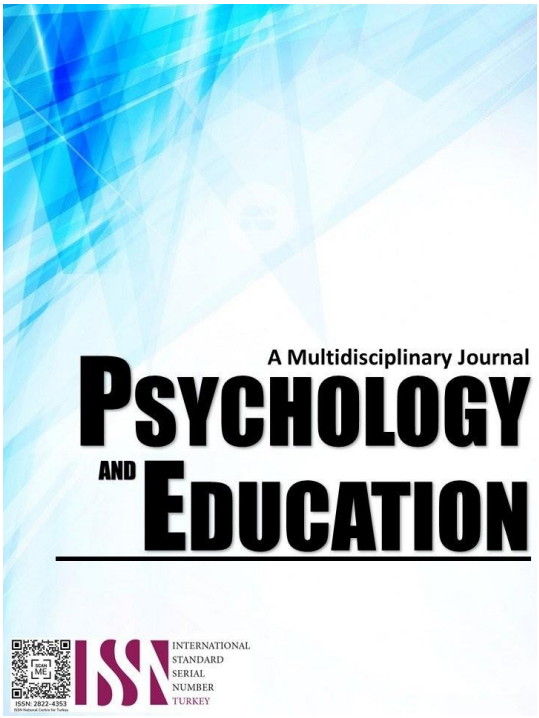
ENHANCEMENT OF LEARNING PERFORMANCE AND ENGAGEMENT OF GRADE 10 LEARNERS IN CHEMISTRY THROUGH VIRTUAL CHEMISTRY LABORATORY



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Research Article

Enhancement of Learning Performance and Engagement of Grade 10 Learners in Chemistry through Virtual Chemistry Laboratory

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Abstract

In teaching chemistry, laboratory activities increase student's interest because it provides hands-on experience for learning. Unfortunately, the school lack these facilities; thus, hands on learning were barely possible. Due to this reason the researcher opted to utilize virtual chemistry laboratory to address the problem. This study attempted to determine the effect of virtual chemistry laboratory to enhance learning performance and engagement of Grade 10 Learners. Pre-experimental research design involving one-group pretest-posttest was utilized. T-tests were used to determine the significant difference between pre-test and post-test scores. Pearson correlation was used to determine the significant relationship between the students' engagement and learning performance and Cohen's d was used to determine the effect size. The result revealed an increase in learning performance of students. Moreover, students agreed that they were moderately engaged. There was a significant difference between pre-test and post-test scores of both learning performance and engagement. However, there was no significant relationship between the two variables. The result further revealed that virtual chemistry Laboratory has a large effect to learning performance and engagement. In the teaching and learning process, technology plays an important role in providing an educational atmosphere that stimulate students and motivate them for better learning. In light of the results of this study, since the app utilized was downloaded by the researcher, modifications as to what the virtual laboratory should have been and should have been not possible. Thus, it is recommended that training and seminars could be provided to teachers in developing useful technologies that are personalized and based on their own context.

Keywords: *virtual laboratory, learning performance, engagement*

Introduction

In teaching chemistry, laboratory activities are a must to increase student's interest in the subject matter and provide them hands-on experience for learning. Laboratory activities help students in understanding theories and chemical principles which are abstract in nature. Also, it assists students to develop scientific thinking, basic manipulations and problem-solving skills. Furthermore, laboratory activities increase students curiosity and positive attitudes towards science while nurturing communication skills between students. Unfortunately, due to lack of laboratory facilities in Gastav High School hands-on practical experiments are rarely performed. As observed, many learners were unable to understand the concepts when it comes to its hands on experiments. Moreover, students are unable to develop practical skills related to laboratory work since equipment is not available. Also, because the school doesn't have the laboratory facilities the teacher find it hard to effectively teach science concepts since it was impossible to demonstrate experiments and provide hands-on learning experiences to learners.

Moreover, students' engagement towards learning science seems to be shaped by how they perceived and meaningfully understand the subject matter. If students do not consider learning science is essential then they will not think that it is worthy enough to spend time on. Thus, engagement of these students would be shallow. Records in Science last School Year 2021-2022 has mean percentage score (MPS) of 45.57% in the fourth quarter which was below average. This MPS showed that the majority of the students failed to reach the average 75%. It further means that there was a need to strategize a teaching method to increase academic performance and engagement in learning the subject matter.

