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Effectiveness and Acceptability of Laboratory Experiment Videos in Blended Chemistry Learning

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ABSTRACT

The COVID-19 pandemic has changed most of the world's norms, from people's lifestyles to the education system. The transition from offline to online teaching, communication barriers inherent in online teaching, preparation, and teaching style were just a few of the difficulties faced by the instructors. On the other hand, problems with the content included creating new materials and using multimedia tools, among other things. This study aimed to determine the effectiveness of using laboratory experiment videos instead of hands-on experiments as an alternative to the blended learning modality. Furthermore, this study also investigated the acceptability of the developed videos from the learners' perspective. According to the study's findings, blended learning for chemistry is successful and acceptable when laboratory experiment videos are included. Students' performance improved significantly from their pretest to posttest when exposed to several teaching strategies for chemical reactions, including lectures, hands-on laboratory activities, and the presentation of videos of laboratory experiments. As a result, utilizing laboratory experiment videos in blended chemistry learning can be an effective tool and approach for delivering education and assisting in the teaching and learning process for teachers and students.

Keywords: *Blended learning; laboratory experiment videos; chemistry education*

INTRODUCTION

The COVID-19 pandemic, considered to be the fifth pandemic that the world has experienced after the 1918 flu pandemic, has been traced to have occurred in its first reporting and subsequent outbreak from Wuhan City, China, since December 2019 (Liu et al., 2020). With the world health organization's assessment of such outbreak on March 11, 2020, covid-19 has been characterized as a pandemic (WHO, 2020). This situation has prompted many countries to control the spread of COVID-19, where the education system has been dramatically affected (Tadesse & Muluye, 2020).

According to the United Nations Education, Scientific, and Cultural Organization (UNESCO), IN 2020, significant educational disruption was recorded due to school closures with over 1.5 billion learners in around 165 countries. In the Philippines, so that this disruption be addressed, the Department of Education, with consideration to access to technology and internet connectivity for learning, has formulated different learning modalities employing the distance learning design through the use of various media such as online/offline technologies, TV, radio, and printed modules (Pitagan, 2021). In this setting of the education system, specific challenges are posed for the delivery of the teaching-learning process. Hermoso et al. (2022) described these challenges as including the management of online science classes, and Siddiquei and Kathpal (2021) mentioned the various challenges with relation to the instructors included the following: a transition to online from offline, communication barriers innate in online teaching, preparation, and teaching style while challenges related to content which include the development of new material and multimedia tools such as videos, PowerPoint presentations, and animations were identified among others. However, teachers have adjusted to technology integration through time, as exemplified by the high levels of motivation, skills, and technology use, including ICT, in education (Sanchez et al., 2023).

In application to science teaching, specific to the concept of matter, which changes – and these changes can be best seen as pieces of evidence from chemical reactions that occur around us. Whether these chemical reactions occur naturally in the environment or through conducts of experimentation in school or at home, one can see how these changes affect our daily lives. Learning the concept of chemical changes drives us to see other evidence of chemical reactions. Chemistry teachers for this cause make use of different teaching styles to deliver this topic in their classes, such as ICT-supported strategy (Seibert et al., 2019), online experimentation (Babinčáková & Bernard, 2020), experiment method and computer simulations (Zendler & Greiner, 2020), and online multiple representations (Opona et al., 2022). With the advent of new technologies and in response to the limitations that the present health crisis brings about, teachers seek to adapt various techniques for students to be able to take hold and deepen their knowledge about pieces of evidence for chemical reactions.

A positive effect on student learning expectations and outcomes is evident when technology is integrated into the classroom through the teaching and learning process (Costley, 2014). Here, the use of educational videos, for one, is a clear application of technology-aided instruction in a classroom. Alber (2019) stated that in order for teachers to assist students in gaining a deeper understanding of the content presented, video clips can be of great utilization with the consideration in mind of how often and how much these video clips provide clear and purposeful use. With this, the application of a teaching strategy that uses video playbacks performed by individuals to show pieces of evidence and comprehend the various changes that occur during chemical reactions is aimed to provide students with a different and improved approach to learning and understanding this concept other than the traditional lecture-delivery strategy.

