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Virtual Laboratory as a Self-Paced Learning Innovation to Improve Learning Achievements and Attitudes in Teaching Physical Science

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Abstract: *The study aimed to determine the effectiveness of using virtual laboratory among grade 11 students of Graceville National High School to improve learners' achievement and attitudes in teaching physical science as a basis for the development of lesson exemplar for grade 11 - physical science learners. Grade 11 students coming from the strands of Accountancy and Business Management (ABM) and Home Economics (HE) who have low mean scores in physical science based on the report of innovation/remediation and intervention for school year 2021-2022 of Graceville National High School were selected as the participants of the study. The study utilized the one-group pretest-posttest design. It was calculated by measuring the effectiveness between the pretest and posttest scores, and attitudes in teaching physical science. The study revealed that the utilization of virtual laboratory in teaching physical science showed a significant difference between the pretest and posttest scores. In addition, the learners perceived the five indicators which are honesty, curiosity, open-mindedness, skepticism, and creativity as always observed in using virtual laboratory. As shown by the significantly higher mean in the posttest than in the pretest, the application of virtual laboratory had a greater effect and positive impact on the learners' achievement. It is, therefore, recommended for the development of the proposed lesson exemplar among senior high school grade 11 students to help deal difficulties in learning physical science and encourage further research into the efficacy of virtual laboratory as a teaching tool*

Keywords: *Attitudes, Learning Achievement, Self-Paced Learning, Teaching Physical Science, Virtual Laboratory*

INTRODUCTION

The Organization for Economic Co-operation and Development (OECD) uses the Programme for International Student Assessment (PISA), which was launched in 2000, to test 15-year-olds' accomplishment and application of core knowledge and abilities in reading, math, and science every three years. Over half a million 15-year-olds from 79 nations and economies took the PISA reading, math, and science test in 2018. PISA results enable participating nations to better understand what students know and don't know, compare their achievements to those of other countries, and draw policy implications from PISA results to improve their education systems.

In 2018, the Philippines took part in PISA for the first time, placing second to last in science and math among 79 participating countries and economies. Most pupils in the Philippines failed to meet minimum competency levels in all three PISA courses, with socioeconomic status having a significant impact. Almost no student was a top performer in science, meaning that they were proficient at Level 5 or 6. The Philippines scored 297 in math and 249 in science, according to the Trends in International Mathematics and Science Study (TIMSS) 2019 by the International Association for the Evaluation of Educational Achievement These findings highlight the critical need to improve basic education quality in the Philippines.

In 2016, the Philippine DepEd started the implementation of the senior high school (SHS) across the country. In the curriculum, physical science is one of the core subjects offered across all tracks in Grade 11. The course deals with the evolution of one's understanding of matter, motion, electricity, magnetism, light, and the universe from ancient times to the present. Physical science is perceived as a daunting topic especially without a laboratory because it brings clarity to the mind of the students regarding the basic concept of the subject. Students understand the difference between theory and application, which helps the student in improvising their approach to the subject. Some researchers conducted a study introducing the virtual laboratory into classrooms. Virtual Laboratories can be used to replicate physical laboratories and augment the incorporation of technology inside science classrooms to provide students with laboratory experiences that would not otherwise be available in high school settings (Samosa, 2021). Science labs were used to improve the student's skills and experiences in terms of using virtual laboratories.

The students are given lab works to further understand the lesson in physical science. Lab work is an essential component of the study of physics as well as other natural science disciplines Despite the benefits, Lab work is still facing many challenges such as the high cost of lab equipment and materials and the dangers encountered when working with dangerous experiments (Kapting'el & Rutto, 2015).

Nowadays, in the field of education, emerging technologies provide opportunities for enhancing and improving the learning and education process and using technological tools effectively in the teaching process will help change learning and communication methods (Meccawy, 2017).

A virtual laboratory is defined as a virtual teaching and learning environment aimed at developing students' laboratory skills. It is one of the most important e-learning tools that can be used and located on the internet, where the student can conduct many experiments without any constraints on place or time, in contrast to the constraints of real labs. It has been used in many universities and schools around the world to keep up with the technological development we are witnessing in the digital age, which is reflected in various forms in the fields of distance and e-learning. In line with this, the researchers will test and measured the effectiveness of a virtual laboratory as self-paced learning innovation to address these goals.

Statement of the Problem:

This study aimed to determine the effectiveness of a virtual laboratory as self-paced learning innovation to improve learners' achievement and attitude in teaching grade 11-physical science.

Specifically, it sought answers to the following specific questions:

1. How effective is the virtual laboratory as self-paced learning innovation in improving the science achievement of Grade 11-Physical Science as revealed by their pretest and post-test mean scores?
2. Is there a significant difference between the pretest and post-test mean scores of the Grade 11 physical science learners?
3. What is the impact of the virtual laboratory as self-paced learning innovation toward learners' attitudes in teaching physical science in terms of:
   - 3.1 curiosity
   - 3.2 honesty
   - 3.3 open-mindedness
   - 3.4 skepticism
   - 3.5 creativity
4. Is there a significant relationship between the science achievement and their attitude toward self-paced learning innovation of virtual laboratory among Grade 11-Physical Science?
5. What lesson exemplar in science virtual laboratory may be developed based on the finding of the study.

2. METHODOLOGY

Research Design

The researchers employed the quantitative method to present the data in this study. It is a systematic empirical investigation of observable phenomena via statistical, mathematical, or computational techniques. Since the study focuses on the effectiveness of a virtual laboratory as a self-paced learning innovation to improve learners' achievement and attitude in teaching physical science, the researchers employ a one-group pretest-posttest design. This design was utilized to determine the effect of the treatment, tests, and innovations on a single group of subjects with the same characteristics who were purposively selected based on the criterion that those learners have difficulties in learning physical science. It indicates that all participants are part of the same condition, which means they receive the same treatments and assessments. In addition, it has linear ordering, which necessitates the measurement of a dependent variable before and after treatment implemented. The differences attributed to the application of innovation are calculated and evaluated between the pretest and posttest scores.

