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Research Article

CONCRETE REPRESENTATIONAL ABSTRACT (CRA) AND ACADEMIC PERFORMANCE IN SCIENCE 9

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Abstract

This study investigated the effect of the Concrete–Representational–Abstract (CRA) strategy on the academic performance of Grade 9 learners in Science at a public technical-vocational school in Bohol during the 2025–2026 school year. Employing a descriptive instructional design, data were collected from 30 students through validated tests and quarterly grades before and after a four-week CRA intervention. Results indicated that pre-intervention performance was generally at the developing level ($M = 82.6$, $SD = 4.38$), while post-intervention scores rose to a higher achievement level ($M = 85.9$, $SD = 4.23$). A paired t-test confirmed a statistically significant improvement ($t = 16.23$, $p < .05$), suggesting that CRA effectively enhanced conceptual understanding and reduced performance variability. Findings support constructivist and scaffolded learning perspectives and highlight the value of learner-centered, evidence-based science instruction. An enhancement program integrating CRA-aligned strategies, professional development, and curriculum support is recommended to sustain improved learning outcomes and inform future research across science domains and grade levels in diverse educational settings.

Keywords: Concrete–Representational–Abstract, Science education, academic performance, scaffolded instruction, conceptual understanding.

INTRODUCTION

Teaching science in secondary education remains a persistent global challenge due to the subject's abstract, mathematical, and conceptually demanding nature. Numerous studies report that students struggle to connect theoretical science concepts with observable real-world phenomena, resulting in weak conceptual understanding and limited problem-solving skills (Bouchée *et al.,* 2022; Owen *et al.,* 2008; Ogunleye, 2009). Traditional lecture-based instruction, still prevalent in many classrooms, often emphasizes symbolic manipulation without adequately scaffolding students' transition from concrete experiences to abstract reasoning. As a result, learners often resort to rote memorization rather than developing meaningful conceptual understanding. International research increasingly highlights the effectiveness of scaffolded instructional strategies that integrate multiple representations to support conceptual development in STEM disciplines (Ainsworth, 2006; Satsangi *et al.,* 2018). The Concrete–Representational–Abstract (CRA) instructional framework has demonstrated positive effects in mathematics and science education by guiding learners progressively from hands-on manipulation (concrete), to visual modeling (representational), and finally to symbolic reasoning (abstract) (Miller & Hudson, 2007; Sealander *et al.,* 2012). Emerging evidence further suggests that integrated approaches linking representations enhance procedural fluency, conceptual understanding, and retention (Strickland & Maccini, 2016; Jaakkola & Veermans, 2019). However, much of the existing literature is situated in mathematics contexts or foreign educational settings, with limited empirical validation in Philippine secondary science classrooms. At the national level, recent assessment data from the President Carlos P. Garcia Technical Vocational School of Fisheries and Arts (PCPGTVSFA) in Bohol indicate that Grade 9 learners obtained a mean post-test score of 35.87% in science, which is substantially below the mastery level.

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This performance gap underscores the urgent need for structured, evidence-based instructional interventions that address the cognitive demands of abstract science concepts. Moreover, current educational reforms in the Philippines including the Philippine Professional Standards for Teachers (DepEd Order No. 42, s. 2017) and the MATATAG Curriculum (DepEd Memorandum No. 54, s. 2023) emphasize learner-centered, developmentally appropriate, and research-informed pedagogy. Despite these policy directions, localized empirical studies examining the impact of the CRA strategy in junior high school science remain scarce. This study is theoretically anchored in Bruner's Enactive–Iconic–Symbolic (EIS) model, which posits that meaningful learning progresses from action-based experiences to image-based representations and ultimately to symbolic reasoning (Bruner, 1966, 1983). Piaget's theory of cognitive development further supports this progression, particularly the transition from concrete operational to formal operational thinking (Piaget, 1952). Additionally, Vygotsky's sociocultural theory and the concept of the Zone of Proximal Development (ZPD) provide a framework for understanding how scaffolded instruction facilitates learners' movement toward independent conceptual mastery (Vygotsky, 1978). The CRA strategy operationalizes these theoretical perspectives by systematically structuring cognitive progression in science instruction. Given the persistent low performance in science 9 and the limited contextualized research on CRA implementation in Philippine secondary education, this study investigates the effectiveness of the Concrete–Representational–Abstract (CRA) strategy in enhancing students' academic performance. Specifically, it examines the academic performance of Grade 9 learners in Science 9 at President Carlos P. Garcia Technical Vocational School of Fisheries and Arts, Puerto San Pedro, Bien Unido, Bohol, during the School Year 2025–2026, evaluates performance before and after the implementation of the CRA strategy, determines whether the strategy significantly improves learning outcomes, and proposes evidence-based instructional recommendations to strengthen Science teaching practices.

