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Culturally Responsive Teaching (CRT): Effects on Students' Academic Performance and Science Process Skills in Chemistry

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Abstract:*This study examined the effects of Culturally Responsive Teaching (CRT) on Grade 10 students' academic performance and science process skills in Chemistry at Kalipay National High School, Gingoog City. CRT emphasizes instruction that connects classroom content to students' cultural backgrounds, lived experiences, and community contexts. Two intact classes (n=74) participated using a quasi-experimental pretest–posttest design: the experimental group received CRT-based laboratory instruction, while the comparison group received non-CRT lecture-based instruction. Academic achievement was measured using a researcher-developed 61-item test, and science process skills were assessed through Arnold et al.'s (2009) validated instrument.Findings show that the experimental group demonstrated substantially higher academic performance (M=83.06) compared to the non-CRT group (M=41.08), with ANCOVA indicating significant differences (p<.05). Students exposed to CRT also attained higher ratings in science process skills (M=3.36), compared to those under non-CRT instruction (M=2.72), with t-test analysis confirming significant differences across most indicators (p<.05). These results support research suggesting that CRT fosters inclusiveness, inquiry, critical thinking, and conceptual understanding by contextualizing science learning and connecting content to cultural knowledge. The study concludes that CRT effectively enhances science learning outcomes and inquiry competence, particularly in diverse classrooms. Recommendations include integrating CRT into science pedagogy, curriculum design, and teacher training.*

Keywords: *Culturally Responsive Teaching, Science Process Skills, Academic Performance, Chemistry Instruction,Inclusive Pedagogy*

INTRODUCTION

Science education in the Philippines continues to face persistent challenges, particularly in relation to students' low academic performance and limited mastery of science process skills (SPS) such as observing, classifying, inferring, predicting, and experimenting. National and local assessment trends consistently indicate below-standard performance in Chemistry, where many students demonstrate difficulty understanding abstract concepts and applying scientific reasoning. Despite the implementation of learner-centered reforms under the MATATAG curriculum framework, a substantial number of learners especially those from Indigenous and culturally diverse backgrounds struggle to connect scientific concepts to their lived experiences (Department of Education [DepEd], 2023). Traditional classroom practices in Chemistry often emphasize content memorization and lecture-based delivery, resulting in disengagement,

decreased inquiry, and limited development of essential SPS competencies.Culturally Responsive Teaching (CRT) offers a promising pedagogical pathway to address these gaps. CRT recognizes learners' cultural identities, values, and community knowledge as foundations for deep learning. By validating students' personal and cultural backgrounds, CRT strengthens motivation, supports cognitive processing, and enhances academic achievement (Gay, 2018; Ladson-Billings, 2021). Existing research also suggests that culturally grounded instruction increases student engagement and fosters higher-order thinking by making content meaningful and relevant (Siwatu, 2019; Hammond, 2020). However, while CRT has been positively associated with improved academic outcomes across disciplines, very few empirical studies—locally or internationally—have examined its direct effects on science process skills, a key determinant of students' scientific literacy and inquiry competence.The Philippine educational landscape is uniquely positioned for CRT integration due to its linguistic and cultural diversity. Many students in Gingoog City, Region X including Indigenous learners experience disconnection from classroom lessons that lack cultural relevance, limiting their engagement and academic confidence. Although the MATATAG curriculum advocates for contextualized, inquiry-driven, and culturally inclusive learning, many science classrooms remain textbook-centered and detached from students' cultural realities. As a result, learners may fail to recognize the value and applicability of Chemistry in their daily lives, contributing to low academic achievement and underdeveloped process skills.By situating scientific learning within culturally familiar contexts such as local environmental issues, traditional ecological knowledge, and community-based chemical practices. CRT may offer a more meaningful learning experience. International literature highlights how culturally relevant science instruction enhances student engagement, conceptual clarity, and problem-solving abilities (Brown, 2021; National Research Council, 2012). However, Philippine-based data examining CRT's impact on Chemistry performance and SPS remain scarce. Existing literature focuses primarily on perceptions, attitudes, or general achievement rather than specific inquiry skill development.This action research seeks to address that gap by examining the effectiveness of CRT in improving students' academic performance and science process skills in Chemistry. Through culturally contextualized learning materials, localized laboratory activities, and community-linked applications of chemical concepts, this study integrates CRT principles into Grade 10 Chemistry instruction to determine whether such an approach leads to measurable improvements in students' performance outcomes. Aligning CRT with Chemistry instruction not only supports conceptual understanding but also strengthens students' ability to ask questions, design experiments, communicate results, and interpret scientific data core SPS competencies essential to scientific inquiry.By analyzing changes in academic performance and SPS before and after CRT implementation, the study aims to contribute local empirical evidence to support culturally grounded science instruction. Ultimately, findings will help inform science pedagogy, teacher capacity-building, and curriculum enhancement within the broader goals of DepEd toward accessible, equitable, and culturally responsive education.

1.1Statement of the Problem

This study aimed to determine how CRT influences academic performance and science process skills in Chemistry. Specifically, it sought to:

1. Compare pretest and posttest academic performance of students exposed to CRT and non-CRT instruction.
2. Measure the level of science process skills in CRT and non-CRT groups.
3. Determine significant differences in academic performance between groups.
4. Determine significant differences in science process skills between groups.

2. METHODOLOGY

2.1 Research Design

This study employed a quasi-experimental pretest–posttest control group design to determine the effectiveness of Culturally Responsive Teaching (CRT) on students' academic performance and science process skills (SPS) in Chemistry. The design involved two intact Grade 10 classes that were randomly assigned as the experimental (CRT) group and the control (non-CRT) group. Although individual randomization was not possible due to natural class organization and ethical constraints, the intact class assignment allowed for authentic classroom conditions and minimized instructional disruption.Prior to the intervention, both groups completed a pretest to establish baseline equivalence in academic performance and SPS. The experimental group then received CRT-based laboratory instruction for the duration of the intervention period, while the control group received a lecture-based instructional approach using traditional teacher-centered delivery. At the end of the intervention phase, both groups completed a posttest using the same standardized academic and SPS measures.

