Virtual Labs as a Tool for Training Preservice Science Teachers

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Abstract: 22 pre-service teachers in the college of education pursuing Bachelor of Education (B.Ed) in science for middle and high school were divided into experimental and controlled groups. Both were surveyed before and after an organic chemistry lesson (Reactions of Carbonyl Compounds) and a lab session. The only difference is that the experimental group were trained prior the lab session via virtual learning interventions. Findings from quantitative data analysis revealed a positive significant difference in pre-service teachers' attitudes towards learning experiences during virtual laboratory experiments post learning interventions. The implications of these findings project virtual laboratories as a supporting tool for experimentation in chemistry especially in approaching 21st century of learning outcomes where issues of integrating technology into learning is part of the teaching practices. Recommendations from these findings are discussed herein.

1 INTRODUCTION

Chemistry is a part of science that consists of theories, facts, concepts, and laws that are tested through a set of experimental activities. One of the main objectives of learning chemistry is to understand how elements and substance are reacting to each other and how to benefit from these reactions in everyday life (Ural, 2016). Furthermore, learning chemistry helps in infinite branches of sciences such as medicine, pharmacy, industry in general and many more which makes it an essential subject in school curriculum (Ural, 2016). K-12 curriculum consist of varied concepts, facts and law that supports building, and developing the potential of learners to master required competencies in the field of chemistry. Cetin-Dindar et. al (2018) stated that learning chemistry has developed and requires incorporating technology too. Technology in chemistry has developed and enhanced the accuracy of the experiments and reflected on development of results and understanding too (Ali & Ullah, 2020). Therefore, many education systems integrated use of technology into the body of sciences in general including chemistry (Nsabayezu, et.al, 2022). However, using technology requires set of standards that need to be integrated professionally to assure best practices and best understanding among students.

Many studies discussed virtual labs' effect and perception on teaching and learning sciences. For example, Peechapol (2021) conducted a study about the effect of virtual lab simulation on chemistry subjects. This study aimed to investigate the impact of virtual labs on three main issues. These issues are learning achievement, self-efficacy, and learning Experience. The design of this study was a quasi-experiment. The number of participants was 95 first-year undergraduate students. The participants were into two groups. The experimental group had 50 students, and the control group had 45 students. Both groups had to take pre-test and post-test. The control group used the virtual lab as a learning method. Both groups had traditional chemistry lecturers. The study results showed that the experimental group students scored significantly higher than the control group in the learning achievement test. In addition, the students in the experimental group positively impacted the students' self-efficacy more than the students in the control group. Also, the students in the experimental group had a positive experience using the virtual lab.

1.1 Purpose of the Study

It is possible to adopt and incorporate the 21st century skills into the school's curriculum using virtual

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approach, by training teachers' specific tools pertaining the 21st century skills and distance learning. Therefore, this study was designed to establish in a virtual lab training for controlled group of preservice science teachers to integrate the 21st century skills with core content and in his study the core subject was chemistry.

The goal of the project was to provide training of use of technology while learning about the core subject and then explored the perspective of both those who were trained (experimental group) and those who did not (controlled group). The 21st century skills in learning needs competent teachers that are skilled and able to integrate technology in their classes while teaching. Therefore, the research question for this study was: Are there statistical significant differences between the experimental group (which experimented with the virtual laboratories) and the control group when looking at their educational and technical perceptions related to organic chemistry lab experiment?

2 METHOD

In order to answer the research question, the research was divided into the design phase which consisted of the following:

Choosing the chemistry lesson that is being taught in the university chemistry course curriculum, part of high school curriculum, and has a virtual experiment in the platform that matches the curriculum. The lesson was Reactions of Carbonyl Compounds. The carbonyl group (C=O) is a foundation of plentiful significant reactions in organic chemistry; mostly a result of the separation of the carbon-oxygen bond because of the relative high electronegativity of the oxygen atom. The experiment consisted of Benzaldehyde-2,4-dinitrophenylhydrazone which is a substituted hydrazine compound commonly used to test for aldehydes and ketones in the Brady's test. The instruments of the study consisted of the virtual lab software that has an Arabicized of different disciplines of science experiment. The research team used school textbook to select the appropriate chemistry lesson and matched it with the chemistry lessons in the college level. Next, the research team preserved a chemistry lab to conduct the experiment for both controlled and experimental groups

In terms of the survey, students' perspective based were tested pre and post the whole procedure based on the statements (that were developed by the team) in table 1 and 2 below. The survey has two sections. The first section focuses on students' perspectives about the educational aspect related to lab experiences. In this section, there are 13 items related to the educational aspect. The second section focuses on students' perspectives on the technical aspects of lab experiences. In this section, there are ten items related to the technical aspect. Finally, experts have validated the instruments. Those experts majored in science education and educational technology.

3 RESULTS

Table 1 shows the MANOVA tests for group, time and for interaction of group and time. The MANOVA tests for group (Pillai's trace = 0.104; Wilk's Lambda = .896; Hotelling's trace = .116, Roy's Largest Root = 0.116; F = 2.890; p-values for all four tests =o.o65), time (Pillai's trace = 0.082; Wilk's Lambda = 0.918; Hotelling's trace = 0.089, Roy's Largest Root = 0.089; F = 2.219; p-values for all four tests =0.119) and group*time (Pillai's trace = 0.034; Wilk's Lambda = 0.966; Hotelling's trace = 0.035, Roy's Largest Root = 0.035; F = 0.869; p-values for all four tests =0.425) were all not significant.

