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Hybrid Laboratory Application: Impact on Students' Process Skills and Knowledge in Pamantasan

Jay Ann V. Consignado; Miriam B. Rañola

Ng Lungsod Ng San Pablo, Laguna

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ABSTRACT

This study determined the effectiveness of hybrid laboratory (both physical and virtual laboratory modality) and its impacts on students' process skills and knowledge in their science course. Using the convergent mixed method research design, for the quantitative data analysis, 160 student-respondents from Pamantasan ng Lungsod ng San Pablo taking up Bachelor of Secondary Education Major in Science and Bachelor of Science in Psychology underwent hybrid laboratory classes and took pre-post tests that served as the resource of data. Eight (8) participants shared their lived experiences regarding the conduct of laboratory classes using virtual and physical set-up.

Results revealed that there was a relative change and significant difference in the score of the post test from the pre-test, indicating that the students increased their level of knowledge when exposed to both laboratory modalities. Student's perception on the use of hybrid laboratory for usability, students viewed it as pleasing to use (satisfaction with a system means basically how pleasing it is to use) and affects the user's motivation and thus the effectiveness of use; and for manipulation, results revealead that virtual laboratory is easy to handle and execute laboratory task. When student-participants described their lived experiences regarding the conduct of laboratory classes using virtual and physical set-up, five (5) themes were generated sucha as functionality, accessibility, cognitive presence, psychomotor presence and social presence.

The use of hybrid laboratory can be recommended for teachers and school administrators to be implemented in their teaching-learning process, also it can be considered to be implemented in the new context of learning modality that shifts from time-to-time depending on the different environmental impacts (pandemic, increasing heat index, etc.)

Keywords: Hybrid Laboratory, Learning Modality, Manipulation, Physical Laboratory, Usability, Virtual Laboratory

THE PROBLEM AND ITS BACKGROUND

Introduction

Pandemic in the year 2020, brought disorder to people's lives worldwide and interrupted the education system. With the current world situation, where classrooms and other facilities are inaccessible because of Online Learning, the need to supplement laboratory work in science courses is inevitable. In the world's education system, e-learning is a trend in blended learning, and laboratory work might be incorporated into this setup. However, educational institutions face inevitable challenges - uncertainty in educational response, skilling strategies, and training procedures among teachers and institutions to meet the demands of the learners and achieve quality education.

Here in the Philippines, the Commission on Higher Education (CHED), with its noble intention of learning continuity, required the Higher Education Institutions (HEIs) to continue delivering quality educational services through the implementation of CHED Memorandum Order (CMO) No.4 series of 2020. This section outlines the guidelines for implementing flexible learning across all programs. Flexible learning is a learner-

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centered approach designed to offer students maximum flexibility regarding learning content, schedules, access, and innovative assessments, utilizing both digital and non-digital tools. In programs with science courses, the theories discussed

in lecture class necessitate practical applications that should be conducted in a physical laboratory. According to Johnstone et al. (2001), as cited by Hamed (2020), it helps students learn concepts, illustrate theory through hands-on activities, increase their curiosity, and develop positive attitudes toward science. Hence, laboratory activities are essential to enhance students' knowledge, skills, and interests in science courses.

The pandemic prevented the actual use of laboratory setups in science courses. The way for HEIs to supplement it is through the use of virtual laboratories. According to Sullivan et al. (2017), as cited by Kageyama et al. (2022), the virtual laboratory has the potential to supplement and improve real-world practical learning.

With the current setup of learning of the institution of the researcher, Pamantasan ng Lungsod ng San Pablo, it followed the order of CHEd in which HEIs delivered degree programs offered in a hybrid learning format with at least 50% of the total contact hours delivered online being spent on on-site learning experiences and 50% online learning, it has drawn attention to the researcher to test virtual laboratory application during online classes and its impact on the science process skills and knowledge during on-site classes in selected science courses. This helped educators find out whether the use of virtual laboratory applications has a significant effect on students' academic performance and science process skills in on-site learning.

Furthermore, the output of this study, the virtual and physical laboratory guide, helped the teacher-instructors by guiding them on how to implement virtual laboratory applications during asynchronous and synchronous learning modality and assess students in physical laboratory setup in Genetics. Teachers clearly understood how effective supplemental virtual laboratory applications are in educational situations where there is a need to shift to flexible learning modalities.

Background to the Study

Hybrid learning became crucial during the COVID-19 pandemic as schools faced closures and social distancing. To maintain educational continuity, institutions rapidly adapted by incorporating remote learning solutions. Combining in-person and online instruction, hybrid learning emerged as a viable solution for many schools and universities.

Developing countries faced unique challenges adapting to hybrid learning during the COVID-19 pandemic. While some regions made notable progress in integrating technology into education, others struggled due to limited infrastructure, technological access, and economic constraints.

As a developing country, higher education institutions prioritized reducing infection risks within the academic community. Strict community quarantine measures necessitated a shift to remote learning. It was always challenging for teachers to teach and students to learn outside of the typical face-to-face classroom setting. Traditional to flexible teaching and learning alternatives have been explicitly explored. Mentors continued to improve and modify learning modalities and adopt new modalities that catered to the needs of the learners brought about by differences in localities. Challenges to maintaining quality education were inevitable but were accepted with grace and determination.

With the CMO No.4 series of 2020, the HEIs were required to train teachers to use technology for enhancing the teaching and learning process across all the different learning modalities, including blended learning, online learning, and offline learning. The schools needed to deliver both synchronous and asynchronous classes. This meant that teachers and students did not report in the classroom in person; instead, they attended classes using online educational platforms like Google Meet in Google Suite, Zoom, Discord, and virtual labs and simulations. This was a great challenge for teachers and students of science courses. Students will not be able to experience performing laboratory experiments in an actual/physical laboratory setup. The 21st-century skills required for every student to master may not be achieved. Science teachers in tertiary education have no

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choice but to develop alternative ways to deliver laboratory courses using home-based setups and resources.

Now that there have been fewer reports of infection after nearly two years of fighting the COVID-19 pandemic and implementing online and offline Learning, Last July of 2022, most Asian nations created learning recovery strategies based on hybrid learning (HL) research findings that emphasized the need to restore in-person Learning. The impact of returning to on-site learning on the overall well-being of higher education students must be evaluated, despite the rapid development and implementation of new technologies, modalities, and methods of learning. CHED was inclined to bring students back to physical campuses safely.

In 2022, the CMO No. 16 series of 2022 was implemented, stating that HEIs may deliver degree programs in a hybrid learning format, with at least 50% of the total contact hours delivered online and on-site learning experiences. The remaining contact hours may be implemented through other flexible learning strategies, such as online Learning and synchronous/asynchronous learning sessions. In addition, laboratory courses shall be conducted primarily through on-site learning experiences (De Vera, 2022).