2.2 Participants

Participants were seventy-four (74) Grade 10 learners enrolled in science classes at Kalipay National High School in Gingoog City, Region X, during the academic year. The sample consisted of two intact sections with 37 students assigned to each group. The experimental group received CRT instruction, while the control group followed non-CRT instruction.

The participants represented a culturally diverse student population, including Indigenous youth and learners from rural farming and fishing communities. This diversity provided an ideal environment for CRT implementation, as students brought varied cultural perspectives, practices, and experiences relevant to Chemistry instruction.

2.3 Research Instruments

2.2.1 Academic Performance Test

Academic performance was measured using a 61-item researcher-developed achievement test, validated by content experts in Chemistry education. The instrument covered key competencies under the Behavior of Gases and Chemical Reactions. Validation ensured content alignment, cognitive level appropriateness (LOTs to HOTS), curriculum relevance, and instructional coherence. Test reliability was verified using Cronbach's alpha 0.906, with strongly acceptable internal consistency.To measure the academic achievement of the students the rating scale used in the interpretation of data. The percentage equivalent scale is described according to the criteria set by the Department of Education (Department Order no. 8, series of 2015, dated April 2015) as shown:

Percentage Equivalent	Transmuted Grade	Score	Qualitative Interpretation
84.00 – 100.00	90 – 100	30-35	Outstanding
76.00 – 83.99	85 – 89	27– 29	Very satisfactory
68.00 – 75.99	80 – 84	24– 26	Satisfactory
60.00 - 67.99	75 - 79	21 – 23	Fairly satisfactory
0 – 59.99	0 - 74	0 - 20	Did not meet the expectation

2.2.2 Science Process Skills Test

Students' science process skills were measured using the Science Process Skills Inventory adapted from Arnold et al. (2009). The instrument evaluated core SPS indicators including observing, communicating, designing, analyzing, interpreting data, questioning, and explaining.

The SPS inventory demonstrated strong reliability with Cronbach α = 0.80, indicating a high level of internal consistency.

2.3 Data Collection Procedure

Data collection occurred in four structured stages to ensure the validity and reliability of findings. During Stage 1 (Orientation and Pretesting), both the control and experimental groups completed the academic performance test and the SPS inventory prior to instruction. The resulting data were used to establish baseline equivalence and support statistical comparison between groups. Stage 2 (CRT Instructional Intervention) involved the implementation of the culturally responsive teaching approach over several weeks, aligned with the Grade 10 Chemistry learning competencies. Instruction for the experimental group featured contextualized laboratory activities, integration of Indigenous practices and cultural knowledge, collaborative group investigation, and community-based Students participated in reflective tasks connecting scientific concepts to lived experiences, engaged in open discussion using shared cultural language and metaphors, and completed inquiry-based activities structured around culturally familiar scenarios. In Stage 3 (Control Group Instruction), the control group was taught using a teacher-centered lecture-demonstration format focused on note-taking, direct explanation, and demonstrations. Instructional materials and activities did not incorporate cultural relevance or community-based examples, and student learning was limited to textbook-based exercises. Finally, Stage 4 (Posttesting and Data Validation) involved the administration of the same academic achievement test and SPS inventory to both groups. All test scores were recorded, tabulated, and verified to ensure scoring accuracy, allowing for robust comparison of post-intervention outcomes.

2.4 Statistical Analysis

Multiple statistical techniques were employed to analyze the data and determine the instructional impact of CRT on academic performance and SPS. Descriptive statistics, including means, standard deviations, and frequency distributions, were computed to summarize students' academic performance and observed SPS levels. ANCOVA was used to compare posttest results between the CRT and control groups while statistically controlling for pretest scores, reducing error variance and increasing the precision of treatment effect estimates. An independent samples t-test was also conducted to examine significant differences in mean SPS ratings across all skill indicators between the two groups. In addition, effect size analysis was performed to measure the magnitude of instructional impact and to provide a more meaningful interpretation of findings beyond statistical significance alone. All analyses were conducted at the .05 significance level, ensuring confidence that observed differences were not attributed to chance.

3. RESULTS AND DISCUSSION

3.1 Academic Performance

Table 1 presents the students' academic performance in the pretest for both the CRT group and the non-CRT group

Table 1. Pretest academic performance of students exposed to CRT and non-CRT instruction

Percent Equivalent	Culturally Responsive Teaching		Non- Culturally Responsive Teaching		Qualitative Interpretation
	n	%	n	%	
90-100	0	0	0	0	Outstanding
85-89	0	0	0	0	Very Satisfactory

80-84	0	0	0	0	Satisfactory
75-79	0	0	0	0	Fairly Satisfactory
Below 75	37	100	37	100	Did not meet expectation
MPS		28.32		29.52	

The pretest data indicate that all students in both groups scored below the 75% mastery level, interpreted as "did not meet expectation." The CRT group obtained a mean percentage score (MPS) of 28.32, while the non-CRT group obtained 29.52, showing that both groups began on comparable academic footing. This baseline similarity confirms the appropriateness of comparing posttest achievement after differing instructional conditions. The low pretest scores suggest that students entered the unit with limited prior knowledge of the targeted chemistry competencies, particularly those related to the behavior of gases and chemical reactions. This aligns with literature indicating that many learners struggle with pre-instruction conceptual understanding in science due to gaps in foundational knowledge and unfamiliarity with abstract scientific concepts (Dogru-Atay et al., 2008; Gonzales, 2016; Montecillo, 2011). From a culturally responsive standpoint, the pretest outcomes reflect the challenge students face when science instruction and assessment are disconnected from their cultural and lived experiences. CRT literature suggests that students' conceptual understanding improves when academic tasks integrate familiar language, prior knowledge, and real-world relevance (Gay, 2018; Ladson-Billings, 2021). Thus, the low scores provide a compelling rationale for exploring CRT as an instructional approach that may improve student access to chemistry learning. While Table 2 presents the posttest academic performance results after the instructional intervention.

