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Virtual Laboratory as A Learning Tool for Anatomy and Physiology Course

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ABSTRACT

The world is continuously suffering due to the COVID-19 pandemic. Online learning was implemented by the Philippine government which brought a serious problem in teaching science courses that requires conducting experiments in a laboratory facility. Thirty-six (36) Laguna University Science major students under the Bachelor of Secondary Education Program were selected as respondents in this study. The students' scores in the pre-test and post-test on plant and animal physiology were analyzed. The purpose of the Quasi-experimental research design was to evaluate the effectiveness of the intervention, Virtual Laboratory, as a learning tool for Anatomy and Physiology Course. Laboratory worksheets and modules were used to test the level of proficiency of the respondents in the pre-intervention stage. To alleviate the difficulty, a virtual laboratory in Anatomy and Physiology course was designed by the researchers. This laboratory was utilized by the respondents before answering the post-test worksheets. An Independent T-test was utilized to determine if there is a significant difference in the test scores before and after the intervention. A survey tool was used to gather data on students' perception on the effectiveness of the virtual laboratory. Based on the results, the virtual laboratory was an effective learning tool that improved students' academic performance in the Anatomy and Physiology course. Results showed that it reduced the time needed to understand the concepts within a topic and helped enhance the quality of the learning process. Therefore, this tool maybe adopted in other experimental-based science subjects.

INTRODUCTION

The immediate spread of the deadly Coronavirus had put everything and everyone to a halt. The current crisis experienced globally disrupted the conduct of face-to-face classes and the Philippine education sector opted to adapt the new normal of teaching and learning. There is an increased dependence on digital tools and modules to ensure the accessibility to quality education amidst the crisis. With the development and widespread online learning modalities, research into the nature and efficacy of teaching and learning in the digital environment has begun. Recent findings have surfaced in the academia demonstrating that online education increases students' satisfaction and creates an atmosphere that enhances student achievement (Chen et al., 2010; Allen and Seaman, 2010).

Learning Science courses had significantly changed after the onset of COVID-19. Laboratory works requires actual and real laboratory experiences but with the current circumstances it was impossible – a strict 'no face to face' classes was implemented in the whole country. Years of study and experience in science teaching and learning have equipped educators with an inquiry-based framework for learning science through engaging in the scientific method (Bransford, Brown, and Cocking 2000; National Research Council, 1996). Studies show that experiences help students modify tools and equipment to understand data processing techniques (practical skills) and to learn some strategies in experimental design, analysis/evaluation, and problem-solving, as well as the

deeper results of strengthening semantic knowledge and improving scientific communication skills (National Research Council 2000; NSTA 2007). For the fields of biology, chemistry, and physics, laboratory experience goals have been established (American Association of Physics Teachers 1998; American Chemical Society 2011; Dikmenli, 2007; Rowe et al. (2017)); face-to-face laboratory experiences, according to these individuals, strengthen the theories and concepts given in the lecture and buildability to think critically. Bruck and Towns (2013) discovered that general and organic chemistry professors felt that laboratory activities enhance the course syllabus from a recent nationwide survey of undergraduate chemistry faculty. Compared to their lecture-only colleagues, students who are enrolled in both lecture and laboratory portions have higher educational outcomes and comprehension (Forcino, 2013).

The virtual laboratory tool includes accessible online simulations that utilizes artificial learning environment to enable learners in the conduct of laboratory experiments and test theories using digital tools such as cellphones and computers. Implementing distance education laboratory component via these modes (virtual or at-home) offers numerous advantages, including almost limitless availability and the opportunity to repeat the experiments (Conway-Klaassen et al., 2012). Investigations of online laboratories utilized primarily as supplementary education have found that they can assist increase lecture exam results, improve students' dispositions and readiness for the hands-on Lab, and boost conceptual understanding

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(Dalgarno et al. 2009).

Objectives of the Study

This research aimed to assess the effectiveness of the virtual laboratory as a learning tool for the Anatomy and Physiology Course of BSSED Science majors. The study specifically sought: 1) to determine the different challenges encountered by students in their courses with laboratory; 2) to design a virtual laboratory with corresponding worksheets aligned with Anatomy and Physiology, 3) to assess the academic performance of the respondents before and after the implementation of the intervention, 4) to determine the efficacy of virtual laboratory in terms of its suitability, relevance, level of engagement, visual quality, and perception of its users.