The researcher was concerned about how using the new modalities may affect laboratory classes conducted in a virtual environment. Therefore, this study aimed to determine whether the new learning modes, used mainly in the course Genetics offered by the institution, would affect how students and teachers perceive and perform in the various lab setups, both physically and online. The researcher used hybrid laboratory applications to supplement the need in the laboratory classes due to a lack of actual laboratory resources in the institution and determined whether these applications affected students' science process skills and academic performance.

Theoretical Underpinnings

Due to the pandemic, testing students' understanding of the scientific method in the physical laboratory setting was impossible as part of their science coursework. As a result, educators generally used the new standard of employing technology. The Connectivism Learning Theory, E-learning Theory, and Experiential Learning Theory were connected to this classroom technology use.

Utecht (2019) explored how Connectivism Learning Theory applies to modern classrooms, emphasizing the need to adapt to the evolving ways people learn, their learning environments, and their interests. Technology is transforming learning both in and out of the classroom, creating new opportunities but also highlighting gaps in traditional teaching methods and the need for updated approaches.

E-learning theory, as outlined by Sweller et al. (2019), is grounded in cognitive science and aims to enhance learning through effective educational technology. This theory is based on Cognitive Load Theory (CLT) Sweller et al. (2019), which focuses on the mental effort required during tasks. CLT identifies three types of cognitive load: germane, intrinsic, and extraneous. Balancing these loads is essential for efficient learning, as working memory has limited capacity, and overloading it with excessive information can hinder learning.

Further, this study was anchored to the concept of experiential learning theory. According to Hodson (1998), as cited by Gericke (2022), experiential learning is applied through practical work in scientific classes. It is described as tasks or deliberate activities where students see or manipulate accurate items or participate in practical demonstrations. Laboratory work, a key component of science education, serves multiple purposes in curricula. It not only motivates students by enhancing their interest and enjoyment but also teaches essential laboratory skills, deepens their understanding of scientific concepts, and provides insights into scientific reasoning. Additionally, it fosters positive scientific attitudes like open-mindedness, objectivity, and the ability to suspend judgment.

Experiential learning, or learning by doing, involves leveraging students' direct experiences to foster effective and enduring learning. By engaging in action, research, discovery, and participation, students develop cognitive skills that benefit both their education and their future endeavors.

In addition, learning begins when the student interacts with the environment and has a clear experience (Trewatha, 2020). The concept of experiential learning allowed the students to participate in both virtual and

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physical laboratory activities, letting them develop skills as they learned by doing, both in online (virtual) and offline (physical) modalities.

Conceptual Framework

The concept framework of different stages emphasized the importance of each step. It helped the researcher explore the impact of the hybrid laboratory application on the process skills and knowledge of students in San Pablo City and the unique experiences of the students in using the hybrid laboratory application in their laboratory science class. The findings of this study served as the basis for the development of a teacher's guide in laboratory science courses.

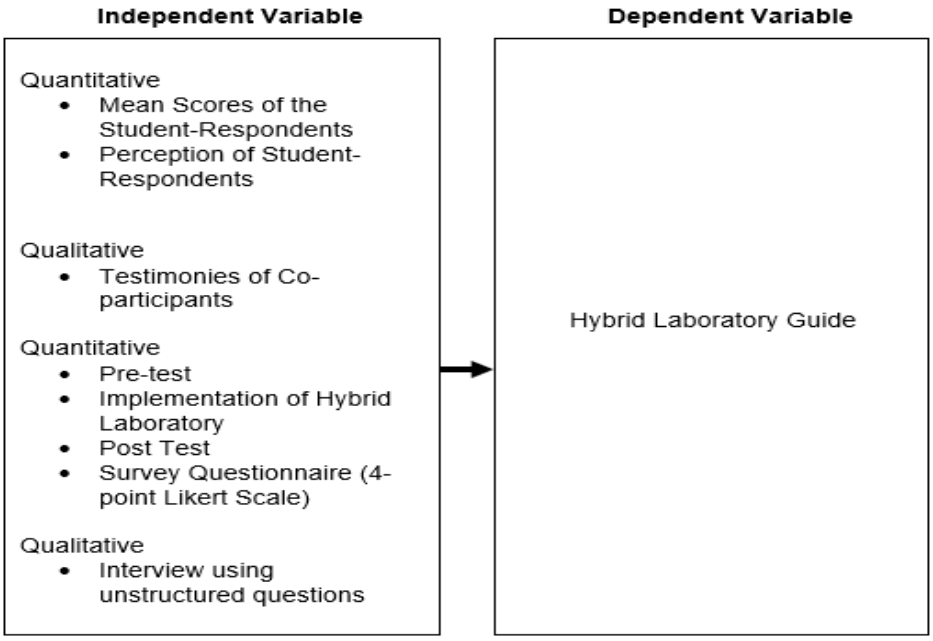

Figure 1. Research Paradigm.

Figure 1 shows the research paradigm. The study employed a convergent mixed-method design, collecting and analyzing both quantitative and qualitative data. The results from these data types were then compared to determine if they corroborated or contradicted each other. Independent variables included mean scores and perceptions from students for the quantitative aspect, and testimonies from co-participants for the qualitative aspect. Also, students used both actual and virtual laboratories for their science activities, with pre- and post-tests measuring scores and a four-point Likert scale assessing perceptions. Interviews were conducted with students after their hybrid laboratory experience. The findings were used to create a hybrid laboratory guide for science classes as the output in the dependent variable.

Statement of the Problem

This study aimed to determine the impact of the hybrid laboratory application on students' science process skills and academic achievement as a basis for developing a teacher's guide in Laboratory Science Courses.

Specifically, this study sought to answer the following questions:

1. What is the mean score of the student-respondents in the pre-test and post-test in genetics?
2. What is the perception of the student-respondents on the use of virtual laboratory applications in Genetics in terms of:
    2.1 Usability
    2.2 Manipulation

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3. Is there a significant difference in the students' pre-test and post-test scores?

4. Is there a significant relationship between the perception of student- respondents and their mean scores in post test after the use of hybrid laboratory application?

5. How do student participants describe their experience regarding the conduct of laboratory classes using virtual and physical setups in Genetics?

6. Based on the findings of the study, what output may be crafted?

Hypotheses/ Assumption of the Study

1. There is no significant difference in the students' pre-test and post-test scores.

2. There is no significant relationship between the perception of student respondents and their academic performance in the use of virtual laboratory applications.

Scope and Limitations

This study focused on determining the significant effect of virtual laboratory applications in developing science process skills and improving the academic performance of college students in Genetics offered in the midterm every First Semester of the School Year. Likewise, it aimed to explore the unique experiences of the students as they used virtual laboratory modalities during laboratory classes in

Genetics. This study was conducted in Pamantasan ng Lungsod ng San Pablo, Province of Laguna, from August to December 2023.