Table 2. Posttest academic performance of students exposed to CRT and non-CRT instruction

Percent Equivalent	**Culturally Responsive Teaching**		**Non- Culturally Responsive Teaching**		**Qualitative Interpretation**
	n	%	n	%	
90-100	17	45.9	0	0	Outstanding
85-89	17	45.9	0	0	Very Satisfactory
80-84	3	8.1	0	0	Satisfactory
75-79	0	0	2	5.4	Fairly Satisfactory
Below 75	0	0	35	94.6	Did not meet expectation
MPS		83.06		41.08	

The results demonstrate a substantial improvement in academic performance among students exposed to Culturally Responsive Teaching. Nearly all students in the CRT group achieved performance levels ranging from "Satisfactory" to "Outstanding," with an MPS of 83.06, representing a dramatic increase from their baseline score. In contrast, the non-CRT group achieved an MPS of only 41.08, with the majority (94.6%) remaining below expectation.

These findings indicate that CRT significantly enhanced students' chemistry achievement. The marked improvement may be attributed to the culturally grounded nature of CRT instruction, which connected abstract chemical concepts to meaningful local contexts, linguistic familiarity, and culturally relevant applications. This aligns with international studies showing that CRT increases academic performance by strengthening cultural identity, promoting deeper engagement, and improving access to conceptual understanding (Hammond, 2020; Siwatu,

2019).Further, CRT research indicates that learning becomes more coherent and memorable when students' cultural schema activate prior knowledge and cognitive connections during instruction (Gay, 2018). CRT has also been linked to increases in student motivation, confidence, and persistence factors closely associated with academic success (Ladson-Billings, 2021; Brown, 2021).The stark posttest contrast also suggests that traditional lecture-based instruction, as experienced by the non-CRT group, offers limited academic benefit in chemistry learning. Teacher-centered methods tend to minimize collaboration, inquiry, and student voice conditions CRT actively counters. Previous studies found similar limitations in non-contextual science instruction, noting that passive learning environments weaken comprehension, discourage critical thinking, and reduce concept retention (Agboghoroma & Oyovwi, 2015; Ngesu et al., 2014).Overall, the results confirm that culturally responsive pedagogy contributes to higher levels of academic achievement in chemistry by enhancing relevance, conceptual clarity, inquiry orientation, and learner engagement.

3.2 Science Process Skills After Exposure to CRT

Table 3 presents the mean scores of students' science process skills after exposure to Culturally Responsive Teaching (CRT) and non-CRT instruction in Chemistry.

Table 3. Mean scores of science process skills after exposure to CRT and non-CRT instruction

Science Process Skills	Culturally Responsive Teaching		Non- Culturally Responsive Teaching	
	Mean	Qualitative Description	Mean	Qualitative Interpretation
Questioning	3.16	High	2.47	Low
Designing	3.10	High	2.68	High
Communicating	3.63	Very High	3.01	High
Recording	3.56	Very High	3.78	Very High
Analyzing	3.08	High	2.37	Low
Explaining	3.45	High	2.44	Low
Interpreting	3.50	High	2.32	Low
Over-all Mean	3.36	High	2.72	High

Legend:

Range	Qualitative Interpretation
1.0-1.50	Very Low
1.51-2.50	Low
2.51-3.50	High
3.51-4.00	Very High

Results show that students exposed to Culturally Responsive Teaching (CRT) attained an overall mean score of 3.36, interpreted as "high". Two process skills, communicating (3.63) and recording (3.56) were rated "very high," indicating strong ability to exchange ideas and document results during laboratory activities.

Under CRT, students were encouraged to share ideas, describe observations, and explain laboratory outcomes using familiar cultural language, metaphors, and collaborative group interaction. These outcomes align with Rambuda and Fraser (2004), who noted that communication-driven instruction enables learners to articulate understanding more confidently and clearly. Similar findings were reported by Hinampas (2017), showing that learners engaged in contextualized inquiry record experimental data more accurately and attentively.Other SPS

indicators, interpreting (3.50), explaining (3.45), questioning (3.16), designing (3.10), and analyzing (3.08) also yielded "high" descriptions. These skills are closely associated with scientific reasoning, reflective judgment, and conceptual processing components strengthened through culturally grounded problem contexts. CRT integrates students' cultural knowledge and real-life experiences to support inquiry and interpretation, which aligns with Gay (2018) and Hammond (2020), who assert that CRT promotes deeper analysis by linking abstract scientific concepts to lived realities.Although all skills improved, designing and analyzing scored the lowest within the CRT group consistent with Barro (2010), who found that students often find these skills more cognitively challenging because they require independent planning, variable control, and evidence-based reasoning. This is expected, as these abilities develop with prolonged exposure to inquiry-based laboratory experiences.Overall, the CRT group's SPS pattern supports the theory that culturally responsive instruction increases learner engagement, strengthens conceptual thinking, and improves inquiry skills by validating student identity and cultural background (Ladson-Billings, 2021; Brown, 2021).On the other hand, students exposed to non-CRT instruction obtained an overall mean score of 2.72, also interpreted as "high," although notably lower than the CRT group. Their strongest skill was recording (3.78), interpreted as "very high," suggesting that documenting observations remains an accessible task even in a lecture-based environment. However, minimal improvement across other SPS indicators suggests that non-CRT strategies offered limited opportunities for higher-order scientific inquiry.The lowest-rated skills were analyzing (2.37) and interpreting (2.32), both interpreted as "low." Students receiving non-CRT instruction had fewer opportunities to connect chemical concepts to meaningful contexts; thus, they struggled to interpret data, identify variables, construct explanations, and solve problems skills that require conceptual depth and cultural relevance. Sudibyo et al. (2014) explain that low SPS performance is typical when students are not guided to analyze datasets, evaluate variables, or discuss outcomes critically. Rahmawati et al. (2013) further report that students often resort to memorization in traditional learning, preventing higher-order skills from developing.These findings align with CRT literature indicating that non-contextual, teacher-centered strategies limit inquiry, suppress critical thinking, and reduce student engagement (Siwatu, 2019; Agboghoroma & Oyovwi, 2015). When learners cannot relate classroom content to prior experiences or cultural identity, their capacity to process and analyze scientific information remains restricted.Overall, results show that students taught under CRT displayed stronger performance in every science process skill category compared to those in the non-CRT group. This supports studies demonstrating that CRT enhances students' inquiry, reasoning, and laboratory performance by incorporating cultural context, community knowledge, and collaborative interaction into instruction (Hammond, 2020; Gay, 2018).CRT classroom practices such as shared cultural dialogue, reflection, contextualized problem-solving, and local examples help students process information more clearly and meaningfully. This outcome echoes Brown (2021), who found that culturally mediated science activities improve interpretation, analysis, explanation, and questioning skills.

