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Multimodal Semiotics in Designing Science Learning Set for an Improved Science Process Skills of Grade 9 Learners

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ABSTRACT

The study aimed to design a Multimodal Semiotics science learning set to improve the science process skills of the learners. This was utilized throughout the teaching and learning process in two selected topics in grade 9 science. The learners initially encountered various activities in different modes, like visual, auditory, and kinesthetic. Afterward, the learners are exposed to various semiotic representations to make meaning to their understanding, such as tables, graphs, illustrations, and oral or written explanations. The researcher used descriptive-developmental research, involving 65 Grade 9 learners of Sta. Filomena Integrated School during the school year 2024-2025. Simple descriptive statistics such as frequency and percentage count formulas were used for the pre-and post-performance assessment and the evaluation of the experts' perception of the acceptability of the designed multimodal semiotics science learning set. A paired sample t-test was used to determine whether there was a statistically significant difference in the means of the pre-and post-performance assessment scores of Grade 9 learners in science process skills before and after they utilized Multimodal Semiotics Science Learning Set. The result indicated a significant difference between the pre-and post-performance assessment in basic science process skills after exposure to multimodal semiotics science learning set in classifying, communicating, and predicting. However, in terms of observing, measuring, and inferring, no significant difference was established from the post-performance assessment. Results also revealed a significant difference between the pre-and post-performance assessment in all integrated science process skills after the exposure to multimodal semiotics science learning set in terms of controlling variables, defining operationally, formulating hypotheses, experimenting, interpreting data, and formulating models. Furthermore, the evaluation by the expert perceived that all indicators of adequacy, coherence, and appropriateness of the designed multimodal semiotics science learning set were highly acceptable.

Keywords: Multimodal semiotics, science learning set, basic science process skills, integrated science process skills.

1. Introduction

The Philippines' K to 12 science curriculum aims to enhance basic education and align it with global standards by focusing on three core areas: understanding and applying scientific knowledge, nurturing scientific attitudes and values, and fostering scientific literacy (Barrot, 2023). Globally, scientific literacy remains the ultimate goal of science education and is evaluated through tools like the Program for International Student Assessment (PISA), as cited by Istyadji (2023). Scientific literacy involves grasping scientific concepts and processes and making informed, ethical decisions to solve real-world problems. A key component is the development of science process skills (Husna, 2022).

Despite these efforts, Filipino students continue to struggle with scientific literacy. Dolapcioglu (2022) noted that students' limited science process skills hinder their literacy development. This is supported by the most recent PISA 2022 results, which placed the Philippines 77th out of 81 nations, highlighting ongoing educational difficulties. Even though DepEd Secretary Senator Sonny Angara (2024) noted some minor advancements over prior years, he underlined the necessity of substantial reforms. In response, the Department of Education introduced the MATATAG curriculum under DepEd Order No. 10, s—2024, which seeks to simplify competencies and instructional time while focusing on foundational skills.

To achieve this, science educators are encouraged to prioritize process skills through engaging, hands-on tasks supported by appropriate learning materials (Gizaw et al., 2024). Integrating multimodal semiotics—symbols, graphs, tables, and visual cues—can support meaning-making in science education. Amid these reforms, the Department of Education remains committed to delivering inclusive, quality education and nurturing lifelong learners.

Recent diagnostic assessments conducted in July 2024 revealed that many students at Sta. Filomena Integrated School demonstrated poor performance in science, with some scoring as low as 1 out of 25 despite comprehensive instruction. With an average Mean Percentage Score (MPS) of only 60.43 over two years in Grade 9 Science, students' mastery remains at a basic level. Lack of teacher creativity, low interest, and passive classroom behavior contributed to this problem. (Kamba, 2018).

Educators are urged to adopt creative, student-centered strategies and improve existing learning materials to address these challenges. Hansen and Richland (2020) highlighted the role of multimodal semiotics in helping students comprehend complex scientific relationships. For this reason, the researcher created a Multimodal Semiotics Science Learning Set to improve students' knowledge of the scientific method. To promote deeper conceptual learning, these interactive sessions included kinesthetic, visual, and aural exercises and resources, including tables, graphs, and written explanations.

2. Review of Related Literature

2.1 Multimodal Semiotics

In this study, multimodal representations were used, such as videos, symbols, images, and textual elements for visuals, records, and discussion for auditory and hands-on activities for kinesthetic such as experimentation. According to Evanick (2023), multimodal is incorporated in various subjects like science. It can support students' diverse learning styles, improve critical thinking, and help them better remember and recall information to grasp particular subjects through various representations.