The study employed a convergent mixed-method design, collecting and analyzing both quantitative and qualitative data. The results from these data types were then compared to determine if they corroborated or contradicted each other. For the **quantitative part**, the study utilized a quasi-experimental research design using a purposive sampling technique. The respondents are students enrolled in Genetics, a course offered for BS Education Major in Science and BS Psychology Programs for School Year 2023-2024. For each degree program, four (4) sections with 40 students were included in the study. A total of 320 student respondents were assigned to experimental and control groups. Each group has two (2) sections with 160 respondents. In order to determine the students' academic performances in Genetics, pre and post-tests were administered to all respondents. For the **qualitative part**, the phenomenological approach was used. A total of 8 students served as co-participants (one from each section) who had the hybrid laboratory experience in Genetics.

Significance of the Study

This study had the potential to address the viability of using virtual laboratory applications as an alternative or support to an actual physical laboratory setup.

Additionally, the study assessed the impact of using the learning strategy on science process skills and academic achievement among college students in science programs. This research offers valuable insights for educators, particularly those in the field of education, on implementing the described learning strategy. The study's findings, along with the potential laboratory guide, could benefit both students and instructors in enhancing laboratory activities during science classes. Furthermore, this study may be a basis for finding possible solutions to the problems regarding the most effective learning strategy for 21st-century learners despite the better normal in the education of blended learning or e-learning during this pandemic.

RELATED LITERATURE AND STUDIES

Numerous studies have explored the benefits of virtual laboratories in science education. Lin (2023) found that e-laboratories are effective pre-laboratory tools, enhancing practical skills and scientific literacy. Gamabri and Falode (2018) demonstrated that virtual labs improved secondary school chemistry students' performance in

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both collaborative settings. Consistent with the literature, these findings suggest that learner-centered and inquiry-based virtual labs promote deeper thinking and better memory retention.

Furthermore, Faour and Ayoubi (2018) found that virtual laboratories improved students' conceptual understanding of science lessons but did not significantly impact their attitudes toward learning. However, virtual labs enhance computer involvement, motivation, and safety, making lab assignments stimulating and experiential. This simulated learning aids in completing cognitive tasks and improving learning processes.

Irwanto (2018) discovered that virtual laboratories enhanced students' analytical ability, capacity for solving problems, imaginative thinking, conceptual comprehension, experimental skills, enthusiasm, curiosity, and perception of learning results. He proposed that both professors and students use virtual labs, emphasizing their importance in developing fundamental competencies in science processes such as observing, classifying, measuring, communicating, inferring, and forecasting.

Dela Cruz and Mendoza (2018) developed a virtual lab due to a shortage of physical resources, highlighting its cost-effectiveness and ease of use compared to traditional labs. Aljuhani and Althabiti (2018) similarly found that virtual labs are engaging for students and improve learning outcomes, although some schools may struggle to afford the necessary equipment. Both studies emphasize that virtual labs save money, time, and space, providing a low-cost alternative for conducting experiments.

Marino (2018) found that virtual labs benefit high achievers but have little impact on low achievers and do not lower overall student achievement in science. Yildrim (2021) and Hamed & Aljanazrah (2020) also compared virtual and physical labs, concluding that both have a similar impact on academic performance. Academic success is crucial for future workforce demands, as higher education levels are linked to better employment and opportunities.

Research has indicated that virtual laboratories boost students' conceptual knowledge, research skills, academic performance, problem-solving, analytical thinking, imaginative thinking, scientific skills, drive, curiosity, and educational outcomes. Teachers were encouraged to employ computer-generated labs to improve instruction quality and learning. Virtual laboratories provide cost-effective options for universities in need of improved infrastructure, as well as flexible learning opportunities that transcend time and location constraints. Additionally, the students appreciate virtual experiments, making learning more engaging.

However, there were some disadvantages cited wherein there was a critical aspect of this modality in which it includes self-evaluation and technicalities. Experts in educational ICT have raised concerns about the challenges faced by first-time instructors using virtual applications, including technical issues, flexibility, and connectivity problems.

The researcher used the studies as basis to investigate the effectiveness and significant relation of virtual laboratories to the science process skills of the students, not just their academic performances.

METHODOLOGY

This chapter details the methods and procedures of the study, covering the research design, study participants, research instruments, data collection methods, and statistical analysis techniques.

Research Design

The study employed a Convergent Mixed Method Research Design, which involved collecting and analyzing both quantitative and qualitative data. The analysis compared the two types of data to determine if they supported or contradicted each other. According to Edmonds and Kennedy (2017), as cited by Williams et al. (2022), a mixed methods research design integrates both quantitative and qualitative approaches to enhance understanding of a research problem. The convergent mixed method design was used to complement quantitative findings with qualitative insights, allowing the qualitative data to clarify and expand upon the quantitative results.

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For the quantitative aspect, the study used a quasi-experimental design, which assesses interventions without randomization. Like randomized trials, quasi-experiments seek to establish causal relationships between interventions and outcomes, employing pre- and post-intervention measurements and non-randomly selected control groups (Thomas, 2020). This approach was applied to evaluate students' science process skills and academic performance. For the qualitative component, a phenomenological approach was employed to explore the unique experiences of participants using a hybrid laboratory application in the Genetics class.

Selection of the Participants

The study employed a total enumeration purposive sampling technique, where the researcher examines the entire population with specific characteristics. In this method, the units being studied are typically individuals within the population (Thomas, 2020).

For the quantitative part, the student-respondents were enrolled in Genetics as their curriculum offered for BS Education Major in Science and BS Psychology Programs for School Year 2023-2024. Two sections for each program were included in the study. Each section has 40 students. Hence, there was a total of 160 student respondents. Since this is a quasi-experimental study, there are 80 respondents for the control group and 80 respondents for the experimental group. Pre- and post-tests were given to assess the students' academic performance in Genetics.

For the qualitative part, two co-participants were chosen from each section, and a total of 8 student-participants were interviewed as they experienced the hybrid laboratory application in Genetics.

Respondents of the Study

The student-respondents were enrolled in Genetics as their science course offered for BS Education Major in Science and BS Psychology Programs for School Year 2023-2024. Two sections from each program were included in the study.

Co-participants of the Study

There were two co-participants from each section, a total of 8 co-participants for the qualitative part. The co-participants were chosen since they had experience working in genetics activities using hybrid laboratory applications.

