Students' Perception of Traditional and Online Laboratories toward Academic Achievement in Biology

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DOI: https://doi.org/10.51584/IJRIAS.2025.100700016

Received: 16 June 2025; Accepted: 18 June 2025; Published: 24 July 2025

ABSTRACT

The study examined how third-year Biology students at Don Carlos Polytechnic College perceive traditional and online laboratories, and whether these perceptions are related to their academic achievement. Sixty students participated, and researchers employed statistical methods, including mean analysis and correlation coefficients, to gather insights.

The findings revealed that students strongly preferred traditional laboratories, rating them highly for their positive impact on learning, engagement, and satisfaction. Students felt that these labs not only enhanced their performance and critical thinking but also provided interactive and enjoyable experiences that boosted their confidence. While online laboratories were also viewed positively—particularly for encouraging independent learning and offering flexibility—students expressed a stronger emotional connection to traditional lab environments. Academically, most students performed well, with the majority receiving grades in the "Very Good" range, and a few achieving "Excellent" or "Good." Overall, the class demonstrated strong academic performance with room for improvement. Finally, correlation analysis revealed no statistically significant relationship between students' perceptions of either traditional or online laboratories and their academic achievement. The correlation coefficients and p-values for online ($r=-0.126$, $p=0.334$) and traditional labs ($r=0.004$, $p=0.974$) indicated weak and insignificant relationships. Based on the results, the study showed no significant relationship and failed to accept the alternative hypothesis.

Keywords: Academic achievement, Students' perception, Traditional and Online Laboratories.

INTRODUCTION

Background of the Study

Laboratory activities are essential to science education because they allow students to explore and apply scientific concepts through hands-on experiments. Traditionally, science laboratories are in physical classrooms where students use actual equipment and materials. However, with technological advancements, online laboratories have become an alternative, allowing students to conduct experiments in a virtual setting. While traditional laboratories offer real-world experience, online laboratories provide flexibility and safety. This shift has sparked discussions on how both types of laboratories affect students' learning, engagement, and academic achievement.

Many studies have investigated how laboratory settings impact student learning. Hofstein and Lunetta (2018) pointed out that traditional laboratories help students develop a deeper understanding of concepts and improve their problem-solving skills. On the other hand, Brinson (2016) noted that virtual laboratories offer greater accessibility and allow students to repeat experiments without worrying about safety risks. However, some argue that online laboratories lack hands-on experience to learn complex scientific concepts. Since there is no clear answer on which type of laboratory is better, it is important to examine students' perspectives on both approaches and how these affect their academic performance and engagement.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

Laboratory activities play a significant role in keeping students engaged in science subjects, particularly in biology. According to Freeman et al. (2020), students actively participating in biology laboratory experiments tend to be more motivated and perform better academically. As schools continue to integrate digital learning tools, understanding students' preferences and challenges in different biology laboratory settings may help teachers create better learning experiences. A well-planned biology laboratory activity not only enhances students' scientific skills but also improves their critical thinking and problem-solving abilities, particularly in areas such as microscopy, dissections, and ecological investigations.

Student engagement plays an important role in academic success. Astin (2016) explained that the more students participate in learning activities, the better they perform in their studies. In laboratory classes, students' opinions about traditional and online laboratories can affect how much they take part and how well they learn. If they believe online labs do not provide sufficient hands-on experience, they may lose interest and struggle with their lessons. On the other hand, if they find online labs useful and convenient, they may feel more motivated and involved. Several studies support this idea. For instance, Bernard et al. (2017) found that students in online science labs who engaged actively with interactive simulations performed comparably to those in traditional labs. Similarly, Sun and Rueda (2017) highlighted that motivation and engagement in virtual learning environments strongly correlate with academic achievement. Furthermore, Means et al. (2019) reported that blended learning, which combines online and face-to-face instruction, can enhance student engagement and learning outcomes. Astin's theory reinforces these findings, emphasizing that the more effort students put into their learning, whether in a physical or virtual lab, the more likely they are to succeed.

The purpose of this study was to assess the level of perception of third-year students toward traditional and online laboratories and examine their relationship with academic achievement in Biology. It aimed to identify the advantages and challenges students experience in both laboratory settings. This understanding helped improve laboratory instruction methods, ensuring students receive effective and engaging science education in traditional and online environments.

The study focused on third-year science students at Don Carlos Polytechnic College. The research took place over one semester, from January 2025 to May 2025, allowing for thorough data collection and analysis of students' perceptions of traditional and online laboratories.

Statement of the Problem

This study aimed to assess students' perceptions of traditional and online laboratories toward academic achievement in biology.

Specifically, this study aimed to answer the following questions:

1. What is the level of perception of third-year students in toward traditional laboratories in terms of:

a. Learning Outcomes;

b. Engagement;

c. Satisfaction?

2. What is the level of perception of third-year students in toward Online Laboratories in terms of:

a. Learning Outcomes;

b. Engagement;

c. Satisfaction?

3. What is the level of academic achievement of third-year students in biology?

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

4. Is there a significant relationship between students' perception of Traditional Laboratory and Online Laboratory, and their academic achievement?

Objectives of the Study

The study aimed to assess students' perceptions of traditional and online laboratories regarding academic achievement in biology.

Specifically, this study aimed to:

1. assess the level of perception of third-year students toward traditional laboratories in terms of:

a. Learning Outcomes;

b. Engagement;

c. Satisfaction.

2. assess the level of perception of third-year students toward online laboratories in terms of:

a. Learning Outcomes;

b. Engagement;

c. Satisfaction.

3. determine the level of academic achievement of third-year students in Biology.

4. examine the relationship between students' perception of traditional and online laboratories, and their academic achievement.

Hypothesis of the study

The hypothesis was drawn based on the given objectives and tested at a 0.5 level of significance.

Ha**:** There is a significant relationship between students' perception of traditional and online laboratories, and their academic achievement.

Significance of the Study

The study on students' perception of traditional and online laboratories and their relationship with academic achievement in biology may provide valuable insights for students, teachers, educational institutions, and future researchers.

For students, this study could help them better understand how different laboratory settings might impact their learning experience and academic achievement. By identifying the potential benefits and challenges of traditional and online laboratories, students may be able to adapt their study habits to maximize their learning potential.

For teachers, the findings may offer insights into how laboratory settings can influence student motivation, participation, and understanding of scientific concepts. Understanding students' perceptions may help teachers refine their instructional strategies, ensuring that traditional and online laboratory activities effectively support skill development, critical thinking, and scientific inquiry.

For educational institutions, the study could serve as a guide for improving laboratory instruction. By recognizing students' preferences and challenges in both traditional and online laboratory, institutions may refine their science curriculum, allocate resources more effectively, and enhance laboratory facilities to optimize learning outcomes.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

For future researchers, this study may serve as a foundation for further investigations into laboratory-based learning. It could provide insights for exploring other factors that might influence student academic achievement in biology. Future studies may expand on this by analyzing different academic levels, subject areas, or instructional approaches.

Scope and De/limitations of the Study

This study focused on students' perceptions of traditional and online laboratories and their relationship with academic achievement in Biology at Don Carlos Polytechnic College. It specifically examined the perceptions of third-year science students regarding traditional and online laboratories without assessing their actual laboratory experiences. The study aimed to understand how students perceive learning outcomes, engagement, and satisfaction in both traditional and online laboratories and whether these perceptions relate to their academic achievement in Biology regarding lesson and task involvement, learning involvement, and effort and preparation.

The study was conducted for one semester, from January 2025 to May 2025, focusing only on third-year students enrolled in Biology courses. However, academic achievement in this study was limited only to the Biology subject, as this is one of the course that involve laboratory activities. Other science subjects that do not require laboratory work were excluded from the study. Additionally, this study did not assess students' actual laboratory performance or skill development, nor did it evaluate the effectiveness of traditional or online laboratories in enhancing science education. The study also excluded students from other academic levels, institutions, or disciplines. The findings were limited to students' perceptions within the defined scope and time frame. Moreover, This study employed a correlational research design; therefore, it did not establish cause-and-effect relationships between variables. While associations were identified, causal conclusions could not be drawn. Future studies were recommended to consider using a mixed-methods or experimental approach to explore deeper causal mechanisms and strengthen the validity of findings.

Definition of Terms

To fully understand the content of this study, the researchers will define the following terms operationally.

Academic Achievement refers to the students' grades in science subjects, specifically in biology, which may be influenced by their perceptions of traditional and online laboratories.

Online Laboratory refers to the virtual learning environment where students conduct science experiments using online tools and resources instead of physical materials.

Perception refers to the viewpoints and opinions of third-year science students regarding traditional and online laboratories, including their perceived effectiveness, advantages, and challenges in learning science.

