Enhanced Digital Augmented Learning Stations for Grade 10 Students' Performance

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ABSTRACT

This study determined the impact of digital augmented learning stations on Grade 10 students' performance in gas laws at Sibonga National High School during School Year 2025–2026. It employed a mixed-method approach with a quasi-experimental pretest–post-test design. The respondents comprised 176 Grade 10 students: 86 in the control group, which used traditional learning stations, and 90 in the experimental group, which used digital augmented learning stations. A researcher-made 30-item multiple-choice test measured performance in three competencies: volume and pressure at constant temperature, volume and temperature at constant pressure, and explaining gas-law relationships using the Kinetic Molecular Theory. Interview responses were analyzed thematically to describe students' experiences. Both groups' post-test mean scores were higher than their pretest means across all three competencies. For the control group, the means increased from 55.81 to 78.37 in volume and pressure, from 50.47 to 81.86 in volume and temperature, and from 77.91 to 83.84 in the Kinetic Molecular Theory competency. For the experimental group, the means increased from 61.67 to 82.78, from 65.67 to 83.56, and from 78.22 to 87.00, respectively. Within-group analyses indicated significant pretest–post-test improvements for the control group in the first two competencies, but not in the Kinetic Molecular Theory competency; the experimental group showed significant improvements in all three competencies. The updated comparison of mean gains showed no significant difference between groups for volume and pressure ($p = .616$) or the Kinetic Molecular Theory competency ($p = .541$). A significant difference was found for volume and temperature ($p = .009$), favoring the control group. Students described digital stations as engaging and helpful for visualization, participation, enjoyment, and applying gas-law concepts. The study's output was a set of digital activity sheets incorporating enhanced digital augmented learning stations for gas laws.

Keywords: digital augmented learning stations, gas laws, Grade 10, quasi-experimental design, Kinetic Molecular Theory

INTRODUCTION

Gas laws are important concepts in Grade 10 science, but learners may find them difficult because they combine abstract particle-level explanations with mathematical relationships among pressure, volume, and temperature. Students are expected not only to recall formulas but also to interpret graphs and data, explain the behavior of gases, and apply scientific principles to real-life situations. At Sibonga National High School, the study addressed the challenge of helping Grade 10 students understand Boyle's Law, Charles' Law, and the Kinetic Molecular Theory.

Digital augmented learning stations integrate technology-based resources into a station-rotation approach. In this study, the experimental group engaged with QR codes, PhET simulations, instructional videos, digital quizzes, worksheets, guided questions, and real-life scenarios. These activities were intended to let students observe changes in gas variables, work through computations, discuss their observations, and apply concepts. The control group used traditional learning stations. The study compared the performance of the two groups and considered students' insights to inform the development of digital activity sheets for gas laws.

The study was guided by Kolb's Experiential Learning Theory and Mayer's Multimedia Learning Theory, together with the policy contexts cited in the thesis: DepEd Order No. 35, s. 2016, on Learning Action Cells,

and DepEd Order No. 21, s. 2019, on the K to 12 Basic Education Program. Specifically, the study determined respondents' demographic profile; compared pretest and post-test performance across three gas-law competencies; documented the experimental group's experiences; tested pretest–post-test differences and between-group mean-gain differences; and used the findings as a basis for developing digital activity sheets.

LITERATURE REVIEW

Learning stations are an educational strategy that structures the classroom environment into distinct areas, each designed to support specific learning objectives through diverse activities and materials. This approach allows students to engage in active participation, explore different concepts independently, and work at their own pace. In science education, learning stations have been shown to significantly enhance students' academic performance, engagement, and conceptual understanding across various scientific disciplines. The SCI Station Approach, for instance, has been effective in improving Grade 8 students' retention of biology concepts by simplifying complex ideas, connecting them to real-life applications, and illustrating key concepts through visual aids and hands-on activities (Cruz et al., 2025). Similarly, the learning station method has been applied successfully in astronomy education, where it was found to be a useful, entertaining, and engaging technique that supports effective learning of astronomy topics for seventh-grade students (Albayrak et al., 2017).

In the context of physics, the learning stations technique has been shown to improve students' understanding of electrical current, with significant differences in achievement test scores favoring students taught using this method (Batman et al., 2019). Furthermore, the Biology Learning Station Strategy (BLISS) has demonstrated improvements in both science achievement and students' attitudes towards biology, indicating its effectiveness as a differentiated learning strategy (Rogayan, 2019). The integration of intelligent tutoring systems into learning stations, as seen in Intelligent Science Stations, further enhances inquiry-based STEM learning by providing personalized interactive feedback, fostering critical thinking, and improving engagement compared to traditional methods (Yannier et al., 2022).