Various representations based on the study of Novitasari et al. (2021), the faculty of teacher training at the University of Maret, Indonesia, these representations are related to visual representations, expressions or equations, and descriptions or statements. Learners who have good representation skills can easily translate their problems into visual representations (tables, pictures, graphs), symbolic representations (formulas, symbols), and verbal representations (word or written). Since science has complex topics that teachers and learners cannot understand well, these representations can help them in that matter.

After the learners' exposure to multimodal representations, they incorporated semiotics techniques, according to Knain et. Al (2021), utilizing semiotics, initially uses multimodal to understand the concept. Afterward, learners drew their understanding, and meaning-making was created using various representations that led to the materiality of the tool's shape for social interactions.

In addition, Danielsson & Selander (2021), states that semiotic resources were used to organize our knowledge for better communication with others. It can also be viewed as multimodal to make meaning using color, verbal language, images, or gestures. In this research, multimodal representations used to interpret and make meaning about the factors affecting climate and how these factors influence climate change through constructing their representations and allow learners to make their own explanation.

Moreover, they allow the individuals to display their engagement through multimodal semiotics, like drawing based on their understanding on a particular topic (Bezemer et al. (2012). Afterward, they let them to explain the illustration to check if their answer is correct. This multimodal semiotics consist of visual, auditory, and kinesthetic senses that make meaning about concepts aligned with the DepEd curriculum in encouraging teachers to used various pedagogies catering different learning styles.

2.2 Multimodal Semiotics

The concept of science process skills in this study is anchored in the work of Kurniawati (2021), a master's graduate in Sociology from the University of Indonesia. Her research identifies two categories of science process skills: basic and integrated. Basic science process skills include observing, classifying, measuring, communicating, inferring, and predicting. In contrast, integrated science process skills encompass controlling variables, defining operationally, formulating hypotheses, conducting experiments, interpreting data, and constructing models.

Science process skills are not only intended for acquiring various concepts inside the classroom but also uses in everyday life of an individual such as observing, classifying, inferring, predicting, and experimenting. By applying these skills outside the classroom, individuals become more analytical and thoughtful when addressing problems in their daily lives (Inayah et al, 2020).

Moreover, science process skills are thought to provide learners with relevant learning experiences because they assist learners in achieving high-level thinking. Science process skills are cognitive abilities that are used to process information, solve issues, and draw conclusions (Darmaji et. al, 2019).

In a classroom setup, it has been discovered that combining teacher guides with student worksheets created using Moodle platform can meaningfully improve the science process skills of the learners. According to the Irdalisa, et al (2022) in the study of Anjugam et.al (2024), these digital resources offer interactive, structures learning experiences that promote skill development. Wherein in makes possible to create personalized learning resources that meet the need of the students and encourage active participation,

It was supported by the study of Kusuma & Rusmansyah (2021) that the creation of instructional models and pertinent teaching resources is essential for developing students' science process skills. These tools offer students organized chances to actively interact with scientific ideas in a variety of subjects such as Biology, Chemistry and Physics. Students are thus better able to observe, hypothesize, experiment, and make conclusions- all of which are fundamental abilities required for studying science.

2.3 Conceptual Framework

INPUT	PROCESS	OUTPUT
I. Diagnosing Student's Science Process Skills **Basic Science Process Skills** Observing Classifying Communicating Measuring Inferring Predicting **Integrated Science Process Skills** Controlling variables Defining operationally Formulating hypotheses Experimenting Interpreting data	**I. Proposed Multimodal Semiotics Science Learning Set based on the result of pre-performance assessment.** - 5E's Lesson Exemplar with note to teacher - Learning Activity Sheets **II. Pilot Test** - Multimodal Semiotics Science Learning Set - Post- Performance Assessment **III. Evaluation of Multimodal Semiotics Science Learning Set** - Adequacy -Coherence - Appropriateness	**Multimodal Semiotics science learning set of Earth Science 9- Quarter 3**

Figure 1. Research Paradigm

3. Hypotheses

The study posited the following:

There is no significant difference between the pre- performance assessment and post- performance assessment of the respondents in basic science process skills after the exposure to multimodal semiotics science learning set.