Statement of the Problem. This study investigated the effectiveness and acceptability of laboratory experiment videos in the blended instruction of Chemistry at the secondary level. Specifically, it sought to: (a) determine the pretest and posttest performances of the students exposed to the lecture method, hands-on laboratory experiments, and laboratory experiment videos; (b) compare the pretest and posttest performances across three teaching methods; (c) compare the mean improvements obtained by students exposed to the said teaching methods; and (d) evaluate the acceptability of the experiment videos and its impact to students' performance in Chemistry.

METHODS

Research Design, Environment, and Participants. This study used the pretest-posttest with a control group quasi-experimental design to determine the effectiveness and acceptability of laboratory experiment videos in blended Chemistry instruction. The researchers implemented the quasi-experiment in a large public secondary school in Cebu City, Philippines. This school offers the Science, Technology, Engineering, and Mathematics (STEM) strand, wherein the blended instruction is specifically conducted in the General Chemistry 1 course.

Three STEM classes participated in the study, wherein one class constituted the control group while the other two were experimental groups exposed to their respective teaching strategies. The control group was exposed to the lecture method, while the experimental groups A and B were exposed to hands-on laboratory experiments and laboratory experiment videos, respectively. Each class has 60 students, totaling 180 students participating in the study.

Research Instruments. Two instruments were utilized in this study. The first instrument was a pretest-posttest tool consisting of 40 items about chemical reactions in their subject in General Chemistry 1. The tool consisted of multiple-choice items distributed across the three subtopics: writing and balancing chemical equations, interpreting balanced equations, and describing evidence of chemical equations. Additionally, the tool was validated by three Chemistry teachers and pilot-tested on 30 students in a comparable group in the same school. The results of the reliability testing indicated that the tool was reliable to be used in the study.

The other instrument used in the study was the acceptability scale modified from the instrument used by Nagy (2018). The modified tool has four parts that measure acceptability constructs. These constructs are perceived usefulness, perceived ease of use, attitude, and satisfaction. The tool was pilot-tested on the same group of students above, and results showed that the tool was reliable to use in the study context.

Data Gathering Procedure. Before the study was conducted, the researchers sought permission to conduct the study. They asked permission from the school head and informed consent from the students for voluntary participation in the study.

Conduct of the Study. Once permissions were secured, the researchers administered the pretest to the three classes of participants. Afterward, they were exposed to their respective teaching strategies. Students in the Control Group were subjected to pure lectures using their teachers' PowerPoint presentations and were supplemented by learning modules about the topics. On the other hand, students in Experimental Group A conducted hands-on laboratory experiments, were given laboratory guides by their teacher, and performed the experiment. Furthermore, students in Experimental Group B were shown compiled video recordings of the experiment on chemical reactions. The flow of the implementation of the teaching strategies is illustrated in Figure 1.

Posttesting. All students in each group were given a posttest. Experimental group A was given the acceptability scale to evaluate the laboratory experiment videos. Data management and analysis followed.