2.2 Participants

The target population of this study was the students at Graceville National High School. Specifically, the grade 11 Senior High School which is purposively selected from the non-sciences' major strands: the Accountancy and Business Management (ABM) and Home Economics (HE). The respondents are carefully chosen in accordance on the criteria which are students with low mean percentage scores and have difficulty in learning physical science subject based on the students' needs remediation/ intervention/innovation report for the school year 2021-2022 of Graceville National High School. The participants of the study consist of 60 students from blended mode of learning. The researchers utilize purposive sampling to provide a controlled data collection as well as interpretation of the sample population's commonalities, traits, and differences in responses. Relatively, it is very convenient on the part of the researchers to make sure that the data to be collected is all coming from the same nature or groups.

2.2 Research Instrument

Corresponding to the research questions of this study, the researchers used a self-made pre-test and post-test that are confirmed by the experts to establish validity and reliability. Moreover, the researchers also administer laboratory worksheets or activities which measured student learning and attitudes as exposed to the virtual laboratory.

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Virtual Laboratory. The researchers used free website simulations that can be run online and offline and downloaded through mobile phone, computer, and laptop. The Virtual Laboratory used by the researchers are (a) Java Lab and (b) Phet Interactive Simulations, which can be used in science subjects specifically in physical science. Figure 1 shows the view of these two virtual laboratories using the desktop and mobile phones. These simulations are used for free to help students in understanding the smaller microscopic particles like atoms and molecules and learn the different chemical reactions that happen in a substance.

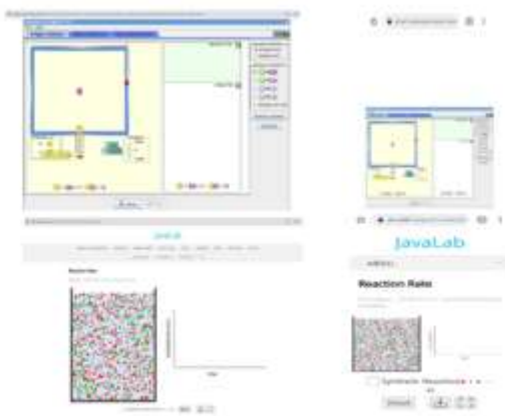

Figure 4: Virtual Laboratories Desktop and Mobile view
(Above – PhEt Interactive Simulations, Below – Java Lab)

Pretest/Posttest. A 20-item multiple-choice type of test is a self-made pretest and posttest utilized by the researchers to test the effectiveness of a virtual laboratory. A table of specifications was made before making the test to ensure that it measures the students' achievements in physical science. This was validated by the experts on the subject matter, who are selected master teachers from two schools in the district. The comments and suggestions are taken into consideration for the final draft of the test. This was given to the senior high school grade 11 students of ABM and HE through google forms and was sent on their Facebook messenger.

To determine the level of internal consistency or reliability of the test, the researchers used Cronbach's alpha. Cronbach's alpha ranges from 0 to 1.00, with values close to 1.00 indicating high consistency. The test obtained an alpha value of .846 and with .846 cronbach's alpha based on standardized items, interpreted as acceptable.

Weekly Laboratory Worksheets. The two sets of self-made laboratory worksheets were administered to the learners' and were distributed physically inside school premises that were given by their adviser. It contains the title, purpose/problem, hypothesis, materials, procedure, observations, and data with four (4) open-ended questions for each worksheet, and the conclusions from the laboratory activities. This instrument has undergone a process and evaluation before applying it to the treatment of data. This was administered on the 3rd to 4th week of April through modular and blended learning.

Science Attitude Survey. To measure the students' attitudes in terms of curiosity, honesty, open-mindedness, skepticism, and creativity, the researchers prepared a survey through google forms, each variable consisted of five (5) indicators. In this view, the researchers opted to have the four -Likert scale survey with four (4) numerical ratings and verbal interpretation of always observed, moderately observed, sometimes, and not observed.

Once necessary information was gathered, the researchers write the first draft of the survey and present it to the thesis adviser for comments and suggestions and considered crafting the second draft and presented to the experts, for their suggestions and comments to further improve the instrument. The edited research survey was then submitted again to the thesis adviser for other suggestions and corrections. The final draft was given to the experts for the reliability and validity of the researchers' made questionnaires. Once all the necessary comments were taken into consideration, the research instruments were finalized and given to the selected senior high schools.

To determine the level of internal consistency or reliability of the learners' science attitudes in using a virtual laboratory, the researchers used Cronbach's alpha**.** The survey obtained an alpha value of .956 and .961 alpha based on the standardized items, interpreted as excellent which is a good indicator on the science attitude of the learners.

2.3 Data collection, processing, and statistical analysis

To test the effectiveness of the virtual laboratory to improve learners' achievement and attitude in teaching physical science among grade 11 students from Graceville National High School, the researchers (1) seek permission from the adviser of grade 11 students to use their modules in Physical Science; (2) review the curriculum guide and check the DepEd Most Essential Learning Competencies (MELCs) for the basis of research instruments and resource materials; (3) prepared pre-test and post-test; weekly laboratory worksheets, and survey for students science attitude based on the given criteria. The researchers begin the data gathering by sending an approval letter to the Dean of Bulacan State University - Sarmiento Campus and requesting approval from the principal of the Graceville National High School to obtain a research survey, research questionnaires, and conduct experimentation among the students through blended learning. A parent letter was sent out notifying the parents of the selected respondents to allow them to participate in the said experimentation. After notification was given, the researchers asked permission from the experts to validate the research instruments. Then the researchers prepared an experimental group, wherein, this group received the pretest and posttest that was administered and was tried out before the treatment was given on the 3rd week of April 2022. The pretest is given to the students' adviser through google forms since the mode of learning of the participants is blended. After administering the pretest, the researchers applied the treatment from the 4th week of April until the 1st week of May 2022. The researchers give weekly laboratory worksheets to the participants using the virtual laboratory of Phet Simulations and Java Lab. Afterward, the posttest was administered using virtual laboratory as the treatment. It was done on the 1st week of May. The last method of data collection is distributing an online survey form to determine the science attitude of the grade 11 students at Graceville National High School in using virtual laboratory as a self-paced learning innovation in teaching physical science. And finally, the results of the data obtained was collected, tallied tabulated, and interpreted.

Data gathered from this study were subjected to the following statistical treatments:

Percentage Mean - to determine the effectiveness of virtual laboratory as self-paced learning innovation in improving the science achievement of Grade 11-Physical Science the researchers used percentage mean as revealed by their pretest and post-test mean scores. More so, **Hake Gain Score** was used to determine the level of the students learning outcomes after being treated with virtual laboratory as self-paced learning innovation

Weighted mean – was used to determine the impact of the virtual laboratory as self-paced learning innovation toward learners' attitudes in teaching physical science in terms of curiosity, honesty, open-mindedness, skepticism, and creativity among grade 11 senior high school learners.