Research Instruments

For the quantitative part, there were two (2) research tools used:

The **first** was an evaluation instrument to get the students' academic achievement. At least five items were prepared for each science process and cognitive skills like observing, classifying, measuring, communicating, inferring, and predicting. There was a total of 30 items. The **second** was the survey questionnaire to determine the effectiveness of using hybrid laboratory applications. It was divided into two (2) parts: Part I was for the demographic profile of the respondents. Part II was for the perceptions and assessment of the students regarding the use of virtual and physical laboratories in terms of usability and manipulation indicators. The survey questionnaire was adapted from the study of Chan and Wok (2015), also adopted from the study of Patel et al. (2023), and was modified using a Likert scale with a 4-response set. The research instruments were validated and pilot-tested. Validators were experts in the field of Science Education. Pilot testing was done by the researcher and implemented in a group of students who did not belong to the total sample population of the study.

The researcher utilized an unstructured self-made interview questionnaire guide for the qualitative part.

Data Gathering Procedure

The researcher sought approval to carry out the study in the Pamantasan ng Lungsod ng San Pablo (PLSP),

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from each of the Dean of College of Teacher Education and College of Arts and Sciences. The study commenced from start of the midterms until the end of midterms. After seeking consent from the respondents and having permission, the researcher immediately conducted the study.

For the quantitative part, at the beginning of the study, the students took a pre-test for the selected topics of the laboratory course before attending the virtual and physical classes. After the students had attend the virtual and physical laboratory classes their skills were evaluated during post-test/assessment in physical laboratory.

Subsequently, respondents were asked to answer a questionnaire on their perceptions of using virtual laboratories in terms of usability and manipulation based on what they have experienced.

For the qualitative part, permission to conduct the study was made, and the researcher explained the objective of the study and got consent from the co-participants. The co-participants were interviewed individually (critical informant interview) by the researcher as to their experience of using virtual laboratory applications during the conduct of laboratory exercises Genetics. Each interview was recorded, and after the data was gathered, it was permanently deleted for ethical considerations.

Statistical Treatment of Data / Data Analysis

The gathered data in this study was subjected to the following statistical treatment and analyses:

The mean score was used to determine the respondents' perception of the usability and manipulation of virtual laboratory applications in selected science courses. The same treatment was used to determine the academic performance of the respondents in selected science courses during the pre-test and post-test.

A paired t-test was used to analyze the differences between the pre-test and post-test scores.

The Pearson Product-Moment Correlation Coefficient (Pearson r) was used to determine the relationship between respondents' perceptions and their post-test scores following the use of the virtual laboratory application.

Thematic Analysis

For the qualitative part, data was analyzed through transcription, coding, and theme generation.

The initial phase of data analysis is transcription, involving detailed listening or viewing to prepare and organize interview data into notes and text narratives (Caulfield, 2019).

The subsequent phase is coding, where specific features of the data are assigned descriptive labels to identify common themes or patterns.

The final phase involves developing themes, which are patterns that convey something noteworthy or fascinating about the data and study topic. The next step is to consider whether the themes work in the context of the entire data set and identify recurring themes, language, opinions, and beliefs. Themes should be coherent and distinct from each other to generate the whole idea/data (Creswell, 2018).

PRESENTATION, INTERPRETATION, ANALYSIS OF DATA

This chapter includes the data gathered, which is presented in tables. The data were analyzed and interpreted for the purpose of having conclusions and recommendations for the study.

Statement of the Problem #1. What is the mean score of the student-respondents in the pre-test and post-test in genetics?

Table 1 shows the pre-test and post-test scores of the student-respondents in genetics. The pre-test and post-test were composed of 30-item questions that were answered by the student-respondents before and after their

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experience using hybrid laboratory modalities.

Table 1. Mean Scores of the Student-respondents in Genetics during their Pre-test and Post-test.

	Pre-Test	**Post Test**
Valid	160	160
Missing	0	0
Mean	7.313	29.181
Std. Deviation	5.381	1.382
Skewness	0.251	-1.908
Minimum	0.000	23.000
Maximum	19.000	30.000

Based on the mean scores of 7.313 and 29.181 for the pre-test and post-test, respectively, indicate that the student respondents' academic performance on the pre-test fell short of passing compared to the post-test mean score of 29.181, which improved and exceeded the passing grade. The pre-test scores (5.313) had a higher standard deviation than the post-test scores (1.382), so academic performance improved following the learning period.

In addition, the skewness of the post-test scores (1.908) which is negative compared to the skewness of the pre-test scores (0.251) revealed that the distribution shifted towards higher scores, indicating a potential improvement in academic performance of the student respondents.

This implies that the test scores of students improved after experiencing the use of hybrid laboratory applications.

Agreeing to this result is the study of Gamabri & Falode in 2018 wherein they conducted a study which investigated the impact of virtual laboratory on the achievements of secondary school chemistry students. A 20-item multiple choice test was used for their data collection. The results also showed that after using the virtual laboratory, the students improved their test scores.

Statement of the Problem #2. What is the perception of the student- respondents on the use virtual laboratory application in Genetics in terms of usability and manipulation?

Table 2 and Table 3 shows the perception of the student-respondents on the use virtual laboratory application in Genetics in terms of usability (Table 2) and manipulation (Table 3).

Table 2. Perception of the Student- respondents on the Use of Virtual Laboratory Application in Genetics in terms of Usability

Indicator	**Mean**	**Std. Deviation**	**Verbal Interpretation**
2. Easy to use, simplicity in interaction and visual design (efficiency)	3.88		Strongly Agree
3.Easy to memorize, (memorability) measures how well users can remember different functions	3.91		Strongly Agree

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4. User interface is clear enough so that the users make as "few errors" as possible	3.40		Agree
5. Pleasing to use (satisfaction with a system means basically how pleasing it is to use). It affects the user's motivation and thus the effectiveness of use	3.94		Strongly Agree
Composite Mean	**3.80**		

4 3.50-4.00 Strongly Agree 3 2.50-3.49 Agree 2 1.50-2.29 Disagree 1 1.00-1.49 Agree

The mean of each indicator in terms of usability reveals that the student respondents have a more positive perception of the use of the virtual laboratory since only one indicator is lower than the composite mean.

The highest mean score, which is valued at 3.94, pertains to the number five (5) indicator of usability; this implies that after the students have experienced using the hybrid laboratory, specifically the virtual laboratory, they find it pleasing to use in terms of their motivation to do the laboratory task.

This finding is reinforced by scholarly literature, as highlighted in Reese's comprehensive review (2013), as referenced by Hamed (2020), which underscores the benefits of virtual laboratories. Virtual labs enhance computer engagement and bolster motivation and safety measures. Consequently, students exhibit a more favorable disposition towards utilizing computers for educational purposes. Furthermore, the simulation of laboratory tasks is a potent motivator, providing students with rich experiential learning opportunities. Such simulations facilitate the completion of cognitive tasks, thereby enriching the learning journey and augmenting overall educational outcomes.