Subramania and Marsic (2001) states that virtual laboratories provides students with opportunities such as enriching their learning experiences; conducting experiments as if they were in real laboratories; and improving their experiment related skills such as manipulating materials and equipment, collecting data, completing experiment process in an interactive way. In addition, Tuyuz (2010) also said that virtual learning environment enable learners to repeat the events several times, to zoom in and out and watch the experimental process again. He also mentioned that virtual laboratory is applicable to a collaborative learning in which students can work collaboratively and complete certain task given to them. The findings of his study showed that virtual laboratory application made positive effects on students' achievements and attitude. Moreover, Tatli and Ayas (2013) who were also examined the effect of a virtual chemistry laboratory, concluded that the developed virtual chemistry laboratory was at least as effective as the real laboratory. From this situation, the researcher opted to utilized virtual chemistry lab to address the problem. The researcher believed that through this intervention, Grade 10 learners were able to visualize real life scenarios in the laboratory that would further increase the learning performance and engagement towards learning Chemistry as a subject.

Research Questions

This study attempted to determine the effect of a virtual laboratory as an applied reinforcement learning platform to increase the learning performance and students' engagement towards Chemistry. Specifically, it sought to answer the following questions.

1. What is the level of learning performance of Grade 10 students before and after the intervention?
2. What is the level of engagement of Grade 10 students before and after the intervention?
3. Is there a significant difference in the level of learning performance of Grade 10 students before and after the intervention?
4. Is there a significant difference in the level of engagement of Grade 10 students before and after the intervention?
5. Is there a significant relationship between the learning performance and level of engagement of Grade 10 students as exposed to intervention?
6. Do Virtual Chemistry Laboratory significantly affect the learning performance of Grade 10 students?
7. Do Virtual Chemistry Laboratory significantly affect the engagement of Grade 10 students?

Methodology

Research Design

This study used a Quantitative pre-experimental research design specifically using a one group pretest-posttest design to assess students' learning performance and level of engagement towards Chemistry. A research design that uses methods and procedures to make observations in a study that is structured similar to an experiment, but the conditions and experiences of participants lack some control because the study lacks random assignment, includes a preexisting factor (i.e., a variable that is not manipulated), or does not include a comparison/control group.

Participants

This study involved 39 Grade 10 students of Gastav High School in school year 2022-2023. Complete enumeration was utilized since all of the learners were subjected to the use of the mobile app Gas Learn. In this method, the information is obtained from every unit of entire population.

Students were grouped heterogeneously with 4 to 5 members to allow collaboration among learners while doing the tasks given to them and the same time cater learners who doesn't have mobile phones. Basis of the students groupings is through counting. They were given printed materials and used the Gas Learn app for the Laboratory activity. Pretest and posttest which determined the learning performance of students were administered before and after the intervention strategy respectively.

Instruments

The virtual chemistry laboratory mobile application Gas Learn was used in this study. Gas Learn is an interactive android learning application that stimulates the three basic gas laws which are the Boyle's Law, Charle's Law and Gay-Lussac's law. It was designed by Dominic Sanchez and Programmed by Marc Daniel Mercado. It was a non-online app that learners manipulated the corresponding objects that represented each of the gas laws and observed what happened if volume, pressure and temperature varied in the experiments.

As to the learning performance of the learners, the researcher constructed 50 items test questions, subjected it for content validation from an expert and a reliability test. It obtained a Cronbach's Alpha .703 indicating it's' reliability. There were 21 items left which served as the instrument for the learning performance. For the engagement part of the learners, the researcher adopted and modified the survey questionnaire utilized by the study of Calog (2022) it has a Cronbach's Alpha reliability coefficient of 0.863.

Procedure

A letter request was sent to the School Head asking permission to conduct the study. A letter was sent also to the parents asking permission of the learner's participation. Students were grouped heterogeneously with 4 to 5 members. Learners were subjected to pre-test first to obtain initial data of the students learning performance and engagement. They were given printed materials and used the Gas Learn app installed in their mobile phones for the Laboratory activity to explore the Gas Laws. After week 2, learners took the post-test for the learning performance and engagement to check if the intervention significantly addressed the research questions.