T-test for independent sample – to compare the scores from a different group which is the pre-test and post-test, the t-test for the independent sample was used to determine if there is a significant difference in the pretest and post-test mean scores of the Grade 11 physical science learners.

Pearson r product moment of correlation coefficient – to determine the significant relationship between the science achievement and their attitude toward self-paced learning innovation of virtual laboratory among Grade 11-Physical Science, Pearson r was utilized.

3. RESULTS AND DISCUSSIONS

Table 1 presents the pretest and post-test mean scores of learners when exposed to a virtual laboratory as self-paced learning innovation in improving the science achievement of grade 11 in teaching physical science. It indicates that before the utilization of a virtual laboratory, the results of the pretest were 82.43 and the posttest mean scores were 88. Therefore, the learners gain a score of .32 (32%) between the pretest and posttest, as evidence it can be noted that using a virtual laboratory as a self-paced learning innovation has a moderate effect on improving the learners' science achievement in physical science. Ambusaidi et. al (2018), Abas et. al (2016) and Edris and Kamtor (2016) confirmed in their studies that using a virtual laboratory is effective to increase the learner's achievement in science.

Table 1
Pretest and Post-Test Mean Scores of Learners When Exposed to Virtual Laboratory as Self-Paced Learning Innovation in Improving the Science Achievement of Grade 11-Physical Science

	Pretest	Posttest	Hake Gain Score	Interpretation
Mean	82.43	88	0.32	Moderate effect

To determine whether the utilization of a virtual laboratory made a significant difference between the pretest and post-test mean scores of the grade 11 physical science learners, a t-test was used to compare the means scores of the pretest and posttest.

Table 2
Test of Significant Difference Between the Pretest and Post-Test Mean Scores of the Grade 11 Physical Science Learners

df	Computed value t-test	Critical value t-test	P-value	Decision	Interpretation
29	13.26	1.70	0.00	Ho is rejected	Significant

p = 0.05

Based on Table 2, the computed t-test value is 13.26 which is greater to the t-test critical value of 1.70 at the 0.05 level of probability with the degree of freedom of 29, the alternative hypothesis (H_a) is accepted and the null hypothesis is rejected (H_o).

It indicates there is significant difference between the pretest and post-test mean scores of the Grade 11 physical science learners. Also, in the study of Faour and Ayas (2015), and Davenport et al, (2018), reveals that most of the students performed well and improve their understanding in science with the application of virtual labs.

Table 3 shows the impact of the virtual laboratory as self-paced learning innovation on learners' attitudes in teaching physical science in terms of curiosity, honesty, open-mindedness, skepticism and creativity. It can be viewed from the table that students find the indicators in terms of curiosity to be always observed with overall weighted mean of 3.50, which is a good indicator that the students show interest in learning physical science by utilizing the virtual laboratory. In fact, most items in this criterion have received always observed ratings from the participants, where the weighted mean of the different indicators are "I can operate a virtual laboratory precisely" (3.45), "develop autonomy through the utilization of a virtual laboratory" (3.34), "answer scientific questions that can be turned into inquiry" (3.56), "hook the fact and conceptual understanding from the virtual experiments in physical science" (3.55), and "improve conceptual understanding and knowledge in learning physical science" (3.58). Ghadeer Hamed and Ahmad Aljanazrah (2020) stated that a virtual lab had a significant impact on students' knowledge, abilities, and attitudes. Also, presents the impact of the virtual laboratory as self-paced learning innovation on learners' attitudes in teaching physical science in terms of honesty. The table revealed that the indicators under honesty are always observed. The result shows that providing transparency and accountability of the results are always observed with the weighted mean of 3.39. Next, the survey results above promoting cooperation and trust among the group are always observed with the weighted mean of 3.29. On the other hand, with the weighted mean of 3.33, recognize the flaws of the student's work, through the process of peer review are always observed. Another indicator under honesty was adherence to the mutual responsibilities of groupmates and teacher with the weighted mean of 3.45. Meanwhile, the table above also indicates that disclosure of conflicts of interest is always observed with a weighted mean of 3.77. And it results of the overall weighted mean which is 3.45. According to Soleman, S. K. and Smith C. (2019), most students have found the simulations to be interesting, and these simulations have prepared them for practical work. The table below also presents the impact of the virtual laboratory as self-paced learning innovation toward learner's attitudes in teaching physical science in terms of open-mindedness. It is shown on the table, that all of the items in this criterion have received always observed ratings from the participants. The indicators "I can ask questions and being active about searching for information that challenges our own belief"' received with the highest weighted of 3.80 and the lowest is "I can tend to score better on tests of general cognitive ability" with weighted mean of 3.25 interpreted as Always Observed.

Table 3: The Impact of the Virtual Laboratory as Self-Paced Learning Innovation Toward Learners' Attitudes in Teaching Physical Science

Indicators	$W\bar{x}$	SD	VI
Curiosity			
I can…			
1. operate a virtual laboratory precisely	3.45	.50	AO
2. develop autonomy through the utilization of a virtual laboratory.	3.34	.59	AO
3. answer scientific questions that can turned into inquiry.	3.56	.45	AO
4. hook the fact and conceptual understanding from the virtual experiments in physical science.	3.55	.58	AO
5. improve conceptual understanding and knowledge in learning physical science.	3.58	.53	AO
Overall Weighted Mean	**3.50**	**.53**	**AO**
Honesty			
I can….			
1. provide transparent and accountable of the results	3.39	.53	AO
2. promote cooperation and trust among the group.	3.29	.67	AO
3. recognize the flaws of my work, through the process of peer review.	3.33	.62	AO
4. adherence to the mutual responsibilities of groupmates and teacher	3.45	.57	AO
5. disclosure of conflicts of interest	3.77	.42	AO
Overall Weighted Mean	**3. 45**	**.56**	**AO**
Open-mindedness			
I can……			
1. able to predict how others will behave and are less prone to projection	3.32	.59	AO
2. tend to score better on tests of general cognitive ability	3.25	.63	AO
3. cognitively complex individuals to less swayed by singular events and are	3.40	.47	AO