3.3 Student's Academic Achievement between two groups

Table 4 presents the results of the Analysis of Covariance (ANCOVA) comparing posttest academic achievement between students exposed to Culturally Responsive Teaching (CRT) and those taught using non-CRT, lecture-based instruction.

Table 4. Analysis of Covariance on students' academic achievement between two groups

GROUP	N	MEAN	STANDARD DEVIATION
Experiential Learning Approach	37	83.06	4.43

Non- experiential Learning Approach	37	41.08	9.18
Total	74	62.07	22.31

Tests of Between-Subjects Effects

SOURCE	Sum of squares	Df	Mean square	f-value	sig.
Model	319554.941	3	106518.314	3956.006	.000*
Pretest (Covariate)	1831.217	1	1831.217	68.010	.000*
Group	43261.200	2	21630.600	80.3343	.000*
Error	1911.726	71	26.926		
Total	321466.667	74			

*significant at $p < 0.05$ level

As shown in Table 4, students exposed to Culturally Responsive Teaching achieved a significantly higher posttest mean score of 83.06 (SD = 4.43) compared to only 41.08 (SD = 9.18) for those in the non-CRT instructional group. The mean difference of 41.98 points strongly favors the CRT group. The ANCOVA results further confirmed a statistically significant difference between groups ($f = 80.334$, $p < .05$), even after adjusting for pretest scores.

These results indicate that CRT produced a substantial improvement in students' Chemistry achievement relative to traditional lecture-based instruction. The statistical significance and effect magnitude demonstrate that CRT was not only beneficial but academically superior in promoting conceptual understanding.The null hypothesis stating that there is no significant difference in academic performance between groups is therefore rejected.The significantly higher posttest scores of students in the CRT group suggest that culturally responsive instructional practices improved comprehension, retention, and application of Chemistry concepts. CRT promotes active learning, deeper engagement, and contextual relevance by embedding cultural background, community experiences, and familiar language into instruction. These pedagogical strengths likely enabled students to process scientific information more meaningfully, making abstract concepts clearer and more memorable.The results support Gay (2018), who reported that CRT improves academic performance by increasing learner motivation, confidence, and conceptual access through cultural integration. Likewise, Ladson-Billings (2021) emphasized that culturally grounded learning strengthens student identity and academic success by making instruction personally relevant and intellectually connected to lived realities.Similarly, Hammond (2020) argued that CRT strengthens cognitive development by activating students' schema, improving comprehension, and increasing neural engagement. These principles closely explain why students exposed to CRT outperformed those receiving non-contextual lecture-based instruction.The lower achievement of the non-CRT group suggests that traditional teaching methods may limit student participation, restrict inquiry, and fail to connect classroom learning to students' cultural knowledge. This aligns with findings from Agboghoroma and Oyovwi (2015), who observed that teacher-centered instruction minimizes engagement and results in poor academic outcomes.Overall, the ANCOVA analysis strongly supports the conclusion that incorporating cultural relevance into instruction significantly improves Chemistry academic performance. CRT appears to function as a transformative instructional approach one that enhances academic rigor by making science learning accessible, meaningful, and personally connected to students' cultural and community realities.

3.4 Comparison of Students' Process Skills

Table 5 presents the comparison of students' science process skills (SPS) after exposure to Culturally Responsive Teaching (CRT) and non-CRT instruction in Chemistry.

The results reveal that students taught using Culturally Responsive Teaching (CRT) achieved significantly higher scores in most science process skills compared to those taught through non-CRT instruction. Significant differences were found in questioning, designing, communicating, analyzing, explaining, and interpreting skills ($p < 0.05$). Only the skill of recording showed no significant difference between groups.These findings provide strong evidence that CRT approaches such as the use of localized laboratory tasks, familiar cultural references, shared inquiry dialogue, and community-based examples enhanced students' ability to engage in scientific practices. The incorporation of personal and cultural relevance may have allowed students to interpret information more confidently, communicate findings more clearly, and construct more meaningful explanations.The total SPS mean score for the CRT group (3.36) was substantially higher than for the non-CRT group (2.73), supporting the conclusion that CRT positively influenced overall inquiry performance.The results align with studies demonstrating that culturally responsive learning environments develop scientific thinking by building on students' cultural knowledge, language patterns, and lived experiences. CRT-based instruction provides context, increases student autonomy, and strengthens inquiry confidence factors essential to science process skill development (Gay, 2018; Hammond, 2020).Significant improvements in questioning, interpreting, and explaining suggest that CRT helped students move beyond memorization toward higher-order thinking. This supports Ladson-Billings (2021), who emphasizes that CRT fosters deeper analysis, critical reflection, and conceptual sense-making by validating cultural identity and promoting collaborative exploration.The strong performance in communication skills under CRT instruction reflects evidence that students learn more effectively when they can articulate reasoning through culturally familiar discourse and peer interaction (Siwatu, 2019). Similarly, higher interpreting and analyzing scores may indicate that CRT enabled students to draw meaning from laboratory observations, linking patterns to real-life cultural practices and shared community experiences.These outcomes contrast with the non-CRT group, whose lower SPS scores reflect limited opportunities for contextual analysis, multimodal communication, and reflective problem-solving. This supports findings that teacher-centered approaches often hinder inquiry skill development because students are passive recipients of information rather than active constructors of scientific understanding (Agboghoroma & Oyovwi, 2015).