Traditional Laboratory refers to the on-campus science laboratory where students engage in hands-on experiments as part of their coursework.

Theoretical Framework

This chapter consists of a review of the related literature and studies, and the conceptual framework of the study.

REVIEW OF RELATED LITERATURE AND STUDIES

Traditional Laboratories in Science Education

In Hofstein, Mamlok, Lunetta, and Russell's (2020) study, traditional laboratories are highlighted as essential in enhancing science learning through hands-on experiences that deepen conceptual understanding, develop practical skills, and foster engagement. These laboratories improve students' grasp of scientific concepts, problem-solving abilities, and appreciation of the nature of science, including the development of theories and

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

creativity. Additionally, they cultivate teamwork, communication, and safety practices. While traditional laboratories are effective, challenges such as resource management and integration with modern technologies remain. Optimizing laboratory management and incorporating digital tools like IoT and blended learning can enhance their impact and address evolving educational needs.

Additionally, laboratory activities allow students to observe and manipulate scientific phenomena directly, reinforcing theoretical knowledge through practical application. These experiences improve critical thinking, problem-solving, and technical skills, which are crucial for scientific work. Additionally, traditional laboratories promote engagement and motivation, as students actively participate in experiments rather than passively receiving information. Studies also highlight that laboratory work helps students understand the nature of science, including hypothesis testing, data analysis, and the iterative nature of scientific discovery. While virtual simulations offer an alternative, they lack the tactile and sensory experiences that traditional laboratories provide, making physical experimentation an indispensable component of science education.

In the study of Abrahams and Reiss (2020)**,** the role of laboratory work in science education was analyzed, focusing on its impact on students' ability to apply theoretical knowledge in practical scenarios. The study concluded that students who actively participate in traditional laboratory experiments develop stronger problem-solving skills, improve their understanding of experimental design, and demonstrate higher levels of scientific inquiry. The researchers highlighted that traditional laboratories enhance teamwork and communication skills, which are crucial for scientific careers.

Smith and Johnson (2020) looked at how traditional laboratories help students better understand science. Just like in this study, Smith and Johnson found that students really appreciated traditional labs because they helped develop practical skills and strengthen their understanding of science concepts. Their research showed that hands-on experiments helped students learn more deeply than online simulations. Similarly, in this study, students preferred traditional labs because they felt they were more effective in helping them remember what they learned and apply it to real situations. Both studies agree that traditional labs are important for improving students' performance in science by allowing them to work directly with the material and experience it firsthand.

In the study of De Jong, Linn, and Zacharia (2018), traditional laboratories are criticized for being resource-intensive and requiring substantial time, materials, and supervision, which can limit accessibility and efficiency. Students in traditional laboratories often focus more on procedural tasks rather than developing a deep conceptual understanding, reducing opportunities for inquiry-based learning. Additionally, Tatli and Ayas (2019) highlight that virtual laboratories offer cost-effective and flexible alternatives that allow students to visualize abstract scientific concepts without safety risks. These studies suggest that while traditional laboratories provide hands-on experience, they may not always be the most practical or effective approach, especially with the availability of modern digital tools that can enhance learning outcomes.

Moreover, Johnson (2019) explored the impact of active participation in laboratory exercises, highlighting that students who are more engaged report a greater sense of agency and ownership over their learning process. By fostering critical thinking and problem-solving skills, these environments encourage students to apply theoretical knowledge practically (Brown & Green, 2018). Satisfaction in laboratory courses plays a crucial role in shaping students' perceptions.

Moreover, Serna and Martinez (2022) also contributed to this theme by focusing on peer collaboration within traditional labs. Their findings showed that the social dynamics in these settings play a pivotal role in enhancing learning experiences and building a sense of community, which is essential for addressing complex scientific challenges.

According to Smith et al. (2020) found that engagement in laboratory work significantly strengthens students' understanding of key scientific principles. Their study emphasizes that traditional laboratories not only aid in grasping complex concepts but also reinforce the efficacy of experiential learning in promoting deep understanding.

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Smith and Johnson (2020) examined how traditional laboratories facilitate students' understanding of science. Similar to this study, Smith and Johnson found that students greatly appreciated traditional labs because they helped develop practical skills and strengthen their understanding of science concepts. Their research showed that hands-on experiments helped students learn more deeply than online simulations. Similarly, in this study, students preferred traditional labs because they felt they were more effective in helping them remember what they learned and apply it to real situations. Both studies agree that traditional labs are important for improving students' performance in science by allowing them to work directly with the material and experience it firsthand.

Online Laboratories in Science Education

In Nyiramukama Diana Kashaka's (2023) study titled *"Virtual Laboratories in Science Education: Benefits and Challenges,"* virtual laboratories were found to enhance conceptual understanding, procedural skills, and accessibility in science education. The research highlighted that online laboratories provide a flexible, cost-effective, and innovative approach to conducting experiments, allowing students to engage in interactive learning at their own pace. Additionally, the study emphasized that virtual laboratories help bridge geographical and financial barriers, making science education more inclusive for students in remote or underfunded areas. However, challenges such as technical requirements, internet connectivity issues, and the need for effective curriculum integration were noted as potential limitations, which may hinder the seamless adoption of virtual laboratories in all educational settings.

Similarly, in the study by Ramy Elmoazen, Mohammed Saqr, Mohammad Khalil, and Barbara Wasson (2023), titled *"Learning Analytics in Virtual Laboratories: A Systematic Literature Review of Empirical Research,"* a systematic review emphasized the advantages of virtual laboratories, including unlimited time for experimentation, immediate feedback, repeatability of experiments, and enhanced safety. The study found that virtual laboratories allow students to learn at their own pace and promote independent problem-solving skills by enabling repeated trials without material waste or safety concerns. Furthermore, integrating learning analytics into virtual laboratories provides instructors with valuable insights into students' progress, enabling them to tailor lessons based on individual learning needs. Despite these advantages, the study also pointed out concerns regarding the lack of hands-on experience, which some educators argue is essential for fully developing scientific skills. Nonetheless, the research concluded that virtual laboratories are a powerful complement to traditional laboratories, particularly when physical resources are limited or unavailable.

Lee and Chang (2021), which looked at how students feel about online labs compared to regular ones. Like this study, their research showed that students like online labs for their flexibility and convenience. However, both studies found that students still prefer hands-on learning in physical labs for certain tasks. This suggests that while online labs are helpful, they can’t fully replace the hands-on experience of traditional labs.

In a study conducted by Science Interactive in 2023, titled "The Pros & Cons of Virtual laboratories abs Based on 1,614 Instructors & Students," it was found that while virtual laboratories offer flexibility and accessibility, they may lack real-world application and can be less effective in facilitating student learning compared to traditional hands-on laboratories. The study highlighted that virtual laboratories might not fully replicate the tactile experience and practical challenges encountered in physical laboratories, which are essential for developing specific scientific skills. Additionally, some students reported lower engagement levels when participating in virtual laboratories, potentially due to the absence of direct interaction with physical materials and equipment. These findings suggest that, despite the advantages of virtual laboratories, they may not entirely substitute the experiential learning and skill development provided by traditional laboratory settings.

Academic Achievement in Science Education

Ilavarasi and Premila (2021) compared the effects of traditional hands-on and simulated (virtual) laboratory experiences on students' academic performance. The study involved 58 ninth-grade students, divided equally into an experimental group, which received instruction through computer-assisted simulations, and a control group, which engaged in traditional laboratory activities. The findings revealed that the experimental group demonstrated significantly higher academic achievement compared to the control group, suggesting that

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simulated laboratory experiences can be more effective than traditional methods in enhancing students' understanding of scientific concepts.

Similarly, in a study by Olubu (2016) the influence of the laboratory learning environment on students' academic performance in secondary school chemistry was examined. The research indicated that students' perceptions of the laboratory environment significantly affected their chemistry performance, highlighting the importance of an engaging and well-structured laboratory setting for effective learning. These studies underscore the critical role of laboratory experiences, both traditional and simulated, in science education. While traditional laboratories provide hands-on experience with scientific phenomena, simulated laboratories offer flexible and innovative approaches that can enhance conceptual understanding and accommodate diverse learning needs. Educators should consider integrating both methods to optimize student learning outcomes in science education.

Recent studies have explored the impact of virtual laboratories on students' academic performance in science education. For instance, a study published in *Education and Information Technologies* examined the effect of virtual laboratories on undergraduate chemistry students' achievements. The findings indicated that carefully planned virtual lab experiences can lead to improved student performance and positive attitudes toward science.