more resistant to suggestion and manipulation.			
4. consider other perspectives or to try out new experiences.	3.67	.55	AO
5. asks questions and being active about searching for information that challenges our own belief.	3.80	.42	AO
Overall Weighted Mean	**3.49**	**.53**	**AO**
Skepticism			
I can……			
1. reach logical conclusions supported by evidence that has been examined and confirmed by others experimenters.	3.55	.49	AO
2. omit stating direct causes within user data that explain how variables is influenced by many factors, including the tested product.	3.57	.45	AO
3. try the best to engage in impactful & specific set of evidence or data, instead of questions based on wild assumptions, or gut feelings.	3.39	.54	AO
4. test with numerous representative sets of data.	3.32	.52	AO
5. use results boldly but back them up with numerous instances of data.	3.78	.42	AO
Overall Weighted Mean	3.52	.48	AO
Creativity			
I can ….			
1. make a lab report appealing from a visual perspective which gain the interest and curiosity of others.	3.32	.51	AO
2. receive positive reinforcement from outside sources that help to raise self-esteem, confidence, and a desire to pursue the endeavor further.	3.45	.43	AO
3. give the group the opportunity to "report out" their findings within the comfort of the group with everyone having an important part to play.	3.40	.49	AO
4. stimulated to explore in a myriad of directions which unlock others minds to go with the evidence and be willing to "step out" into the unknown can be a valuable asset to academic achievement.	3.89	.33	AO
5. create a climate where others want to find results and then report those results in a way that is easily understood and interesting to their peers and themselves.	3.87	.35	AO
Overall Weighted Mean	**3.59**	**.42**	**AO**

Legend:
1 – (1.00 – 1.75) – Not Observed (NO)
2 – (1.76 – 2.51)- Sometimes Observed (SO)
3 – (2.52 – 3.27)- Moderately Observe (MO)
4 – (3.28 – 4.00) – Always Observed (AO)

The overall weighted mean in the science attitude of the learners in terms of open-mindedness is 3.49 with a verbal interpretation of Always Observed. This particular results on this criterion were consistent with the findings of Josephen & Hvidt (2015) which showed that using virtual laboratory helps the students to improve their attitudes in science learning that allow them to develop their practical skills and knowledge in physical science. As noted in table above, which present the impact of the virtual laboratory as self-paced learning innovation toward learners' attitudes in teaching physical science in terms of skepticism, it can be viewed from the table that most of the items interpreted as Always Observed with over all weighted mean of 3.52. In fact, most of the items in this criterion have received Always Observed rating from the students. The item with the highest weighted mean (3.78) is "I can use results boldly but back them up with numerous instances of data", and the item got lowest weighted mean is "I can try the best to engage in impactful and specific set of evidence or data, instead of questions based on wild assumptions, or gut feelings" (3.39). A positive attitude towards science can increase student engagement (Ross et al., 2020). Also, a positive attitude can improve students' interest in the subject and their potential to study the subject in the future (Kaur & Zhao, 2017). Akkus (2019) found that students who have high positive attitudes toward science are open to new ideas, which is important for students to carry into their futures.

The last criterion in improving the learners' attitudes in teaching physical is creativity. As noted in table 3, shows the impact of the virtual laboratory as self-paced learning innovation toward learners' attitudes in teaching physical science in terms of creativity, most of the students perceived the items as Always Observed with an overall weighted mean of 3.59. The indicator got the highest weighted mean is "I can stimulated to explore in a myriad of directions which unlock others minds to go with the evidence and be willing to "step out" into the unknown can be a valuable asset to academic achievement" with weighted mean of 3.89 and the lowest weighted mean with 3.32 is "I can make a lab report appealing from a visual perspective which gain the interest and curiosity of others interpreted" as Always Observed. In line with the study of Hamed and Aljanazrah (2020) et al, proclaim to their study that the use of virtual laboratory has positive effect on the attitude of the students in increasing their performance and more engaged in the science laboratory.

Table 4 indicates the test of significant relationship between the science achievement and their attitude toward self-paced learning innovation of virtual laboratory among grade 11-physical science. In the course of the investigation, the study hypothesized that there is significant relationship between science achievement and their attitude toward self-paced learning innovation of virtual laboratory among grade 11 physical science.

Table 4
Test of Significant Relationship Between the Science Achievement and their Attitude Toward Self-Paced Learning Innovation of Virtual Laboratory among Grade 11-Physical Science

Pearson r	Association/Relationship	P-value	Decision	Interpretation
.771	High positive association	0.0	Ho is rejected	Significant

The pearson r computed .771 which is associated with the high positive association at the 0.00 p-value, the decision is to reject the null hypothesis interpreted as significant between the learners' science achievement and attitudes. Lewis (2015) found results implicate that teaching the science topics in virtual laboratory by using virtual experiments affected students' attitudes toward science.

Development of Proposed Lesson Exemplar Using Virtual Laboratory in Physical Science

As this study progresses, the researchers determine that using a virtual laboratory as self-paced learning innovation helps improve learners' achievement and science attitudes in teaching physical science. Therefore, the researchers developed a proposed lesson exemplar that includes What I Need to Know (objectives), What I know (pretest), What's in (review/motivation), What's New (Activity and Discussion), What's More (Enrichment Activities), What I Have Learned (Generalization), and What I Can Do (Posttest). This can benefit all Grade 11 Senior High School students who take the subject of Physical Science, specifically those learners who have low academic achievement and attitudes in learning physical science.

The proposed lesson exemplar was based on the given Most Essential Learning Competencies (MELCs) of K12 learners for 2nd quarter of the school year 2021-2022. Furthermore, the topic discussed was collision theory in order to address the problem of grade 11 science learners who have low mean scores in physical science specifically in collision theory. The concept was only based on the three modules of grade 11 science learners in physical science which are Module 8 - The Factors Affecting the Rate of Reaction, Module 9 - Catalyst, and Module 10 - Limiting Reactants and Product Formed in a Reaction.

The virtual laboratory, which is the Phet Interactive Simulation, a free website that can be run online and offline, and can be downloaded anytime using mobile phones, laptops, computers, and internet connections was utilized to discuss the topic of collision theory. The application of virtual laboratory can be applied before, during, and after the discussion of the lesson.

