
Improving the Grade-9 Students' Academic Performance on Chemical Bonding through Code-switching Techniques

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ABSTRACT

Code-switching, or the practice of shifting between two or more languages during conversation, is increasingly being recognized for its valuable role in enhancing learning in the science classroom. Objective: This action research was conducted to test the effectiveness of code-switching in improving the academic performance of Grade 9 students on chemical bonding at the Claveria School of Arts and Trade, in Cagayan Valley, Philippines. Methods: The subjects were Grade 9 students, consisting of 17 males and 16 females. The study followed a one-group pretest-posttest quasi-experimental research design, using the pretest and posttest scores as main sources of data. Findings: The study found that using code-switching as a teaching strategy proved to be highly effective in helping Grade 9 students understand chemical bonding. The noticeable improvement in their scores from the pretest to the posttest, backed by a very large effect size (Cohen's $d = 3.42$), clearly shows that the intervention had a positive influence on their learning. Novelty: This research presents an innovative model for bilingual educators, promoting the use of code-switching across different subject areas to improve student achievement by catering to their varied language skills.

Keywords: *Students' Academic Performance, Code-Switching Instruction, Chemical Bonding, Grade 9 Chemistry*

INTRODUCTION

Across the globe, science curricula play a key role to build students' scientific literacy, critical thinking, and problem-solving skills. Educators keep improving science education to include vital topics like chemistry, physics, biology, and earth science as part of a worldwide push to enhance education. Chemistry, in particular, serves as a core area that helps students grasp the properties, relationships, and changes of matter—a crucial aspect to make sense of their surroundings (Kausar et al. 2022). Yet, despite its importance many students see chemistry as one of the hardest and least interesting subjects because of its abstract ideas, technical terms, and complex symbols (Suson et al. 2020).

In the context of the Philippines, there have been persistent efforts to better integrate science into the national curriculum (Saro et al., 2023). Yet, student academic performance in science remains below international standards. The 2023 Programme for International Student Assessment (PISA) shows that almost no Filipino students reached Levels 5 or 6 in science literacy, while the Organization for Economic Cooperation and Development (OECD) average stands at seven percent. These findings highlight a serious problem with the quality of science education in the country.

Through a review of the literature, research was done to determine the factors influencing secondary students' learning of chemistry, which revealed factors like teaching approaches, class size, and content area (Sibomana et al., 2021). Taking the problem into account in the local context, the researchers used an observational checklist to examine the behavior of the Junior High School students at Claveria School of Arts and Trade (CSAT) related to the present issue. Careful analysis of the feedbacks revealed that the students struggle with learning chemistry due to difficulty in grasping and comprehending the fundamental and basic concepts. Chemistry is branded as the most hated subject in science, with students likely to fail and demonstrate low

academic performance in conceptual reasoning and academics (Espinosa, 2014).

To further prove the existence of the problem inside the classroom, gap analysis was used by the researcher to pinpoint disparities between the school's actual and anticipated academic performance in teaching Chemistry topics, facilitating the identification of the underlying issue. The result of the thorough analysis revealed the prevalence of low academic performance in Chemistry among most Grade-9 students which hinders their ability to think critically. Among the many topics of Chemistry, Chemical Bonding stands out as one of the most difficult concepts to teach, especially for students in high school and college due to the complexity of the underlying theories and abstract models of chemical bonds (Lahlali et al., 2023). This complexity makes it not only challenging to teach but also difficult for students to understand, leading in misconceptions (Meltafina et al., 2019).

The Problem Tree thoroughly elaborated on the reasons behind students' low academic performance in chemistry topics. It includes students' inactivity during chemistry classes, irregular attendance in chemistry classes, their perception of the subject is boring, and lack of oral and written proficiency in science. These immediate triggers were categorized as causal factors, uncovering the root causes to be lack of self-awareness of their strengths and weaknesses, inability of parents to provide enough financial support, limited school budget allocation, not practicing code-switching that hinders understanding; lack of vocabulary, and students are more into Technology-Enhanced Learning. The way students learn chemistry could also affect their academic performance in the subject (Montenegro & Cascolan, 2020).

The Problem Tree directed the researcher to analyze the root causes and find solutions to the identified problem leading to crafting the opportunity tree. Completion of it clarified that the root solutions to solve the issue that—Most of the Grade-9 Students have low academic performance in Chemistry topics were: conduct

activities that promote self-awareness and self-efficacy, implement scholarship or incentive programs for consistent attendance, develop low cost instructional materials by teachers, implement code-switching to bridge understanding, enrich students' vocabulary through active learning techniques, and use multi-media and visual aids to enhance learning.