Table 1: Multivariate tests use the MANOVA test, used Pillai's Trace, Wilks Lambda, Hotelling's Trace, and Roy's Largest Root analysis at a significance level of 5% (α = 0.05) for students' scores in both tests A and B.

		value	F	df1	df2	p
Group	Pillai's Trace	0.104	2.890	2	50	0.065
	Wilks' Lambda	0.896	2.890	2	50	0.065
	Hotelling's Trace	0.116	2.890	2	50	0.065
	Roy's Largest Root	0.116	2.890	2	50	0.065
Time	Pillai's Trace	0.082	2.219	2	50	0.119
	Wilks' Lambda	0.918	2.219	2	50	0.119
	Hotelling's Trace	0.089	2.219	2	50	0.119
	Roy's Largest Root	0.089	2.219	2	50	0.119
Group ✻ Time	Pillai's Trace	0.034	0.869	2	50	0.425
	Wilks' Lambda	0.966	0.869	2	50	0.425
	Hotelling's Trace	0.035	0.869	2	50	0.425
	Roy's Largest Root	0.035	0.869	2	50	0.425

The results of follow-up tests for the main effect of group and time and for interaction effect of group*time are reported in Table 2. The results of follow up test shows that the scores of the students in test A differ significantly in control and experiment condition (p=0.028). Additionally, a significant difference in students score was also observed in pre and posttest (p = 0.046).

Table 2: Univariate tests of between-subjects effects of students scores between group levels and time levels.

	Dependent Variable	Sum of Squares	df	Mean Square	F	p
Group	PartAOverall	0.502	1	0.502	5.108	0.028
	PartBOverall	0.809	1	0.809	3.375	0.072
Time	PartAOverall	0.019	1	0.019	0.188	0.666
	PartBOverall	1.003	1	1.003	4.184	0.046
Group ✻ Time	PartAOverall	0.160	1	0.160	1.631	0.207
	PartBOverall	0.016	1	0.016	0.068	0.796
Residuals	PartAOverall	5.016	51	0.098		
	PartBOverall	12.224	51	0.240		

Estimate Independent Mean Difference for Part A and B test scores

A significant difference was observed in the students' scores of in test A under experimental and control condition (t = 2.264, df = 53, and p-value = 0.028). The mean score of students under experiment condition (mean =3.734) was high as compared to the mean score of students belong to control group (mean =3.542) (Table 3).

Table 3: Compare Two Means of students' scores between group levels for part A test scores.

		95 % CI			
Condition	M	Lower	Upper	S	N
Experiment	3.734	3.644	3.825	0.247	30
Control	3.542	3.391	3.694	0.378	25
Difference	0.192	0.022	0.362	0.313	55

Note: CIs are at the 95 % level. This comparison was made on unpaired data. Equal variance was assumed. s in the row for the difference is the pooled standard deviation. Also, $u_{nbiased}$ = 0.60 95% CI [0.07, 1.19] Note that the standardized effect size is dunbiased because the denominator used was SDpooled which had a value of 0.313 The standardized effect size has been corrected for bias.The bias-corrected version of Cohen's d is sometimes also (confusingly) called Hedges' g. The decision for this hypothesis is there is significant differences between group level regarding overall scores for test A(t = 2.264, df = 53, and p-value = 0.028).

4 DISCUSSION

In this study, a Multivariate analysis of variance (MANOVA) was applied in order to investigate the perspective of preservice science teachers about the use of virtual lab for chemistry lessons as a tool of training. The study consisted to two groups (controlled and experimental). The controlled group were lectured and did the chemistry lab while the controlled were lectured, practiced virtually then conducted the experiment in the actual lab. The results of this study indicated that, virtual labs enhanced the experimental preservice teachers to have higher responses in terms of the education aspects, this is in line with the findings of Mutlu and Acar Şeşen (2016) who concluded that students were more engaged via virtual labs and help in supporting in real labs context. This means virtual labs have very important effects on real experiments and could be a useful tool of practice prior an actual lab. It was also observed that the level of interactive and engagement was higher for the experimental group during conducting the lab compared to control group.

Next, the statistical results of this study showed that score of students are high in experiment group as compared to the control group. Additionally, the finding shows that student' scores more in posttest as compared to pretest. This was due to students' active participation in learning through discussions and to complete the tasks via Praxilab. This outcome was in line with Falode (2018) who exposed that the use of virtual lab improved students' conceptual understanding and it was reflected on their achievement. Also, the results indicated that students were significantly towards the educational aspect in control and experiment condition (p=0.028) where experimental group had more exposure to different educational method (virtual lab) compared to the controlled one. Both groups however did not show any significant different towards the technical aspects of the experiments. Thus, it could be said that the effect of virtual lab related to their perspective on the technical aspects of the chemistry lab was not different for both groups.

5 CONCLUSION

Many research expressed positive results towards using technology in education and that the students are engage in the use of virtual labs helped both teachers and students together ((Cetin-Dindar et. Al, (2018); Nsabayezu, et.al, (2022).).

Also, conducting experiments come across many obstacles such as costs, lack of time and shortage of supplies (Ali & Ullah, 2020). Applying technology via virtual labs could be an option for solving the long lasting problem of aiding students in science in general and in chemistry in specific for better lab performance. Based on the data analysis and discussion above, it could be concluded that: the application of Praxilab is able to effectively enhance students' learning experiences but may require more investigations to know more about enhancing students' technical aspects.

5.1 Recommendation

The study made the following recommendations:

- It is evident that, virtual lab is effective in improving preservice teachers' learning experiences in chemistry. Therefore, educators should use this teaching tool to facilitate their science teaching.
- Preservice programs should incorporate educational technology into their curriculum for practicing during their years of studying so that they can embrace the skills of the teaching model for effective implementation of the in teaching biology.
- Preservice teachers should be exposed to virtual lab experiences prior reaching their student teaching level and be familiarized using it in their future classrooms.
- Virtual labs should be suggested for some chemistry content areas in the curriculum especially very difficult concepts or those that are risky to be implemented in classrooms.

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