LESSON EXEMPLAR
Grade 11 – Physical Science

Quarter	**Second**
Topic	**Collision Theory**
Subtopic	**Module 8- The Factors Affecting Rate of Reaction** **Module 9 – Catalyst** **Module 10 – Limiting Reactants and Products Formed in a Reaction**

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What I Need to Know
(Objectives)

Content Standards:
The learners demonstrate understanding of the following are the aspects of chemical changes:
a. how fast a reaction take place
b. how much reactants are needed and how much products are formed in a reaction
c. how much energy is involved in a reaction?

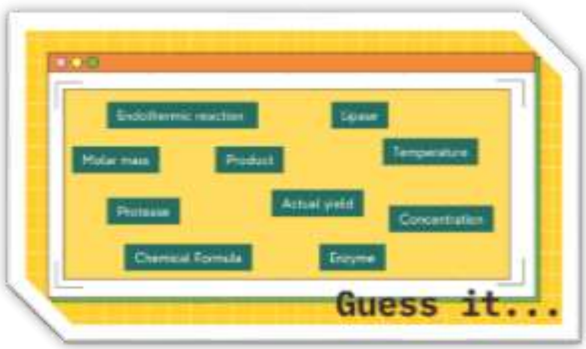
Performance Standards:
The learner performs a virtual laboratory using Phet Interactive Simulations to better understand the collision theory.

Learning Competency:
Use simple collision theory to explain the effects of concentration, temperature, and particle size on the rate of reaction (S11/12PS – IIIf-23)

Learning Objectives:
At the end of this lesson, the student is expected to;
- Define and describe collision theory.
- Perform a virtual laboratory about collision theory using Phet Interactive Simulation.
- Reflect the collision theory in a real-life scenario.

What I Know
(Pre-test)

Direction: Read the questions carefully. Fill in the blank and choose the corresponding answer in the box above.



1. _______________ absorbed all energy so that the reactions will feel cool to touch and the heat of reactions is positive.
2. A substance that mold by a chemical reaction. _______________
3. In the concentration, when ______________ increase the molecules inside the concentration move faster and have more energetic collision.
4. It is measure of a substance that mixed with another substance. _________________
5. _____________ is an enzyme that helps to provide energy for the body.
6. ____________ a catalyst that help to extract energy from the food we eat.
7. _____________ an enzyme that helps to breakdown proteins into amino acids.
8. A quantity of a product received from a chemical reaction. ________________
9. It is the way of presenting symbols such as parentheses, dashes etc. _____________
10. __________ known as the mass in grams of one mole of a substance.

What's In

(Review/ Motivation)

Activity 1: Fact or Bluff

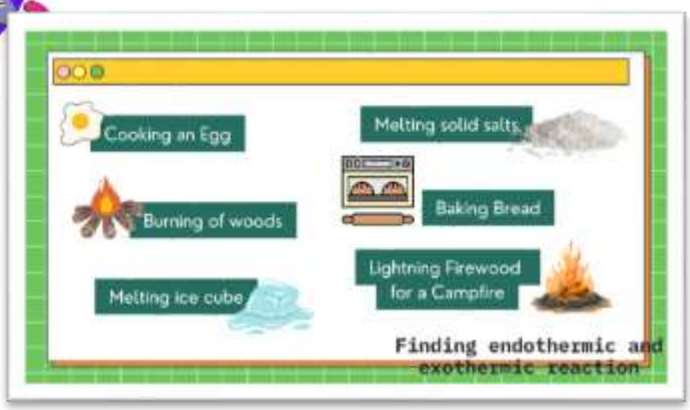
Direction: Based on the topic discussed yesterday, identify the following statement if it's fact or a bluff. **Fact** if the statement is true and **Bluff** if it's false.

1. Biomolecules are large organic compounds that are important to life's processes, such as respiration and metabolism.
2. Proteins, carbohydrates, lipids, nucleic acids are the different types of Biological Micromolecules.
3. Fats remain solid at room temperature while oil remains liquid.

What's New

Activity 2: Finding Endothermic and Exothermic Reaction

Direction: Complete the table. Identify the words below whether it is an endothermic or exothermic reaction.



Endothermic Reaction	Exothermic Reaction

What Is It

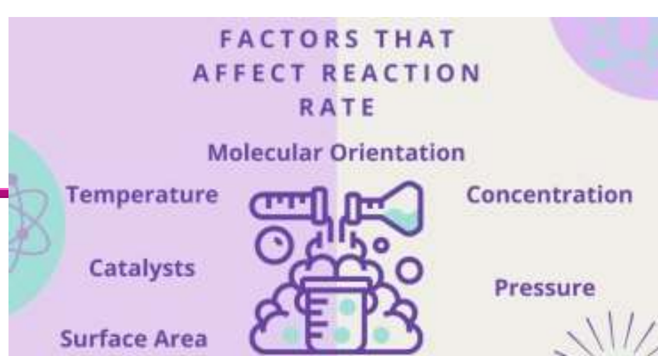
(Discussion)

MODULE 8: THE FACTORS AFFECTING RATE OF REACTION

In this module, you will learn about collision and the factors affecting it, such as in macromolecules wherein their properties and functions differ on the chemical reactions which is governed by collision.

Collision Theory or Reaction Rates

This theory states that for reactions to occur, molecules, atoms, or ions must first collide. Not all collisions are successful. In order for collisions to be effective collisions, particles must possess the minimum amount of energy needed for the reaction and must collide with proper orientation.



Transition State Theory

Chemical reactions which require bond breaking and forming is accompanied by changes in potential energy. According to the theory, the reactants must pass through a high-energy, short-lived intermediate state called the transition state in order for reactions to occur. The kinetic energy of the particles must overcome the potential energy needed to break and create bonds. The activation energy, Ea (or activation barrier) is the kinetic energy needed by reactants to allow them to reach the transition state.

Factors Affecting Reaction Rates

Concentration

Increasing the concentration of the reactants will increase the frequency of collisions between the two reactants. There are more reacting particles in a given volume. So, there are more collisions and more effective collisions.

Temperature

The two molecules will only react if they have enough energy. By heating the mixture, the energy will raise the average energy levels of the molecules involved in the reaction. Increasing temperature means the molecules move faster and have more energetic collision and therefore more effective collisions that can overcome the activation energy required for a chemical reaction.

Exothermic reaction

C + D CD + energy (negative heat of reaction)

Energy absorbed is less than the energy released. Hence, heat of reaction is negative.

