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EFFECTIVENESS OF VIRTUAL LAB USAGE IN ENHANCING GRADE 9 STUDENTS' PERFORMANCE IN SCIENTIFIC EXPERIMENTS

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Abstract:
The research investigated how the use of virtual laboratories affected Grade 9 students' scientific testing capabilities. The research employed a quantitative methodology within a quasi-experimental design. The research involved 55 Grade 9 students from De La Salle Andres Soriano Memorial College, assigned to a control group that used traditional laboratory methods and an experimental group that used both traditional and virtual laboratory technology. The researchers conducted pre- and post-laboratory assessments with the participants to evaluate their understanding of the Flame Test experiment. The results showed that both groups improved their post-test scores, but the experimental group achieved better performance improvement than the control group. The research results showed that students performed better in both virtual and traditional laboratory

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environments than in traditional laboratory environments alone. Virtual laboratories create a better learning environment, enabling students to learn at their own pace and practice in a safe, repeatable way. The study found that virtual laboratory use is an effective teaching method because it helps students develop their scientific experimentation skills and deepen their understanding of scientific concepts.

Keywords: virtual laboratory, scientific experiment, science performance

1. Introduction

Traditional laboratory settings, though vital for science education, present limitations, including limited opportunities for repeated practice, safety concerns, and limited individual learning. These challenges often leave students struggling with core aspects of the scientific method, including hypothesis formulation, experimental design, and data analysis. Recent studies suggest that virtual laboratories can address some of these gaps by providing flexible, cost-effective, and hazard-free environments where learners can repeatedly practice experiments and receive immediate feedback. A meta-analysis has shown that virtual laboratories have a significant positive effect on student achievement, particularly at the secondary level, with notable benefits in chemistry and physics education (Santos & Prudente, 2022).

Studies show that scientific literacy is at a concerning level globally. For instance, a study concludes that secondary students in Lebanon have extremely low scientific literacy levels. It has been observed that students lack methods of inquiry, data organization, data analysis, and interpretation, resulting in their proficiency being well below established standards (Baltikian *et al.*, 2024). In the Philippines, 15-year-old Filipino students ranked second-to-last among 78 countries in the 2018 Program for International Student Assessment (PISA). The students' poor performance is evident: 77% did not even reach the minimum proficiency level. The assessment also determines their limited ability to understand data and to design scientific inquiry (Bernardo *et al., 2023)*. This unfortunate conclusion is also reflected in the 2023 PISA results, where the Philippines' performance remains low and has changed little (Cabural, 2024). This significant problem stems largely from teachers' reluctance or even resistance to moving away from traditional methods of instruction (Iwuanyanwu, 2019).

Technology has brought so many ways to teach various subjects. Virtual laboratories are powerful tools for teaching science because they provide a low-cost, safe environment for learners to enhance their laboratory skills in a highly flexible way. It serves as a practical alternative when facilities are not available. Overall, virtual laboratories support students' learning by addressing challenges such as limited resources, timeliness, and learner safety (Udin, Ramli, and Muzzazinah, 2020). A study compared the average performance of students in the control group who used the traditional method with that of the experimental group, which used virtual laboratories.

The study showed that the experimental group scored higher in the post-test than the control group. In addition, the virtual nature of the experiments also allows students to safely make mistakes, which is an essential part of reinforcing the scientific method to young learners (Yassin, 2022).

The primary objective of this research is to evaluate the effectiveness of Virtual Lab in enhancing scientific method literacy among students at DLS ASMC by comparing the students' scientific method literacy before and after the integration of Virtual Lab and present an evidence-based perception of the impact of virtual laboratories on education.

2. Purpose of the Study

This study aimed to determine whether the traditional laboratory environment would differ significantly from the virtual laboratory environment in students' learning in conducting scientific experimentation among Grade 9 learners at De La Salle Andres Soriano Memorial College for the School Year 2025-2026.

Furthermore, this study seeks to answer the following:

1) What is the level of academic achievement of the control and experimental groups during the pre-test?
2) What is the level of academic achievement of the control and experimental groups during the post-test?
3) Is there a significant difference between the Pretest and Posttest Scores of:
   3.1 control group; and
   3.2 experimental?
4) Is there a significant mean gain difference on the pre-test and post-test scores between the two groups?

3. Materials and Methods

3.1 Research Design

This study employed a quantitative, quasi-experimental research design, with respondents divided into two groups: a control group that used the traditional science laboratory and an experimental group that used the Virtual Lab. This study analyzed students' laboratory performance across different settings using knowledge-based assessments.