Table 5. Comparison of students' science process skills between CRT and non-CRT instruction

Science Process Skills	Culturally Responsive Teaching		Non- Culturally Responsive Teaching		t-value	p-value
	Mean	Std. Deviation	Mean	Std. Deviation		
Questioning	3.16	0.46	2.47	0.39	6.98	0.000*
Designing	3.11	0.37	2.69	0.30	5.32	0.000*
Communicating	3.63	0.47	3.01	0.43	5.94	0.000*
Recording	3.57	0.60	3.78	0.48	-1.71	0.092^{ns}
Analyzing	3.08	0.60	2.38	0.49	5.54	0.000*
Explaining	3.46	0.34	2.44	0.28	13.90	0.000*
Interpreting	3.51	0.42	2.32	0.27	14.59	0.000*
TOTAL	3.36	0.30	2.73	0.17	11.25	0.000*

4. CONCLUSION

The findings of this study demonstrate that Culturally Responsive Teaching (CRT) had a significant and positive impact on students' academic performance and science process skills in Chemistry. Pretest results showed that both groups began at comparable levels, with students in both conditions performing below the mastery standard. Following the intervention, however, students exposed to CRT achieved markedly higher posttest scores compared to those taught through traditional, non-CRT instruction. This substantial improvement indicates that CRT effectively supported student learning by making Chemistry content more meaningful, relevant, and accessible.Results from the ANCOVA analysis further confirmed the statistical significance of these achievement gains, demonstrating that CRT students attained superior conceptual understanding even when controlling for prior performance. The size and direction of these differences reflect not only statistical significance but also strong practical relevance, reinforcing CRT's value as an instructional approach for improving science learning outcomes. Similarly, CRT students showed significantly stronger science process skills across nearly all indicators including questioning, communicating, interpreting, explaining, designing, and analyzing, compared to their non-CRT counterparts. These outcomes suggest that integrating students' cultural knowledge, language patterns, and lived experiences into instruction enhances their capacity to engage in scientific inquiry and laboratory processes. CRT appears to promote higher-order cognitive engagement, deeper conceptual reasoning, and more confident scientific participation.Taken together, the results confirm that culturally grounded instruction provides a powerful framework for strengthening conceptual mastery and inquiry-based competence in Chemistry. By validating learners' cultural identities and embedding instruction in relevant and familiar contexts, CRT fosters greater motivation, engagement, and comprehension. The findings support international research indicating that CRT not only improves academic achievement but also enhances scientific thinking, collaboration, and reflective problem-solving. Overall, this study affirms that Culturally Responsive Teaching is an effective and transformative instructional approach, particularly within diverse learning environments such as Philippine public secondary schools. CRT aligns closely with the goals of the MATATAG curriculum, advancing both equity and excellence in science education. The positive outcomes observed in this study provide compelling evidence for the continued integration and expansion of CRT practices in science classrooms, especially for learners from culturally diverse and historically underserved communities.

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REFERENCES

Agboghoroma, T. F., & Oyovwi, E. O. (2015). Evaluating effect of students' academic performance in Integrated Science in Delta State. *Journal of Education and Practice, 6*(6), 17–23.

Alkan, F. (2016). Experiential learning: Its effects on achievement and scientific process skills. *Journal of Education and Training Studies, 4*(6), 197–208. https://doi.org/10.11114/jets.v4i6.1500

Arnold, K., Boone, W., Kremer, K., & Mayer, J. (2009). Assessment of science process skills. *Journal of Science Education, 18*(1), 65–80.

Barro, L. G. (2010). Science process skills and laboratory performance among high school students. *Philippine Journal of Science Education, 25*(3), 55–64.

Brown, B. A. (2021). Science identity development, critical agency, and culturally responsive pedagogy in science education. *Science Education, 105*(5), 934–958. https://doi.org/10.1002/sce.21665

Department of Education. (2023). *MATATAG K–12 curriculum implementation framework*. DepEd Philippines.

Dogru-Atay, P., Cetin, O., & Bal, S. (2008). Misconceptions and pre-knowledge barriers among high school chemistry students. *Journal of Turkish Science Education, 5*(4), 23–38.

Ercan, S. (2007). The relationship between science process skills and students' academic performance. *Hacettepe University Journal of Education, 32*(3), 67–76.

Feyzioglu, B. (2009). An investigation of the relationship between science process skills with efficient laboratory use and science achievement in elementary school. *Journal of Turkish Science Education, 6*(3), 114–132.

Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice* (3rd ed.). Teachers College Press.

Gonzales, M. C. (2016). Academic performance and science process skills in chemistry using concept mapping strategy. *International Journal of Learning, Teaching and Educational Research, 15*(4), 18–32.

Groves, F., Bowd, A., & Smith, J. (2010). Experiential approaches and student-centered learning in science. *Journal of Science Teacher Education, 21*(5), 559–574.

Hammond, Z. (2020). *Culturally responsive teaching and the brain: Promoting authentic engagement and rigor among culturally and linguistically diverse students*. Corwin Press.

Hinampas, R. T. (2017). Science process skills development using inquiry-based 5E learning model. *International Journal of Research in Science Education, 3*(2), 44–53.

Khurshid, F., & Ansari, U. (2012). Effects of teaching strategies on student achievement. *International Interdisciplinary Journal of Education, 1*(1), 41–46.

Ladson-Billings, G. (2021). *Culturally relevant pedagogy: Asking a different question* (2nd ed.). Teachers College Press.

Lebata, B. (2014). Teacher-centered learning approaches and science performance: An evaluation. *South African Journal of Education, 34*(2), 117–130.

Miles, M. (2010). Relationship between science process skills and laboratory performance. *International Review of Education, 56*(4), 567–583.

Montecillo, J. C. (2011). Students' conceptual learning and chemistry performance. *Asia Pacific Journal of Education, Arts and Sciences, 3*(3), 35–42.

National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press.