Heat of reaction = Energy of products - Energy of reactants
= Lower energy of product – higher energy of reactant
= Negative value of Heat of Reaction

$$C (s) + O_2(g)\ CO_2(g) + 393.5\ kJ$$
$$C (s) + O_2(g)\ CO_2(g)\ \Delta H= -393.5 kJ$$

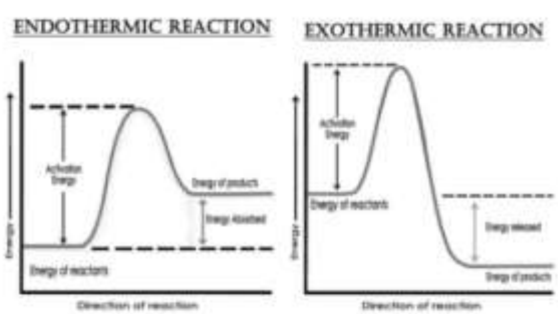
Endothermic reaction

A+B AB – energy (positive heat of reaction)

Energy absorbed is more than the energy released. Hence, heat of reaction is positive.

Heat of reaction = Energy of products – Energy of reactants
= Higher energy of product – lower energy of reactant
= Positive value of Heat of Reaction

$$N_2(g) + O_2(g) + 180.5\ kJ\ 2NO(g)$$
$$N_2(g) + O_2(g)\ 2NO(g)\ \Delta H= +180.5\ kJ$$



In endothermic reactions, energy is absorbed overall so the reactions will feel cool to touch. On the other hand, exothermic reactions have a net release of energy so the reactions will feel warm to touch. Energy is always part of a chemical reaction. The activation energy state for both is still the highest energy state in the whole reaction. The transition state is also created when the activation energy is reached. The heat of reaction is used in many things.

For example, in power production, coal is reacted with oxygen in the process of combustion. This reaction produces a lot of heat (exothermic). The heat turns water into steam which then powers the turbines. Baking bread is an endothermic reaction wherein the dough absorbs heat from the environment to rise and cook properly. As more substances are involved in a chemical reaction, more energy is either absorbed or released to the environment.

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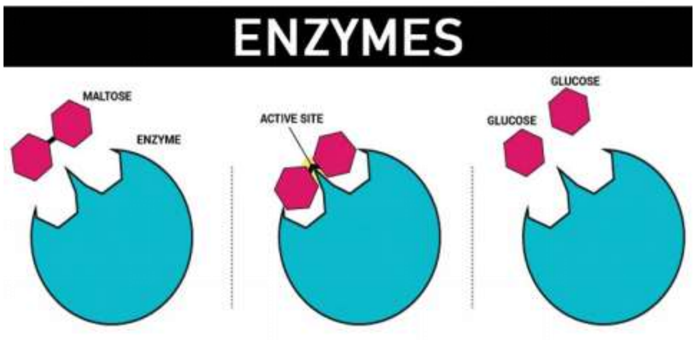
Particle size

Solids with a smaller particle size react more quickly than solids with a larger particle size.

MODULE 9: CATALYST

This module will discuss catalyst where decomposition of certain elements will take place. Hydrogen peroxide (agua oxigenada), water, and red meat such as beef, chicken, frog muscle or any flesh animals will be used to test a catalyst.



If the desired reaction has to be carried out swiftly, without elevating the temperature too much, CATALYSTS are used. ***Catalysts*** are substances that alter the rate of chemical reaction without being consumed. It simply means that catalysts take part in the reaction but after the reaction has been completed, they can be recovered and used again.

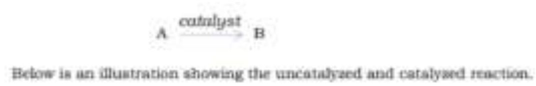
According to the collision theory, the rate of reaction is directly proportional to the number of collisions between the reactants. An effective collision is characterized by reactants colliding with proper orientation and enough energy to surpass the activation energy. The activation energy or energy barrier is the energy needed to be surpassed by the reactants so that they will be transformed into products. There are three factors that affect the rate of the reaction:

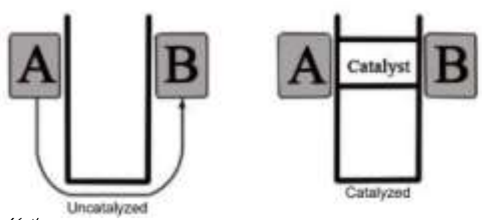
1) concentration; 2) temperature, 3) particle size

Increasing the concentration or the temperature of the reaction leads to an increase in reaction rate. On the other hand, decreasing the particle size increases the reaction rate.

A **catalyst** is a substance that increases the reaction rate without being consumed by the reaction. It provides a new pathway for the reaction, one which has lower activation energy.

Similarly, in chemical reactions, reactants (A) are combined to form products (B).





For **uncatalyzed reactions** (re[illegible] on to be completed is quite longer. However, for **catalyzed reactions**, the catalysts (green bridge) speed up the reaction by providing an alternative path with less required energy for the reactants to turn into products.

What should be the difference in energy between a catalyzed and an uncatalyzed reaction?

The catalyzed reaction has lower activation energy or energy barrier. When there is less energy required for a reaction to proceed, then the reacting molecules will form the products in less time. See the graph below.

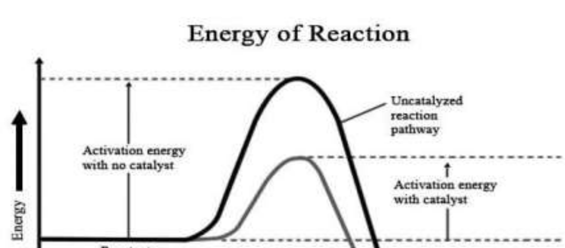
Types of Catalysts

A catalyst can be homogeneous or heterogeneous. A **homogeneous catalyst** exists in the same phase as the reaction it catalyzes. It is often in gas or liquid phase. For example, the decomposition of ozone in the atmosphere is catalyzed by chlorine atoms.

Step 1: Cl +O3 à ClO3
Step 2: ClO3 à ClO2
Step 3: ClO + O àCl + O2
Overall reaction: O3 + O à O2

The chlorine atom is a catalyst that is regenerated at the end of the reaction.