Similarly, a study in the *Smart Learning Environments* journal conducted a systematic literature review on learning analytic in virtual laboratories. The review highlighted that virtual laboratories offer benefits such as unlimited time for experimentation, immediate feedback, and enhanced safety, contributing to a more effective and accessible learning environment.

However, it is important to note that virtual laboratories may have limitations. According to a 2023 report by Science Interactive, while virtual laboratories provide flexibility and accessibility, they might lack real-world application and can be less effective in facilitating certain hands-on skills compared to traditional laboratories. The report emphasizes that dealing with the frustrations of getting equipment to work and developing the muscle memory of performing hands-on work cannot be fully replicated in virtual platforms. In summary, while virtual laboratories offer several advantages, including flexibility, safety, and the ability to repeat experiments, they may not entirely replace the experiential learning and skill development provided by traditional laboratory settings. Educators should consider integrating both virtual and traditional lab experiences to optimize student learning outcomes in science education.

According to Lee et al. (2020) found that students reported a high level of engagement during virtual laboratories activities, attributing this to interactive elements that encourage participation and collaboration. However, despite positive perceptions of engagement and learning outcomes, student satisfaction often does not meet expectations. A study by Garrison and Kanuka (2004) noted that while online environments enhance accessibility, they can lack the tangible, hands-on experiences vital for comprehensive skill development. This suggests that while students appreciate the flexibility offered by online laboratories, some express concerns over the depth of their experiential learning (Miller & Pappas, 2022). Addressing these concerns may necessitate a blended learning approach that combines the benefits of both online and traditional laboratory experiences to optimize student satisfaction and facilitate deeper learning (Gonzalez & Garrison, 2023).

Traditional Laboratories on Academic Achievement

Traditional laboratory experiences have long been a fundamental component of science education, particularly in biology, where hands-on experimentation is crucial for understanding complex biological processes. According to Freeman et al. (2018), a meta-analysis of 225 STEM education studies found that active learning strategies, such as hands-on experiments in traditional biology laboratories, significantly enhance student engagement and improve exam scores. The study emphasized that laboratory-based learning in biology fosters critical thinking, problem-solving, and experimental skills, which directly contribute to higher academic achievement.

Similarly, a study by Rodriguez et al. (2023) examined the relationship between laboratory type and student achievement, revealing that students who participated in traditional biology laboratories demonstrated higher

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confidence in conducting independent experiments. The study noted that hands-on experience with microscopy, dissections, and biochemical testing helped students develop stronger analytical skills and deeper comprehension of biological concepts, ultimately leading to better academic outcomes.

Further supporting this, Liu et al. (2020) found a significant relationship ($p < 0.05$) between students' perceptions of their laboratory environment and their academic performance in biology courses. The study highlighted that students who viewed their biology lab settings as engaging and effective exhibited higher motivation and better grades in theoretical and practical assessments. These findings reinforce the importance of well-designed traditional laboratories in improving academic achievement in biology.

While traditional laboratories provide essential hands-on learning experiences, some studies suggest that their effectiveness depends on the level of student engagement. Johnson et al. (2022) found that students who actively participated in biology experiments involving live specimens and biochemical reactions showed higher knowledge retention and exam scores compared to those who passively followed instructions. This suggests that active participation in physical biology laboratories directly impacts academic achievement, emphasizing the role of experimental learning in biological sciences.

Brown and Lee (2021), which examined the impact of traditional laboratory experiences on student engagement in science. Brown and Lee found that students who engaged in hands-on laboratory work felt more connected to the subject, participated more actively, and enjoyed the learning process more compared to those using virtual simulations. Similarly, this study shows that third-year students view traditional laboratories as crucial for fostering engagement, motivation, and active participation, reinforcing the importance of hands-on learning in science education.

Chen and Zhang (2021) found a positive correlation between students' satisfaction in laboratory courses and their perceived learning outcomes. This suggests that when students view their lab experiences positively, they are more likely to believe these environments contribute to their academic success.

Additionally, Serna and Martinez (2022) connected collaborative learning in labs with improved academic performance, further reinforcing the idea that traditional lab settings contribute meaningfully to student achievement in science.

Online Laboratories on Academic Achievement

The rise of digital learning tools has led to the integration of virtual and online laboratories in biology education. These online environments offer flexibility and accessibility, allowing students to conduct experiments in a simulated setting. However, their effectiveness in enhancing academic achievement remains a topic of debate.

Brown and Davis (2021) looked at how online laboratories help students stay engaged and learn in university settings. Their results are similar to what we found in this study—students liked how online labs gave them more flexibility and the chance to work at their own pace, which made learning more interesting and motivating. However, Brown and Davis also found that students remembered information better and felt more confident when they could work with real equipment, just like students in this study who recognized that traditional labs were better for developing hands-on skills.

A study by Sun and Rueda (2017) found a strong positive correlation between student engagement in virtual biology laboratories and academic achievement. The study emphasized that interactive simulations, such as virtual dissections and molecular modeling, significantly improved students' understanding of biological concepts and resulted in higher assessment scores. Similarly, Chen et al. (2022) found that students who actively participated in simulation-based biology experiments scored higher on conceptual assessments compared to those who engaged passively, demonstrating that interactivity in online laboratories plays a crucial role in academic success.

However, not all studies fully support the effectiveness of online laboratories in biology. De Jong et al. (2017) highlighted that while online laboratories offer greater flexibility, some students perceive them as lacking the

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hands-on experience needed for mastering biological techniques. This perception often leads to decreased engagement, which can negatively impact academic achievement in practical biology courses. The study suggested that while virtual dissections and simulations can aid theoretical learning, they may not fully replace physical laboratory experiences, particularly in experiments requiring tactile skills and direct observation.

Evans and Wilson (2020) found in their study. They also saw that students found online labs helpful for learning science concepts and doing experiments that may not be possible in physical labs. However, their study also pointed out that students sometimes felt the lack of physical interaction with materials made learning less complete. Similarly, this study shows that while students find online labs beneficial, they still see the value of traditional labs for hands-on learning.

A more recent study by Means et al. (2016) investigated the effectiveness of blended laboratory environments, which integrate both traditional and online biology laboratories. The study found that students in blended settings exhibited significantly higher engagement levels ($p < 0.01$) and better academic achievement than those in purely traditional or online settings. This suggests that combining hands-on experimentation with digital simulations enhances students' understanding of biological processes, leading to improved academic performance in biology courses.

Johnson and Miller (2020), which examined the academic performance of third-year students in science courses. Their research found that the majority of students in science programs tend to perform well, with a significant portion achieving "Very Good" grades. Similar to the findings in this study, their results also showed that while most students excelled, there was a small group of students who performed at a "Good" level, suggesting room for further improvement. Both studies indicate that a strong foundation exists, but there is always an opportunity for growth, particularly for those who are on the cusp of achieving higher academic standards.

Miller and Davis (2017), which looked at how students' views on online and traditional learning affect their academic performance. Their study found no strong connection between students' perceptions and their grades, suggesting that while students may prefer certain types of learning, these preferences don't have a direct impact on their academic success.

While numerous studies suggest that laboratory environments influence academic achievement in biology, some research challenges this assumption. Kim et al. (2021) conducted a large-scale study comparing students' biology grades in traditional, online, and blended laboratory settings. Their findings revealed no statistically significant difference ($p > 0.05$) in student achievement across the three groups, suggesting that the format of the laboratory experience alone does not determine learning outcomes. The study argued that factors such as prior knowledge, instructor effectiveness, and individual study habits play a more crucial role in academic success than the laboratory format.

Similarly, Patel and Green (2022) found that while students reported different levels of engagement depending on the biology laboratory format, their final grades and comprehension of biological concepts remained relatively consistent across traditional and online laboratories. The researchers concluded that while engagement in laboratory activities may enhance motivation, it does not necessarily translate to higher academic achievement. Their study also noted that students who found traditional laboratories engaging did not always achieve higher grades, indicating that external factors such as study strategies and assessment difficulty may have a more substantial influence on biology academic performance.

Conceptual Framework

This study explores how students' perceptions of traditional and online laboratories influence their academic performance and engagement in science. The research is grounded in three key theoretical frameworks: Constructivist Learning Theory by Jean Piaget, Cognitive Load Theory by John Sweller, and the Technology Acceptance Model (TAM) by Davis.

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One of the foundational theories of this study is Jean Piaget's Constructivist Learning Theory, which posits that learners actively construct knowledge through experiences rather than passively receiving information. In the context of laboratory learning, traditional hands-on experiments allow students to interact directly with materials, fostering deeper conceptual understanding. Meanwhile, online laboratories, through simulations and virtual experiments, provide an alternative environment where students can explore scientific concepts in a controlled setting. This theory supports the idea that students' engagement and learning outcomes depend on how well the laboratory format aligns with their cognitive development and learning style.