There is no significant difference between the pre- performance assessment and post- performance assessment of the respondents in integrated science process skills after the exposure to multimodal semiotics science learning set.

4. Methodology

The researchers used the descriptive-correlational method. This study's respondents were 228 students drawn from various levels and courses at the university (1st to 4th year from the College of Teacher Education (CTE), College of Business Administration (CBMA), College of Arts and Sciences (CAS), College of Industrial Technology (CIT), College of Engineering (COE), College of Computer Science (CCS), College of Criminal Justice Education (CCJE), and College of Hospitality Management and Tourism (CHMT). The items in the survey were adapted and modified from the articles and studies of Martin, S. (2022, January 24); Robert Half, (2022, May 9); and Self-regulation in the Classroom Worksheets. The instrument was subjected to validation with a pool of evaluators from the selected internal and external faculty members. The researchers virtually conducted the floating of the survey after seeking permission from the Dean of Instruction. Frequency, percentage, weighted mean, and Pearson-r Correlational Coefficient were the statistical treatments used in this study. The questionnaire regarding independent variables and dependent variables was given in Google Forms and sent through e-mail. Further measures were undertaken for the refinement and finalization of the major instrument, and to ensure the validity of the instrument, Cronbach alpha was applied. Before the conduct of the research, the questionnaire was drafted, revised, and finalized to assure that it contained all the pertinent information and data needed in the investigation. This is covered until May 2023. The researchers used descriptive statistics and tests of significance in determining the perceived level of significance of the respondents. For the profile of the respondents, the frequency and percent of the statistical tool were used. For the perception of the assimilative approach and the perception of the assessment indicators on soft skills, mean and standard deviation were applied. In determining the relationship between the independent and dependent variables of the study, Pearson's Product Moment of Correlation was used.

5. Results and Discussion

Table 1. Pre-Performance Assessment of the Learners in Basic Science Process Skills

Legend: 5- Advanced Mastery (AM); 4- Proficient Mastery (PM); 3- Basic Mastery (BM); 2- Low Mastery (LM); 0-1- Very Low Mastery (VLM); VI-

Score	*Observing*		*Classifying*		*Communicating*		*Measuring*		*Inferring*		*Predicting*		VI
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	
5	17	26.2	6	9.2	10	15.4	8	12.3	4	6.2	1	1.5	AM
4	18	27.7	6	9.2	7	10.8	14	21.5	14	21.5	8	12.3	PM
3	23	35.4	16	24.6	16	24.6	24	36.9	31	47.7	16	24.6	BM
2	5	7.7	14	21.5	23	35.4	12	18.5	13	20.0	14	21.5	LM
0-1	2	3.0	23	35.4	9	13.8	7	10.7	3	4.6	26	40.0	VLM
TOTAL	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	

Verbal Interpretation

Table 1 presents the results of the pre-performance assessment of learners' basic science process skills. The data reveal that classifying and predicting were the least mastered skills, categorized under the "Low Mastery" and "Very Low Mastery" levels, respectively. These findings suggest a significant need for improvement in these areas, which the Multimodal Semiotics Science Learning Set was specifically designed to address. Many learners struggled to organize information systematically and to anticipate outcomes in given scenarios—challenges that stem from their limited conceptual understanding of the factors influencing climate.

For classifying, the highest frequency—23 learners—fell under the "Very Low Mastery" level. This indicates minimal to no understanding of how to categorize or relate concepts about climate. The learners showed difficulty grouping items based on similarities, differences, and relationships, as supported by their responses in Appendix I, where scores reflected an inability to apply these concepts to real-life scenarios.

Similarly, the assessment of predicting skills showed that most learners also fell under the "Very Low Mastery" category. This suggests a lack of foundational understanding necessary to anticipate what might occur in different environmental conditions. The data indicate that students had not yet developed the ability to recognize how various factors affecting climate—such as latitude, altitude, and ocean currents—relate to changes in temperature and weather patterns.

In contrast, science process skills that were not the focus of the designed learning set showed slightly better results. For example, in observing, a majority of learners scored a level of "Basic Mastery." This indicates that students were able to meet minimum expectations, particularly through the use of their senses—mainly sight—to analyze visual data. According to sample responses in Appendix I, many learners could correctly identify concepts illustrated in pictures, suggesting a familiarity with interpreting visual information.