A **heterogeneous catalyst** exists in a different phase as the reaction it catalyzes. It often involves gaseous reactant molecules being adsorbed on a solid catalyst surface. For example, gaseous ethylene is hydrogenated to form ethane in the presence of a palladium catalyst.

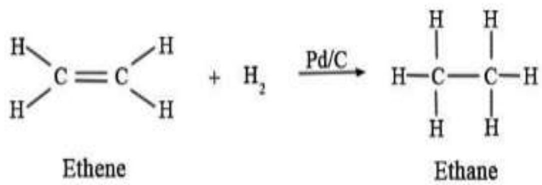


Enzymes are present in our body and act as a catalyst that is responsible for the extractions of energy from the food we eat.

Do you know that a cell contains more than 1000 enzymes? Some of these enzymes are specific and catalyse only one reaction.

For example, a raw meat contains catalase (an enzyme), serves a catalyst in decomposing hydrogen peroxide into water and oxygen gas.

Another example is the enzyme amylase, is found in saliva. It helps change starch to simple sugar. For instance, potato tastes sweet after chewing it for a few minutes because it contains starch, which will be converted in chemical reactions that control the transmission of nerve impulses, the clotting of blood, and the contraction of muscles. In general, enzymes are part of many reactions ensures the normal function of our body.

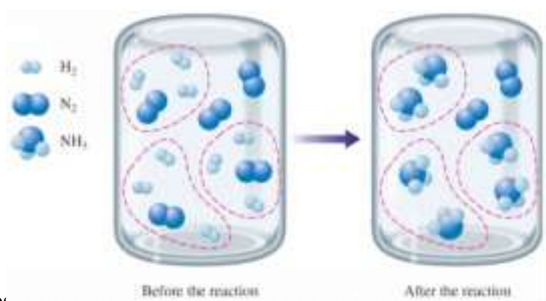


Refer to Table 1 to learn more about enzymes and their functions.

Table 1. Shows important digestive enzymes and their food sources Sources: Science and technology for the Future (DIWA)

MODULE 10: LIMITING REACTANT AND PRODUCTS FORMED IN A REACTION

This section describes how a reactant may 'limit' a chemical reaction, meaning, how one reactant may determine how much of the other substance used in the reaction and how much of the product can be formed. It also discusses why the actual yield of the product of a reaction may be less than expected.



- **Chemical Formula** is a way of presenting information about the chemical proportions of atoms that constitute a particular chemical compound or molecule, using chemical element symbols, numbers, and sometimes also other symbols, such as parentheses, dashes, brackets, commas and plus (+) and minus (−) signs.
- **Chemical equation** is the symbolic representation of a chemical reaction in the form of symbols and formulae, wherein the reactant entities are given on the left-hand side and the product entities on the right-hand side
- **Molar mass** is a physical property, defined as the mass of a given element or molecule per mole of that substance. Since a mole is defined as the amount of a substance and substances have different masses, each element or molecule will have a different molar mass.
- **Molecular weight** is a measure of the sum of the atomic weight values of the atoms in a molecule.
- **Limiting reactant** is a reactant that is completely used up in a chemical reaction.
- **Excess reactant** is a reactant that remains after the reaction stops.
- **Actual yield** is the amount of product obtained in a chemical reaction.
- **Theoretical yield** is the amount of product that could be produced in a chemical reaction. It can be calculated through stoichiometry.
- **Percent yield** refers to the efficiency of a chemical reaction. It is the ratio of the actual yield to the theoretical yield multiplied by one hundred. The formula for calculating the percent yield is

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$$\text{Percent yeild} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

ctant

A chemical reaction stops when one of the reactants is completely used up. In most chemical experiments, the reactants are not in exact ratios specified by the balanced chemical equation. Often, one of the reactants is used in excess, and the reaction is allowed to proceed until one of the reactants is used up. To determine the limiting reactant, calculate the number of moles of product that will be produced from the given reactants. The reactant that will yield a smaller amount of product is the limiting reactant.

Follow Me!

Sample Problem no. 1

Consider the reaction between potassium oxide and hydrochloric acid.

$$K_2O + 2\ HCl \rightarrow 2\ KCl + H_2O$$

If 10.0g K_2O was made to react with 10.0g of HCl, which reactant is limiting? Which reactant is in excess? (Use the following molar masses: K_2O = 94.2 g/mol; HCl = 36.5 g/mol.)

Solution:

Step 1: Convert the mass of both reactants to their corresponding moles.

$$\text{moles } K_2O = \frac{\text{mass } K_2O}{\text{molar mass } K_2O}$$

$$\text{moles } K_2O = \frac{10.0\ g}{94.2 g/mol}$$

$$\text{moles } K_2O = \frac{\text{mass } K_2O}{\text{molar mass } K_2O}$$

moles K_2O = 0.1062 mol of K_2O are present in the reactant.

$$\text{moles HCl} = \frac{\text{mass HCl}}{\text{molar mass HCl}}$$

$$\text{moles HCl} = \frac{10.0\ g}{36.5 g/mol}$$

moles HCl = 0.2739 mol of HCl are present in the reactant.

St ... e formed from each reactant.

You may use either H_2O or KCl.
Let x = amount of H_2O formed from 0.106 mol of K_2O

$$\frac{1 \text{ mol } K_2O}{1 \text{ mol } H_2O} \times \frac{0.106 \text{ mol } K_2O}{x}$$

Rearrange the equation, and solve for x.

$$x = \frac{(0.106 \text{ mol } K_2O)(1 \text{ mol } H_2O)}{(1 \text{ mol } K_2O)}$$

x = 0.106 mol H_2O would be produced.

Let y = amount of H_2O formed from 0.274 mol of HCl

$$\frac{2 \text{ mol HCl}}{1 \text{ mol } H_2O} = \frac{0.274 \text{ mol HCl}}{y}$$

Rearrange the equation, and solve for y.

$$y = \frac{(0.274 \text{ mol HCl})(1 \text{ mol } H_2O)}{(2 \text{ mol HCl})}$$

y = 0.137 mol H_2O would be produced.

Step 3: Compare the number of moles of product formed from each reactant.

The number of moles of H_2O produced from K_2O is less than the number of moles of H_2O produced from HCl.

Step 4: Tag the reactant that gives a lower amount of product as the limiting reactant.

K_2O is the limiting reactant.