John Sweller's Cognitive Load Theory provides insight into the differences in students' cognitive processing in traditional and online laboratories. The theory suggests that learning is most effective when cognitive load is optimized—balancing intrinsic load (complexity of the material), extraneous load (distractions or unnecessary processing), and germane load (effort devoted to learning). Traditional laboratories may impose a higher intrinsic and extraneous load due to the need for physical manipulations, whereas online laboratories may streamline cognitive processes by reducing extraneous load through guided simulations and step-by-step instructions. Understanding how students perceive cognitive load in each setting helps explain their academic performance and engagement levels.

The Technology Acceptance Model (TAM) by Davis further underpins this study by explaining students' acceptance and use of online laboratory environments. The model suggests that students' willingness to engage in online laboratories is influenced by perceived usefulness (how well the technology supports learning) and perceived ease of use (how simple it is to navigate the platform). If students perceive online laboratories as effective and user-friendly, they are more likely to engage with them and perform well academically. Conversely, if they find them challenging or ineffective compared to traditional laboratories, their engagement and learning outcomes may suffer.

By integrating Constructivist Learning Theory, Cognitive Load Theory, and the Technology Acceptance Model, this study presents a comprehensive framework for examining students' perceptions of traditional and online laboratories, as well as their impact on academic performance and engagement in science. Understanding these dynamics allows educators to optimize laboratory learning experiences, ensuring both traditional and digital approaches effectively support students' scientific understanding and motivation.

Research Paradigm

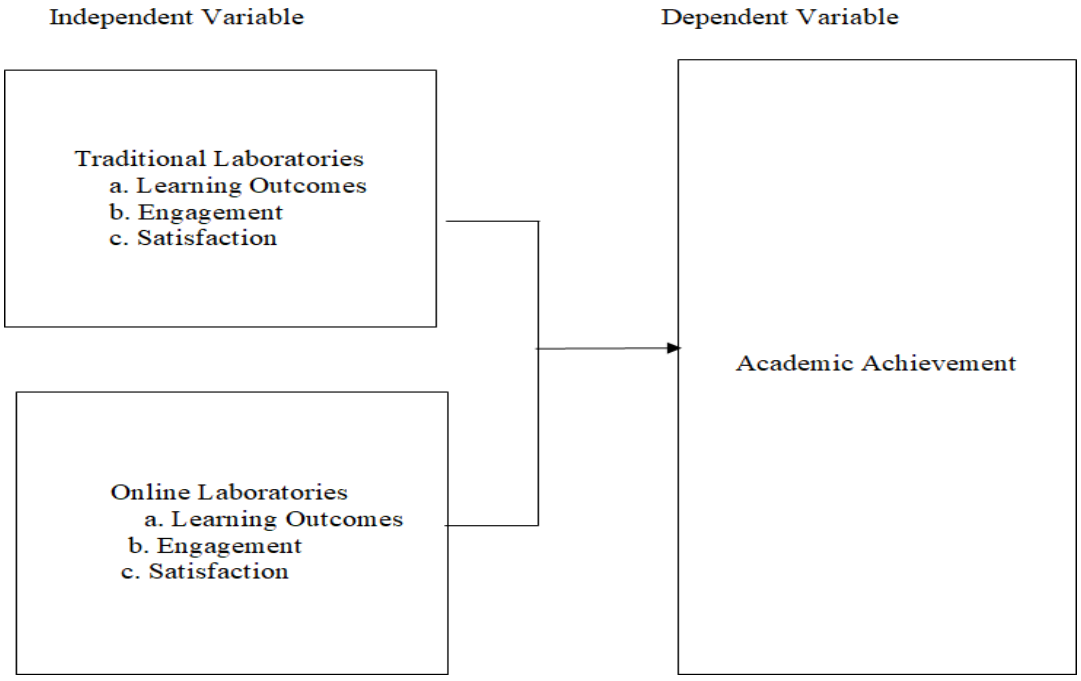

Figure 1: Research Paradigm showing the relationship between students' perception of traditional laboratories and online laboratories, and academic achievement.

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METHODOLOGY

This chapter discussed the methods and procedures used in the study. It includes the research design, locale of the study, respondents of the study, sampling procedure, and research instruments.

Research Design

This study used a descriptive-correlational research design with quantitative methods to examine third-year students' perceptions of traditional and online laboratories and their relationship with academic achievement in Biology at Don Carlos Polytechnic College. Students' perceptions are assessed in terms of learning outcomes, engagement, and satisfaction, while academic achievement is measured using their grades in Biology.

Locale of the Study

The study was conducted at Don Carlos Polytechnic College (DCPC), situated in P-2 Norte, Don Carlos, Bukidnon. The college is operated by the Local Government Unit (LGU) of Don Carlos, making it a vital part of the local educational landscape. Don Carlos Polytechnic College (DCPC) offers quality education, helping students grow academically and professionally, particularly in science and technical fields. Its location and focus on community education make it suitable for studying how laboratory learning affects student performance.

Map of the Locale of the Study

Figure 2: Map of Don Carlos and location of Don Carlos Polytechnic College.

Respondents of the Study

The participants in this study were 61 third-year students majoring in Science at Don Carlos Polytechnic College. The sample size was determined using Slovin's formula with a 5% margin of error to ensure a representative and manageable group for data collection. This study explored students' perceptions of traditional and online laboratories and their potential impact on academic performance and engagement in science. By focusing on third-year Science majors, the researchers sought to gain valuable insights into their experiences, preferences, and challenges in adapting to different laboratory learning environments.

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Sampling Procedure

This study employed a purposive sampling method to select participants from the total population of 71 third-year Science major students at Don Carlos Polytechnic College. Purposive sampling is used because the study focuses on students who have already completed subjects that involve laboratory activities, making them the most relevant respondents for the research. Using Slovin's formula with a 5% margin of error, the sample size was determined to be 61 students. The researchers selected participants based on their experience with laboratory-related subjects to ensure that the study gathers accurate insights into their perceptions, engagement, and academic performance.

Research Instrument and Scoring Procedure

The first part of the study examined the level of perception of third-year students toward traditional and online laboratories, consisting of 10 statements for each category: learning outcomes, engagement, and satisfaction. The researchers developed this section and underwent validation by three (3) research and content experts to ensure content validity and pilot testing to ensure internal consistency with a Cronbach's alpha of 0.975. In this section, respondents were instructed to indicate their level of perception by marking the appropriate column. Using a five-point Likert scale, the responses were as follows: 5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree, and 1-Strongly Disagree.

Table A. Scoring procedure of students' level of perception of laboratories

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

The level of academic achievement of third-year students in Biology was evaluated using their official grades, as recorded in the Don Carlos Polytechnic College (DCPC) grading system. This grading system follows a numerical scale, which corresponds to specific achievement descriptions.

Table B. Academic Achievement Grading System

Grade	Percentage Equivalent	Qualitative Interpretation
1.00 - 1.25	88 - 100	Excellent
1.50 - 1.75	78 - 87	Very good
2.00 - 2.25	64 -75	Good
2.50 - 3.00	50 -63	Satisfactory
5.00	49 below	Failure

Administration of the Research Instrument

The researchers asked authorization from the College Dean of Education at Don Carlos Polytechnic College to initiate their study. A consent form was provided to potential participants, allowing them to voluntarily decide

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whether to participate. The data collection process involved distributing printed questionnaires and ensuring their quality and validity.

Ethical Considerations

To ensure ethical standards in the research, participants were fully briefed on the study's objectives and provided with key information prior to their involvement. Informed consent was obtained, allowing participants to voluntarily agree to take part in the survey. Interviewees were assured that the information they shared would remain confidential, unless there was a disclosure of harm to themselves or others. To uphold anonymity, confidentiality, and prevent potential harm, all data were handled with the highest level of confidentiality, adhering to the principles outlined in RA 10173, also known as the Data Privacy Act, while maintaining the anonymity of participants.

Data Gathering Procedure

In collecting the data, the researchers asked permission from the College Dean of Education at Don Carlos Polytechnic College, Don Carlos, Bukidnon, to conduct the study. The questions were distributed in printed copies, ensuring the questionnaire is well-designed and valid. The researchers also conducted short interviews with the participants. After providing the respondents with sufficient time to complete the surveys, the researchers collected and reviewed all the questionnaires to ensure accuracy.