In the context of this study, the intervention utilized digital augmented learning stations, which integrated technology-based resources into the traditional learning station approach. Unlike conventional learning stations that mainly rely on printed worksheets and teacher-led discussions, the enhanced digital augmented learning stations incorporated QR codes, PhET simulations, instructional videos, digital quizzes, and interactive activities to enrich the learning experience. These digital tools allowed students to visualize abstract scientific concepts such as Boyle's Law, Charles' Law, and Kinetic Molecular Theory through simulations and multimedia presentations.

METHODOLOGY

Research Design and Participants

The study used a mixed-method approach. Its quantitative component followed a quasi-experimental pretest–post-test design involving a control group and an experimental group. The qualitative component gathered students' insights through interviews or open-ended responses about their experiences during the implementation. The study was conducted at Sibonga National High School, Cebu, during School Year 2025–2026.

The respondents were 176 Grade 10 students from regular sections. The control group consisted of 86 students from Sapphire and Garnet, with 43 students from each section. The experimental group consisted of 90 students from Amethyst and Beryl, with 45 students from each section. The control group experienced traditional learning stations, while the experimental group used digital augmented learning stations.

Research Instruments

The quantitative instrument was a researcher-made 30-item multiple-choice test aligned with the Science 10 competencies. Ten items assessed each of the following: (1) volume and pressure at constant temperature of a gas; (2) volume and temperature at constant pressure of a gas; and (3) explaining these relationships using the Kinetic Molecular Theory. A semi-structured interview guide was used to gather students' insights.

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Intervention and Data Collection

Data collection lasted three weeks and involved pre-assessment, implementation, and post-assessment. Both groups completed the pretest before instruction. In the experimental group, students rotated through stations that included concept discovery using PhET simulations and QR codes, mathematical application using instructional videos and worksheets, and real-life application using videos, images, and guided questions. Kinetic Molecular Theory activities included multimedia lessons, digital quiz activities, and situational analysis. The teacher facilitated activities, monitored progress, and clarified misconceptions. The control group received instruction through traditional learning stations. After the intervention, both groups completed the post-test, and students in the experimental group provided feedback about their experiences.

Data Analysis

The study used frequency counts, percentages, mean scores, descriptive interpretations, and statistical tests to analyze the quantitative data. Pretest and post-test performance was compared within each group and mean-gain results were compared between the control and experimental groups. Interview responses were analyzed thematically. Statistical significance was evaluated at the .05 level.

Paired samples t-tests were used to determine whether there were statistically significant differences between the pretest and posttest scores within the control and experimental groups for each of the three competencies. Independent sample comparisons were used to examine differences in performance gains between the two groups. In addition, analysis of covariance (ANCOVA) was conducted to compare the posttest scores of the control and experimental groups while controlling for their corresponding pretest scores. The level of significance was set at 0.05. Statistical decisions were based on the computed test statistics, p-values, and relevant effect sizes.

Before conducting the analyses, the assumptions of the statistical tests were examined. For the paired-samples t-test, the distribution of the difference scores was assessed for approximate normality, and potential outliers were inspected. For independent-samples comparisons, the independence of observations, approximate normality within groups, and homogeneity of variances were evaluated. When the equal-variance assumption was not satisfied, Welch's t-test was considered as an alternative. For ANCOVA, the linear relationship between pretest and posttest scores, homogeneity of regression slopes, normality and homoscedasticity of residuals, independence of observations, and potential influential outliers were assessed. Effect sizes, including Cohen's d for mean comparisons and partial eta squared η_p^2 for ANCOVA, were reported to complement statistical significance and describe the magnitude of observed differences.

RESULTS AND DISCUSSION

Respondent Profile

Most respondents in both groups were 14–16 years old: 96.51% of the control group and 95.56% of the experimental group. The control group comprised 52.33% male and 47.67% female respondents, while the experimental group comprised 52.22% male and 47.78% female respondents. Prior exposure to interactive videos was reported by 89.53% of the control group and 91.11% of the experimental group. The groups therefore had broadly similar demographic profiles and high prior exposure to interactive videos.