Step 5: Tag the reactant that gives a greater amount of product as the excess reactant.

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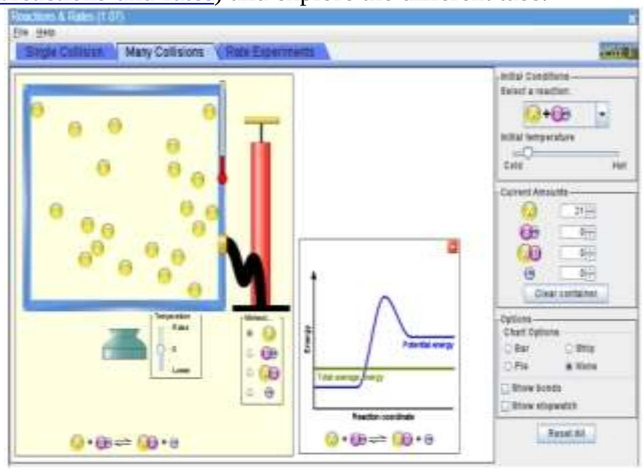
HCl is the excess reactant.

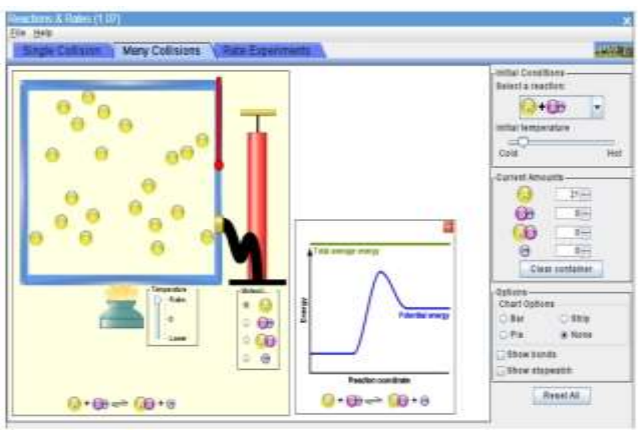
APPLICATION OF PHET SIMULATION

The PhET simulation design principles are based on research on how students learn (Bransford et al., 2000). Using [PhET Reactions & Rates] interactive. The student will use the Single Collision tab to represent how the collision between monatomic oxygen (O) and carbon monoxide (CO) results in the breaking of one bond and the formation of another. Go to the website (https://phet.colorado.edu/en/simulation/reactions-and-rates) and explore the different tabs.

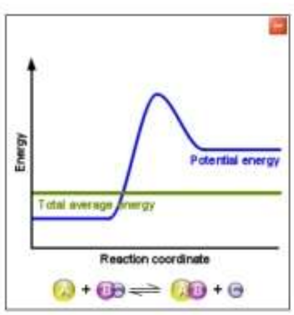


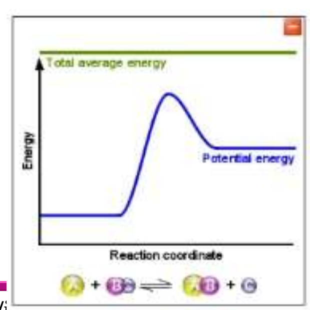
- Pull back on the red plunger to release the atom and observe the results.

- You can observe that the higher concentration the more chances for the molecules to collide because the space becomes smaller, and they can easily interact with one another.



- As we add temperature to it the heat energy will give kinetic energy to the molecules resulting faster movement, this will help more the molecules to interact with one another.





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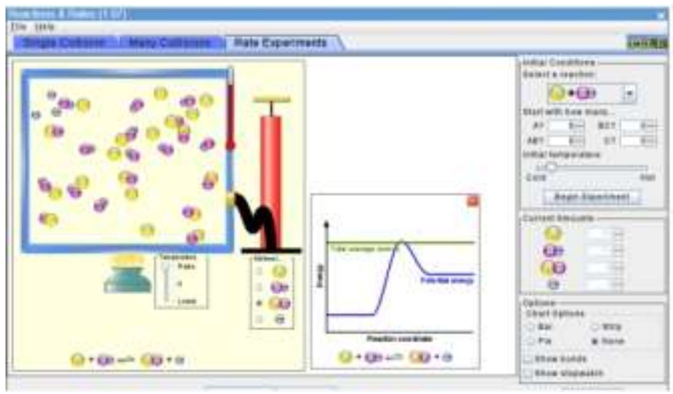
(A) (B)

- In picture (A) it is the average energy without heat added. Now, observe the picture (B), you can notice the total average energy rises because we add heat energy.



- Now, as the molecules collide you can observe the changes in particles change its size. It is because of the collision between the particles. As they combine the size of it becomes larger comparing to the particles that does not undergo collision theory.

What's More
(Enrichment Activities)

Activity 3: Collision Theory in Real Life Scenario

Situation:

Imagine that you are cooking a sinigang using a burning wood, how would you define your understanding of collision theory and rate of reaction?
Explain your answer on the space provided below.

Answer Key:

Pretest

1. Endothermic reactions	6. Enzyme
2. Product	7. Protease
3. Temperature	8. Actual yield
4. Concentration	9. Chemical Formula
5. Lipase	10. Molar Mass

Activity no.1:

1. Fact
2. Bluff
3. Fact

Activity no.2:

Endothermic Reaction	Exothermic Reaction
Cooking an Egg	Burning of woods
Melting ice cubes	Melting solid salts
	Baking bread
	Lightning firewood for a campfire

Activity 3:

Explanation:

When the temperature of a chemical reaction is raised, the reaction rate normally increases. Heat causes the reactant particles to travel quicker and faster. As a result, collisions occur more frequently. The temperature increase has a more significant effect in that collisions occur with more force, making them more likely to overcome the activation energy barrier and create products. The number of effective collisions between responding particles grows as the temperature of the reaction rises, increasing the reaction rate.

4. CONCLUSION

Based on the findings of the study, the following conclusions were drawn.

1. Adopting a virtual laboratory as a self-paced learning innovation improves learners' science achievement in physical science.
2. The utilization of virtual laboratory has significantly differed in pretest and posttest results.
3. The learners always observed a positive attitude as described by the five indicators when exposed to the virtual laboratory.
4. The problem in the learners' achievement and attitudes towards physical science can be properly addressed through the development of the proposed lesson exemplar using virtual laboratory in physical science.

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