Statistical Treatment

To determine the level of perception of students toward traditional and online laboratories, as well as their academic achievement in Biology, the researchers employed descriptive statistics such as the mean. The data were subjected to a normality test, which determined the type of correlation test to be used in the study. If the data are normally distributed, the study used a parametric test, specifically the Pearson r correlation. On the other hand, if the data are not normally distributed, the study used a non-parametric test, specifically Spearman's rho correlation.

Presentation, Analysis, and Interpretation of Data

This chapter presents the analysis and interpretation of the data gathered through the survey questionnaire. The study aimed to assess students' perceptions of traditional and online laboratories toward academic achievement in Biology.

The findings in Table 1 indicate the level of perception of third-year students toward traditional laboratories in terms of learning outcomes. The table presents the mean scores for each item and the descriptive rating. The overall mean score of 4.44 confirms the collective perception of traditional laboratories as not only effective but essential components in science education, particularly in Biology. This shows that students do not merely see labs as complementary activities but as core learning experiences that enrich their understanding of the subject.

Table 1. Level of Perception of Third-Year Students Toward Traditional Laboratories in terms of Learning Outcomes

Indicator	Mean	Qualitative Interpretation
1. I think working with real laboratories equipment is more beneficial than using virtual simulations.	4.63	Very Positive Perception
2. I believe, hands-on experiments are necessary for effective science learning.	4.60	Very Positive Perception
3. I believe traditional laboratories provide the best way to understand	4.48	Very Positive Perception

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

science concepts.		
4. I think traditional laboratories enable students to apply scientific principles to real-world situation.	4.45	Very Positive Perception
5. I believe physical experiments improve retention of scientific concepts.	4.45	Very Positive Perception
6. I think traditional laboratories provide a more comprehensive understanding of scientific theories compared to lectures alone.	4.43	Very Positive Perception
7. I believe traditional laboratories are more effective in developing practical scientific skills.	4.35	Very Positive Perception
8. I believe traditional laboratories offer more reliable learning experience than online laboratories in science.	4.33	Very Positive Perception
9. I think students who use traditional laboratories perform better in science subjects.	4.33	Very Positive Perception
10. I believe conducting real experiments enhances problem-solving skills.	4.43	Very Positive Perception
Average	4.44	Very Positive Perception

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

The very positive ratings suggest that students feel more confident, motivated, and engaged when given the opportunity to conduct actual experiments, which may, in turn, lead to better academic performance and a deeper interest in scientific fields. These findings underscore the significance of traditional laboratories in fostering students' understanding, critical thinking, and problem-solving skills in science education. While digital tools can supplement learning, they cannot fully replace the hands-on experience and intellectual engagement that real lab work offers. Therefore, schools and policymakers should prioritize investing in well-equipped laboratories to support meaningful, skills-based learning.

The findings in Table 1 reveal the level of perception of third-year students toward traditional laboratories in terms of learning outcomes. The highest-ranked item is "I think working with real laboratory equipment is more beneficial than using virtual simulations," with a mean score of 4.63. It falls under "Very Positive Perception," showing that students overwhelmingly prefer real laboratory equipment over virtual simulations.

The second highest-ranked item is "I believe, hands-on experiments are necessary for effective science learning," with a mean score of 4.60, which falls under "Very Positive Perception." This score indicates that students consider hands-on experiments essential for a meaningful science education.

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The third highest-ranked item, “I believe traditional laboratories provide the best way to understand science concepts,” with a mean score of 4.48, falls under the category of "Very Positive Perception." This suggests that students place strong trust in the hands-on and experiential nature of traditional laboratories, seeing them as the most effective method for grasping complex scientific ideas. The preference indicates that for many students, real-life engagement with scientific equipment, materials, and procedures offers clarity that virtual or theoretical learning often cannot match.

Interestingly, the least-ranked items "I believe traditional laboratories offer more reliable learning experiences than online laboratories in science," "I think students who use traditional laboratories perform better in science subjects," and "I believe conducting real experiments enhances problem-solving skills" all received a mean score of 4.33, which still falls under the "Very Positive Perception" category. Although slightly lower in rank, these items confirm that students highly value traditional laboratories for their reliability, academic impact, and skill development. This consistency across responses reveals a cohesive and strong belief in the benefits of physical lab experiences.

These findings are similar to the study by Smith and Johnson (2020), which looked at how traditional laboratories help students better understand science. Similar to this study, Smith and Johnson found that students greatly appreciated traditional labs because they helped develop practical skills and strengthen their understanding of science concepts. Their research showed that hands-on experiments helped students learn more deeply than online simulations. Similarly, in this study, students preferred traditional labs because they felt they were more effective in helping them remember what they learned and apply it to real situations. Both studies agree that traditional labs are important for improving students' performance in science, as they allow students to work directly with the material and experience it firsthand.

The findings in Table 2 indicate the level of perception of third-year students toward traditional laboratories in terms of engagement. The table presents the mean scores for each item, along with the descriptive rating. The overall average mean score of 4.42 strongly confirms that third-year students perceive traditional laboratories as highly engaging environments. This suggests that active participation, physical manipulation of materials, and peer interaction play a critical role in sustaining their interest in science. The positive emotional response associated with lab work implies that traditional laboratories are not only instructional spaces but also motivational tools that enhance student involvement and enjoyment. From an educational standpoint, these findings suggest that laboratory work should remain a vital component of science education. Teachers should be supported in creating lab activities that help students work together, think creatively, and ask questions. School leaders should also ensure that science labs have the necessary tools and are user-friendly for students, as this fosters a sense of engagement and enhances learning in these settings.

Table 2. Level of Perception of Third-Year Students Toward Traditional Laboratories in terms of Engagement.

Indicator	Mean	Qualitative Interpretation
1. I find the hands-on nature of traditional laboratories makes learning more enjoyable.	4.60	Very Positive Perception
2. Traditional laboratories encourage better teamwork and collaboration among students	4.53	Very Positive Perception
3. In my opinion, handling real laboratories materials make science more engaging.	4.48	Very Positive Perception
4. I think traditional laboratories make learning science more interesting.	4.48	Very Positive Perception
5. I feel that students are more likely to participate actively in traditional laboratories	4.43	Very Positive Perception

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6. I believe traditional laboratories activities help students more focus than online laboratories.	4.40	Very Positive Perception
7. I believe traditional laboratories help students stay motivated in science subjects.	4.38	Very Positive Perception
8. Traditional laboratories make science learning feel more interactive.	4.35	Very Positive Perception
9. I think students feel a stronger connection to science when using traditional laboratories.	4.27	Very Positive Perception
10. Traditional laboratories provide a more immersive learning experience compared to online laboratories.	4.23	Very Positive Perception
Average	4.42	Very Positive Perception

Legend:

Rating	Scale	Desciptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

The findings in Table 4 reveal the level of perception of third-year students toward traditional laboratories in terms of engagement. The highest-ranked item, “I find the hands-on nature of traditional laboratories makes learning more enjoyable,” with a mean score of 4.60, reflects that students genuinely enjoy participating in laboratory activities and see them as a source of excitement and motivation in learning science. Although this is the top-rated item, the overall range of scores still falls within the "Very Positive Perception" category, indicating a consistent appreciation across all indicators. The second highest-ranked item, “Traditional laboratories encourage better teamwork and collaboration among students,” with a mean score of 4.53, also reinforces the social and cooperative aspects of laboratory learning. This suggests that beyond individual understanding, students value the opportunity to work with peers, exchange ideas, and develop interpersonal skills, which are crucial in both academic and professional scientific environments.

The third highest-ranked items, “In my opinion, handling real laboratory materials makes science more engaging” and “I think traditional laboratories make learning science more interesting,” both with a mean score of 4.48, highlight the role of physical interaction in fostering deeper interest. The use of real materials not only stimulates curiosity but also helps students visualize and understand abstract concepts through concrete experiences, making learning more meaningful and lasting.

The least-ranked items, while slightly higher in mean scores ranging from 4.35 to 4.23, still fall under "Very Positive Perception." Statements such as “Traditional laboratories make science learning feel more interactive” and “I think students feel a stronger connection to science when using traditional laboratories” show that students believe traditional labs not only enhance cognitive understanding but also create an emotional and intellectual bond with the subject. This emotional engagement can significantly influence long-term interest in science-related fields. These findings align with the study by Brown and Lee (2021), which examined the impact of traditional laboratory experiences on student engagement in science. Brown and Lee found that students who engaged in hands-on laboratory work felt more connected to the subject, participated more

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actively, and enjoyed the learning process more compared to those using virtual simulations. Similarly, this study shows that third-year students view traditional laboratories as crucial for fostering engagement, motivation, and active participation, reinforcing the importance of hands-on learning in science education.