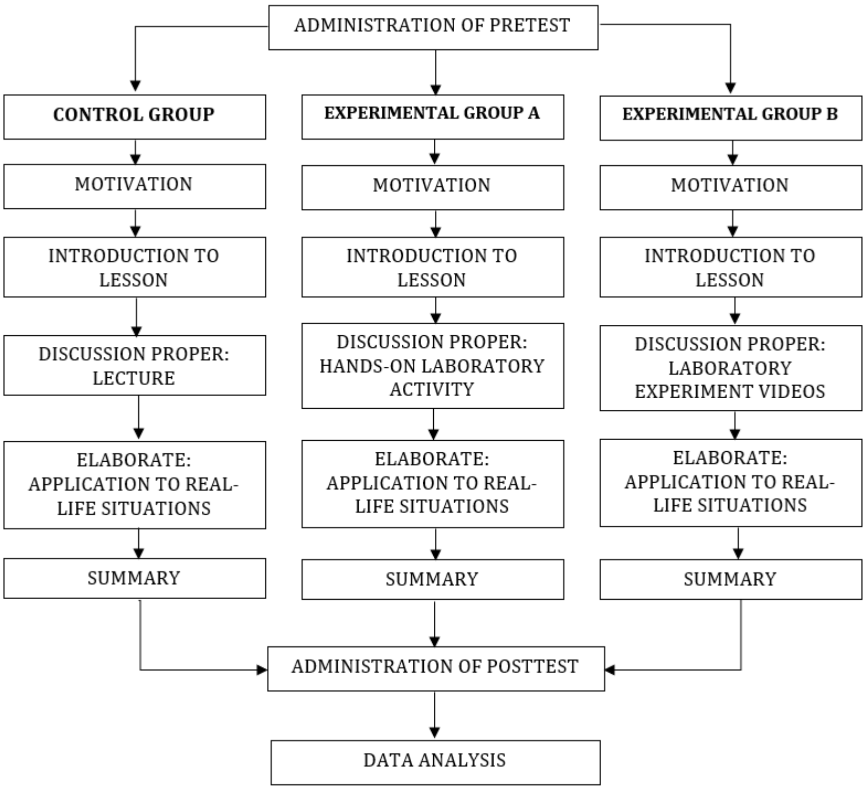

Figure 1. Flow diagram of the methods conducted to the control and experimental groups.

Data Analysis. The collected data were managed in Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS) version 27.0. The pretest and posttest performances were analyzed through means, standard deviations, and *t*-tests for one sample. The pretest and posttest performances were compared through a *t*-test for paired samples. In contrast, comparing the mean gains of the control, experimental A, and experiment B groups were conducted using analysis of variance with conditional post-hoc Tukey HSD test. All tests were conducted at a 95% confidence level, with p-values less than .05 considered significant.

Furthermore, the acceptability levels were analyzed using means and standardized deviation and qualitatively described using the following intervals: 1.00-1.80, 1.81-2.60, 2.61-3.40, 3.41-4.20, and 4.21-5.00 with appropriate descriptors. The interplay of the acceptability constructs and the Chemistry performance was subjected to structural equation modeling using Smart PLS version 4.0.9.2. All p-values less than .05 were considered significant.

RESULTS AND DISCUSSION

Pretest and Posttest Performance of the Students in Chemistry. This study utilized three groups: the control group, which is composed of students who are only exposed to the typical classroom lecture; experimental group A, which is composed of students who are exposed to hands-on laboratory experiments; and experimental group B, which is composed of students who are exposed to the laboratory experiment videos. All of the groups took the same pretest and posttest.

Table 1. Students' Performance in Chemistry

Performance		Control Group	Experimental A	Experimental B
Pretest	Mean (SD)	17.33 (7.88)	17.43 (2.75)	17.10 (4.52)
	t (p-value)	-6.55* (.000)	-18.49* (.000)	-11.82* (.000)
	Description[1]	Below Average	Below Average	Below Average
Posttest	Mean (SD)	25.57 (2.05)	26.95 (2.88)	28.07 (2.25)
	t (p-value)	5.91* (.000)	7.92* (.000)	14.02* (.000)
	Description[1]	Above Average	Above Average	Above Average
*** Significant at α=.05**				
[1] Description based on HM=24 (60% standard)				

The control group, experimental group A, and experimental group B obtained *t* (p-values) of -6.55 (.000), -18.49 (.000), and -11.82 (.000), respectively (Table 1), in the pretest performance. The pretest performance of the students can be described as below average. There is a notable increase in the post-test performance, in which the control group, experimental group A, and experimental group B obtained a *t* (p-values) of 5.91 (.000), 7.92 (.000), and 14.02 (.000), respectively. The posttest performance can be described as above average.