Ngesu, L., Gunga, S., & Kanduku, M. (2014). Teacher-centered pedagogy and student outcomes in science. *International Journal of Education and Research, 2*(12), 245–260.

Nwafor, C. (2012). Effects of interactive science instruction on student achievement. *Journal of Education and Practice, 3*(9), 15–23.

Okoli, J. N., & Abonyi, O. (2014). Effect of experiential-based science instruction on achievement and retention. *International Journal of Science Education, 36*(13), 2160–2178. https://doi.org/10.1080/09500693.2014.917342

Pallisera, M., Fullana, J., Palaudarias, J. M., & Badosa, M. (2013). Students' learning outcomes through experiential learning. *Teaching in Higher Education, 18*(3), 285–297.

Rahmawati, R., Amirudin, A., & Burada, M. (2013). Barriers to analytical science process skill development. *Journal of Science Learning, 12*(2), 77–85.

Rambuda, A., & Fraser, W. (2004). Perceptions of science process skills and laboratory instruction. *South African Journal of Education, 24*(1), 10–17.

Serin, O. (2009). Effects of problem-solving instruction on reasoning and science performance. *Education and Science, 34*(152), 13–23.

Siwatu, K. (2019). Measuring culturally responsive teaching self-efficacy and outcome expectancy. *Teaching and Teacher Education, 82*(1), 1–12.

Singer, S. R., Hilton, M. L., & Schweingruber, H. (2006). *America's lab report: Investigations in high school science*. National Academies Press.

Sudibyo, W., Saputra, A., & Rukmawan, T. (2014). Factors affecting the development of students' analytical skills in science. *Journal of Indonesian Science Education, 2*(4), 101–112.

Wu, H., He, Q., Weng, X., & Yang, J. (2013). Experiential learning and student achievement in chemistry. *Journal of Chemical Education, 90*(1), 12–19.

Appendices

Appendix A. Pretest/Posttest

Chemistry Achievement Test

Direction: Read each question carefully and ENCIRCLE the letter of best answer.

1. Which of the following is TRUE about gases?
   a. have high densities
   b. are lighter than air
   c. exhibit similar chemical behavior
   d. have no definite shape and volume

2. Which of the following statement is TRUE during chemical reaction?
   a. atoms are destroyed
   b. atoms are rearranged
   c. elements are destroyed
   d. new elements are produced

3. Which of the following evidences shows that chemical reactions occur?
   a. evolution of gas
   b. temperature change
   c. formation of precipitate
   d. statement A, B, and C is correct

4. When the equation $Fe + Cl_2 \rightarrow FeCl_3$ is balanced, what is the coefficient for Cl_2?
   a.1
   b. 2
   c. 3
   d. 4

5. What is the balanced equation for the decomposition of lead (IV) oxide?
   a. $PbO \longrightarrow Pb + O_2$
   b. $PbO_2 \longrightarrow Pb + O_2$
   c. $2PbO \longrightarrow 2Pb + O_2$
   d. $PbO \longrightarrow Pb + 2O_2$

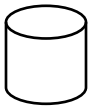
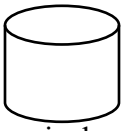
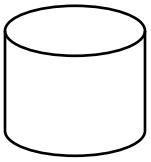
6. Fresh fish and meat that are not stored in refrigerator show signs of spoilage in less than a day. What has caused this spoilage?
   a. oxygen in air
   b. temperature changes
   c. presence of microorganism
   d. all statement is correct

7. Which of the following statements about collisions is TRUE?
   a. Only fast-moving particles collide with each other.
   b. Reaction occurs even without collision of molecules.
   c. All colliding particles have the same amount of energy.
   d. Reactions can happen if the colliding particles have enough energy.

8. How does the temperature affect the average kinetic energy of gas molecules?
   a. As the temperature decreases the average kinetic energy of gas molecules decreases.
   b. As the temperature decreases the average kinetic energy of gas molecules increases
   c. As the temperature decreases the average kinetic energy of gas molecules remains the same.
   d. As the temperature decreases the average kinetic energy of gas molecules fluctuates.

9. What volume will 2.90 moles of oxygen gas occupy at 25°C and 1.70 atm pressure?
   a. 3.5 L
   b. 22.4 L
   c. 41.7 L
   d. 4220 L

10. Each of the following containers is tight and has the same number of gas molecules. Which container has the highest pressure?

a.  b.  c.  d. 

11. What determines an atom's ability to undergo chemical reactions?
   a. protons
   b. neutrons
   c. innermost electrons
   d. outermost electrons

12. Quicklime (CaO) is used as drying agent. When water is added to this, slaked lime $Ca(OH)_2$ is formed. What type of reaction is this?
   a. Combination
   b. Single displacement
   c. Decomposition
   d. Double displacement

13. The volume of a gas is increased from 150.0 mL to 350.0 mL by heating it. If the original temperature of the gas was 25.0°C, what will its final temperature be in °C?
   a. 146 °C b. 10.7°C c. 58.3°C d. 422°C

14. What quantities being preserved in any chemical reaction?
   a. mass and moles
   b. mass and number of atoms
   c. number of moles and the volumes
   d. number of molecules and the volumes

15. What is the chemical formula for the product if a combination reaction takes place between rubidium and bromine?
   a. RuBr
   b. $RbBr^2$
   c. RbBr
   d. Rb^2Br

16. What type of chemical reaction is shown below?

$CH_4 + O_2 \longrightarrow CO_2 + 2H_2O$

a. Decomposition reaction
b. Combination (Synthesis) reaction
c. Double Displacement reaction (metathesis)
d. Single Displacement (replacement) reaction

17. If a sealed syringe is plunged into cold water, in which direction will the syringe piston slide?
a. in
b. out
c. No movement will occur
d. The direction cannot be predicted

18. Mercury freezes at a temperature of -39°C. What is the freezing point of mercury on the Kelvin scale?
a. 39 K
b. 234 K
c. 273 K
d. 312 K

19. Which of the following statements does not agree with the kinetic theory of gases?
a. Gas particles are in constant motion.
b. Gas particles move in predictable patterns.
c. Gas particles are spaced far apart from each other.
d. Gas particles move independently of one another.