The findings in Table 3 indicate the level of perception of third-year students toward traditional laboratories in terms of satisfaction. The table presents the mean scores for each item, along with the descriptive rating. The overall average mean score of 4.40 indicates a very positive level of satisfaction among third-year students toward traditional laboratories. Students feel that these environments support their learning needs through structured activities, real-life applications, personal confidence-building, and instructor-led guidance. Their high satisfaction also suggests that hands-on experience in a lab is not just about learning science; it is about building confidence, reinforcing knowledge, and creating a meaningful and enjoyable educational experience. These results suggest that schools and educators should continue to invest in traditional laboratory environments as a core part of science education. Well-structured lab activities, guided by trained teachers, can boost student confidence, enjoyment, and long-term interest in the subject. Furthermore, the integration of real-world skills and practical applications strengthens students' readiness for higher education or careers in science-related fields. Maintaining and improving access to such facilities is essential for promoting student satisfaction and achieving high-quality science education.

Table 3. Level of Perception of Third-Year Students Toward Traditional Laboratories in terms of Satisfaction.

Indicator	Mean	Qualitative Interpretation
1. I think students are generally more comfortable learning in a physical laboratory environment.	4.48	Very Positive Perception
2. I think students enjoy science more when they have access to traditional laboratory experiments.	4.45	Very Positive Perception
3. I think students benefit more from instructor guidance in traditional laboratories.	4.45	Very Positive Perception
4. I think traditional laboratories provide a satisfying learning experience.	4.45	Very Positive Perception
5. I believe traditional laboratories allow students to develop real-world science skills.	4.42	Very Positive Perception
6. I believe traditional laboratories offer a better balance between theory and practices.	4.42	Very Positive Perception
7. Traditional laboratories are more likely to meet students' expectations for science learning.	4.37	Very Positive Perception
8. I believe traditional laboratories help build students confidence in performing experiments.	4.35	Very Positive Perception
9. Traditional laboratories provide a structured and organized approach to learning science.	4.32	Very Positive Perception
10. I believe traditional laboratories provide a sense of accomplishment after completing experiments.	4.25	Very Positive Perception
Average	4.40	Very Positive Perception

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Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

The findings in Table 3 reveal the level of perception of third-year students toward traditional laboratories in terms of satisfaction. The highest-ranked item is “I think students are generally more comfortable learning in a physical lab environment,” with a mean score of 4.48. It still falls under the "Very Positive Perception" category, which means that students genuinely feel at ease in physical lab environments. This comfort likely contributes to reduced anxiety, better focus, and more productive learning during science activities. The second highest-ranked items, “I think students enjoy science more when they have access to traditional laboratory experiments,” “I think students benefit more from instructor guidance in traditional laboratories,” and “I think traditional laboratories provide a satisfying learning experience,” all have a mean score of 4.45. These statements reflect a strong belief that traditional labs not only make science more enjoyable but also provide clearer instruction and overall satisfaction. Students seem to value face-to-face guidance from teachers and the structured experience that traditional labs offer. The third highest-ranked items, “I believe traditional laboratories allow students to develop real-world science skills” and “I believe traditional laboratories offer a better balance between theory and practice,” each have a mean score of 4,42. These findings suggest that students appreciate how traditional laboratories connect classroom concepts to real-world applications, which helps them understand scientific principles more deeply and prepares them for future careers.

The least-ranked items “I believe traditional laboratories help build students’ confidence in performing experiments” (mean = 4.35), “Traditional laboratories provide a structured and organized approach to learning science” (mean = 4.32), and “I believe traditional laboratories provide a sense of accomplishment after completing experiments” (mean = 4.25) still fall within the "Very Positive Perception" range. This indicates that even the lowest-rated aspects are viewed positively, showing that students value the sense of achievement and the clarity that lab work brings, even if these are slightly less emphasized compared to other benefits.

These findings are consistent with the study by Johnson and Roberts (2019), which explored the role of traditional labs in student satisfaction. Johnson and Roberts found that students felt more satisfied with traditional labs because they offered a structured approach to learning, a balance of theory and practice, and opportunities for hands-on experiments. Similarly, in this study, students expressed high levels of satisfaction with traditional laboratories, valuing the structured learning, instructor guidance, and practical skills they developed, all of which contributed to their overall positive perception of traditional science labs.

The findings in Table 4 indicate the level of perception of third-year students toward online laboratories in terms of learning outcomes. The table presents the mean scores for each item and the descriptive rating. The overall average mean score of 3.75 shows that third-year students hold a positive perception of online laboratories. Students see them as helpful, flexible, and informative, especially for reviewing and visualizing science concepts. However, the slightly higher scores compared to traditional labs suggest that while online labs are appreciated, they may not fully satisfy the need for hands-on, collaborative, and real-world lab experiences. The preference still leans toward traditional labs when it comes to deep engagement, skills development, and practical application. These findings suggest that educators and schools should continue to integrate online laboratories as a supportive learning tool, especially in times when physical labs are not accessible. Online labs should be seen as a complementary method, ideal for visual learning, self-paced study, and concept reinforcement. At the same time, schools must ensure that students still have regular access to real

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lab experiences, which are essential for developing critical thinking, collaboration, and technical skills. A blended approach using both traditional and online labs may offer the most complete science learning experience.

Table 4. Level of Perception of Third-Year Students Toward Online Laboratories in terms of Learning Outcomes

Indicator	Mean	Qualitative Interpretation
1. Online laboratories allow students to repeat experiments until they understand the concept.	3.93	Positive Perception
2. I believe online laboratories are a useful alternative when access to a physical laboratory is limited.	3.84	Positive Perception
3. I think, online laboratories are helpful in visualizing abstract science theories.	3.82	Positive Perception
4. I think online laboratories provide a convenient way to learn science at any time.	3.77	Positive Perception
5. Online laboratories provide access to experiments that may be possible in a traditional laboratory.	3.77	Positive Perception
6. Online laboratories provide a structured way to learn science without needing physical equipment.	3.74	Positive Perception
7. I think online laboratories can still develop students' problem-solving skills.	3.72	Positive Perception
8. I believe online laboratories can present scientific concepts in an interactive way.	3.70	Positive Perception
9. I believe online laboratories can effectively teach science concepts.	3.61	Positive Perception
10. I believe virtual simulations can be as effective as hands-on experiments.	3.54	Positive Perception
Average	3.75	Positive Perception

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

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The highest-rated statement is "Online laboratories allow students to repeat experiments until they understand the concept," which has the lowest mean score of 3.93 but still falls under the "Positive Perception" category. This shows that students appreciate the flexibility of online labs, especially the ability to repeat activities at their own pace. This feature supports different learning styles and helps students build confidence as they can revisit experiments until the concept is clear. It highlights how online platforms can support self-paced, independent learning.

The second-highest-rated statement is "I believe online laboratories are a useful alternative when access to a physical laboratory is limited," with a mean score of 3.84. This reflects students' practical mindset, recognizing the importance of having a backup when physical labs are unavailable, such as during remote learning or emergencies. It suggests that students value the availability and accessibility of digital learning tools, especially when traditional methods are not an option.

The third-highest-rated statement, "I think online laboratories are helpful in visualizing abstract science theories," with a mean score of 3.82, indicates that students find online labs beneficial for understanding complex scientific ideas. Interactive simulations and animations can make invisible or complex concepts (such as atoms, molecules, or forces) more understandable. This suggests that virtual labs are particularly effective in helping students visualize, explore, and grasp theoretical knowledge that may be hard to imagine in a traditional setting.

The least-ranked statements, although still under the "Positive Perception" category, include: "I believe online labs can present scientific concepts in an interactive way" (mean = 3.70), "I believe online laboratories can effectively teach science concepts" (mean = 3.61), and "In my opinion, virtual simulations can be as effective as hands-on experiments" (mean = 3.54). These results indicate that while students acknowledge the interactivity and usefulness of online labs, they may still have reservations about their effectiveness compared to traditional, hands-on experiences. It appears that students value the support role that online labs play, but do not see them as full replacements for the deeper engagement and real-world practice provided by physical labs.

These results align with those found by Evans and Wilson (2020) in their study. They also saw that students found online labs helpful for learning science concepts and doing experiments that may not be possible in physical labs. However, their study also pointed out that students sometimes felt the lack of physical interaction with materials made learning less complete. Similarly, this study demonstrates that while students find online labs beneficial, they also recognize the value of traditional labs for hands-on learning.

The findings in Table 5 indicate the level of perception of third-year students toward online laboratories in terms of engagement. The table presents the mean scores for each item, along with the descriptive rating. The overall average mean score of 3.76 falls under "Positive Perception," showing that third-year students generally appreciate the engaging features of online labs, such as freedom to explore, repeat experiments, and learn at their own pace. Students are motivated by the flexibility and reduced pressure that virtual platforms provide. They feel more comfortable, curious, and interested in learning science when these tools are used effectively.