In communicating, 33 learners demonstrated a "Basic Mastery" level, indicating they could express at least a minimal understanding of climate-related concepts through written explanations. Most students were able to name three factors affecting climate, drawing from both the lesson content and familiar ideas such as deforestation, pollution, and human activities. Although their explanations were brief and simple, they showed the ability to apply what they had learned.

Regarding measuring, most students also achieved a "Basic Mastery" level. Their ability to perform calculations related to temperature and distance appears to have been supported by their prior knowledge in mathematics. In particular, students successfully solved problems involving the relationship between latitude and temperature and interpreted coordinates from a graph, as noted in Appendix I.

For inferring, learners demonstrated basic skills in evaluating statements about climate factors using a diagram of an imaginary continent. Many were able to judge whether the statements were true or false, again supported by their skills in observation. The performance in this skill also fell within the "Basic Mastery" level, indicating a foundational understanding, albeit limited in depth.

To address the gaps identified in classifying and predicting, these two skills were explicitly targeted in the Multimodal Semiotics Science Learning Set. In Learning Activity Sheets (LAS) 1 and 2, students engaged with tables, Venn diagrams, videos, and guided questions to develop their classifying skills. In LAS 3, learners practiced predicting by interpreting legends and using them to anticipate the effects of climate factors on temperature and precipitation.

Through these structured multimodal activities, the learning set aimed to strengthen the targeted science process skills and promote deeper conceptual understanding.

Table 2. Pre-Performance Assessment of the Learners in Integrated Science Process Skills

Score	***Controlling Variable***		***Defining Operationally***		***Formulating Hypothesis***		***Experimenting***		***Interpreting Data***		***Formulating Models***		**VI**
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	
5	0	0	4	6.2	14	21.5	10	15.4	6	9.2	10	15.4	AM
4	3	4.6	7	10.8	15	23.1	10	15.4	24	36.9	17	26.2	PM
3	13	20.0	12	18.5	11	16.9	11	16.9	15	23.1	14	21.5	BM
2	13	20.0	18	27.7	14	21.5	18	27.7	11	16.9	12	18.5	LM
0-1	36	55.4	24	37.0	11	17.0	16	24.6	9	13.9	12	18.5	VLM
TOTAL	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	

Legend: 5- Advanced Mastery (AM); 4- Proficient Mastery (PM); 3- Basic Mastery (BM); 2- Low Mastery (LM); 0-1- Very Low Mastery (VLM); VI-Verbal Interpretation

Table 2 shows a pre-performance assessment of the learners in integrated science process skills. It was evident that the integrated science process skills such as controlling variables, defining operationally, and experimenting are other focused skills that need to be addressed. It indicates that the learners struggle to identify and manipulate variables, establish a precise definition for scientific concepts, and knowing various experimental setups and their influence.

Before utilizing the designed multimodal semiotics science learning set, most of the learners were classified as having a “Very Low Mastery” level in their skills in controlling variables. It indicates that many learners do not know how to identify the variables in the given scenarios or the contributing factors that could be controlled. It was observed that they had difficulty in answering the questions about variables. One of the reasons was a lack of recalling information about what dependent, independent, and controlled variables was, since they only encountered the topic of the scientific method, and one of which was identifying variables when they were in grade 7 and did not give importance to other grade-level competencies based on the MELCS provide by the Department of Education.

In terms of defining operationally, the highest frequency falls under the “Very Low Mastery” level. It describes that most learners had minimal understanding of how to express their ideas on climate change. This was due to their pre-performance assessment indicating that the operational definition of the learners in climate change was highly incomplete or incorrect, with no mentioned factors and real-life scenarios to support the idea. This was due to their limited information about other concepts of climate change as seen in Appendix I.

In terms of experimenting, most of the learners fall under the “Low Mastery” level. This infers that the learners know little knowledge about following an experiment’s procedure and analyzing and thinking about various experimental setups. It was supported by their scores in controlling variables; since learners did not yet know all the variables to be studied as part of the experiment, it was challenging to think of the best experimental setups on some of the factors affecting climate and its relation to temperature.