20. What is the average kinetic energy of the particles in a substance?
a. Increases as the temperature of the substance decreases.
b. Increases as the temperature of the substance increases.
c. Unaffected by changes in the temperature of the substance.
d. Equal to the total thermal energy absorbed by the substance.

21. Which of the following phenomena does NOT involve the application of gas pressure?
a. burning fuels
b. falling leaves
c. vulcanizing tire
d. rising hot air balloons

22. What gas law best explains the explosion of the heated aerosol container?
a. Boyle's Law
b. Charles' Law
c. Ideal Gas Law
d. Combined Gas Law

23. Consider the following reaction: $Cs + H_2O \rightarrow H_2 + CsOH$. Which statement about the above reaction is TRUE?
a. 2 g of Cs will react with 2 moles of water.
b. 2 g of water will produce 2 g of hydrogen.
c. 2 moles of water will produce 2 g of hydrogen

d. 2 moles of cesium will produce 2 moles of hydrogen

24. How do gas particles respond to an increase in volume?
    a. Increase in temperature and increase in pressure
    b. Decrease in kinetic energy and decrease in pressure
    c. Increase in kinetic energy and increase in temperature
    d. Increase in kinetic energy and decrease in temperatur

25. The pressure of a gas is 750.0 torr when its volume is 400.0 mL. Calculate the pressure (in atm) if the gas is allowed to expand to 600.0 mL at constant temperature.
    a. 0.0067 atm
    b. 1.48 atm
    c. 500.0 atm
    d. 1125 atm

26. Which of the following will complete the Avogadro Law "equal volumes of gases under the same conditions of temperature and pressure have"?
    a. Atoms
    b. molar masses
    c. number of grams
    d. number of molecules

27. What volume of CH_4 at 0°C and 1.00 atm contains the same number of molecules as 0.50 L of N_2 measured at 27°C and 1.50 atm?
    a. 0.37 L
    b. 0.46 L
    c. 0.50 L
    d. 0.68 L

28. Ammonia gas is synthesized according to the balance equation $N_{2(g)} + 3H_{2(g)}$ $2NH_{3(g)}$. If 15.0 liters of nitrogen are reacted with an excess of hydrogen, how many liters of ammonia could be produced? Assume all gas volumes are measured at the same temperature and pressure.
    a. 5.00 L
    b. 10.0 L
    c. 15.0 L
    d. 30.0 L

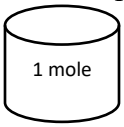
29. What will be the result if you convert 2.3 atm into mmHg?
    a. 0.0030 mmHg
    b. 2.3 mmHg
    c. 1750 mmHg
    d. 2300 mmHg

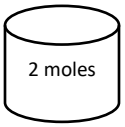
30. What is conserved in the reaction shown below?
    $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$
    a. mass only
    b. mass and moles only
    c. mass, moles and molecules only
    d. mass, moles, molecules and volume

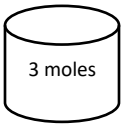
31. What does the symbol Δ in a chemical equation mean?
    a. Yields
    b. Precipitate
    c. A catalyst is needed
    d. Heat is supplied to the reaction

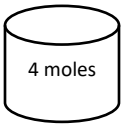
32. A box with a volume of 22.4 L contains 1.0 mol nitrogen and 2.0 mol of hydrogen at 0°C. Which of the following statements is TRUE?
    a. The total pressure is 101.3 kPa
    b. The partial pressure of N_2 is 101.3 kPa
    c. The total pressure in the box is 202.6 kPa
    d. The partial pressures of H_2 and N_2 are equal.

33. Each of the following containers has the same size. Which of the following containers has the most compressed gas molecules?

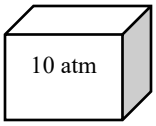
a. 

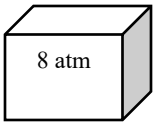
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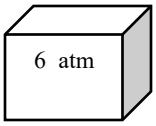
c. 

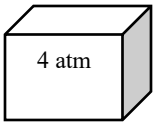
d. 

34. All the gas samples have the same temperature and mass. In which of the following conditions will gas sample have the highest density?

a. 

b. 

c. 

d. 

35. A gas evolved during the fermentation of sugar was collected at 22.5°C and 702 mmHg. After purification its volume was found to be 25.0 L. How many moles of gas were collected?
    a. 0.95 mol
    b. 1.05 mol
    c. 12.5 mol
    d. 22.4 mol

36. What is conserved in the reaction shown? $N_2(g) + 3F_2(g) \quad 2NF_3(g)$
    a. atoms only
    b. mass only
    c. moles only
    d. mass and atoms only

37. At what temperature will a fixed mass of gas with a volume of 125 L at 15°C and 750 mm Hg occupy a volume of 101 L at a pressure of 645 mm Hg?
    a. -73°C
    b. 2°C
    c. 10.4°C
    d. 34°C

38. At which of the following temperatures will a gas diffuse through a room most rapidly?
    a. 30°C
    b. 20°C

c. 10°C
d. 0°C

39. Which of the following gas law describes the relationship between volume and number of moles?
    a. Boyle's law
    b. Dalton's law
    c. Charles's law
    d. Avogadro's law

40. What type of chemical reaction is shown below?

$$P_4 + O_2 \longrightarrow P_2O_5$$

    a. Decomposition reaction
    b. Combination (Synthesis) reaction
    c. Double Displacement reaction (metathesis)
    d. Single Displacement (replacement) reaction

41. Why is it possible for equal volumes of gases at standard pressure and temperature to contain equal numbers of particles?
    a. This is not possible.
    b. Gas particles are large in size.
    c. Gas particles are spaced far apart.
    d. The volume of a gas is inversely proportional to its mass.

42. Last summer vacation, Sanchez family decided to go to Boracay to have a beach party. On their way to Boracay, all of them were surprised when the tire suddenly exploded. What is the probable explanation for the blown out tire during a long summer drive?
    a. High temperature causes a decrease in volume.
    b. The amount of the gases inside the tire is increased.
    c. The mass of the gases inside the tire increases causing a blown up tire.
    d. The volume of gases increases as the temperature increases, causing a blown up tire.