The pretest results could be attributed to the students being unfamiliar with chemical reactions. Before the posttest, Experimental Group A was given time to perform lab experiments. In contrast, Experimental Group B was shown videos about laboratory experiments, and the Control Group was given lectures about chemical reactions rather than laboratory experiments. The significant increase in the mean for Experimental Group B is attributed to incorporation of laboratory experiment videos. Using video for educational purposes aids in bringing new and imaginative views to practically any subject topic, as it involves the methodical and inventive merging of product and concept technologies (Masats & Dooly, 2011). Moreover, it will make learning more enjoyable and worthwhile, making it easier for students to memorize what they learn (Mecida et al., 2023).

Comparison of Pretest and Posttest Performances. The scores of all the groups were compared using the *t*-test and Cohen's d. The standard deviation of each group was also taken.

Table 2. Comparison of pretest and posttest performances in Chemistry

Group	Mean Difference (SD)	t (p-value)	Cohen's d
Control	8.23 (7.39)	-7.83 (.000)*	1.43 (large)
Experimental A	9.52 (3.61)	-18.49 (.000)*	3.38 (large)
Experimental B	11.97 (4.59)	-16.83 (.000)*	3.07 (large)
*** Significant at α=.05**			

Table 2 shows a considerable increase in the student's performance. The increased performances of the Control Group and Experimental Group A showed that traditional methods of teaching chemistry are applicable. Having hands-on laboratory activities allows the students to experience learning, which makes it a good option for learning Chemistry, as observed in recent literature on chemistry education (e.g., Sanchez, 2017, 2018, 2021; Opona et al., 2022). The posttest performance of Experimental Group B is commendable because it showed that in the absence of lectures and physical labs, students could self-learn through videos. Students can discover new ideas through the videos and apply them in their posttest. Videos can have a favorable impact on students' academic performance. Learning outcomes in social studies and science are improved by video applications (Almurashi, 2016). These videos have significantly improved the understanding of the students about the topic of chemical reactions.

Comparison of Mean Gains. The scores of each group were compared to the other groups to see how they improved with the intervention used. Since the three groups were compared, the Analysis of Variance (ANOVA) was used. The post-hoc test determined which group had the greatest and lowest improvement.

Table 3. Comparison of mean gains in Chemistry

Group	F (*t*-value)	Cohen's d	Post-hoc Test		
			Pair	**HSD (p-value)**	**Cohen's d**
Control	7.30 (.000)	0.29 (Medium)	C and EA	3.49* (.038)	0.59 (medium)
Experimental A			EA and EB	1.83 (.401)	0.22 (small)
Experimental B			EB and C	5.32* (.000)	0.61 (medium)
*** Significant at α=.05**					

The control group and experimental group A have a resulting p-value of 0.038, less than the established value of 0.05 (Table 3). This result indicates that the control and experimental group A are significantly different. Having the traditional lecture has a different effect on the level of the students' learning compared to exposing them to hands-on laboratory activities. Their exposure to hands-on laboratory activities allows them to experience learning by themselves and draw conclusions based on what they actually see in the experiment compared to having a traditional lecture wherein they only tend to absorb the knowledge but fail to apply them. Hands-on experiments can increase curiosity (Kibga et al., 2021), improve learning, develop skills, integrate values, and enhance students' satisfaction with the subject (Sanchez et al., 2021).

For experimental groups A and B, it has a p-value of 0.401, more significant than the established value of 0.05. This result denotes that the students' performance exposed to the hands-on laboratory activities and laboratory videos is similar. Moreover, having hands-on laboratory activities and showing laboratory videos have the same effect on the level of students' learning. Exposing students to laboratory videos allows them to see results rather than experience them. However, this gives them an idea of what will happen if they can experiment. The results show that laboratory videos can be utilized instead of hands-on activities because the data are comparable. Hands-on activities and experiment videos can help students better understand complex chemistry knowledge and skills (Lo et al., 2021).