As to formulating the hypothesis, many learners were categorized as having a “Proficient Mastery” level. This implies that they could demonstrate a good understanding of the concepts of factors affecting climate and how these factors influence climate change based on their schema and ability to analyze passages effectively. Since pre- performance assessment involved reading text and templates such as “If and then”, they analyzed some of the information based on what they read. As a result, they could easily formulate an educated guess through writing. You may see the sample answer in Appendix I

As to interpreting data, the highest frequency fall under the “Proficient Mastery” level. It means that the learners efficiently analyzed the given information since most have at least basic mastery in observing, indicating that they can observe and study the present data in the table. In their pre-performance assessment, they answered correctly about the region with the lowest and highest temperature because most were already familiar with how to see information in the given table, as seen in Appendix I.

In terms of formulating the model, many learners were categorized as “Proficient Mastery” level where their graphical organizer had a valid, correct, and the cross link represents a purposeful connection between segments of the map with minor grammatical errors on the explanation of symbols/elements used about factors affecting climate and how this contributes to climate change. Since they have a hint on what are those factors affect climate after they encountered the task in classifying states that “Match the factors that affect climate in Column A with its influence on the temperature in Column B.” In addition, making graphic organizers is known to most of the learners since they did it in other subjects related to concept mapping such as mathematics that uses various graphic organizers to present data.

In each Learning Activity Sheets (LAS) of the multimodal semiotics science learning set, controlling variable, defining operationally and experimenting were the three focused integrated science process skills that need to improve. Defining operationally in LAS 4 allowed learners to illustrate their answer on the canvass and give a brief explanation by writing it in the scroll provided about the factors affecting climate and climatic phenomenon. For the enhancement of controlling variables skills, LAS 5 was given to the learners wherein activities 6 and 7 allowed the learners to draw the given scenario inside the whiteboard and determine its independent, dependent and controlled variables by filling out the blanks provided and make their own activity that show the relationship between the given variables. For experimenting, learners were asked to perform an experiment and observe how factors such as elevation and proximity to bodies of water influence temperature. All of the learning activity sheets were graded with the use of the rubrics.

Table 3. Post- Performance Assessment of the Learners in Basic Science Process Skills

Score	***Observing***		***Classifying***		***Communicating***		***Measuring***		***Inferring***		***Predicting***		**VI**
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	
5	13	20.0	28	43.1	10	15.4	8	12.3	7	10.8	5	7.7	AM
4	26	40.0	6	9.2	19	29.2	20	30.8	18	27.7	16	24.6	PM
3	19	29.2	13	20.0	18	27.7	17	26.2	21	32.3	25	38.5	BM
2	7	10.8	10	15.4	10	15.4	17	26.2	15	23.1	12	18.5	LM
0-1	0	0	8	12.3	8	12.3	3	4.6	4	6.2	7	10.7	VLM
TOTAL	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	

Legend: 5- Advanced Mastery (AM); 4- Proficient Mastery (PM); 3- Basic Mastery (BM); 2- Low Mastery (LM); 0-1- Very Low Mastery (VLM); VI- Verbal Interpretation

Table 3 presents the post-performance assessment of the learners in basic science process skills. It can be gleaned that most of the learners have at least “basic mastery” in all basic science process skills with a score of three to five (3-5). It implies that they have acquired fundamental competencies in basic science process skills after the exposure to multimodal semiotics through science learning activities especially for the focused skills such as classifying and predicting.

For classifying, most learners improved their skill level from “very low” to “advanced mastery.” It reflects an excellent understanding of the learners on the topic with the help of the choices inside the box, which they can choose from, and they are enabled to analyze real-life scenarios according to the factors affecting climate because of the key- words on each statement that helped them to answer each question correctly, as evident in appendix O.

In terms of predicting, a large portion of the learners belonged to the “basic mastery” level enhanced from the “very low mastery” level. It denotes that most of the learners can already anticipate what will happen to the given scenario about the factors affecting climate. Since they know the relationship between the factors affecting climate to temperature and precipitation. Multiple choice type of questions supported learners to eliminate the distractors correctly as seen in appendix O. However, it still need for further enhancement in this skill to achieve the highest mastery level.

While the other skills that were not focused in the multimodal semiotics science learning set were also improved wherein in terms of observing, most of the learners were improved from having a “basic to proficient mastery” level. This indicates that they can now have a good understanding and apply the concepts of factors affecting climate effectively, even the image that they need to observe was changed and new to them. The use of their sense of sight in analyzing the text and images per questions and the familiarization on the type of test evidently helps them to know the difference between climate and weather as well as the factors affecting climate as seen in appendix O.