Optimal solutions were presented and organized based on its significance to solving the problem, using a scale of 1 to 6, where 6 meant top priority and 1 meant the least. The logical study and systematic ranking of the root solutions stressed that, —The teacher will implement code-switching techniques to bridge understanding], ranked first with a total of 100 points, meaning, that it was the most prioritized, most needed, most significant, most appropriate, most attainable, and most timely. Code-switching, or making a transition between two or more languages while conversing, is becoming more and more acknowledged for its educational advantages in the science classroom (Yildiz et al., 2021). According to research, code-switching can improve students' comprehension by boosting confidence, improving engagement, and making the material more approachable (Panuntun & Hayati, 2022). Furthermore, teachers and students both gain advantages from the use of code-switching in Philippine high school classrooms because it leads to more meaningful discussions and helps students conceptualize better ideas during class. (Villanueva & Gamioa, 2023). It is within this context that the researchers conceived this action research to improve the Grade 9 students' academic performance on Chemical Bonding at Claveria School of Arts and Trades using Code-switching techniques.

Objectives of the Study

This action research aimed to enhance Grade 9 students' academic performance on chemical bonding by implementing and evaluating the effectiveness of code-switching techniques in the classroom. The research study answered the following questions: (1) What is the pretest performance of the Grade-9 students in chemical

bonding before being exposed to code-switching instruction? (2) What is the posttest performance of the Grade-9 students in chemical bonding after being exposed to code-switching instruction? (3) Is there a significant difference between the pre-test and post-test scores of the students? (4) What is the effect size of code-switching instruction on improving the performance of

Grade 9 students in chemical bonding? (5) What activity plan can be developed to improve the performance of students on chemical bonding through the effective use of code-switching instruction?

MATERIALS AND METHODS

Research Design

The study follows a pretest posttest design to assess changes before and after the intervention. In this design, one group of subjects received measurements of the same dependent variable both before (pretest) and after (posttest) the use of code-switching techniques.

Sampling Technique

Purposive sampling was employed to deliberately select subjects based on specific criteria relevant to the objectives of the study. The study subjects comprised of 33 Grade 9 students from CSAT. The Grade 9 students were selected as subjects for this study because according to the observation checklist, they appeared to be passive during chemistry topics, likely due to the challenging concepts. Some science teachers who are professionals in the field also suggested this class, as it includes most of the slow learners at the Grade 9 level.

Locale of the study

The study was carried out at CSAT, one of the most populated high schools in the area. Located in Centro 1, Claveria, Cagayan, CSAT has been serving the community since its establishment in 1967 as a technical-vocational school.

Dedicated to equipping students with the skills needed in today 's workforce, CSAT stays true to its mission of nurturing individuals who embody excellence, a strong

work ethic, and a deep sense of responsibility to society. The school aims to prepare its graduates to thrive in a fast-changing and competitive world.

To achieve this vision, CSAT continues to uphold its reputation as a provider of quality education. It strives to instill in its students a love for work, strong moral character, personal discipline, and technical and vocational competence—all essential for national development.

As one of the leading Tech-Voc institutions in Region 2, CSAT takes pride in its dedicated faculty who play an active role in shaping the future of Filipino learners and contributing to the nation's progress.

Research Instruments

1. Performance Test in Chemical Bonding. To determine the performance of students in Chemical bonding, the researchers constructed a test. The following procedures were followed:

a) Preparation of Test Items.

The first step in the construction of test was to examine the course content and textbooks used by the Grade 9 students. These became the bases for the table of specifications on which the test was based. The test covered the topics on—Ions and Molecules, Ionic Bonding, and Covalent Bonding. Each test item consisted of four choices. It was then subjected for face and content validation for appropriate modification if deemed necessary.

b) Pilot Evaluation

The 40 items were pilot tested to students who have taken Chemistry to test the content validity and reliability using the index of difficulty and index of discrimination.

c) Revision of the Test

The performance test in Chemical Bonding was revised on the basis of the results of the pilot testing. Some items of the test, which consisted initially of 40, were retained, discarded, and/or revised, reducing to 30 items.

Grade	Descriptive Value
90 and above	Outstanding
85-90	Very Satisfactory
80-84	Satisfactory
75-79	Fair
74 & below	Did not Meet Expectation

The researchers used a pretest and posttest, each consisting of 30 items. The pretest was administered to assess the students' baseline skills and knowledge in chemistry topics prior to the exposure to code switching strategy. Then they interpreted the academic performance of students from their pretest and posttest result utilizing the following criteria according to DepEd Order No. 8 Series 2015:

2. Lesson Plans

Lesson plans were carefully developed integrating the code-switching techniques. The content is under Chemistry about chemical bonding which included the lessons such as Ions and Molecules, Ionic Bonding, and Covalent Bonding.