Students learning performance was interpreted using the scale adopted from the standards of DepEd Order no. 8 series of 2015. As to the learner's engagement, the rating was based on the five (5) point scale. The following statistical measures were employed to analyze the data gathered: frequency count, mean and SD was used to determine the learning performance and measure the level of students' engagement.

Paired T-test was used to determine the significant difference between pre-test and post-test scores. Pearson correlation was used to determine the significant relationship between learning performance and level of students' engagement as exposed to the virtual chemistry laboratory. Cohen's d to assess the effect size of the intervention used to the learning performance and students' engagement.

Ethical Considerations

Since participants of the study were still minors, an orientation of the study was conducted with the parents and parent consent was obtained.

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Results

This section presents the findings according to the study's research questions to compare the mean and determine the significance between variables.

Table 1 presents the Pre-test and Post-test Mean Scores of Students in Chemistry. As reflected in the table below, the pretest score of 39 students was 75% below. Obtaining an overall mean of 7.13 (SD=2.88) with a percentage score of 33.95 indicating "very low performance".

Table 1. *Mean scores of students' learning performance*

Percent Equivalent	*Pretest*		*Posttest*		*Descritive Interpretation*
	N	%	N	%	
90-100	0	0	10	25.64	Very High Performance
85-89	0	0	8	20.51	High Performance
80-84	0	0	1	2.56	Moderate Performance
75-79	0	0	3	7.69	Low Performance
75 below	39	100	17	43.59	Very Low Performance
Total	39	100	39	100	
Over-all Mean	7.13 (SD=2.88)		16.15 (SD=2.90)		
	33.95 (VLP)		76.90 (LP)		

Table 2 presents the mean scores of students' engagement before and after exposure to the Virtual Chemistry Laboratory.

Table 2. *Mean scores of students' engagement*

Indicators	*Before Intervention*		*After Intervention*	
	Mean	*Qualitative Interpretation*	*Mean*	*Qualitative Interpretation*
Apply critical thinking skills to the science activities.	2.90	Moderately Engaged	3.26	Moderately Engaged
Integrate my own views with that of others when learning the concept.	2.38	Negatively Engaged	3.26	Moderately Engaged
Prepare study notes to understand the course material	2.56	Moderately Engaged	3.28	Moderately Engaged
Apply my learning of the mobile app to real-life situation.	2.26	Negatively Engaged	3.00	Moderately Engaged
Interact with my science teacher about the topic discussed.	2.85	Moderately Engaged	3.31	Moderately Engaged
Discuss academic performance and other matters related to the achievement of academic goals with my science teacher.	2.31	Negatively Engaged	3.38	Moderately Engaged
Obtain meaningful feedback on assignments from my science teacher.	2.15	Negatively Engaged	3.31	Moderately Engaged
Understand difficult concepts and content better after interacting with my science teacher.	2.95	Moderately Engaged	3.56	Positively Engaged
Collaborate with my peers/classmates in a one-to-one or group relationship.	3.15	Moderately Engaged	3.44	Moderately Engaged
Interact with peers/ classmates on mastering the topic.	2.82	Moderately Engaged	3.41	Moderately Engaged
Respect peer differences.	3.08	Moderately Engaged	3.51	Positively Engaged
Value peer differences.	2.95	Moderately Engaged	3.18	Moderately Engaged
Use the mobile app to participate in the chemistry subject activities.	1.51	Negatively Engaged	3.64	Positively Engaged
Over-all Mean	2.61	Moderately Engaged	3.35	Moderately Engaged

4.50-5.00 Strongly Agree; 3.50-4.49 Agree; 2.50-3.49 Undecided; 1.50-2.49 Disagree; 1.00-1.49 Strongly Disagree

Table 3 presented the significant difference between students' pre-test and post-test scores in chemistry as exposed to virtual chemistry laboratory. The Pre-test had a mean score of 7. 13 (SD= 2.88) while post-test mean score is 16.15 (SD= 2.90).

Table 3. *Summary table showing the significant difference between students' pre-test and post-test scores of Grade 10 Learners*

Variable	*N*	*Mean*	*SD*	*T-value*	*P-value (2-tailed)*
Pre-Test	39	7.13	2.88	-22.76	0.000**
Post - Test	39	16.15	2.90		

*Legend: ** significant*

Table 4 presents the significant difference between students' pretest and posttest engagement scores as exposed to Virtual Chemistry Laboratory. The Pretest had a mean score of 2.6 (SD= 0.24) while the posttest mean score is 3.35 (SD= 0.28).