LITERATURE REVIEW

The conduct of laboratory classes is a required component of any bachelor's degree in science in general. These enable learners to hone their practical knowledge, create a sense of the intricacy of natural phenomena, and enable them to realize how complex it can be to obtain comprehensive information (Josephsen & Hvidt, 2015). Technology-enhanced Anatomy and Physiology learning environments deliver advantages to strengthen students' involvement, engagement, and positive attitudes toward

science in the modern age (Kapici et al., 2020).

However, the conduct of laboratory experiments was hampered by the COVID-19 pandemic. Learners encountered various challenges in accomplishing laboratory works since the lockdown was implemented in the Philippines from March 15, 2020. This challenge led the researchers to design an appropriate intervention tool to cater the needs of the students and alleviate the challenges encountered in conducting laboratory activities. Virtual laboratories allow the place to undertake experiments in a virtual community and may be utilized independently or collaborate with other real-world, hands-on labs (Roblyer & Hughes, 2019). Virtual laboratory design processes may include animations and simulation technologies, instructional lectures, and collaborative demonstrations.

The theory underlying this educational technology is to have a creative teaching environment where the students may interact with web-based learning information at any time and in any location where internet access is accessible and at their leisure. Students may conduct online experiments in the virtual laboratory cheaper and under safer circumstances than in natural laboratories (Brinson, 2015). Moreover, representation of data and events aids learners in comprehending complex scientific new concepts.

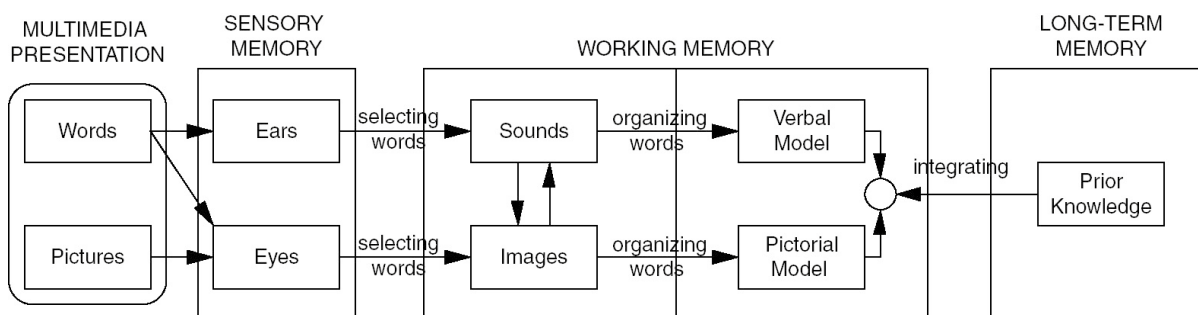


Figure 1. Cognitive Theory of Multimedia Learning (Mayer, 2005)

The principles of Cognitive Theory of Multimedia learning (Figure 1) were used to build the virtual laboratory. The Cognitive Theory of Multimedia Learning (Mayer, 2005), multi-dimensional depictions of notions in both visual and verbal formats allow learners to employ various knowledge acquisition channels simultaneously, developing their sensory information and frameworks.

Furthermore, operational modeling (gathering facts from the theoretical world, theoretical inquiry) assists students in understanding the structure of a system, the interactions between things, and their reactions. It involves the teacher and students in the modeling process in science by analyzing the situation, identifying the problem, translating into a model, producing and interpreting the results, including visual and textual representations, using equations and text representation, and quantifying the model (Van Buuren et al., 2010).

The main objective of virtual laboratory introductory courses is to aid students in comprehending fundamental principles and broad notions. According to research,

inquiry-based learning (IBL) or inquiry education, in which students organize an experiment, observe, collect data, hypothesize, interpret experimental results, and generate predictions, is the best way to attain such goals. The use of Information and Communication Technologies (ICTs) can promote scientific inquiry because they can encourage higher-order thinking abilities, which are required for scientific reasoning.

Learners can understand critical inquiry processes in a virtual laboratory environment, including analyzing scientific questions and issues using various web resources and digital content, gathering data through data logging with sensors and video measurement, analyzing data using online statistical programs, and communicating results online with tutors and peers (Roblyer & Hughes, 2019).

MATERIALS AND METHODS

A Quasi- Experimental Approach was used to analyze the effectiveness of virtual laboratory on the students'

academic performance in Anatomy and Physiology course. Moreover, the quasi-experimental design, pretest, and post-test were used to examine the effectiveness of the virtual laboratory as learning tool in Anatomy and Physiology. A survey was conducted to evaluate the efficacy, accessibility, reliability, and usefulness of the virtual laboratory.