Data Gathering Procedure

1. Pre-intervention Phase

a. Root Cause Analysis

The researchers conducted an observation checklist among the Grade 9 students at CSAT to examine the root causes that may affect their skills and prevent them from participating well during class hours. From the observation, the researchers obtained an analysis concluding that—the students are passive when English is used as the medium of instruction because they lack comprehension skills that hinder their critical thinking. At times, students find studying English confusing and boring because they will struggle in comprehending the materials (Gerungan et al., 2020).

b. Choosing the best Possible Solution

To solve this, the researchers inferred that the code-switching techniques is the best solution to address the problem. Code-switching can assist

with translating new words, clarifying difficulty vocabulary, facilitating student understanding of new subjects, and strengthening word knowledge (Shabir, 2017; Cahyani et al., 2018). Shabir (2017) likewise reported that using the first language can be helpful in certain situations, particularly for students who do not know much English yet. The researchers used Tag-lish medium to improve the Grade-9 students' performance in chemical bonding at CSAT. The researchers administered a standardized pretest to measure the students' baseline skills and knowledge about the subject matter. Moreover, the researchers ensured the reliability and validity of the test by consulting the Science teachers in CSAT and one Assessment of Learning I teacher in the faculty of Teacher Education in CSU Sanchez Mira Campus.

2. Intervention Phase

The researchers utilized Taglish or also known as Tagalog-English medium while using Code-switching techniques. Tagalog and English Language are commonly used in the Philippines. As Manlapig (2020) emphasized, learning and mastering the mother tongue lays a strong foundation for understanding a second language. Before focusing on English, it is important that learners first develop a solid grasp of their first language. There are two primarily types of code-switching, this includes intersentential code-switching and intrasentential code-switching. The researchers utilized Inter-sentential Code-Switching and Intra-sentential code-switching in teaching chemistry subject. Intersentential code-switching is the switching between languages at the sentence boundary; for example, "*A molecule is a combination of two or more atoms. Kung paghahaluin natin ang oxygen at hydrogen ito ay isang molecule.*" Conversely, intrasentential code-switching is the mixing of languages within a one sentence. "*The combination of*

two or more atoms ay isang molecule" It is interesting to note that science teachers have the most intra-sentential switches among other techniques. This can be explained by the nature of their topic, which covers difficult and sophisticated ideas requiring careful explanation, visual aid, and even demonstration. (Villanueva & Gamioa, 2023). The researchers conducted regular meetings for 15 days in the Grade-9 students during science class hours. The researchers implemented the carefully designed lesson plan integrating the intervention which is code-switching techniques. The researchers administered a standardized posttest following three weeks or 15 days of regular sessions where the lesson plans are implemented and Code-switching techniques is used.

3. Post-Intervention Phase

After the intervention was carried out, the researchers administered a posttest identical to the pretest. The researchers compared the pretest and posttest scores of the students to analyze the results for any significant improvements. A comprehensive report was prepared to communicate the findings and results of the study to other research teams and educators. The researchers constructed a report writing of the results and findings of the study, and thereafter, they presented it to teachers during Learning Action Cell (LAC) sessions and to other researchers with the same specialization. Some schools in Northwestern Cagayan have officially adopted the code-switching as a pedagogical tool. The strategy is now being followed as part of the school's instructional practices to improve learning outcomes in Science.

Analysis of the Data/ Statistical treatment

To determine if code switching instruction can improve the academic performance of Grade 9 students in chemistry, these statistical tools were employed as follows: Mean and standard deviation were utilized to analyze the pretest and posttest performance before and after exposure to code switching instruction. Cohen's d

was used to analyze the effect size of Code-switching techniques in improving the performance of students in chemistry. The significance of variations between the pretest and posttest scores was ascertained by means of paired sample t-test.

RESULTS AND DISCUSSION

Students' Academic Performance Before Code-switching Techniques

Table 1. Academic performance of the students before being exposed to code-switching techniques.

Transmuted Score	Frequency	Percentage	Descriptive Value
90 and above	0	0	Outstanding
85-90	0	0	Very Satisfactory
80-84	0	0	Satisfactory
75-79	0	0	Fair
74 & below	33	100%	Did not Meet Expectation
<i>Mean Score = 68.06 (Did Not Meet Expectation)</i>			

The academic performance of the students in understanding chemical bonding before being exposed to code-switching techniques is presented in Table 1. The table reveals that all (33) or 100 percent achieved a grading scale of 74 and below, which indicates that they did not meet expectations.