In terms of communicating, the majority of the learners had at least a “basic mastery” level increased from a total respondent of thirty-three (33) to forty-seven (47) due to their understanding of climate change and their exposure to writing essays as they practiced on other subjects. Some of the learners had minor grammatical problems but still can outline the effect of climate change in clear, precise discussions and descriptions. This was supported by their answer in no. 11-15 as seen in appendix O.

As for measuring, many learners improved from “basic mastery” to “proficient mastery” level. Even the problem in no. 16 to 20 were different, their mastery level demonstrated a good understanding and applying the concept of the topic effectively, due to additional information about how to solve the problems with correct units without any hesitations as seen in appendix O. The graph and symbols present in the assessment helped them to deal with the problems as they also practice this skill on the other subject when solving situational problems such as in Math and TLE.

As to inferring, many of the learners still have “basic mastery” levels but some were improved to higher levels. This reflects that many of them still exhibited fundamental scientific abilities and minimum expectations of competency due to their familiarity with the diagram of the imaginary continent on Earth and many of them already identified each statement as true or false as seen in appendix O. However, some of them have a better understanding and can now apply the concepts of factors affecting climate. This was due to the information obtained with the help of images, symbols and explanations throughout the whole teaching and learning process.

Based on the interpretations above, it was presented that there was improvement on the tests result between the pre- and post-performance assessment in all basic science process skills. Since they heightened their senses using various activities, it triggers its individual learning styles that results to perform well in other science process skills. It is suggested that continuation of the use of the multimodal semiotics can help learners to have at least the basic mastery level.

Table 4. Post- Performance Assessment of the Learners in Integrated Science Process Skills

Score	***Controlling Variable***		***Defining Operationally***		***Formulating Hypothesis***		***Experimenting***		***Interpreting Data***		***Formulating Models***		VI
	f	**%**	**F**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**F**	**%**	
5	7	10.8	25	38.5	25	38.5	6	9.2	24	36.9	22	33.8	AM
4	9	13.8	25	38.5	16	24.6	24	36.9	19	29.2	15	23.1	PM
3	29	44.6	9	13.8	9	13.8	16	24.6	12	18.5	13	20.0	BM
2	16	24.6	3	4.6	6	9.2	12	18.5	5	7.7	14	21.5	LM
0-1	4	6.2	3	4.6	9	13.9	7	10.7	5	7.7	1	1.5	VLM
TOTAL	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	**65**	**100.0**	

Legend: 5- Advanced Mastery (AM); 4- Proficient Mastery (PM); 3- Basic Mastery (BM); 2- Low Mastery (LM); 0-1- Very Low Mastery (VLM); VI- Verbal Interpretation

Table 4 shows the post-performance assessment of the learners in integrated science process skills. It implies that upon the exposure to Multimodal semiotics science learning set, improvement occurred in their integrated science process skills, which led them understand the focused integrated science process skills such as controlling variables, defining operationally and experimenting into “Basic”, “Proficient” and “Advanced” mastery levels.

Integrated science process skills were observed as higher compared to the basic science process skills due to the cognitive association whereas the learners answered the basic science process skills questions, it helped them to have a hint on what and how to answer the integrated science process skills questions.

In terms of controlling variable skill, most of the learners obtained scores that fall under “basic mastery” level from “very low mastery” level. It indicates that during their assessment, most of the learners can easily identify the variables in the given scenarios about the factors affecting climate and different climatic phenomenon as observed in appendix O, since they can comprehend the content of the passage and recall what is the definition of independent, dependent and controlled variable.

When it comes to defining operational skills, most of the learners were classified with “Advanced mastery” and “Proficient mastery” levels from “very low mastery” level. It reveals that their skill in conceptual understanding was enhanced by expressing their understanding through writing. It was also observed that they answered easily each specific concepts that could lead to various ideas due to their overall activities and active participation during the discussion. As compared to their pre-performance assessment, that emphasizes on the concept of climate change but needed a comprehensive and precise operational definition with real- life scenarios and well-organized data, on their post- performance assessment, they asked to operationally define five various concepts such as climate, weather, global warming, greenhouse effect and climate change as seen in appendix O. In that way, it helped learners to easily sort their understanding based on the given concepts and define them operationally in a brief and precise manner.