Research Locale

This action research was conducted on the first semester of 2021-2022 in the College of Education located at Laguna University, Laguna Sports Complex, Brgy. Bubukal, Santa Cruz, Laguna. This institution utilizes the Seamless Blended Distance Learning Program (SBDLP) to continue the teaching learning process in the midst of a pandemic. SBDLP integrates the use of digital educational tools to deliver knowledge and facilitate class activities through the university's Learning Management System, ilearnu.

Population of the Study

For the pre-test, twenty-one (21) 3rd year BSED Science students taking the Anatomy and Physiology course were chosen as respondents through complete enumeration. For the post-intervention, the respondents who obtained low scores (15 students) in the pre-test stage were chosen as part of the post-test. Additional fifteen students were chosen to take the post-test because they have a stable internet connection. The total number of respondents in the post-test stage is thirty (30).

Research Instruments

The digital modules provided for Anatomy and Physiology course were given to the respondents in the pre-test stage. The modules covered the following topics: Muscular System and Plant Hormones and Tropisms. All of the respondents in the pre-test stage answered worksheets relevant to the topics. After determining that learners encounter challenges in the online mode of learning, the researchers developed a virtual laboratory relevant to Muscular System and Plant Hormones and Tropism with the help of an illustrator/digital artist capable of making 3D Figures. The Virtual Laboratory (iLabUAghamTech.com) can be accessed via this link: <https://www.ilabuaghamtech.com/>. The domain was purchased on the Wix website, and this is where the virtual laboratory was programmed and created as a HTML5 website and mobile site.

The respondents used the intervention, virtual laboratory, before answering the post-test. This was done to determine if there is a significant difference in the pre-test and post-test results. Guidelines were provided to the respondents before the actual data gathering. The researchers used a survey tool administered through Google form to determine the effectiveness of the virtual laboratory based on the actual experiences of the respondents.

Data Gathering Procedure

In developing the worksheets in the Anatomy and Physiology course, a Table of Specification (TOS) was used wherein 50% of the test items belong to the Lower Level of Bloom Taxonomy (remembering, understanding, and application) and the other 50% belong to the higher level that includes analyzing, evaluating, and creating domain. The result of the pre-test and post-test was tallied and compared in Microsoft Excel. The average scores of the pre-test and post-test were computed and analyzed. To reduce cheating, all worksheets were administered via Google Forms and supported by Quilgo, a third-party application that prevents the respondents to use another application while answering the pre-test and post-test.

Treatment of Data

The raw scores from the pre-test and post-test were recorded and statistically analyzed to interpret the data. The statistical means and scores of the pretest and post-test were calculated. The Independent T-test was used to identify the statistical relationship between the pre-intervention and post-intervention results. The analysis was conducted to determine if there was a significant difference in the results after the utilization of the virtual laboratory. For the survey tool, a likert scale from 1-5 was used for the virtual laboratory evaluation. Number 1 was designated as "Strongly Agree" and 5 as "Strongly disagree." The results of the survey to determine the efficacy of virtual laboratory in terms of its suitability, relevance, level of engagement, visual quality, and perception of its users were summarized using Microsoft Excel. Parallel to the pre-test and post-test average scores, a proficiency scale (adopted and modified from Sabasales, 2018) was also utilized.

Interactive simulations that allowed students to make the inquiry online and practice critical thinking are necessary components in a virtual laboratory. Online videos that are seen online are reliable and well evaluated by the researchers are essential components of the virtual laboratory concept. Thus, they are well equipped to carry out the real world independently. Visual representations of scientific concepts and ideas were heavily employed in constructing interactive simulations and digital videos seen online.

The virtual laboratory in this study was developed to promote students' continuous interest and inclusion in building their knowledge and developing mental and practical skills. The virtual laboratory intends to enhance students' knowledge and skills at their own pace of learning.

RESULTS AND DISCUSSION

Based on the questionnaire wherein each student selected more than two answers, the challenges encountered by the students in their science courses with laboratory were (from greatest to least):

1. Lack of laboratory materials and equipment (90%)
2. Lack of money to buy the required materials (86.67%)

3. Videos are not enough to answer all the questions (6.67%)

4. Difficulty in following the procedure (83.33%)

The identified challenges led the researchers to design a virtual laboratory for Anatomy and Physiology course with the goal of improving the academic performance of the students.

The average pre-test score of the respondents in plant worksheet is 13.38 with a proficiency rating of “approaching proficiency,” while the post-test average score is 22.27 with the proficiency rating of “advance.”