Table 4. *Summary table showing the significant difference between students' pretest and posttest engagement scores of Grades 10 Learners*

Variable	*N*	*Mean*	*SD*	*T-value*	*P-value (2-tailed)*
Pre-Test	39	2.6	0.24	-15.29	0.000**
Post Test	39	3.35	0.28		

*Legend: ** significant*

Table 5 presented the correlation between students' learning performance and students' engagement in chemistry as exposed to Virtual Chemistry Lab.

Table 5. *Summary table showing the correlation between students' learning performance and students' engagement in Chemistry*

Variable	*N*	*Mean*	*SD*	*Correlation r- value*	*P-value*
Learning Performance	39	16.15	2.91	0.27	0.09^{ns}
Students' Engagement	39	3.35	0.28		

Legend: ns- Not Significant

Table 6. Presents the effect size of virtual chemistry laboratory to the Grade 10 Learning Performance. The pre-test obtained a mean score of 7.13 (SD=2.88) while the post-test mean score is 16.15 (SD= 2.90).

Table 6. *Summary table showing the effect size of Virtual Chemistry Laboratory to learning performance*

Variable	*Mean*	*SD*	*T-value*	*P-value (2-tailed)*	*Cohen's d*
Pre-Test	7.13	2.88	-22.76	0.000**	3.65
Post Test	16.15	2.90			

Legend: <0.2- Small Effect Size, <0.2- 0.8- Medium Effect Size, >0.8 above -Large Effect Size

Table 7. Presents the effect size of virtual chemistry laboratory to the Grade 10 engagement. The pre-test obtained a mean score of 2.60 (SD=0.24) while the post-test mean score is 3.35 (SD= 0.28) with a P-value of 0.000** indicating a significant difference.

Table 7. *Summary table showing the effect size of Virtual Chemistry Laboratory to engagement*

Variable	*Mean*	*SD*	*T-value*	*P-value (2-tailed)*	*Cohen's d*
Pre-Test	2.60	0.24	15.29	0.000**	2.37
Post Test	3.35	0.28			

Discussion

This study attempted to determine the effect of virtual chemistry laboratory to enhance learning performance and engagement of Grade 10 Learners. Specifically, it aimed to: determine the level of learning performance before and after the intervention; identify the level of engagement; find out the significant difference in the level of learning performance and engagement; find out the significant relationship between the learning performance and level of engagement and find out if the intervention significantly affect the learning performance and engagement of students.

As shown in Table 1, students had less prior knowledge on the Gas Laws concept before exposure to the intervention however, in the post-test there was 25.64 % indicating "Very High Performance, 20.51% "High Performance, 2.56% " Modertae Performance, 7.69 % "Low Performance" and 43.59% "Very Low Performance" . The post-test had an overall mean of 33.11 with a percentage score of 75.90 indicating "Low performance". The post-test revealed students gained higher scores after exposure to virtual chemistry laboratory. This means that the intervention help students acquire better test scores. Moreover, students who were exposed to virtual chemistry laboratory gained better performance after the intervention.

The findings conform to the study conducted by Yaman et al. (2008) which stated that virtual activity applications induced an expectation of higher student achievement. Similarly, the study of Baladoh et al. (2017) results clearly revealed the effectiveness of the virtual laboratory in improving students' achievement. In addition, Tatli and Ayas (2013) on their study concluded that virtual chemistry laboratory was at least as effective in terms of raising students' achievement. Likewise a study conducted by Ahmad (2010) revealed the effectiveness of the virtual lab in raising the level of achievement in academic concepts.

Looking at the data in table 2, the student's level of engagement before the intervention obtained an overall mean of 2.61 which means that students were "moderately engaged". While after the intervention an over-all mean score of 3.35 was obtained which indicates that students were still "moderately engaged" in the class with the use of virtual chemistry laboratory.