Table 1Respondents' Demographic Profile

Demographic		**Control**		**Experimental**	
		Frequency	**Percentage**	**Frequency**	**Percentage**
Age	11 – 13	0	0.00	0	0.00
	14 – 16	83	96.51	86	95.56

	17 – 19	2	2.33	4	4.44
	20 and above	1	1.16	0	0.00
	Total	**86**	**100.00**	**90**	**100.00**
Gender	Male	45	52.33	47	52.22
	Female	41	47.67	43	47.78
	Non-binary	0	0.00	0	0.00
	Prefer not to say	0	0.00	0	0.00
	Total	**86**	**100.00**	**90**	**100.0**
Exposure to Interactive Videos	Yes	77	89.53	82	91.11
	No	9	10.47	8	8.89
	Total	**86**	**100.00**	**90**	**100.00**

Pretest and Post-test Performance

For volume and pressure at constant temperature, the control group's mean score increased from 55.80 (Did Not Meet Expectations) to 78.40 (Fairly Satisfactory), while the experimental group increased from 61.70 (Did Not Meet Expectations) to 82.80 (Satisfactory). In the digital stations, learners manipulated a gas simulation, observed pressure and volume changes, interpreted graphs, solved problems, and related Boyle's Law to scenarios such as syringe compression and scuba diving. These activities provided opportunities to visualize the inverse relationship between pressure and volume. However, computational tasks and data interpretation could still be demanding, particularly when students needed more time to work through formulas or access digital resources.

For volume and temperature at constant pressure, the control group improved from 50.50 (Did Not Meet Expectations) to 81.90 (Satisfactory), and the experimental group improved from 65.70 (Did Not Meet Expectations) to 83.60 (Satisfactory). The experimental group had the slightly higher post-test mean, although the control group's gain was larger in the between-group comparison. The digital intervention allowed learners to manipulate temperature in simulations, observe volume changes, study video demonstrations, and solve Charles' Law problems. At the same time, the procedural nature of some computation items may have benefited from the control group's structured worksheet practice and direct guidance. Connectivity, device performance, audio quality, and station time limits were potential implementation constraints discussed in the thesis context; these should be interpreted as plausible influences rather than proven causes of individual scores.

For explaining gas-law relationships using Kinetic Molecular Theory, the control group's mean increased from 77.90 (Fairly Satisfactory) to 83.80 (Satisfactory), while the experimental group increased from 78.20 (Fairly Satisfactory) to 87.00 (Very Satisfactory). The digital stations included animations and videos of gas-particle movement, digital quizzes, and real-life situations such as heated aerosol cans, tires exposed to high temperatures, and the diffusion of coffee aroma. These representations may have helped learners connect microscopic particle behavior to observable events. The experimental group's higher post-test score was consistent with the intended strength of digital visualization for abstract concepts.

Table 2 Summary of Pretest and Post-test Results

Competencies	**Control Group**				**Experimental Group**			
	Pre-test	**Description**	**Post-test**	**Description**	**Pre-test**	**Description**	**Post-test**	**Description**
Volume and Pressure at Constant	55.80	Did Not Meet Expectations	78.40	Fairly Satisfactory	61.70	Did Not Meet Expectations	82.80	Satisfactory

Temperature of a Gas								
Volume and Temperature at Constant Pressure of a Gas	50.50	Did Not Meet Expectations	81.90	Satisfactory	65.70	Did Not Meet Expectations	83.60	Satisfactory
Explains These Relationships Using Kinetic Molecular Theory	77.90	Fairly Satisfactory	83.80	Satisfactory	78.20	Fairly Satisfactory	87.00	Very Satisfactory

Students' Insights

The thematic analysis identified four central themes: enhanced conceptual understanding through interactive visualization; increased active engagement and participation; enjoyment of interactive and technology-driven activities; and development of conceptual and applied understanding of gas laws. Students' responses indicated that simulations helped them observe changes that would otherwise be difficult to see, while group tasks and digital activities encouraged participation. Students also described enjoying the interactive format and reported learning to connect gas-law concepts with real-life situations. At the same time, implementation challenges, including distractions, limited device audio, internet delays, and the need to navigate digital resources—were relevant considerations when planning future use.

Tests of Significant Difference

Within-group analyses showed that the control group's pretest–post-test improvement was statistically significant for volume and pressure at constant temperature (55.81 to 78.37; mean difference = 22.56; reported $p < .001$) and volume and temperature at constant pressure (50.47 to 81.86; mean difference = 31.39; reported $p < .001$). The control group's score for explaining gas-law relationships using the Kinetic Molecular Theory increased from 77.91 to 83.84, but this difference was not statistically significant (mean difference = 5.93, $p = .129$). For the experimental group, pretest–post-test differences were statistically significant in all three competencies: volume and pressure at constant temperature (61.67 to 82.78; mean difference = 21.11; reported $p < .001$), volume and temperature at constant pressure (65.67 to 83.56; mean difference = 17.89; reported $p < .001$), and the Kinetic Molecular Theory competency (78.22 to 87.00; mean difference = 8.78; $p = .002$).