This agrees with the result that after being exposed to the use of virtual laboratory, they increased their motivation of doing the laboratory task, because they find it pleasing to use.

On the other hand, indicator no. 4 is less than the composite means, which is valued at 3.40. The respondents found the virtual laboratory's user interface to be clear, minimizing errors during use.

This implies that some students find it hard to use the virtual laboratory interface as the application interface was not clear enough for them to manipulate.

This finding aligns with the 2018 study by Aljuhani and Althabiti, who developed a Virtual Science Lab (VSL) and highlighted the benefits of computer simulations in enhancing science education. They suggested adding features like a personalized interface to improve usability. Similarly, Kumar et al. (2018) noted that virtual lab designs often lack a focus on usability, indicating a need to update design and implementation guidelines to address this issue.

This study agrees with the result that students had a hard time using the virtual laboratory because of its unclear user instructions or interface.

Table 3. Perception of the Student- respondents on the Use of Virtual Laboratory Application in Genetics in terms of Manipulation

Indicator	**Mean**	**Std. Deviation**	**Verbal Interpretation**
1. Easy to operate.	3.78	0.415	Strongly Agree
2. Flexible to use in relation to time efficiency.	3.89	0.317	Strongly Agree
3. Flexible to use in relation to gadget used (cellphone,	3.42	0.495	Agree

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laptop/computer).			
4. Easy to handle and execute laboratory task	3.93	0.264	Strongly Agree
5. Fit to use in repeating laboratory experiments.	3.92	0.274	Strongly Agree
Composite Mean	**3.79**		

4 3.50-4.00 Strongly Agree 3 2.50-3.49 Agree 2 1.5-2.29 Disagree 1 1.00-1.75 Agree

The mean of each indicator in terms of manipulation reveals that the student respondents have a more positive perception of the use of the virtual laboratory since only one indicator is lower than the composite mean.

The highest mean score pertains to the fourth indicator of manipulation, which they find that virtual laboratory is easy to handle and execute laboratory tasks.

This implies that after the students have experienced using the hybrid laboratory, specifically the virtual laboratory, in terms of manipulation, they find that the virtual laboratory is easy to handle and execute laboratory tasks.

This finding is supported by Scheckler (2003), as cited by Byukusenge and Mamlok-Naaman (2018), who found that virtual laboratories can safely conduct hazardous experiments. Furthermore, Bortnick (2017), as cited by Lin (2023), stated

that simulations and virtual labs encourage deeper levels of thinking and memory retention since they are learner-centered and inquiry-based.

On the contrary, the third indicator for manipulation received the lowest mean score, indicating that respondents perceived the virtual laboratory as less adaptable to different devices such as cellphones, laptops, or computers.

This suggests that certain students encountered difficulties accessing the application based on the type of gadget they used.

Based on the recent study by Elmoazen et al. (2023) in which adaptability issues of virtual laboratories across different devices were addressed. The study titled "Learning Analytics in Virtual Laboratories: A Systematic Literature Review" highlighted that students often encounter difficulties when accessing virtual labs on various devices, such as cell phones, laptops, and computers. These challenges are due to differences in screen size, processing power, and software compatibility, which can hinder the usability and effectiveness of virtual lab applications.

This finding aligns and agrees with the previous observation about adaptability issues in virtual laboratories.

Table 4. Composite Mean of Perception of the Student- respondents on the Use of Virtual Laboratory Application in Genetics in terms of Usability and Manipulation

Table	Perception of the Student- respondents on the Use of Virtual Laboratory Application in Genetics in terms of:	Composite Mean	Verbal Interpretation
2	Usability	3.80	Strongly Agree
3	Manipulation	3.79	Strongly Agree

4 3.50-4.00 Strongly Agree 3 2.50-3.49 Agree 2 1.5-2.29 Disagree 1 1.00-1.75 Agree

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The table highlights the student-respondent's perceptions of the virtual laboratory application in genetics, focusing on two key aspects: usability and manipulation. Both aspects received high composite mean scores, with usability scoring 3.80 and manipulation scoring 3.79. These scores fall within the "Strongly Agree" range (3.50 - 4.00), indicating a positive reception.

The composite mean of 3.80 for usability suggests that students found the virtual laboratory application highly user-friendly. This could imply that the interface is intuitive, the features are accessible, and the overall user experience is smooth. Usability is critical in educational tools as it can significantly affect the learning process. A user-friendly application can simplify the learning process, enabling students to concentrate on the content rather than the tool itself.

The composite mean of 3.79 for manipulation indicates that students also strongly agree on the effectiveness and ease of manipulating variables within the virtual laboratory. This is an essential feature for virtual labs, as it allows students to experiment with different scenarios and understand complex genetic concepts through interactive learning. The high score suggests that the application provides robust and accurate manipulation capabilities essential for simulating real-life genetic experiments.

The strong agreement in both usability and manipulation suggests that the virtual laboratory application is well-designed and meets the students' needs effectively. This positive feedback can encourage further use and development of such applications in educational settings. It also underscores the importance of user-centric design in educational technology, where ease of use and practical functionality can enhance the learning experience.

Statement of the Problem #3. Is there a significant difference in the pre-test and post-test scores of the students?

Table 5 shows the result of T-test between the scores in pre-test and post-test of the student-respondents. T-test was determined to see if there is a significant difference between the means of the two tests and if they are related.

Table 5. T-Test in the Pre-test and Post-test scores of the Student-respondents

Paired Samples T-Test						
Measure 1		**Measure 2**	**T-value**	**df**	**p**	**Decision**
Pre-Test	-	Post Test	-50.694	159	< .001	Reject

**Significant level $p < 0.05$.

The obtained p-value of less than 0.001, signifying statistical significance by conventional standards, is indicative of a strong difference between the pre-test and post-test scores of the student-respondents. This pronounced differentiation underscores a substantive change in academic performance subsequent to the introduction of hybrid laboratory tasks.

Furthermore, this significant difference is rooted in the distinct improvement of post-test scores compared to pre-test scores among the participating students. Such an outcome signifies the efficacy of integrating hybrid laboratory methods into the educational strategy in the science class. The notable improvement in performance following exposure to these tasks suggests an impact on the students' learning.

The observed increase in post-test scores reflects a quantitative advancement and implies qualitative progress in comprehension, problem-solving abilities, and critical thinking skills.

Integrating theoretical concepts with hands-on experiential learning, the hybrid laboratory method adopts a more comprehensive understanding and application of subject matter in science classes.

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Moreover, this satisfactory change in score results emphasizes the adaptability and effectiveness of the hybrid laboratory model in accommodating diverse learning styles and needs. By providing a dynamic learning environment that engages students actively, the hybrid approach cultivates a deeper level of conceptual mastery and adopts a sense of autonomy and self-directed learning.