METHODOLOGY

This study employed a descriptive design to examine changes in students' academic performance following the integration of the Concrete–Representational–Abstract (CRA) instructional strategy in Grade 9 Science. First-quarter grades were used as baseline data to describe students' prior academic performance and identify learning difficulties. The intervention was implemented during the second quarter, and second-quarter grades, together with posttest scores, were used to describe academic performance after exposure to CRA-based instruction. Formative, summative, and quarterly assessments were administered before and after the intervention to document performance changes aligned with the targeted Most Essential Learning Competencies (MELCs).

The study was conducted at President Carlos P. Garcia Technical Vocational School of Fisheries and Arts (PCPGTVSFA) in Barangay Puerto San Pedro, Bien Unido, Bohol, Philippines. The target population comprised all Grade 9 students enrolled during the School Year 2024–2025. Of the five Grade 9 sections, one Special Science Class (SSC) was excluded due to its advanced curriculum and higher academic standing to ensure comparability of participants. The remaining two sections were considered academically comparable based on school sectioning policies. Through simple random sampling, one intact section was assigned to the Concrete–Representational–Abstract (CRA) group, while the other section served as the conventional instruction group. Each section consisted of 30 Grade 9 students, and the CRA group received instruction using the Concrete–Representational–Abstract strategy over a four-week intervention period.

Instructional Materials and Intervention

The instructional intervention was grounded in the Concrete–Representational–Abstract (CRA) instructional framework, a structured pedagogical model designed to promote conceptual understanding through progressive cognitive representation. The CRA sequence facilitates learning by transitioning students from experiential manipulation of physical objects to visual representation and finally to symbolic abstraction. The intervention was implemented during the second academic quarter and covered the following Grade 9 Science topics: Uniform Motion, Projectile Motion, Impulse and Momentum, and Conservation of Mechanical Energy. These topics were selected based on identified learning gaps from first-quarter performance data and alignment with the Department of Education (DepEd) Most Essential Learning Competencies (MELC codes S9FE-IVa-34–35 and S9FE-IVb-36–37).

The CRA strategy was implemented over four (4) consecutive weeks, with three 60-minute instructional sessions per week. Each topic followed a structured instructional progression:

In the Concrete phase, students engaged in hands-on activities using physical materials such as toy cars, improvised launchers, meter sticks, and locally available manipulatives to model motion and energy transfer. Activities were structured to ensure observable measurement and guided inquiry. In the Representational phase, students translated observed phenomena into diagrams, motion graphs, vector models, free-body diagrams, and schematic representations. Teachers facilitated guided questioning to scaffold conceptual linkage between experience and visual abstraction.In the Abstract phase, students solved quantitative problems using mathematical formulas and symbolic equations related to kinematics, momentum, impulse, and energy conservation. Problem-solving tasks progressed from structured to independent application. Lesson plans integrating the CRA sequence were developed by the researcher following DepEd curriculum guidelines. To ensure pedagogical validity and content alignment, the plans underwent expert review by a Master Teacher in Science. Minor revisions were incorporated based on feedback prior to implementation.