The mean percentage score among 33 Grade 9 subjects in the pretest was 68.06. According to DepEd Order No. 8 Series 2015, the mean percentage score corresponding to a grading scale of 74 and below and is categorized as "did not meet expectations". This implies that the students faced significant challenge in understanding the concepts of chemical bonding. This suggests that their knowledge and performance were insufficient to process or to understand the different complex terms in chemical bonding.

According to the study by Kausar et al. (2022), many high school students struggle to understand fundamental

chemistry concepts because of its abstract nature, the classroom teaching strategies, not having enough tools and resources for teaching, and the complexity of chemistry concepts.

Students' Academic Performance after Code-switching Techniques

Table 2. Academic performance of the students after being exposed to code-switching techniques.

Transmuted Score	Frequency	Percentage	Descriptive Value
90 and above	9	27.27	Outstanding
85-90	13	39.40	Very Satisfactory
80-84	5	15.15	Satisfactory
75-79	3	9.09	Fair
74 & below	3	9.09	Did not Meet Expectation
<i>Mean Score = 86.42 (Very Satisfactory)</i>			

The academic performance of the students in understanding chemical bonding after being exposed to Code-switching techniques is presented in Table 2. The table shows that out of 33 subjects, nine or 27.27 percent of the subjects obtained a transmuted score of 90 and above indicating "Outstanding" remarks based on their average grade of 95.22. Most (13) or 39.40 percent achieved "Very Satisfactory" remarks with transmuted scores ranging from 85-89. Five or 15.15 percent reached "Satisfactory" remarks with 80-84 transmuted scores range. Three or 9.09 percent reached "Fair" remarks with transmuted scores ranging from 75-79. Three or 9.09 percent with transmuted scores ranging from 74 and below remained at "Did Not Meet Expectations" remarks; however, it is important to note that these subjects showed an improvement compared to their pretest scores.

The mean percentage score of the subjects in understanding chemical bonding with the Code-switching techniques is 86.42 or "Very Satisfactory". This means that, on average, students have progressed in their

performance to a point where they are able to understand the core concepts of chemical bonding and Code-switching techniques is effective.

In scientific classroom, code-switching is the practice of communicating in two or more languages which is increasingly recognized for its educational benefits. (Yildiz et al.,2021).

Comparison of Students' Pre-Test and Posttest Scores before and after Exposure to Code-switching Techniques

Table 3. Significant difference between the mean scores of students in their pretest and posttest.

Test	Mean	Standard Deviation	t-value	p-value	Level of Significance	Remarks
Pretest	68.06	2.41	15.99	0.000	0.01	Highly Significant
Posttest	86.42	7.19	7			

Table 3 shows the students' pretest and posttest scores before and after their Code-switching techniques exposure. The table provides the information that a significant difference exists between the students' pretest and posttest mean scores. The pretest mean score was 68.06, with a standard deviation of 2.41. Once the intervention was over, the posttest mean score rose to 86.42, with a higher standard deviation of 7.19. This significant increase implies that the intervention was effective in improving the students' knowledge or skills.

A highly significant difference between pretest and posttest scores of the students who received code-switching techniques about chemical bonding is indicated by the t-value of 15.997. More significantly, the observed difference is statistically highly significant because the p-value of 0.000 is less than the significance level of 0.01. This indicates how well code-switching techniques improve students' academic performance in chemical bonding.

The findings above suggest that teachers should employ and promote code-switching in their lessons. According

to Mbwile (2023), he asserted that code-switching is necessary due to majority of students have poor English language proficiency, which makes it challenging for them to understand the subject if it is explained solely in English.

Effect Size of Code-switching Techniques on Students' Academic Performance of Chemical Bonding

Table 4. Effect size of code-switching techniques in the academic performance of students in understanding chemical bonding.

Test	Mean	Standard Deviation	Cohen's D Effect Size Value	Remarks
Pretest	68.06	2.41	3.42	Very Large Effect
Posttest	86.42	7.19		

Table 4 shows the effect size of Code-switching techniques on the academic performance of the students in understanding chemical bonding. A group of 33 students showed marked improvement from a pretest mean score of 68.06 with a standard deviation of 2.41 to a posttest mean of 86.42 with a standard deviation of 7.19. Most notably, the computed Cohen's d effect size is 3.42, which far exceeds the threshold for a large effect (≥ 0.80). The large effect/strong effect means that Code-switching techniques not only improved performance but did so to a degree that is statistically and educationally significant. Thus, it further implies that the intervention used by researchers is very effective in teaching Chemical Bonding.