In essence, the significant improvement in post-test scores serves as an evidence to the transformative potential of innovative pedagogical approaches like hybrid laboratories in enhancing student learning outcomes and preparing them for success in educational and technological landscape.

A study by Smith and Jones (2019) investigated the impact of hybrid learning environments on student achievement in STEM subjects. Their findings revealed that students who participated in hybrid laboratory activities exhibited significantly higher academic performance levels than those engaged in traditional instructional methods alone. This suggests integrating hands-on laboratory tasks within a hybrid framework positively influences students' learning outcomes.

Furthermore, blended learning, which combines online instruction with face-to-face interactions, has gained traction in educational practice. Studies by Garrison and Vaughan (2018) and Picciano (2019) have highlighted the benefits of blended learning approaches, including increased student engagement, flexibility, and improved learning outcomes. As a subset of blended learning, hybrid laboratory methods leverage these advantages by providing students with hands-on experiential learning opportunities supplemented by online resources and instruction.

The significant enhancement in post-test scores following participation in hybrid laboratory tasks supports findings from existing literature, emphasizing the effectiveness of such pedagogical approaches in promoting student learning and achievement in diverse educational settings. These studies collectively support the notion that hybrid laboratory models hold promise for enhancing student outcomes and fostering more profound understanding and engagement in STEM subjects.

Statement of the Problem #4. Is there a significance relationship between the perception of student-respondents and their academic performance in the use of virtual laboratory application?

Table 5 shows the Pearson Correlation, which determines the relationship between the perception of student respondents and their post-test scores since they were exposed to the virtual laboratory modality in their science class.

Table 6. Pearson's Correlations between the Perception of Student- respondents and their Post test scores

			Pearson's r	**p**
Post Test	-	MU	0.628	< 0.0001
Post Test	-	MM	0.232	< 0.0001

**Significant level p < 0.05.

Correlation between post-test scores and the perception of students in terms of usability of virtual laboratory (r = 0.628). This correlation coefficient suggests a moderately strong positive relationship between the post-test scores and the student's perception in terms of the usability of the virtual laboratory. Generally, students who perceive the virtual lab as more usable tend to score higher on the post-test.

Usability refers to how easily and effectively the students find the virtual lab to complete tasks. A higher usability perception likely means that the interface is intuitive, the tasks are easy to follow, and the overall experience is smooth. This positive experience could lead to better engagement, understanding, and, consequently, higher post-test scores.

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This correlation suggests that improving the usability of the virtual laboratory could lead to improved learning outcomes. It highlights the importance of designing educational tools that are user-friendly and accessible to enhance student performance.

Correlation between post-test scores and the perception of students in terms of manipulation of virtual laboratory (r = 0.232). This correlation coefficient indicates a weak positive relationship between post-test scores and the students' perception in terms of manipulation of virtual laboratory. Although the relationship is positive, it is much weaker than the usability correlation, meaning that while students who find the lab more straightforward to manipulate tend to score slightly better, this is not a solid or consistent trend.

Manipulation in this context likely refers to how well students can interact with the virtual lab environment, for example, handling virtual instruments, navigating the interface, or performing specific tasks. A weak correlation suggests that usability is more critical to post-test performance than ease of manipulation. Students can achieve good scores even if they find manipulation challenging, perhaps because other factors (like content quality or support materials) offset the challenges in manipulation.

The weak correlation indicates that while manipulation is somewhat related to performance, it may not be the primary driver of success in this virtual lab context. This could imply that students might be focusing more on understanding the concepts rather than the process of interacting with the laboratory. However, enhancing the manipulation aspects could still contribute to a more engaging and immersive experience, improving learning outcomes in the long term.

These correlations emphasize the importance of usability in educational tools. High usability fosters better engagement, less cognitive load, and improved comprehension, leading to better academic performance.

While usability and manipulation are essential, improving usability should be a priority. Addressing issues that make the virtual lab less usable could significantly improve student learning outcomes.

The moderate relationship with usability indicates that students who enjoy using the virtual laboratory because it's easy to use may spend more time on it, leading to better learning and higher scores.

In addition, since the computed p-value is less than the significant level 0.05 therefore, it indicates that there is a significant relationship between the perception of student-respondents and their post test scores after they experienced having hybrid laboratory applications.

This suggests that students' attitudes, beliefs, or experiences regarding these virtual tools may impact their success in academic tasks related to them.

The findings align with existing research in educational psychology and technology-enhanced learning by Keller et. al (2023) used the the self-efficacy theory introduced by Bandura, Albert in 2003 which states that students' beliefs in their capabilities to perform tasks can significantly impact their actual performance outcomes. In the context of virtual laboratory applications, students' perceptions of their ability to navigate and utilize these tools effectively could influence their academic achievements.

In addition, studies in technology-enhanced learning have investigated the relationship between students' experiences with educational technologies and their academic outcomes. For instance, research by Hew and Cheung (2014), as cited by Al-Okaily et al. (2020), examined the impact of students' perceptions of e-learning systems on their learning outcomes. They found that students' satisfaction and perceived usefulness of e-learning systems were positively associated with their academic performance. Similarly, in virtual laboratory applications, students' satisfaction with the usability, functionality, and relevance of these tools could contribute to their success in related academic tasks.

Furthermore, insights from the study of Norman (2013) as cited by Lee (2021) suggest that user experience (UX) design principles can shed light on the relationship between students' perceptions of virtual laboratory applications and their academic performance. Research in UX design emphasizes the importance of designing

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interfaces and interactions that align with users' needs, preferences, and cognitive processes.

Hence, this study suggests that the findings on students' perceptions of virtual laboratory applications may be influenced by factors such as interface design, ease of use, and the overall user experience, in turn can impact their engagement and performance in learning tasks facilitated by these tools, which agrees to the significant results.

Statement of the Problem #5. How do student-participants describe their experience regarding the conduct of laboratory classes using virtual and physical set-up?

Among the main themes generated were: 1) functionality, 2) accessibility, 3) cognitive presence, 4) psychomotor presence, and 5) social presence. Each of the major themes is described and discussed below.

Interfacing

With the constantly changing learning modalities in the field of education, students are struggling to complete laboratory tasks or activities in their science subjects. Due to this, the researcher decided to seize the opportunity to implement a hybrid laboratory to help students better understand their science lessons. Adopting a hybrid learning modality for laboratory tasks is also an opportunity to address science laboratories' shortage or lack of equipment, which students need to see and experience firsthand.

The quantitative findings indicate a clear improvement in students' test scores after implementing hybrid laboratory applications. This is evident from the comparative analysis of pre-test and post-test results, which shows a significant increase in scores following the use of these applications.