The average pretest score of the respondents in Animal Worksheet is 14.76 with a proficiency rating of

“approaching proficiency,” while the post-test average score is 21.5 with the proficiency rating of “advance.

Students are expected to demonstrate content-related basic knowledge and skills and higher-order thinking and creativity (Brookhart, 2010; Collins, 2014) Respondents are moderately proficient in knowledge and skills in both topics. Table 1 shows that utilization of virtual laboratory increased the post-test scores and obtained a corresponding proficiency level of ‘advance’ in both topics. Integrating a virtual laboratory in the learning process will increase the students’ academic performance and stimulate their interest in the subject matter.

The pre-test and post-test for Plant Worksheet obtained

Table 1: Summary of the Average Scores of all the respondents in the Worksheets

Worksheet Topics	Pre-test Average Score	Level of Proficiency*	Post-test Average Score	Level of Proficiency*
1.Plant Tropism	13.38	Approaching Proficiency	22.37	Advance
2.Muscular System	14.76	Approaching Proficiency	21.5	Advance

Source: adapted and modified from Sabasales (2018)

a t-test value of -9.6094 and a critical value of 2.0423 which means that the Virtual Laboratory has a significant effect on the proficiency level of the respondents. Like the research findings of Darrah et al. (2014), virtual Labs assisted students in developing essential scientific investigation and valuable skills.

The pre-test and post-test for Animal Worksheet obtained a t-test value of -4.3857 and a critical value of 2.0739 which means that the Virtual Laboratory has a significant effect on the proficiency level of the respondents.

Therefore, the null hypothesis (There is no significant difference in academic performance in using a virtual laboratory as a learning tool for the Anatomy & Physiology course) was rejected.

The virtual laboratory has a significant effect in answering the Muscular System worksheet in Anatomy and Physiology. Hamed and Aljnazrah (2020) concluded that virtual laboratories are as good as traditional face-to-face instruction. An interactive and flexible learning environment could provide the students with a deeper contextual understanding. The result in the research of Price et al. (2013) showed that virtual laboratories have

the same advantages that administrators and teachers have identified. Convenience is a significant benefit of virtual laboratories. In addition, it also gives teachers the freedom to offer courses and laboratory experiences that they might not be able to offer otherwise.

If students have access to the internet, these laboratory activities can be held at any time and in any location. Furthermore, learning in a class setting from a virtual laboratory, allows the students to collaborate with their classmates.

The average time the respondents took to finish answering the plant and animal worksheet in the pre-test using written modules was 30 minutes. In comparison, the average time the respondents took to finish answering the plant and animal worksheet in the Post-test using the virtual laboratory was 15 minutes. Therefore, the virtual laboratory reduced half the time answering the worksheet compared to using written modules. This is similar to the research findings of Bhargava et al. (2006), which stated that virtual laboratories allow students to work through at their speed while discovering challenging or exciting parts.

Based on the result of the survey that used a likert scale for determining the perceptions of students on the relevance and sustainability of virtual laboratory as a learning tool, one student stated that the virtual laboratory made it easier to answer the worksheet. The weighted mean of 2.0345 is an indication that students believed that it helped them in answering the worksheets. “The Virtual Laboratory is a suitable learning tool in answering the worksheet” obtained a weighted mean of 1.9655 which means the student agreed that the virtual laboratory is suitable as a learning tool in answering the worksheets. “The features and the content of the virtual laboratory is relevant to the concept of the lesson” got a result of 2.000, which means the student agreed that the content and features were relevant to the lesson concepts. “Laboratory experiments reinforced topics from lecture and text” obtained a weighted mean of 1.4138 which means the student strongly agreed that laboratory experiments or 3D models are connected to the lecture and text in the module. “Laboratory experiments helped me understand the concept of the lesson thoroughly” got the weighted mean of 1.4138 which translated to “strongly agree.”

“Virtual Laboratory 3D models helped me understand the purpose of the multimedia models” got a weighted mean of 1.4138, which the students strongly agree that the 3D models in virtual laboratories helped them to understand and explore the concept further for understanding. A weighted mean of 1.9655, means that the students perceived that the use of virtual laboratory helped them perform better in their quiz and exam.

“The virtual laboratory helped to improve the learning interaction with my teacher and classmate in understanding the lesson.” The students strongly agreed (weighted mean of 1.4138) that the virtual laboratory helped them in improving their learning interaction with the integration of 3D models in the learning process. “The Virtual Laboratory enhanced my understanding of the lesson by unveiling reliable features and information.” A weighted mean of 1.9655 means the student agreed that the virtual laboratory enhanced their “understanding of the lesson, which allowed them to access reliable features and information.