Table 5. Level of Perception of Third-Year Students Toward Online Laboratories in terms of Engagement

Indicator	Mean	Qualitative Interpretation
1. Online laboratories provide opportunities for students to experiment without fear of making mistakes.	3.95	Positive Perception
2. Online laboratories allow students to explore different scientific scenarios easily.	3.84	Positive Perception
3. I believe students feel more comfortable exploring science concepts in an online setting.	3.82	Positive Perception

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4. I believe gamified elements in online laboratories.	3.79	Positive Perception
5. Online laboratories encourage independent learning more than traditional laboratories.	3.79	Positive Perception
6. I think online laboratories make learning science more interactive.	3.72	Positive Perception
7. Online laboratories allow students to learn at their own pace, increasing engagement.	3.69	Positive Perception
8. I think using technology in online laboratories make science more appealing to students.	3.69	Positive Perception
9. I my opinion, online simulations keep students interested in science.	3.67	Positive Perception
10. I think students stay motivated when using online laboratory platforms.	3.66	Positive Perception
Average	3.76	Positive Perception

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

The highest-ranked item is “Online labs provide opportunities for students to experiment without fear of making mistakes,” with a mean score of 3.95, still within the “Positive Perception” range. This suggests that students value the safe and low-pressure environment provided by online laboratories. Since there are no real risks involved, students are more willing to try, fail, and learn from their mistakes, which supports a more profound understanding. The implication here is that educators should emphasize this benefit in instruction, particularly for students who may feel anxious in high-stakes physical lab settings.

The second-highest item, “Online laboratories allow students to explore different scientific scenarios easily,” has a mean score of 3.84. This reflects the students’ appreciation for the flexibility and variety online labs offer. In a traditional lab, some scenarios may not be feasible due to cost, time, or safety concerns. Online labs, however, allow students to simulate complex or dangerous experiments safely. This suggests that online labs are an effective tool for broadening students’ exposure to scientific situations that would otherwise be difficult or impossible to conduct in person.

The third-ranked item, “I believe students feel more comfortable exploring science concepts in an online setting,” with a mean of 3.82, implies that students feel less intimidated in a virtual learning space. The comfort provided by online platforms may lead to increased curiosity, independence, and willingness to experiment. This is particularly important for shy or hesitant students who may not speak up or engage as much in physical settings. Teachers can use online labs to build students’ confidence before transitioning them to more hands-on activities.

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The least-ranked items include: "Online laboratories allow students to learn at their own pace, increasing engagement. "I think using technology in online laboratories makes science more appealing to students." Both have a mean score of 3.69, which is still within "Positive Perception." These results demonstrate that students recognize the benefits of online labs in enhancing their engagement with science through interactivity and personalized pacing. While these items are ranked lower, they still underscore that flexibility and the use of technology play a crucial role in capturing students' attention and making science learning more enjoyable.

Another lower-ranked statement, "In my opinion, online simulations keep students interested in science," with a mean score of 3.67, supports the idea that simulations capture attention and stimulate interest, though possibly not as much as real-world lab experiences. This shows the importance of design and quality in online labs. Well-made simulations can hold students' interest, while less interactive ones may feel boring or repetitive.

The lowest-ranked item, "I think students stay motivated when using online laboratory platforms," with a mean score of 3.66, suggests that while online labs do help with motivation, they may not fully replace the energy and excitement of a live, hands-on lab environment. It may also mean that external factors, such as distractions at home or limited access to a stable internet connection, can reduce students' motivation when working online.

A study by Brown and Davis (2021) examined the role of online laboratories in helping students stay engaged and learn in university settings. Their results are similar to those found in this study—students appreciated the flexibility and pace of online labs, which made learning more engaging and motivating. However, Brown and Davis also found that students remembered information better and felt more confident when they could work with real equipment, just like students in this study who recognized that traditional labs were better for developing hands-on skills.

The findings in Table 6 indicate the level of perception of third-year students toward online laboratories in terms of satisfaction. The table presents the mean scores for each item, along with the descriptive rating. The overall average mean score of 3.73, categorized as "Positive Perception," shows that third-year students generally acknowledge the educational potential of online laboratories in terms of skill development, flexibility, and learning satisfaction. Students appreciate the autonomy, accessibility, and effectiveness that online labs offer, particularly when physical access to real laboratories is limited.

Table 6. Level of Perception of Third-Year Students Toward Online Laboratories in terms of Satisfaction.

Indicator	Mean	Qualitative Interpretation
1. I believe students who use online laboratories can still develop important scientific skills.	3.84	Positive Perception
2. In my view, online laboratories provide an alternative learning environment that is just as valuable.	3.80	Positive Perception
3. Online laboratories provide a positive learning experience even without physical equipment.	3.77	Positive Perception
4. Online laboratories offer a structured and organized approach to science learning.	3.77	Positive Perception
5. Online laboratories allow students to access a wide variety of experiments.	3.75	Positive Perception
6. I believe online laboratories provide a good balance between theory and practice.	3.70	Positive Perception

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7. I think students feel accomplished when completing online experiments.	3.67	Positive Perception
8. I think students appreciate the flexibility of learning in an online laboratory.	3.67	Positive Perception
9. Online laboratories can meet students' expectations for science learning.	3.66	Positive Perception
10. In my opinion, online laboratories provide a satisfying learning experience.	3.62	Positive Perception
Average	3.73	Positive Perception

Legend:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	1.00 - 1.80	Strongly Agree	Very Positive Perception
4	1.81 - 2.60	Agree	Positive Perception
3	2.61 - 3.40	Neutral	Neutral Perception
2	3.41 - 4.20	Disagree	Negative Perception
1	4.21 - 5.00	Strongly Disagree	Very Negative Perception

The highest-ranked item, “I believe students who use online labs can still develop important scientific skills,” with a mean score of 3.84, reflects a strong confidence among students in the educational effectiveness of online labs. Despite the absence of hands-on physical tools, students believe they can still acquire essential scientific competencies such as observation, analysis, data interpretation, and critical thinking. This belief suggests that online labs are viewed not just as supplementary tools but as viable learning platforms that support cognitive skill development. The implication here is that curriculum planners and instructors can confidently integrate virtual labs, especially in situations where physical labs are limited, without significantly compromising learning outcomes.

The second-highest item, “In my view, online labs provide an alternative learning environment that is just as valuable,” with a mean score of 3.80, indicates that students recognize the legitimacy and academic value of online laboratories. While they might not entirely replace the physical experience, students see them as equal in potential to achieve educational goals, especially when well-designed. This perception reinforces the idea that diverse learning environments can coexist and be effective. It encourages educators to invest in improving the design and accessibility of online labs as a permanent part of science instruction.

The third-ranked item, “Online laboratories provide a positive learning experience even without physical equipment,” with a mean score of 3.77, further supports the idea that meaningful engagement and learning can occur in the virtual space. This demonstrates that physical tools are not the only requirement for effective science education; digital interactivity, simulations, and visualization tools can successfully replicate the conceptual depth of lab activities. This has important implications, especially for remote learning settings or institutions with limited resources, showing that students can still experience success even when actual materials are not available.

The item, “I think students appreciate the flexibility of learning in an online laboratory,” with a mean score of 3.67, still falls within the “Positive Perception” category. This reflects that students value being able to work at their own pace, revisit instructions, and repeat experiments as needed, a level of autonomy not always possible

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in traditional labs. However, its lower rank may indicate that while flexibility is appreciated, it is not the top priority compared to skill development or engagement. This suggests that students might still crave structure and guidance, and that instructors should strike a balance between freedom and direction in online lab activities.

Another equally scored item, "Online laboratories can meet students' expectations for science learning," also at 3.66, suggests that while students generally believe online labs are capable of meeting baseline academic goals, there may still be some gaps between expectations and experience. These gaps may be related to the lack of real-world application or hands-on experience with tools and substances. It implies that online labs should be continuously evaluated and upgraded to better align with what students expect from a robust science education.

The lowest-ranked item, "In my opinion, online laboratories provide a satisfying learning experience," with a mean score of 3.62, reveals a slight hesitation in fully embracing the subjective satisfaction of online science learning. This does not mean students are dissatisfied, but rather that the "emotional and experiential richness" found in traditional labs might still be lacking in the virtual format. The implication is that developers and educators should focus on enhancing the user experience in online labs by incorporating more interactive features, immediate feedback, gamified elements, and realistic simulations to increase engagement and satisfaction.