Table 3 Significant Difference Between the Pretest and Posttest of the Control Group Based on the Identified Competencies

Competencies	**Control Group**		**Mean Difference**	**p-value**	**Decision**	**Interpretation**
	Pretest	**Posttest**				
Volume and Pressure at Constant Temperature of a Gas	55.81	78.37	22.56	0.000	Reject H_0	Significant
Volume and Temperature at Constant Pressure of a Gas	50.47	81.86	31.39	0.000	Reject H_0	Significant
Explains These Relationships Using Kinetic Molecular Theory	77.91	83.84	5.93	0.129	Fail to Reject H_0	Not Significant

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Table 4 Significant Difference Between the Pretest and Posttest of the Experimental Group Based on the Identified Competencies

Competencies	Experimental Group		Mean Difference	p-value	Decision	Interpretation
	Pretest	Posttest				
Volume and Pressure at Constant Temperature of a Gas	61.67	82.78	21.11	0.000	Reject H_0	Significant
Volume and Temperature at Constant Pressure of a Gas	65.67	83.56	17.89	0.000	Reject H_0	Significant
Explains These Relationships Using Kinetic Molecular Theory	78.22	87.00	8.78	0.002	Reject H_0	Significant

The comparison of mean gains showed that the control group gained 22.56 points in volume and pressure at constant temperature, while the experimental group gained 21.11 points; the difference was not statistically significant ($p = .616$). For volume and temperature at constant pressure, the control group's mean gain was 31.40, and the experimental groups were 17.89. This difference was statistically significant ($p = .009$), in favor of the control group. For explaining gas-law relationships using the Kinetic Molecular Theory, the control group's mean gain was 5.93, and the experimental groups was 8.78. The difference was not statistically significant ($p = .541$). Thus, the updated results do not show a statistically significant advantage for digital augmented learning stations across all three competencies. The control group had a significantly higher mean gain only in the volume–temperature competency.

Table 5Significant Difference Between the Mean Gained Results of the Control and Experimental Group

Competencies	Mean Gained		p-value	Decision	Interpretation
	Control	Experimental			
Volume and Pressure at Constant Temperature of a Gas	22.56	21.11	0.616	Fail to Reject H_0	Not Significant
Volume and Temperature at Constant Pressure of a Gas	31.40	17.89	0.009	Reject H_0	Significant
Explains These Relationships Using Kinetic Molecular Theory	5.93	8.78	0.541	Fail to Reject H_0	Not Significant

Taken together, the results indicate that both instructional approaches were associated with higher post-test scores, but the statistical evidence for improvement differed by group and competency. Within the control group, improvement was statistically significant for Boyle's Law and Charles' Law, but not for the Kinetic Molecular Theory competency. Within the experimental group, improvement was statistically significant in all three competencies. However, the between-group comparison found no significant difference in mean gains for Boyle's Law or the Kinetic Molecular Theory competency, and the significant difference for Charles' Law favored the control group. The qualitative themes complemented the quantitative findings by indicating that students generally perceived the digital activities as engaging and useful for visualization and application. Taken together, the findings support using digital augmented learning stations as a supplementary approach, while retaining explicit instruction and structured practice where these appear helpful.

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Table 6. Analysis of Covariance (ANCOVA) for Posttest Scores Across the Three Competencies

Competency	**Source**	**df**	**F**	**p**	**Partial η_p^2**
1. Volume and pressure at constant temperature	Group	1, 169	1.561	.213	.009
	Pretest (covariate)	1, 169	4.412	.037	.025
2. Volume and temperature at constant pressure	Group	1, 169	0.024	.877	.000
	Pretest (covariate)	1, 169	0.346	.557	.002
3. Kinetic Molecular Theory	Group	1, 169	1.954	.164	.011
	Pretest (covariate)	1, 169	0.912	.341	.005

Table 7. Adjusted Posttest Means and Effect Sizes by Competency

Competency	**Control adjusted mean**	**Experimental adjusted mean**	**Adjusted mean difference**	**Cohen's *d***
1. Volume and pressure at constant temperature	0.787	0.812	0.024	0.193
2. Volume and temperature at constant pressure	0.821	0.824	0.004	0.025
3. Kinetic Molecular Theory	0.838	0.870	0.031	0.213