3.2 Research Locale

This study was conducted at De La Salle Andres Soriano Memorial College, located in the vicinity of Carmen Copper Corporation (CCC), formerly known as Atlas Consolidated Mining Development Corporation (ACMDC), in Barangay Don Andres Soriano (DAS), Toledo City. This is accessible in any form of land transportation and is

32.5 km away (via Manipis Road) or 39.3 km away (via Uling Road) from Cebu City and is located 14.1 km from Toledo City.

De La Salle Andres Soriano Memorial College (DLS ASMC) is a district school established by the De La Salle Brothers in Lutopan, Toledo City, Cebu. This institution was established in 1965 and is currently headed by Mrs. Ma. Donitha C. Hernando. This is a private, sectarian institution and a non-stock, non-profit school, with a current population of less than 2,000, including students, personnel, and administrators.

The researchers chose De La Salle Andres Soriano Memorial College as the study's target area not only because of its accessibility and convenience but also because of the institution's capacity to facilitate both traditional and virtual laboratory setups.

3.3 Research Participants

The focus of this study was the fifty-five (55) Grade 9 students of De La Salle Andres Soriano Memorial College. All the Grade 9 students served as respondents for this study. At this school, the Grade 9 level is divided into two pods: St. Br. Jaime Hilario and St. Br. Benilde Romancon. For this study, St. Br. Jaime Hilario was designated as the experimental group, while St. Br. Benilde Romancon was assigned as the control group. The researchers chose the mentioned student group for this study because the Junior High School Science curriculum typically uses experiments and scientific research to apply different competencies, in which the Scientific Method is heavily applied.

Table 1: Distribution of Participants

Group	**n**	**%**
Experimental Group	28	50.91
Control Group	27	49.09
Total	**55**	**100.00**

3.4 Research Instrument

The study involved conducting the Flame Test, a simple experiment that can be performed in both the traditional science laboratory facility of De La Salle Andres Soriano Memorial College and the Virtual Lab. The study also used both a Pre-Test and a post-test containing objective-based questions related to the Flame Test experiment and the concepts associated with it.

3.5 Data Gathering Procedure

The data were collected from the Pre-Test results conducted before the Flame Test experiment and the Post-Test results conducted after the experiment. The numerical results (raw scores) from both assessments were obtained and recorded. The results were used to formulate a quantitative analysis of students' performance in the science laboratory.

3.6 Ethical Considerations

The data collected in this study contained critical information, including students' identities and assessment scores. The researchers of this study assured that the information collected was kept in the strictest confidence and used solely for this Action Research.

4. Results and Discussion

The Second Quarter curriculum of Grade 9 Science focuses on the Electronic Structure of Matter, with one competency requiring learners to explain how the Quantum Mechanical Model of the atom describes the energy and position of electrons. Fifty-five (55) took part in this study. Out of the population of the batch, twenty-seven (27) students were part of the control group, and 28 were part of the experimental group. Both groups, although the experimental group used the virtual laboratory set-up and the control group used the traditional laboratory set-up, completed an assessment before and after the Flame Test. The data gathered from both the Pre-Test and the Post-Test showed differences in the students' proficiency levels before and after the experiment.

Table 2: Level of Academic Achievement of the Two Groups during Pre-test

Level	Ranges of Scores	Control		Experimental	
		f	%	f	%
Excellent	16-20	0	0.00	0	0.00
Good	11-15	1	3.70	1	3.57
Fair	6-10	13	48.15	16	57.14
Poor	0 - 5	13	48.15	11	39.29
Total		**27**		**28**	
Average		**5.96**		**6.54**	
St. Dev.		**2.07**		**2.36**	

The pre-test scores of the control and experimental groups, prior to the implementation of the instructional intervention, are presented in Table 2. The scores revealed that most students in both the control and experimental groups were classified as Fair or Poor performers. In the control group, 13 students were rated Fair, and 13 were rated Poor, while only one student attained a Good level and none attained an Excellent rating. In the experimental group, 11 students had poor grades, and only one reached the good level; no child reached the excellent level.

The mean score of the experimental group on the pre-test was higher (M = 6.54, SD = 2.36) than that of the control group (M = 5.96, SD = 2.07), but both were far below a satisfactory level according to the grading scale. The proximity of the two means and their standard deviations suggests that there was no significant difference in academic achievement between the two groups before the instructional intervention.

In biology and chemistry, studies show that students who complete a virtual pre-lab start real experiments faster, waste less time on apparatus handling, and ask

higher-level questions (Chan *et al.*, 2021). Virtual labs allow students to observe real experiments, greatly improving their learning experience. Virtual labs enable students to conduct experiments independently, combining theoretical and practical aspects (Rosli & Ishak, 2024). Therefore, virtual labs are framed by constructivist and experiential learning perspectives as instruments for scientific inquiry and active learning rather than merely for procedure demonstration (Reyes *et al.*, 2024).