For Experimental Group B and the Control Group, the resulting p-value is 0.000, less than 0.05. This result means that the use of laboratory videos significantly improved the students' performance compared to having a traditional lecture. Being able to see the results makes learning more effective compared to simply learning it without visuals. Students tend to understand and absorb the topic well when exposed to laboratory videos. According to Shabiralyani et al. (2015) and Benkada and Moccozet (2017), the use of audio-visual aids had positive perceptions of the students and teachers. These experiments are also contextualized, adding to the students' meaningful hands-on and multimedia experience in chemistry learning (Rivera & Sanchez, 2000; Picardal & Sanchez, 2022).

Students' Acceptance of Laboratory Experiment Videos. A Google form was sent to the student respondents to assess the level of acceptability of the laboratory experiment videos.

Table 4. Students' acceptance of laboratory experiment videos

Construct	Mean (SD)	Description[1,2,3,4]
Perceived Usefulness	4.05 (0.68)	Useful
Perceived Ease of Use	3.67 (1.03)	Easy
Attitude	3.77 (0.88)	Positive
Satisfaction	3.72 (0.99)	Satisfactory

[1] **1.00-1.80 (Not useful), 1.81-2.60 (Fairly useful), 2.61-3.40 (Moderately useful), 3.41-4.20 (Useful), 4.21-5.00 (Very useful)**
[2] **1.00-1.80 (Not easy), 1.81-2.60 (Fairly easy), 2.61-3.40 (Moderately easy), 3.41-4.20 (Easy), 4.21-5.00 (Very easy)**
[3] **1.00-1.80 (Not positive), 1.81-2.60 (Fairly positive), 2.61-3.40 (Moderately positive), 3.41-4.20 (Positive), 4.21-5.00 (Very positive)**
[4] **1.00-1.80 (Not satisfactory), 1.81-2.60 (Fairly satisfactory), 2.61-3.40 (Moderately satisfactory), 3.41-4.20 (Satisfactory), 4.21-5.00 (Very satisfactory)**

Table 4 summarizes how the students perceived the laboratory experiment videos. The mean for the *perceived usefulness* of the video is 4.05 with a standard deviation of 0.68, which meant that the students perceived the laboratory experiment videos to be helpful in their learning process. Although not in the laboratory, students can still learn laboratory skills and learn what they should learn in an experiment through laboratory experiment videos which is why they found the videos helpful in their learning process. The mean for *perceived ease of use* is 3.67, with a standard deviation of 1.03. This result means that the students found the videos easy to use. The mobility of gadgets and the availability of the internet in the comforts of their homes makes learning through laboratory experiment videos easy for students.

Meanwhile, for the *attitude*, the mean was 3.77, with a standard deviation of 0.88. This result means the students have a positive attitude toward using the laboratory experiment videos. Because the videos were helpful and easy to use, students have a positive attitude towards using laboratory experiment videos as part of their learning process. Lastly, the mean for *satisfaction* is 3.72, with a standard deviation of 0.99. This result means the students are satisfied with using the laboratory experiment videos in their learning process. Students are satisfied with laboratory experiment videos because they are easy to use and valuable for learning. Their positive attitude towards these videos also helps them feel satisfied with the learning experience.

According to a study by Kosterelioglu (2016), students claimed that lessons involving video presentations affected them positively. They enjoyed the class and had fun when they viewed videos about their lessons. One of the student respondents said that incorporating videos during lectures is an effective way of teaching because the information in the videos is transferred visually to their memory, making the topic more permanent and allowing learning to be enjoyable. This result makes laboratory videos effective in blended chemistry learning.