The ANCOVA results showed that there were no statistically significant differences between the control and experimental groups after controlling pretest scores in any of the three competencies. For volume and pressure at constant temperature, the group effect was not statistically significant, ($F(1,169)=1.561$, $p=.213$, $\eta_p^2=.009$). For volume and temperature at constant pressure, the difference was also not statistically significant, ($F(1,169)=0.024$, $p=.877$, $\eta_p^2<.001$). Similarly, for the Kinetic Molecular Theory, no statistically significant group difference was found, ($F(1,169)=1.954$, $p=.164$, $\eta_p^2=.011$). The adjusted means were slightly higher for the experimental group in all three competencies, but the effect sizes were small. These findings indicate that, after accounting for pretest scores, the analysis did not establish a statistically significant advantage of digital augmented learning stations over traditional learning stations for any of the three competencies.

Limitations of the Study

This study had several limitations that should be considered when interpreting its findings. First, the intervention was implemented over a relatively short period, which may have limited the opportunity to determine whether the improvements in students' performance could be sustained over time. The results primarily reflected students' performance immediately following the intervention and did not establish the long-term effects of digital augmented learning stations on learning retention or the transfer of gas-law concepts to new situations.

Second, the study employed a quasi-experimental design in which participants were not randomly assigned to the control and experimental groups. Although pretest scores were considered in the analysis, differences in students' prior knowledge, learning preferences, motivation, and other unmeasured characteristics may have influenced the results. Consequently, the findings should be interpreted cautiously, and the observed differences in performance cannot be attributed exclusively to the instructional approach.

Third, the implementation of digital augmented learning stations may have been affected by variations in device availability, device capability, and internet connectivity. These factors could have influenced students' access to

digital materials, participation in interactive activities, and completion of learning tasks. However, unless these issues were systematically documented, their specific effects on student performance cannot be determined from the available results.

Fourth, teacher-related factors may have influenced the implementation and outcomes of the intervention. Differences in instructional delivery, classroom management, familiarity with digital tools, feedback practices, and the amount of guidance provided could have affected students' learning experiences. Such factors may have contributed to variations in performance independently of the learning station format. Therefore, the findings should be interpreted within the context of the teachers and classroom conditions under which the intervention was conducted.

Despite these limitations, the study provides useful evidence regarding the implementation of traditional and digital augmented learning stations in teaching Gas Laws to Grade 10 students. Future studies may consider longer intervention periods, follow-up assessments, more rigorous assignment procedures where feasible, systematic documentation of technological barriers, and measures to monitor teacher implementation. These improvements could provide stronger evidence regarding the comparative effectiveness and sustainability of digital augmented learning stations across different learning competencies and classroom contexts.

CONCLUSION

Both traditional learning stations and digital augmented learning stations supported improvements in Grade 10 students' performance in Gas Laws. Although the experimental group obtained higher posttest mean scores in all three competencies, the comparison of mean gains revealed that the effectiveness of the two instructional approaches varied according to the competency assessed. There was no statistically significant difference between the control and experimental groups in the competency involving volume and pressure at constant temperature ($p = 0.616$) or in explaining gas-law relationships using the Kinetic Molecular Theory ($p = 0.541$). However, a statistically significant difference was found in the competency involving volume and temperature at constant pressure ($p = 0.009$), favoring the control group, which obtained a higher mean gain of 31.40 compared with 17.89 for the experimental group. These findings indicate that digital augmented learning stations did not demonstrate a statistically significant advantage over traditional learning stations across all three competencies. Nevertheless, students' reported experiences suggested that the digital approach supported engagement, visualization, and the application of abstract scientific concepts. Therefore, digital augmented learning stations may be used as supplementary instructional materials alongside structured traditional learning activities to support students' procedural skills, conceptual understanding, and application of gas-law principles.

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Ethical Considerations

Ethical approval for the conduct of this study involving human participants was obtained under Protocol Code MC-2025-038-Cabillo. The study was conducted with due consideration for the rights, dignity, privacy, and welfare of the participants. Appropriate measures were observed to ensure informed consent, confidentiality of collected information, voluntary participation, and the protection of participants throughout the research process.

The authors declare that there is no conflict of interest regarding the conduct of this study. The study was conducted independently, and no financial, personal, or professional interests influenced the research design, data collection, analysis, interpretation of results, or preparation of the manuscript.