Furthermore, this quantitative data is reinforced by qualitative insights derived from the participants' lived experiences.

From the participants' narratives, it is apparent that engaging with hybrid laboratory applications has facilitated a deeper level of cognitive engagement. This finding is particularly relevant to the emerging theme of **cognitive presence**, which emphasizes creating meaningful learning experiences that foster critical thinking and reflection. The participants' experiences highlight how hybrid labs can enhance cognitive presence by providing interactive and immersive educational settings.

Cognitive presence is the process by which learners build and validate understanding through ongoing reflection and discussion.

Students have reported that these applications helped them understand complex concepts and encouraged them to apply critical thinking and problem-solving skills. This dual approach of combining traditional and virtual learning experiences has enabled them to tackle cognitive tasks more effectively, leading to a noticeable improvement in their higher-order thinking skills, which includes analysis, evaluation, and creation. Overall, integrating hybrid laboratory applications has proven beneficial not just in boosting test scores but also in enhancing students' cognitive capabilities, thereby providing a more comprehensive learning experience.

Supporting the other quantitative data, the average scores for each usability indicator revealed that student respondents had a favorable perception of using both virtual and physical laboratories.

Supporting the other quantitative data, the average scores for each usability indicator revealed that student respondents had a favorable perception of using both virtual and physical laboratories.

Notably, the highest average score pertained to the fifth usability indicator, indicating that students found the virtual laboratory enjoyable. This enjoyment was a key factor, as satisfaction with a system and how pleasant it was to use directly impacted user motivation, affecting its overall effectiveness.

Further strengthening this finding was the emerging theme of **functionality**. Participants highlighted that both the virtual and physical laboratories offered a user-friendly experience, were easy to navigate, and were

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efficient in time management. Specifically, students appreciated the intuitive interfaces of the virtual labs and the up-front procedures in the physical labs, which minimized the learning curve and allowed them to focus more on the experiments than on understanding how to use the tools.

Moreover, students noted that the virtual laboratory provided additional advantages such as accessibility and convenience, allowing them to conduct experiments remotely and at their own pace. This flexibility was seen as a significant benefit, particularly for those who had scheduling conflicts or other commitments. On the other hand, the physical laboratory was praised for its hands-on experience, providing tangible interactions that enhanced understanding and retention of the subject matter.

These findings emphasized the importance of user satisfaction and enjoyment in fostering effective engagement with both virtual and physical laboratory environments. By ensuring that these labs were user-friendly and enjoyable, educational institutions could enhance the learning experience, thereby improving student motivation and the overall efficacy of laboratory-based education.

Regarding the quantitative data on manipulation indicators, the average scores indicated that the fourth manipulation indicator had the highest mean. This suggested that students found the virtual laboratory easier to handle and more effective for executing laboratory tasks. As a result, after utilizing the hybrid laboratory, which integrated both virtual and physical elements, students perceived the virtual component as more manageable and efficient than the physical laboratory.

Co-participants' views on **accessibility** further supported this perception. They noted that virtual and physical laboratories were generally easy to access, mainly when all required equipment was readily available. However, they identified some challenges and advantages unique to each type. For the virtual laboratory, connectivity issues were cited as a significant downside, sometimes hindering the completion of laboratory activities. Despite this, many participants appreciated the cost efficiency of the virtual laboratory, finding it less expensive than maintaining and using physical laboratory spaces. This feedback highlighted the complex balance between convenience, accessibility, and technical limitations in adopting virtual laboratories in educational settings.

The significance test for the p-value between pre-test and post-test scores revealed a significant difference, indicating a notable change in academic performance following the introduction of hybrid laboratory tasks. This difference is attributed to the distinct improvement in post-test scores compared to pre-test scores among the participating students.

The test of significance for the p-value between pre-test and post-test scores revealed a significant difference, indicating a notable change in academic performance following the introduction of hybrid laboratory tasks. This difference is attributed to the distinct improvement in post-test scores compared to pre-test scores among the participating students.

Such results highlight the effectiveness of incorporating hybrid laboratory methods into the science class curriculum. The marked improvement in performance after engaging with these tasks suggests a positive impact on students' learning.

The observed increase in post-test scores demonstrates quantitative progress and suggests qualitative advancements in comprehension, problem-solving abilities, and critical thinking skills. By combining theoretical concepts with hands-on experiential learning, the hybrid laboratory method fosters a deeper and more comprehensive understanding and application of scientific subject matter.

This is supported by the emerged theme from the lived experiences of the co-participants which is **psychomotor presence**. Student-participants expressed that hands-on experiences during the laboratory tasks led to more meaningful engagement and a deeper understanding of the science concepts. They felt that actively participating in experiments and handling materials significantly enhanced their grasp of the subject.

Additionally, participants stressed the importance of safety precautions during laboratory activities. They

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emphasized that while virtual laboratories provide a risk-free environment, physical laboratories require strict adherence to safety protocols due to the risks of handling actual materials and equipment. This aspect of safety was seen as vital to their learning experience, as it ensured their well-being and taught them crucial real-world laboratory practices and the necessity of caution in scientific experimentation.

Generally, the hybrid laboratory method, by combining theoretical knowledge with practical, hands-on experiences and emphasizing safety, offers a comprehensive educational approach that enhances students' cognitive and practical skills. This multifaceted approach improves their academic performance and prepares them for real-world scientific work.

Furthermore, a significant relationship was identified between the students' perceptions of hybrid laboratory applications and their academic performance.

These findings suggest that students' attitudes, beliefs, or experiences with these virtual and physical tools can influence their academic success in tasks related to them.

This relationship can be further understood through **social presence**, which promotes collaboration and independent learning. Social presence pertains to the ability of students to feel connected and interact with others in a learning environment, even in a virtual setting. In physical laboratory, it was stated by the co-participants that a high level of social presence was evident specifically engagement, interaction, and collaboration.

Students who perceive laboratories positively are more likely to participate and collaborate with peers actively. This collaborative environment enables students to share ideas, solve problems, and learn from one another, which can deepen their understanding of the material. For example, group projects or peer discussions in physical laboratories and even virtual labs can simulate real-world scientific teamwork, where students can practice and refine their collaborative skills.

At the same time, virtual laboratories also support independent learning by providing flexibility and accessibility. Students can access virtual labs conveniently, learning independently and revisiting complex concepts as needed. This independence helps students take ownership of their learning, develop self-discipline, and enhance their problem-solving abilities.

The combination of collaborative and independent learning facilitated by virtual labs creates a balanced and comprehensive educational experience. The positive perceptions of virtual laboratory applications likely reflect an environment where students feel supported by their peers and empowered to learn independently. This dual approach improves their academic performance and prepares them for future academic and professional endeavors by fostering essential skills such as teamwork, analytical thinking, and independent learning.