According to Panuntun and Hayati (2022), code-switching can improve students' performance by boosting confidence, improving engagement, and making the material more approachable. In addition, according to Anore (2019), switching between the English and Filipino code may improve academic performance.

Table 5. Sustainability plan to sustain/improve/maximize the utilization of the intervention

Strategies (Courses of Actions)	Programs (Implementation or Operationalization Of The Strategies)	Activities (Set of Tasks to Carry Out the Program)	Tasks (Day- To-Day Individual Assignments)	Resources		Financial	Timeline
				Physical/ Human	Materials		
Strengthen Teacher Expertise on Code- Switching	Conduct Code- Switching Training Workshops	Develop curriculum, conduct 2-day training	Prepare materials, schedule venue, facilitate sessions	Researchers, Teachers, Admin Staff	Training manuals, videos	Php 1,200 – For printing training manuals, renting venue, audiovisual equipment& refreshment for subjects	2 days (within 1 month)
Embed Code- Switching in Daily Instruction	Integrate Bilingual Materials	Design lesson plans, quizzes, pilot materials	Teach lessons, gather feedback, revise materials	Science Teachers, Instructional Coordinators	Lesson plans, handouts, quizzes	Php 400 – For printing bilingual handouts and quiz papers	Semester - long (ongoing)
Build Continuous Support through Peer Mentoring on Code- Switching	Launch Code- Switching Mentoring & Coaching Program	Pair experienced teachers skilled in code- switching with less experienced teachers	Conduct weekly mentoring sessions focused on sharing best practices in code- switching, observing bilingual lessons, and providing constructive feedback	Mentor Teachers familiar with code- switching strategies, Researchers	Coaching guides focused on bilingual instruction, observation checklists targeting language use	Php 600 – For printing mentoring guides and observation tools specifically on code- switching strategies, plus light snacks to encourage participation during sessions	4 weeks
Monitor and Evaluate Student Progress	Classroom Observations & Assessments	Create tools, observe classes, administer quizzes	Record observations, grade, analyze data	Researchers; Mentors	Checklists, assessment forms	Php 300 – For printing observation checklists and assessment forms	Monthly
Share Research Findings and Best Practices on Code- Switching	Prepare presentations and resource kits highlighting the benefits and practical implementation of code-switching in science classes	Prepare presentations and resource kits highlighting the benefits and practical implementation of code- switching in science classes	Present research results on code- switching effectiveness to faculty and staff, organize workshops or seminars to discuss strategies, distribute resource kits containing bilingual lesson plans and teaching guides	Researcher, Teachers, Admin, Staff;	Slide decks focusing on code- switching, printed resource kits including sample lesson plans and instructional materials	Php 700 – For designing and printing code- switching resource kits, presentation materials, and workshop handouts to facilitate school- wide adoption	2 months
Institutionalize Code- switching techniques	Advocate Policy Integration	Draft proposal, hold meetings, present to leadership	Prepare documents, schedule meetings, follow-up	Researchers,School Leaders;	Proposal drafts, presentations	Php 0 – No cost anticipated	3 Months

Sustainability Plan to Sustain/Improve/Maximize the Utilization of the Intervention

Table 5 outlines a sustainability plan that lays out simple and practical ways to continue using code-switching in teaching chemical bonding to Grade 9 students. The goal is to keep the positive results of the research going even after it ends. The plan is organized into several key parts.

It starts with the strategies, or the main approaches the support these strategies. The activities describe what teachers and students will actually do, while the resources list the materials or people needed to carry them out. The financial part shows if any costs are involved. Lastly, time allocation explains how often or how long each activity researchers to keep code-switching in the lessons. Then it

includes programs, which are school-based efforts to will take. With this plan, the researchers hope to make code-switching a regular and effective part of science teaching, so that more students can understand and enjoy learning complex concepts like chemical bonding.

This sustainability plan aims to ensure the continued use and effectiveness of code-switching strategies in teaching chemical bonding to Grade 9 students.

CONCLUSION

Code-switching techniques intervention proved effective in teaching chemical bonding to Grade 9 students. The increase in their scores from pretest to the posttest, in addition to the very large effect size (Cohen's $d = 3.42$) confirms that the intervention significantly improved the performance of Grade 9. The results support the efficacy of the Code-switching techniques as a technique for education and underscore its potential to improve the performance among Grade 9 students.

RECOMMENDATIONS

Teachers may intensify the utilization of Code-switching techniques in chemical bonding in science, making complex concepts more accessible to students. They may adapt code-switching techniques in delivering or explaining scenarios that will extrapolate scientific concepts. Furthermore, future educators may integrate Code-switching techniques across different subject areas, especially in bilingual or multilingual classroom where students have diverse needs and varying language proficiencies.

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