The result agreed with Ross et al. (2020) who stated that positive attitude of learners led to increase student engagement in learning chemistry concepts. Also, Nolen and Koretsky (2018) in their study entitled affordances of virtual and physical laboratory projects for

instructional design: impacts on student engagement revealed that virtual laboratories contribute to higher engagement and to higher reported interest in solving problems.

The data further revealed that learning performance in terms of pre-test and post-test is highly significant since the p-value is 0.000** and t- value is -22.76 as shown in table 3, indicating that there is a significant difference between variables. This was supported by the findings of Ahmad (2010) in his study entitled "the effect of using virtual lab on the physics concepts achievement, acquisition of higher-order thinking skills and motivation toward science learning among students of the third preparatory class". His results indicated statistically significant differences in favor of using the virtual lab in increasing the level of learner's achievement. In addition, Al-Balushi (2009) results of the study showed statistically significant difference between the mean scores of pre-post-tests in the academic achievement of learners.

Furthermore, the table 4 shows that pre-test and post-test of engagement is highly significant since the p-value is 0.000** which indicates that variable has significant difference. The result is supported by Bryson and Hand (2007) on their research found that student is more likely to engage in school if their teachers engage with them and the materials being taught. Kamenetz (2014) also added that collaboration within the school increases student engagement.

The data in table 5 revealed the relationship exist between learning performance and students' engagement is not significant since the p-value is 0.09 which is greater than 0.05 level of significance. However, the r- value is 0.27 indicated that there is a very low relationship between variables. The present findings contradicts to the study of Urquijo and Extremera (2017), concluded that the more engaged students demonstrated higher academic achievement. Also, Casuso-Holgado et al. (2013) hypothesized that the more engaged students would be more likely to have the best academic achievement. Furthermore Gunuc (2014), found on his study that cognitive, behavioral and emotional engagements predicted academic achievement. In addition Lei, Cui and Zhou in their study revealed that there was a moderately strong and positive correlation between overall student engagement and academic achievement.

The table 6 revealed a significant difference since the P-value is 0.000**. Moreover, the table below shows that the study obtained 3.65 Cohen's d result which means that it has a "Large effect size". This only mean that the intervention used which was the virtual chemistry laboratory significantly affect the learning performance of Grade 10 students. This was in agreement with the results of El-Koumy (2009) who reported that there is a significant greater pre-to-posttest improvement in students as exposed to the virtual laboratories. In previous studies conducted also by Yaman et al. (2008) investigating the effects of virtual laboratories on student achievement, virtual laboratory applications induce an expectation of higher student achievement. It is also supported by the theory that, by maximizing interactivity, virtual laboratory applications render students active thinkers instead of passive observers and hereby constructs effective and meaningful learning process (Trindade et al., 2002).

Table 7 revealed that the Cohen's d result obtained 2.37 which means that virtual chemistry laboratory has a "Large effect size" to students engagement as exposed to virtual chemistry laboratory. This only mean that the intervention used significantly affect the engagement of Grade 10 students. This result conforms to the study of Ahmad (2010) who demonstrated the impact of the virtual laboratory in raising the level of achievement in academic concepts at the same time increasing student's motivation thus making students more engage in the teaching and learning process.

Conclusion

The result of the study revealed an increase in learning performance of Grade 10 students as exposed to virtual chemistry laboratory. Moreover, students agreed that they were moderately engaged during the intervention. There was also a significant difference between pre-test and post-test scores of both learning performance and engagement. However, it was found out that there was no significant relationship existed between engagements and learning performance. In addition the result also showed that the intervention used which was the virtual chemistry Laboratory has a large effect to the Grade 10 students learning performance and engagement.

In the present teaching and learning process, technology plays an important role in the development of different learning environment providing educational atmosphere that stimulate students and motivate them for better learning. In light of the results of this study the following recommendations was made for further research and better practice. First, teachers can innovate or browse useful ICT tools that they can utilized. Second, other research should be conducted to explore more benefits of virtual laboratory not just in science but also in other subjects. Third, virtual laboratory instruction should be encouraged in teaching chemistry or other sciences since it can also allow promising result in increasing students' academic performance and engagement. Lastly, the app utilized in this study was downloaded by the researcher, modifications as to what the virtual laboratory should have been and should have was not possible thus it is recommended that training and seminars could be provided to teachers in developing useful technologies that is personalize and based on their own context.

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