43. What type of chemical reaction takes place when one element replaces another element from a compound?
    a. Acid-Base reaction
    b. Combustion (Burning)
    c. Double displacement (Metathesis)
    d. Single displacement (Replacement)

44. If the volume of a confined gas is doubled while the temperature remains constant, what change would be observed in the pressure?
    a. It would be double
    b. It would be ¼ as large
    c. It would be half as large
    d. It would be four times as large

45. How can you possibly prove that gases have negligible mass?

a. Support your claim of through equation.
b. Ask two persons to hold a box filled with air.
c. Feel the weight of the sample on both hands.
d. Put a balloon in a digital balance before and after you fill it with air.

46. Which of the following is the application of Charles's law?
a. sky lantern
b. vulcanizing tire
c. inhale and exhale process
d. d. rising hot air balloons

47. Which of the following statements is TRUE about single-replacement reactions?
a. They are restricted to metals
b. They involve a single product.
c. Two reactants produce two products.
d. Two reactants produce two products.

48. Which of the following phenomena best illustrates Charles' Law?
a. Carbon dioxide being dissolved in water.
b. Breathing apparatus being used by a patient.
c. Leavening agent causing the fluffiness of cake products.
d. Expansion of the balloon as it is being submerged in hot water.

49. Which of the following is TRUE about double-replacement reaction?
a. One of the reactants is often water.
b. The reactants are usually a metal and a nonmetal.
c. Energy in the form of heat or light is often produced.
d. The reactants are generally two ionic compounds in aqueous solution.

50. What will happen to the particles of the gas when the Kelvin temperature of an enclosed gas is doubled?
a. Move faster
b. Decrease in volume
c. Decrease in average kinetic energy
d. Strike the walls of the container with less force

51. James can still pump air in the party balloon even though it is already inflated. What explains this phenomenon?
a. The air inside the balloon is hot
b. Balloons are made up of plastic
c. Air molecules can be compressed
d. Balloons look better if its size is bigger

52. What are the standard temperature and pressure conditions for gases?
a. 0°C and 0 torr
b. 0 K and 760 torr
c. 0°C and 760 torr
d. -273 °C and 1 atm

53. How will you increase the pressure of a gas?
    a. Increase volume
    b. Decrease temperature
    c. Increase the number of gas particles
    d. Lower the kinetic energy of the gas molecules

54. The product of a combination reaction is $Ba(OH)_2$. If one reactant was H_2O what was the other reactant?
    a. Ba_2O
    b. BaO
    c. BaH
    d. BaO_2

55. What will happen to the gas particles if you increase the temperature of gas in a sealed container?
    a. It will move quickly.
    b. It will have more energy.
    c. It will exert greater pressure.
    d. Statement A, B and C is correct.

56. Which of the following is TRUE about the mass of the products in a chemical reaction?
    a. It is equal to the mass of the reactants.
    b. It is less than the mass of the reactants.
    c. It is greater than the mass of the reactants.
    d. It has no relationship to the mass of the reactants.

57. What will happen when a gas in a rigid container cools?
    a. Its volume increases
    b. Its volume decreases
    c. Its pressure increases
    d. Its pressure decreases

58. Which of the following is TRUE about chemical equations?
    a. describe chemical reactions
    b. describe only biological changes.
    c. show how to write chemical formulas
    d. give directions for naming chemical compounds

59. Why it is when you increase the volume of a given amount of gas at constant temperature causes the pressure to decrease?
    a. There are more molecules
    b. There are fewer molecules
    c. The molecules are moving more slowly
    d. The molecules are striking a larger area with the same force.

60. In a chemical equation, $H_2O_{2(aq)}$ $H_2O_{(l)} + O_{2(g)}$, what is the reactant?
    a. H_2O_2

b. H_2O
c. O_2
d. H_2

61. Which of the following is the reactant in a combustion reaction?
    a. Metal
    b. Nitrogen
    c. Oxygen
    d. Hydrogen

ANSWER KEY:

1.D	21.B	41.C
2.D	22.C	42.A
3.D	23.D	43.C
4.C	24.B	44.C
5.B	25.A	45.B
6.D	26.D	46.A
7.A	27.D	47.D
8.D	28.D	48.C
9.C	29.B	49.D
10.B	30.D	50.B
11.C	31.D	51.A
12.D	32.B	52.C
13.C	33.C	53.A
14.B	34.D	54.B
15.A	35.A	55.C
16.D	36.D	56.A
17.A	37.A	57.D
18.B	38.D	58.A
19.B	39.D	59.D
20.B	40.B	60.A
		61.C

Appendix B. Science Process Skills Inventory (SPS)

Science Process Skills Inventory

Student Questionnaire

Direction: Given below are for you to rate the following science processes skills used in the laboratory. Rate each skill by ENCIRCLING the number following the given key below:

1 – Never
2 – Sometimes
3 – Usually
4 – Always

Choose one of the above four choices that best expresses how much you currently use each of the following skills when you work on a science investigation.

Process Skills	Never	Sometime	Usually	Always
1. I can use scientific knowledge to form question.	1	2	3	4
2. I can ask a question that can be answered by collecting data.	1	2	3	4
3. I can design a scientific procedure to answer a question.	1	2	3	4
4. I can communicate scientific procedures to others.	1	2	3	4
5. I can record data accurately.	1	2	3	4
6. I can use data to create a graph for presentation to others.	1	2	3	4
7. I can create a display to communicate my data and observations.	1	2	3	4
8. I can analyze the results of a scientific investigation.	1	2	3	4
9. I can use science terms to share my results.	1	2	3	4
10. I can use models to explain my results.	1	2	3	4
11. I can use the results of my investigation to answer the question that I asked.	1	2	3	4
12. I can interpret the results after an exploration of a specific activity.	1	2	3	4

Adopted with modification from Arnold et al., (2009)