The study utilized multiple research instruments to ensure comprehensive measurement of students' academic performance. The primary instruments included a researcher-developed pretest and a parallel-form posttest, supplemented by formative assessments, summative assessments, and the official quarterly examination. The pretest and posttest each consisted of 40 multiple-choice items designed to measure both conceptual understanding and problem-solving skills aligned with the identified Most Essential Learning Competencies (MELCs). To ensure content validity, a Table of Specifications (TOS) was constructed to provide proportional representation of learning competencies, cognitive levels, and content domains. All test items underwent expert review by a Master Teacher in Science and received approval from the School Principal to ensure compliance with Department of Education (DepEd) curriculum standards. Prior to administration, the instruments were pilot tested with a comparable group of Grade 9 students from a neighboring school. Internal consistency reliability was established using Cronbach's alpha, yielding a coefficient of $\alpha \geq 0.80$, which indicates good reliability. Items with low discrimination indices were revised or removed. Scores were transmuted using the official DepEd grading system with a 60% passing benchmark and interpreted according to established proficiency levels.

Data collection followed a structured four-phase procedure to ensure methodological rigor and consistency. Ethical clearance and administrative approval were secured before implementation, and written parental consent and student assent were obtained to uphold voluntary participation. Baseline data were gathered through the collection of first-quarter grades and administration of the pretest under standardized classroom conditions. The four-week CRA-based instructional intervention was then implemented during regular Science class hours, with instruction delivered by the researcher to maintain fidelity. A structured lesson guide ensured consistency in instructional sequencing, and formative assessments were conducted weekly to monitor student progress. Upon completion of the intervention, the posttest was administered under conditions comparable to the pretest. Summative assessment scores and quarterly grades were subsequently collected to provide additional measures of academic performance. All collected data were encoded and analyzed. Descriptive statistics, including arithmetic mean, standard deviation, variance, and percentage mean score, were computed to summarize student performance. Prior to conducting inferential analysis, statistical assumptions were examined; normality was assessed using the Shapiro–Wilk test, and homogeneity of variance was evaluated using Levene's Test where applicable. Given that parametric assumptions were satisfied, paired samples t-tests were employed to determine significant differences between pretest and posttest scores, while independent samples t-tests were conducted for group comparisons when necessary. The level of significance was set at α = 0.05. To determine the magnitude of the intervention's effect, Cohen's d was computed and interpreted using established benchmarks for small, medium, and large effects. Ethical standards were strictly observed throughout the study in compliance with Republic Act No. 10173 (Data Privacy Act of 2012), with confidentiality maintained through coded identifiers and secure data storage. Artificial intelligence tools were used solely for language refinement and manuscript organization, while all research procedures, analyses, and interpretations were independently conducted by the researcher in accordance with international publication ethics guidelines.

RESULTS AND DISCUSSION

The study investigated the effect of the Concrete–Representational–Abstract (CRA) strategy on the academic performance of Grade 9 learners in Science 9. The results indicate a measurable improvement in student performance following the implementation of the CRA instructional approach.

Descriptive Analysis of Academic Performance

As shown in Table 1, pre-intervention scores reveal that the majority of students performed at the Developing (40%) and Approaching Proficiency (30%) levels, with smaller proportions achieving Proficient (23%) and Advanced (7%) classifications. The pretest mean score was 82.6 (SD = 4.38), suggesting moderate variability and indicating that most learners possessed foundational knowledge but had not yet reached higher conceptual mastery.

Table 1. Academic performance of grade 9 students before CRA

Score Range	Performance Level	Before CRA	
		Frequency	Percentage
90–100	Advanced	2	7%
85–89	Proficient	7	23%
80–84	Developing	12	40%
75–79	Approaching Proficiency	9	30%
Below 75	Beginning	-	-
Total		30	100%
Mean:	83	SD	4.38

Post-intervention results (Table 2) show a clear upward shift in performance distribution. The proportion of students classified as Advanced increased to 30%, while those at the Proficient level rose to 27%. Students at Approaching Proficiency declined to 3%, and none were classified as Beginning. The posttest mean increased to 85.9 (SD = 4.23), representing a mean gain of 3.3 points.

The slight reduction in standard deviation indicates more consistent outcomes across learners, suggesting that the CRA strategy not only improved achievement but also helped standardize performance.