These findings show that the control and experimental groups were equal in terms of statistical and academic attributes before the treatment. This is an essential requirement in experimental research. It ensures that any significant difference found in the posttest results can be attributed to the experimental treatment, which is the use of the Virtual Laboratory in this study, and not to any pre-existing difference in the students' knowledge and skills. Table 2 provides a valid basis for establishing the effect of the Virtual Laboratory on the students' academic achievement in scientific experiments. This comparable baseline supports the validity of examining the effects of the instructional strategy, such as virtual laboratories grounded in constructivist and experiential learning, on subsequent student learning outcomes.

Table 3: Level of Academic Achievement of the Two Groups during the Post-test

Level	**Ranges of Scores**	**Control**		**Experimental**	
		f	**%**	**f**	**%**
Excellent	16-20	1	3.70	14	50.00
Good	11-15	13	48.16	12	42.86
Fair	6-10	12	44.44	2	7.14
Poor	0 - 5	1	3.70	0	0.00
Total		**27**		**28**	
Average		**10.41**		**15.32**	
St. Dev.		**2.91**		**2.61**	

The post-laboratory assessment scores for the control and experimental groups for the Flame Test are also presented in Table 3. A significant discrepancy in academic success across groups is noted. For the experimental group, which used the virtual laboratory, higher performance was observed compared to the control group using a traditional laboratory Setup. More notably, 50% of participants in the experimental group obtained an Excellent grade, whereas only 3.70% in the control group did.

In addition, a significant majority of the experimental group (42.86%) were rated Good, while only a single-digit percentage (7.14%) fell into the Fair category, and none into the Poor category. On the contrary, the control group continued to show a wider range of scores, with many students still at Fair (44.49%) and only 3.70% at the Poor level. A quasi-experiment in general chemistry found that adding a virtual lab simulation after the lecture increased achievement, self-efficacy, and the learning experience, especially for students with lower prior knowledge and self-efficacy (Peechapol, 2021). Students who used a virtual lab demonstrated improved performance in a primary context, as evidenced by significantly higher post-test scores than controls (Xuan & Chongco, 2025).

Virtual labs improve intrinsic motivation, perceived usefulness, effort, and self-efficacy, all of which influence attitudes towards science (Alnaser & Forawi, 2024).

These results indicated that conducting virtual laboratories significantly improved students' post-test performance. The increase in the number of students who scored Excellent and Good in the Experimental group suggests that exposure to the virtual laboratory increased students' knowledge of scientific concepts and the skills necessary for experimentation. This provides evidence for the hypothesis that virtual laboratories are an excellent learning environment in which students can safely explore, repeat procedures, and correct errors, helping them consolidate both their understanding of concepts and their scientific skills.

Table 4: Test of Significant Difference between the Pretest and Posttest Scores of the Control Group

Source of Difference	Mean	Standard Deviation	Mean Difference	t-value	p-value	Decision	Result
Pretest	5.96	2.07	4.45	7.16***	0.000	Reject Ho	Significant
Posttest	10.41	2.91					
***significant at $p < 0.001$ (two-tailed); df=26							

The t-test for the significant difference between the pretest and posttest scores of the control group is shown in Table 4. The pre-test scores for the sample group differed from the post-test scores, indicating that the sample group improved as a result of the various educational interventions.

For the statistical test in this study, a t-value of 7.16 and a p-value of 0.000 indicated that the gain scores from pre- to post-test for the intervention group were statistically significantly different from zero. Thus, the null hypothesis was rejected, and there was a statistically significant difference between the pre-test and post-test scores of the control group after using the traditional laboratory instruction method.

This significant increase in posttest scores indicates that the traditional laboratory setup improved students' learning and understanding of the scientific concepts involved in the experiment. Nevertheless, the control group's post-test mean remained comparatively moderate despite the statistically significant improvement, as evidenced by previous descriptive results where a sizable percentage of students still performed at the Fair level (Pellas, 2023). This suggests that while traditional laboratory instruction is effective in improving students' performance, its impact may be limited when compared to more interactive and flexible instructional approaches, such as virtual laboratories.

Table 5: Test of Significant Difference between the Pretest and Posttest Scores of the Experimental Group

Source of Difference	Mean	Standard Deviation	Mean Difference	t-value	p-value	Decision	Result
Pretest	6.54	2.36	8.78	11.7***	0.000	Reject Ho	Significant
Posttest	15.32	2.61					
***significant at p < 0.001 (two-tailed); df=27							

According to Table 5, students in Grade 9 showed improved scientific performance after exposure to the Virtual Lab. The data collected from the experimental group, "before" and "after" the Laboratory Experiment, show that Grade 9 students increased their mean scores from 6.54 before exposure to the Virtual Lab to 15.32 after exposure. The two tests show an 8.78-point difference between their average test scores. The findings demonstrate that virtual simulations improve Grade 9 students' academic performance when they study the Flame Test and related scientific concepts (Bazie *et al.*, 2024).

