity with virtual laboratory platforms, gaps remain in their ability to troubleshoot technical issues and in designing pedagogically sound and inquiry-based virtual laboratory activities. Addressing these gaps is essential to ensure meaningful and confident implementation of virtual laboratories in classroom teaching.

The objective of this program is to enhance the readiness of science teachers in integrating virtual laboratories into science instruction by strengthening their technological, pedagogical, and content knowledge competencies through a targeted professional development program.

C. Proposed Professional Development Program

Table 14. Lab Beyond the Classroom: Strengthening Science Teachers' Readiness in Virtual Laboratory Integration

Key Result Areas	**Specific Objectives**	**Action Plan**	**Persons-in-Charge**	**Time-frame**	**Budget/ Source**	**Expected Output / Success Indicators**
Technological Competence	Demonstrate digital literacy and virtual laboratory (VL) skills	Conduct hands-on workshops on VL platforms, including basic troubleshooting	IT Coordinator /STEM Coordinator	2 weeks	School Fund	Teachers independently navigate platforms and resolve basic technical issues
Pedagogical Competence	Develop skills in designing and implementing VL-based lessons; promote best practices	Reinforce PLAG sessions focused on VL lesson design; conduct weekly teaching demonstrations following PLAG sessions	STEM Coordinator & Science Teachers	Ongoing	N/A	Teachers effectively design and deliver VL-based lessons (Lesson Plans)
Content Knowledge	Align VL activities with curriculum standards and science concepts	Conduct curriculum mapping to identify topics suitable for VL integration	STEM Coordinator & Science Teachers	3 weeks	N/A	Completed course outlines and lesson plans with VL activities aligned to standards
Resource Awareness	Increase familiarity with available VL resources	Conduct seminars/training on various VL platforms and resources	STEM Coordinator	2 weeks	School Fund	Teachers identify the most appropriate VL platforms based on needs analysis

DISCUSSION

The results show that the overall awareness of virtual laboratories is very high among the science teachers (M = 4.53). The awareness of teachers was very strong in terms of the knowledge (M = 4.79) and pedagogical awareness (M = 4.69) as it was observed that teachers have the clear understanding of what the virtual laboratories are and what is the effectiveness of them in developing the conceptual understanding and the inquiry-based learning. However, the resource awareness was a little lower (M = 4.13), which indicates that although teachers know the purpose and teaching benefits of virtual laboratories, they are not equally knowledgeable in terms of the availed platforms or training opportunities. This is in line with the statement made by Kolil and Achuthan (2022) on how awareness is not a sufficient determinant of implementation, especially in a case where training and other institutional facilitation resources are accessible.

In terms of readiness, the teachers were well prepared to utilize virtual laboratories in terms of preparedness (M = 4.18), which aligns with the TPACK model. The knowledge of content was also very good (M = 4.40), indicative of the fact that the teachers are able to effectively match virtual laboratory activities with curriculum standards and find out which concepts in science can be taught in simulations. There was also good pedagogical preparation (M=4.19), but some teachers were not as confident in the process of designing and structuring virtual lab-based activities. The technological preparedness, though continuing to be rated high (M = 3.96) was also lower, which indicated difficulties with troubleshooting and use of some specific aspects of the platform. This goes in line with Montero-Masa et al. (2023), who reported that teachers can be willing to incorporate digital tools and fail when technical challenges come up.

Moreover, the research has found a very good positive relationship between awareness and readiness (r = 0.698, p = 0.003), where teachers with greater awareness and knowledge of virtual laboratories have a greater readiness to use it in their teaching. The result is consistent with Amemasor et al. (2025), who have stressed that awareness-building programs are the direct causes of teacher preparedness and digital instructional competence.

Finally, there were no significant differences between the awareness and readiness of teachers when teachers were divided by the age, years of teaching experience, or by their educational attainment. This implies that professional development exposure and constant practice is more determinant of preparedness to use virtual laboratories than demographic background. This validates the argument by Mane (2025) that school environment, training, and institutional encouragement are the main factors of digital competence and not the age and educational qualification of the teacher.

CONCLUSION

In this study, the level of awareness and the willingness of science teachers to use virtual laboratories as a platform to propose a professional development program were evaluated. Results showed that there was a very high awareness of virtual laboratories among the teachers, especially in awareness of what VLs are and how they have been used to facilitate conceptual and inquiry-based learning. However, the level of awareness of available resources among teachers was lower, which means that only some of them were more familiar with the existing platforms and training options.

Teachers were highly prepared in terms of readiness with the best ratings under content knowledge. This implies that educators will be able to successfully match virtual laboratory lessons with the standards of the curriculum and also identify the most effective concepts to be taught with the help of VLs. Pedagogical preparedness was also high with some teachers claiming to require more assistance on development and administration of VL based learning processes. In terms of technological readiness, which is still high, it was the most problematic area, especially in the area of troubleshooting technical problems.

There was no noticeable difference in awareness or preparedness depending on teachers age, teaching experience, or educational attainment, which means that demographics do not correlate to preparedness to integrate VL. Significantly, the research observed that there is a strong and significant positive association between awareness and readiness ($r = 0.698$, $p = 0.003$), meaning that the intention to enhance awareness can directly influence the readiness of the teachers to implement the classroom practices in reality.

According to the findings, it was proposed to develop a professional development program, which was named as "*Lab Beyond the Classroom: Reinforcing the Readiness of science teachers in Virtual Laboratory Integration*". The program also seeks to expand the technological, pedagogical, and content knowledge competencies among teachers by taking them through organized, practical, and contextually oriented learning experiences.

Overall, the study concludes that while science teachers possess strong foundational competencies and positive perceptions toward virtual laboratories, targeted and sustained professional development is essential to address gaps in technical troubleshooting, platform familiarity, and pedagogical design. Strengthening these areas will support more effective, confident, and meaningful integration of virtual laboratories in science instruction.

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