These findings align with the research of Lee and Chang (2021), which examined students' perceptions of online labs compared to traditional ones. Like this study, their research showed that students like online labs for their flexibility and convenience. However, both studies found that students still prefer hands-on learning in physical labs for certain tasks. This suggests that while online labs are helpful, they can't fully replace the hands-on experience of traditional labs.

The findings in Table 7 indicate the level of academic achievement of third-year students in Biology. The table presents the mean scores for each item and the descriptive rating. These results suggest that, overall, the students performed well in their Biology course, but there is still potential for some to improve their understanding and achieve even higher levels of academic success. The distribution of grades highlights both strengths in the class and areas where students could focus more effort for improvement.

Table 7. Level of Academic Achievement of Third-Year Students in Biology

Grade	Frequency	Percentage (%)	Qualitative Interpretation
1.00-1.25	1	2%	Excellent
1.50-1.75	58	94%	Very good
2.00-2.25	2	4%	Good
2.50-3.00	0	0%	Satisfactory
3.25-5.00	0	0%	Failure
Total	61	100%	

The results show that the majority of third-year students in Biology achieved high academic performance, with 94% earning a grade of 1.50-1.75, which is categorized as "Very Good." This indicates that most students were able to demonstrate strong understanding and mastery of the subject. A small portion of the students, 2%, achieved the highest grade of 1.00-1.25, classified as "Excellent," reflecting exceptional performance. However, a few students, totaling 4%, received grades in the "Good" category (2.00 and 2.25), indicating that while they performed well, there is room for improvement.

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These levels of academic achievement align with the study of Johnson and Miller (2020), which examined the academic performance of third-year students in science courses. Their research found that the majority of students in science programs tend to perform well, with a significant portion achieving "Very Good" grades. Similar to the findings in this study, their results also showed that while most students excelled, a small group of students performed at a "Good" level, suggesting room for further improvement. Both studies indicate that a strong foundation exists, but there is always room for growth, particularly for those who are on the verge of achieving higher academic standards.

The findings from Table 8 indicate the relationship between students' perceptions of traditional and online laboratory and their academic achievement. The table presents the Coefficient of correlation, p-value, and the result.

Table 8. Relationship between students' perceptions of traditional and online laboratory and their academic achievement.

Indicators	Coefficient of Correlation (r-value)	P-value
Perception of Online Laboratories	-0.126	0.334
Perception of Traditional Laboratories	0.004	0.974

The findings from Table 8 show that there is no statistically significant relationship between students' perceptions of traditional and online laboratories and their academic achievement. The coefficient of correlation between students' perceptions of online laboratories and their academic achievement is -0.126, indicating a very weak negative relationship. However, the p-value of 0.334 is much higher than the significance level of 0.05, suggesting that this correlation is not statistically significant.

Similarly, the coefficient of correlation between students' perceptions of traditional laboratories and their academic achievement is 0.004, which indicates an almost negligible positive relationship so weak that it is statistically meaningless. The corresponding p-value of 0.974, which is far above the conventional threshold of 0.05, confirms that this relationship is not statistically significant. This result strongly suggests that there is virtually no connection between how students perceive traditional laboratories and their academic performance.

Moreover, the relationship between students' perceptions of online and traditional laboratories, with a correlation coefficient of 0.076, reveals a very weak positive correlation between the two perceptions. This suggests that while some students might view both formats similarly, this tendency is minimal and not consistent across the group. The p-value of 0.562 reinforces the lack of statistical significance, indicating that students do not necessarily view online and traditional laboratories as closely related in terms of perceived effectiveness or educational value.

These findings, drawn from Table 8, collectively support the conclusion that there is no significant relationship between students' perceptions of laboratory types and their academic achievement. The alternative hypothesis, which posits that no such relationship exists, is therefore rejected. This means that regardless of whether students view online or traditional laboratories positively or negatively, these perceptions do not appear to influence their academic performance in any measurable way. This outcome may reflect that students are capable of separating their subjective opinions from their academic responsibilities. For example, even if a student finds online labs less engaging or harder to follow, they may still exert effort in studying, submitting requirements, and preparing for assessments. Likewise, a student who enjoys traditional labs may not necessarily perform better academically if they lack study discipline or face external challenges.

These results align with the study by Miller and Davis (2017), which examined how students' views on online and traditional learning impact their academic performance. Their study found no strong connection between students' perceptions and their grades, suggesting that while students may prefer certain types of learning, these preferences do not have a direct impact on their academic success.

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SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of the study, the conclusions derived from the findings, and the proposed recommendations.

Summary of Findings

The findings indicate that third-year students have a very positive perception of traditional laboratories. In terms of learning outcomes, the average mean score of 4.44 indicates strongly agree, suggesting that students strongly value traditional laboratories for their reliability, effectiveness in improving performance, and their role in developing critical problem-solving skills. When it comes to engagement, the average score of 4.42 indicates strongly agree, reflecting that students believe traditional labs foster a stronger emotional connection to science, making the learning experience interactive, immersive, and motivating. Additionally, in terms of satisfaction, the average score of 4.40 indicates that students find traditional labs to be well-structured, enjoyable, and effective in meeting their expectations for science education, while also helping to build their confidence.

In contrast, online laboratories also received a generally positive perception. In terms of learning outcomes, the average score of 3.75 indicates agree, reflects students' belief that online labs are effective in teaching science concepts, presenting theories interactively, and developing problem-solving skills. The flexibility of online laboratories, allowing students to access experiments at their convenience and visualize abstract concepts, was highly appreciated. Regarding engagement, the average score of 3.76 indicates agree, shows that online laboratories motivate students, promote self-paced learning, and encourage independent exploration. In terms of satisfaction, the average score of 3.73 suggests that students recognize the value of online labs in developing scientific skills and balancing theory with practice. Despite these positive perceptions, students still feel more comfortable in traditional laboratory environments, as shown by the lower comfort rating for online labs. While online labs are seen as valuable in certain aspects, students continue to prefer traditional laboratories, especially in terms of emotional engagement and comfort during the learning process.

Regarding academic performance, the majority of third-year Biology students performed well, with 94% earning a "Very Good" grade of 1.50-1.75, and 2%, earned an "Excellent" grade, while 4% received "Good" grades, suggesting room for improvement. Overall, the class demonstrated strong academic performance with potential for further growth.

Finally, the study found no statistically significant relationship between students' perceptions of traditional and online laboratories and their academic achievement. The correlation coefficients for both online (−0.126) and traditional (0.004) laboratories, along with high p-values (0.334 and 0.974), indicate weak or negligible relationships that are not significant. Therefore, based on the study's results, no significant relationship was found, and the alternative hypothesis was not accepted.

Conclusions

Based on the results of the survey, the following conclusions were drawn:

The findings of the study reveal that third-year students strongly agree or have a very positive perception of the effectiveness of traditional laboratories in achieving learning outcomes, fostering engagement, and providing a high level of satisfaction.

Students generally agree that online laboratories are also effective, though to a slightly lesser extent than traditional labs. They are seen as helpful in supporting learning outcomes, promoting student engagement, and providing a satisfying learning experience, especially when access to traditional labs is limited.

Regarding academic achievement, the third-year students performed well, with the majority earning "Very Good" grades.

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However, there was no significant relationship between students' perceptions of traditional and online laboratories and their academic performance. This study failed to accept the alternative hypothesis.

Recommendations

The study's results and findings led to several recommendations for further research and action. These are the following:

Students may consider actively engaging with both traditional and online laboratory experiences to maximize their learning outcomes. While traditional laboratories provide a more hands-on, interactive learning environment, students may benefit from the flexibility and access to a wide range of resources that online labs offer. This approach may cater to their individual learning styles and provide a more comprehensive educational experience.

Teachers may consider incorporating a combination of traditional and online laboratories in their teaching strategies to cater to the diverse learning preferences of their students. By blending the hands-on engagement of traditional labs with the flexibility and accessibility of online laboratories, teachers may foster a more inclusive and comprehensive learning environment. This approach can enhance student engagement, improve learning outcomes, and cater to the diverse needs of learners.

Educational institutions may want to continue investing in both traditional and online laboratory facilities, ensuring students have access to a variety of learning tools. Providing students with opportunities to experience both formats can enhance their overall scientific education. Institutions may also consider offering professional development programs for educators to integrate onlinelaboratories effectively with traditional laboratory work, ensuring that both formats complement each other to optimize learning experiences.

Future researchers may explore the impact of laboratory formats on long-term student retention and the application of scientific concepts. Further studies may also investigate how hybrid or blended learning models, which combine traditional and online laboratories, influence student performance and engagement. Additionally, research may focus on the role of various factors such as discipline, student motivation, and prior academic experiences in shaping perceptions of laboratory formats.

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