Table 6: Test of Significant Mean Gain Difference on the Pre-test and Post-test scores between the two groups

Source of Difference	Mean Gain	Standard Deviation	Mean Gain Difference	t-value	p-value	Decision	Result
Control Group	4.45	3.23	4.34	4.44***	0.000	Reject Ho	Significant
Experimental Group	8.78	3.98					
***significant at p < 0.001 (two-tailed);df=53							

There is a pretty big distinction between the two groups, as the average improvement in scores is divergent. The control group had a mean gain of 4.45, whereas the experimental group had a substantially higher gain of 8.78. The Virtual Lab contributed 1.94 times more academic growth for students than learning in a traditional setting.

The t-value was 4.44, and the p-value was 0.000, indicating that the difference in average gains was highly significant. The null hypothesis, that both groups perform equally, must be rejected based on these findings. The experimental group demonstrated higher performance, as evidenced by Virtual Lab technology producing better learning outcomes.

The results from Table 6 demonstrate that Virtual Lab technology outperforms traditional laboratory techniques in improving scientific achievement among Grade 9 students in this study (Kolil *et al.*, 2024).

6. Conclusion

The study results demonstrate that virtual laboratories yield better results than traditional laboratories for Grade 9 students conducting scientific experiments. The experimental group, which used virtual laboratories, achieved higher mean score improvements than the control group, as both groups progressed from pre-test to post-test. Virtual laboratories enable students to better understand scientific concepts and experimental procedures according to this evidence. The statistical analysis showed that students who used traditional laboratories performed differently from those who used virtual laboratories. The results show that virtual laboratories provide a learning environment that enables students to conduct multiple experiments securely while maintaining their interest, resulting in better educational outcomes. Virtual laboratories are effective teaching tools in science education.

7. Recommendation

It is recommended that virtual laboratories be integrated alongside traditional laboratory activities to enhance students' understanding of scientific experiments. The school may adopt a virtual laboratory platform such as Praxilabs and ensure that each student has access to it. School administrators are also encouraged to renew the subscription to maintain continuous, effective use. Future studies may further explore the use of virtual laboratories in other topics and grade levels.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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Manilyn P. Cadeliña is a dedicated educator and a graduate of the Bachelor of Elementary Education Major in Science from Cebu Normal University. She is deeply passionate about both learning and teaching, continually striving to grow professionally while inspiring her students to do the same. Known for her compassionate, student-centered approach, she creates a positive, engaging learning environment where every learner feels valued and supported.

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Flordeliza Hurboda is a Licensed Professional Teacher currently serving as a faculty member at Pandong Bato Elementary School in Toledo City, Cebu, Philippines. Her research interests focus on science education and the effectiveness of instructional technologies. She recently co-authored a study investigating the impact of virtual laboratory use on student performance and scientific literacy, specifically examining how digital simulations can enhance traditional classroom experiments.

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Stephanie Mores is an academic achiever who graduated with Latin Honors from Cebu Normal University, earning a Bachelor of Science in Chemistry. While currently lending her technical expertise to the digital sector as a Virtual Assistant, she maintains a strong professional footprint in both scientific research and campus journalism. Her academic achievements include the successful publication of her co-authored study, "Extraction and Characterization of Chitin from Lethrinus ornatus (Ornate Emperor) Fish Scales," featured in the CTU (Can Tho University) Journal of Innovation and Sustainable Development (Vol. 17, No. 1, 2025). Furthermore, she contributed to the field of pedagogy as a co-author of a study investigating the effectiveness of virtual laboratory technology in enhancing student performance in scientific experiments. Beyond her scientific pursuits, Stephanie was an accomplished School Paper Adviser of De La Salle Andres Soriano Memorial College. Her work continues to focus on the intersection of scientific inquiry, educational innovation, and the fostering of ethical journalism among the youth.

Carl Repunte is a Licensed Professional Teacher and an alumnus of De La Salle Andres. Soriano Memorial College. He is currently applying his pedagogical expertise as a faculty member at Carmen Elementary School in Cebu, Philippines. His academic contributions include co-authoring research on the effectiveness of virtual laboratories in enhancing student performance and scientific literacy. His professional interests center on modernizing science education by integrating digital simulations and traditional laboratory methods to create safer, more interactive learning environments.

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