Predictive Relationship Between Students' Acceptance of Laboratory Experiment Videos and Their Chemistry Performance.

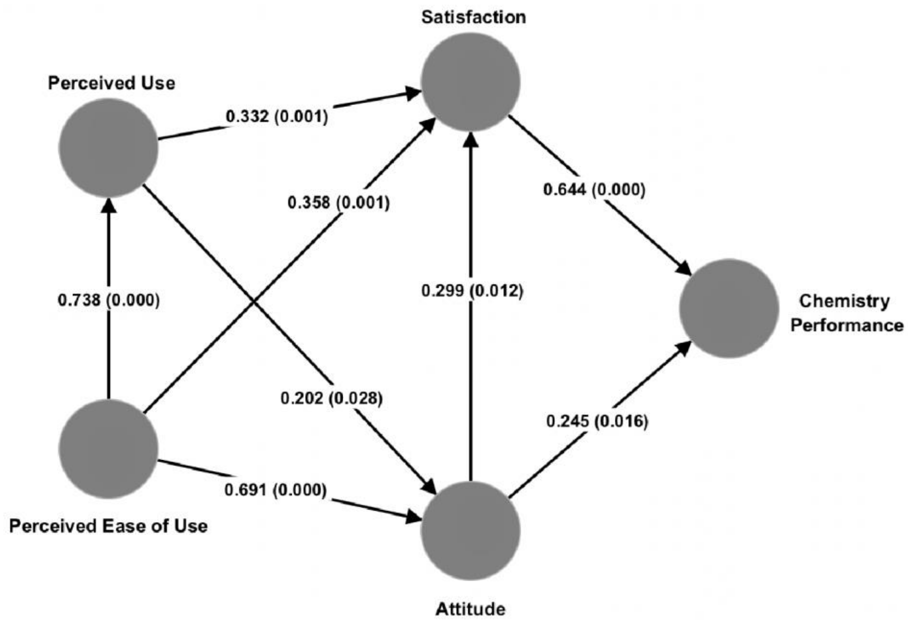

Figure 2. The results of partial least squares regression

Figure 2 shows the interrelation of the different variables of this study. The number inside the parenthesis denotes the p-value of each variable. If the value is less than 0.05, the variable affects the other variable. Based on the results given in Table 4, all variables are positively correlated with each other. This result means that if the student demonstrates a positive use of the laboratory videos, it will lead to a positive attitude towards the video, effectively improving their chemistry performance. Another correlation is when the student perceives the laboratory videos positively. This finding means the student is satisfied, which can positively help their chemistry performance. With these results, the laboratory experiment videos improve chemistry performance and the student's satisfaction and attitudes (Christensson & Sjöström, 2014; Cresswell et al., 2019; Petillion & McNeil, 2020).

CONCLUSIONS

The results of the conducted study showed that blended chemistry learning is found to be effective and acceptable with the use of laboratory experiment videos. Exposing students to different methods of teaching chemical reactions, such as lectures, hands-on laboratory activity, and showing laboratory experiment videos, all significantly increased their performance from their pretest to posttest performances. It can be noted that out of these three methods, the use of laboratory experiment videos showed a commendable comparison value from the other methods as it would emphasize that individual or self-learning of students can be possible and provide a good impact in assessing their performance with their understanding of the concept on chemical reactions, thus proving the efficacy of such method towards blended chemistry learning.

Further, upon assessing the level of the acceptability of using laboratory experiment videos in learning the concept presented, the derived mean of its perceived usefulness and ease of use was found to be acceptable in the student's perceptions of attributing it to self-learning. Thus, this result correlates as well with the students' acceptability of using this method towards their positive attitude and satisfaction in handling the video materials provided as it is easily and readily accessible in their learning process.

Therefore, the use of laboratory experiment videos in blended chemistry learning can be a great tool and method in the delivery of instruction to aid in the teaching and learning process provided to teachers and learners.

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