A weighted mean of 1.4138 is an implication that the student strongly agreed that the virtual laboratory helped them become interested in acquiring knowledge and new information using virtual laboratory learning tool.

“The virtual laboratory has helped me conduct science activities with the limited time and resources I have.” A weighted mean of 1.4138 means that the students strongly agreed that the virtual laboratory helped them in conducting science activities in a short time. “The virtual laboratory enables me to repeat the same activity based on my ability to comprehend the lesson.” A weighted mean of 1.3448 implied that the student strongly agreed that the virtual laboratory enabled them to repeat the same activity to comprehend the lesson further.

The overall satisfaction rating of the respondents to

the performance of the virtual laboratory as a learning tool comparing the virtual laboratory to the traditional laboratory obtained 93.33% with the description, “much better than or better than.” Virtual Laboratory helps strengthen the learning processes by providing users with a safe and interactive laboratory environment. It was discovered to be an enjoyable, helpful, and entertaining learning environment through continuous delivery. It also allows users to perform tests independently and repeat them as many times as required. As we live in a fast-expanding technological era due to the extensive use of information technology, which has entered nearly every aspect of society. Innovations in education can increase and improve the learning and education process so that virtual laboratories are established. They play an essential role in supporting scientific learning subjects by permitting learners to achieve practical skills through experiments and by providing them with the opportunity to gain a more in-depth understanding (Khulood Aljuhani et al., 2018).

The respondents rating for the Relevance and Sustainability of the Virtual Laboratory obtained a mean of 1.65 with the description of “strongly agree.” The respondents rating for the Levels of Engagement of the Virtual Laboratory obtained a mean of 1.63 with the description of “strongly agree,” and the respondents rating for the visual quality of the virtual laboratory has a mean value of 1.41 with the description “strongly agree.” The content of the virtual laboratory-like videos and images affects the students’ attention in performing and doing the activity; it hooks the students’ attention so that they can feel he or she is in the natural and actual scenario even if the set – up is virtual. Students virtually analyze the anatomy utilizing 3-D technology on devices (tablets, laptops, etc.) during a virtual session in 3-D. 3-D virtual models differ in that they overlay static digital information over real-world visuals, often accomplished via tablets or smartphones. Virtual environment, on the other hand, allows the user to observe their physical surroundings while managing interactive virtual 3-D objects (Philips, 2021).

CONCLUSION AND RECOMMENDATIONS

The most prevalent challenges experienced by the students in their science courses with laboratory were the following: lack of laboratory materials and equipment, lack of money to buy the necessary materials in accomplishing laboratory works, videos available online and offline are not enough to answer all the questions in the worksheet, and difficulty in following the laboratory procedure.

Designing a learning tool, virtual laboratory, aimed to address the needs of the students in accomplishing their laboratory activities. The study showed that students’ academic performance had significantly improved when the virtual laboratory was used as a learning tool in answering Anatomy and Physiology worksheets. Also, the virtual laboratory was a suitable learning tool

that increased the productivity level of the students. It enabled the students to finish answering plant and animal worksheet at a shorter period of time compared to the utilization of written modules. Students explored the lesson by zooming the models and it reduced the time needed to learn and comprehend a specific topic because it provided all the necessary information.

The virtual laboratory had provided appropriate learning experiences needed by the students amidst the COVID-19 pandemic. Based on students' feedback, the virtual laboratory helped them in understanding the concepts even with limited time and resources. However, the researchers had also concluded that using the virtual laboratory on mobile devices can consume too much mobile data. According to the findings, the virtual laboratory can improve students' problem-solving abilities, critical thinking, creativity, conceptual understanding, science process abilities, laboratory skills, motivation, interest, perception, and learning outcomes. Overall, the researchers concluded that the integration of the virtual laboratory had been effective in improving the academic performance of the students in Anatomy and Physiology. The researchers recommend the integration of virtual laboratory in science courses to alleviate the challenges encountered by the students in conducting laboratory activities. Simulation games that will encourage the students to engage in the lessons can also be included in the design of a virtual laboratory. To enhance the multimedia function of the virtual laboratory, redesigning the website to make it more compatible for mobile phones is also recommended. The readability mode, animations, and music may still be enhanced to make it more attractive, efficient, and convenient to users.

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