As a result, students' experiences with laboratory classes using virtual and physical set-ups were shaped by factors related to functionality, accessibility, cognitive presence, psychomotor presence, and social presence. Effective design and implementation of laboratory activities in both settings can contribute to positive learning experiences and outcomes for students.

Statement of the Problem #6. Based on the findings of the study, what output may be crafted?

Based on the findings, a hybrid laboratory guide was crafted for the students and teachers to use during their science laboratory classes. The following is the rationale and objective of the crafted hybrid laboratory guide.

Rationale

Modern education is rapidly evolving due to technological advancements and changing student needs. Educational institutions increasingly adopt hybrid learning models that blend traditional face-to-face instruction with online components. This shift addresses several key factors:

Flexibility and accessibility are major benefits of hybrid models. They allow students to engage with learning

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materials and conduct experiments at their own pace, overcoming the scheduling and logistical constraints of traditional labs. Hybrid laboratories also enhance accessibility by overcoming limitations related to physical space, equipment availability, and accessibility for students with disabilities.

The integration of digital tools is another crucial aspect. Advances in technology enable the use of virtual simulations, interactive software, and online platforms, which enhance the learning experience and complement physical lab work.

A hybrid laboratory guide offers a comprehensive learning experience by combining traditional and virtual modalities. This approach allows students to benefit from both hands-on lab work and interactive simulations, creating a more dynamic learning environment.

Objectives:

1. Provide flexible learning options by allowing students to access virtual laboratory components at their convenience.
2. Facilitate learning for students with varied schedules and those who may face challenges attending physical lab sessions.
3. Develop interactive virtual experiments and simulations that deepen students' understanding of complex scientific concepts.
4. Maximize the use of available resources by incorporating virtual components that reduce the need for physical materials and lab space.
5. Implement assessment tools that evaluate student performance in both virtual and physical lab components.
6. Encourage collaborative projects and discussions that integrate both virtual and physical lab components.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes findings, conclusions, and recommendations based on the data analyzed in the previous chapter.

Summary

The focus of this study was to determine the impact of using a hybrid laboratory (physical and virtual laboratory) on science classes, process skills, and academic performance of the students exposed to the said laboratory set-ups.

The research approach used in this study was a convergent mixed-method research design. The respondents were 160 students who were taking up the course of genetics. The study participants were eight students from the Bachelor of Secondary Education sections, majoring in Science and Bachelor of Science in Psychology. The students were exposed to using a hybrid laboratory, inclusive of both physical and virtual laboratory use, for four consecutive laboratory classes in genetics.

The study utilized pre-tests and post-tests for the quantitative data and a researcher-made questionnaire for the qualitative data.

Summary of Findings

The following reveals the findings of this research.

1. The pre-test and post-test mean scores of the students in the hybrid laboratory showed a relative change in the score of the post test from the pre-test.

2. The perception of the student- respondents on the use virtual laboratory application in selected science courses in terms of usability the highest mean score pertains to the fifth indicator “Virtual laboratory is

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pleasing to use (Satisfaction with a system means basically how pleasing it is to use). It affects the user's motivation and thus the effectiveness of use". In terms of manipulation, highest mean score pertains to the fourth indicator "virtual laboratory is easy to handle and execute laboratory task".

3. There is a significant difference in the pre-test and post-test scores of the students after they have undergone hybrid laboratory.

4. There is a significance relationship between the perception of student- respondents and their academic performance in virtual laboratory application.

5. As per the student-participants they described their experience regarding the conduct of laboratory classes using virtual and physical set-up in terms of the 5 themes: functionality, accessibility, cognitive presence, psychomotor presence and social presence. In terms of functionality, they find both laboratories easy to use, has a user-friendly environment and is in relation with time efficiency. For accessibility, students find that both laboratories are easy to access, requires a specific equipment for use that must have internet connectivity, deals with availability of materials in relation with cost efficiency. Furthermore, dealing with cognitive presence relates with enhancement of cognitive task and promotes higher order thinking. In addition, psychomotor presence deals with having hands-on experience while maintaining safety precautions. Lastly, social presence, students find both laboratories encourage collaboration and independent learning.

6. Based on the findings of the study, a hybrid laboratory module may be crafted in order to supplement and enhance the laboratory activities both in the physical laboratory and the virtual laboratory.

Conclusion

Based on the findings the following conclusions were drawn:

1. The students' mean scores demonstrated a significant improvement, with the post-test mean score significantly increased after the hybrid laboratory sessions.

2. The student respondents perceived the virtual laboratory application positively, with the highest usability score for the indicator "Virtual laboratory is pleasing to use," highlighting user satisfaction and motivation. Regarding manipulation, the highest score was for the indicator "Virtual laboratory is easy to handle and execute laboratory tasks," emphasizing ease of use.

3. There are significant differences between the pre-test and post-test scores of the students after they experienced having the hybrid laboratory. Therefore, the null hypothesis is not sustained.

4. There is a significant relationship between the perception of student-respondents and their post test scores after using hybrid laboratory application. Therefore, the null hypothesis is not sustained.

5. It was found out that student-participants described their experience regarding the conduct of laboratory classes using virtual and physical set-up in terms of the 5 themes: functionality, accessibility, cognitive presence, psychomotor presence and social presence.

6. A hybrid laboratory guide was crafted to be used in enhancing students' academic performance during their science laboratory classes.

Recommendations

Based on the results and conclusions of the study, the following recommendation are hereby suggested:

1. Since the study revealed a significant difference between the pre-test and post-test scores of the students after they experience using hybrid laboratory, the school may encourage its teachers or instructors to use the hybrid laboratory activities and the crafted output of the researcher (hybrid laboratory guide) in the science classes of

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the institution.

2. Since the study revealed a significant relationship between the perception of student- respondents and their post test scores after experiencing hybrid laboratory application, the teachers may use virtual laboratories to supplement or be the alternative for the physical laboratory in which some of the laboratory apparatus are not available for use, as their academic performance (post test scores) enhanced through this strategy.

3. Since the study revealed that there are some disadvantages regarding the use of virtual laboratory in terms of required equipment and connectivity, the administration can still consider allocating budget for both laboratory modalities (physical and virtual) to serve as supplement or alternative either one is available or not.

4. A similar study may be conducted but not limited to the pre-post test scores of the students and the interview from the student-participants. The researcher may add interviews for the teachers and school administrators for their perceptions.

5. Hybrid laboratory specifically the hybrid laboratory guide can be considered to be implemented in the institution and other institutions since this strategy is a part of the new normal, where flexible learning is being implemented. Both laboratories enhance the academic performance and process skills of students in science laboratory classes

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