Table 2. Academic performance of grade 9 students after CRA

Score Range	Performance Level	After CRA	
		Frequency	Percentage
90–100	Advanced	9	30%
85–89	Proficient	8	27%
80–84	Developing	12	40%
75–79	Approaching Proficiency	1	3%
Below 75	Beginning	-	-
Total		30	100%
Mean:	86	SD:	4.23

Table 3 presents the inferential analysis comparing students' academic performance before and after the CRA intervention. The mean score increased from 82.6 (SD = 4.38) prior to the intervention to 85.9 (SD = 4.23) post-intervention, resulting in a mean difference of 3.3. The computed t-value of 16.23 with a corresponding p-value of 0.001 indicates a statistically significant difference at the 0.05 level. The null hypothesis, which states that there is no significant difference in academic performance before and after the CRA intervention, is therefore rejected. This confirms that the CRA strategy contributed to a meaningful improvement in Science achievement. The observed improvements align with Bruner's (1978) scaffolding framework and theory of representation, as well as Piaget's (1952, 1972) cognitive development theory. By progressing from concrete manipulation to representational modeling and finally to abstract reasoning, learners construct knowledge meaningfully rather than rely on rote memorization. Integrated CRA approaches (Strickland & Maccini, 2016; Moreno *et al.,* 2011; Jaakkola & Veermans, 2019) further emphasize the simultaneous use of concrete, representational, and abstract forms, enhancing procedural fluency, conceptual understanding, and retention. Vygotsky's (1978) Zone of Proximal Development also supports the findings, highlighting that guided instruction, scaffolding, and peer collaboration enable learners to move from assisted to independent problem-solving. From a policy perspective, the CRA strategy aligns with the Philippine Professional Standards for Teachers (DepEd Order No. 42, s. 2017) and the MATATAG Curriculum (DepEd Memorandum No. 54, s. 2023), which emphasize learner-centered, developmentally appropriate, and evidence-based teaching approaches. Despite being conducted over four weeks and within a single school context, the combination of descriptive improvements, statistical significance, and performance-level gains provides robust evidence that the CRA strategy effectively enhances both academic achievement and performance consistency among Grade 9 Science learners.

Table 3. Significant difference in academic performance of Grade 9 students before and after the CRA intervention

Groups	Mean	SD	Mean Difference	Computed Value T-value	p- value	Decision on Ho	Interpretation
Before CRA	82.6	4.38	3.3	16.23	0.001	Reject the null hypothesis	Significant
After CRA	85..9	4.23					

Conclusion

This study highlights the significance of adopting structured, representation-based instructional strategies, such as the Concrete–Representational–Abstract (CRA) approach, in fostering meaningful learning in Science education. By aligning instruction with learners' cognitive readiness and guiding them from concrete experiences to abstract reasoning, the study demonstrates that students are better able to develop conceptual understanding, problem-solving skills, and active engagement in the learning process. Instructional approaches that scaffold understanding, integrate multiple representations, and encourage guided exploration not only support individual academic growth but also contribute to more consistent learning outcomes across the classroom. The study carries important implications for teaching, curriculum development, policy, and educational equity. Pedagogically, educators are encouraged to prioritize strategies that connect experiential learning with symbolic reasoning, promoting critical thinking and conceptual understanding over rote memorization. At the curricular level, planners can embed representation-based frameworks and scaffolded approaches into lesson design, particularly for abstract and mathematically intensive topics, to enhance comprehension and retention. From a policy and professional development perspective, teacher training programs should emphasize the implementation of CRA and integrated instructional strategies, supporting evidence-based, learner-centered teaching aligned with national standards. Furthermore, structured approaches like CRA can reduce variability in performance, helping learners who struggle with abstract concepts and fostering more equitable learning outcomes within diverse classrooms. For future research, longitudinal studies are recommended to examine the long-term retention and transfer of knowledge when using CRA strategies across various Science topics and grade levels. Comparative studies between sequential CRA and Integrated CRA (CRA-I) approaches could identify which instructional sequence most effectively enhances conceptual understanding and procedural fluency. Additionally, investigations into collaborative learning, peer-mediated scaffolding, classroom environment, learner motivation, and teacher fidelity of implementation would provide deeper insights into factors influencing the success of CRA interventions. Expanding the research to multiple schools and regions can generate localized and generalizable evidence to guide curriculum planning, instructional practices, and policy-making in Science education.

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