Regarding experimenting, most learners exposed to multimodal semiotics science learning set achieved a “proficient mastery” level from “low mastery” level. It shows that their good understanding and applying the concepts on the factors affecting climate and climate change demonstrate a skill to follow an experiment’s procedure, analyze and think of various experimental setups that were the same on the given concepts. This was because of their creative thinking in imagining each experimental set of variables in the choice if it is fitted to the questions asked. Since they already have knowledge on the topic after the exposure to various activities from LAS 1 to LAS 6, it was not difficult for them to eliminate the choices that were not related to the experiment as shown in appendix O

For the other integrated science process skills, improvement is also evident for formulating hypotheses, interpreting data and formulating hypothesis. In terms of formulating hypothesis, a large portion of the learners improved from “proficient mastery” to “advanced mastery” level. During their pre-performance assessment, learners already know how to construct hypotheses. Now, combining the use of multimodal semiotic helps students to relate variables more efficiently. Through the aid of the passages given in their post-performance assessment, they easily analyzed the relationship of the specific variables that they needed to relate and make educational guess, this can be observed in appendix O. Even if this skill was not the focused science process skill to be improved, it shows a firm grasp of scientific concepts, enabling them to formulate more precise and logical hypotheses.

In terms of interpreting data, many learners improved from “proficient mastery” to “advanced mastery” level. Since the beginning of the assessment, learners have the capacity to analyze the given information and it was improved more after the utilization of multi-modal semiotics science learning set. Where the learners were exposed to the series of activities that need to make illustrations and interpret their work based on their understanding, this can be seen in appendix J. This enhances their critical thinking, helping learners draw logical conclusions from the given data in the table about the factors affecting climate and explain the reasons based on the other factors written in the table as shown in appendix O. Even this skill is not the focused of the science learning set, still the improvement was evident with the use of multimodal semiotics.

For formulating model, greater part of the learners enhanced their mastery level from "proficient" to "advanced". This indicates that learners had a valid, correct, shows deep understanding of the relationship between segments of the map with correct explanation of symbols/elements used in factors affecting climate and the concept of climate change. This was due to deeper processing of information and better retention while they are answering the observing part to interpreting data in the assessment which then translates into improved model formulation showing the factors affecting climate or concepts of climate change after the exposure to multimodal semiotics science learning set as seen in appendix O.

Using multimodal semiotics techniques, including visuals, symbols, and textual elements, probably improved students' capacity to analyze, communicate, and apply scientific concepts. This holistic engagement may have indirectly supported the development of other science process skills by promoting deeper cognitive connections and problem-solving strategies.

Table 5. Expert Respondents' Perception on the Extent of Acceptability of the designed Multimodal Semiotics Science Learning Set as to Adequacy

Statements	$\bar{x}$	**SD**	**VI**
1.aligns instructions with activities to target development of least mastered science process skills of the learners.	3.85	0.37	*HA*
2.satisfied the stated objectives through learning activities with a specific focus on the enhancement on least mastered science process skills of the learners.	3.80	0.41	*HA*
3.provides independent activities that caters the development of least mastered science process skills of the learners.	3.80	0.41	*HA*
4.clearly integrates multimodal semiotics, such as visual, textual, and hands-on, in service of responding to the needs of learners at differing levels of skill.	3.85	0.37	*HA*
5.presents science concepts logically so that progression is maintained from basic to more complex skills.	3.85	0.37	*HA*
Overall	**3.83**	**0.39**	***HA***

Legend: 3.50-4.00 (HA-Highly Acceptable); 2.50-3.49(A-Acceptable)1.50-2.49 (NR-Needs to be Reworded); 1.00-1.49 (NA-Not Acceptable)

Table 5 reveals the perception of the experts on the acceptability of the content and satisfaction of the developed multimodal semiotics science learning set to achieve the goal of improving the science process skills of learners specifically classifying, predicting, controlling variables, defining operationally and, experimenting. It implies that all of the indicators were considered to be highly acceptable. The computed overall mean of 3.83 with the verbal interpretation of highly acceptable implies that the expert respondents affirm that the designed science learning set adequately addresses the least mastered science process skills by providing structured, targeted, and learner-centered activities as seen in Appendix J where the objectives and activities with the used of multimodal semiotics such as visual, textual and hands-on activities were present in the science learning set. It was parallel to the result of the study of Quillao (2020) which states that as the learners use multimodal learning materials for science topics through various modes of representation, they will gain a deeper understanding of scientific concepts. As a result, most science process skills were enhanced to a higher level, and some were sustained as "basic mastery" level.

The highest acceptability level recorded for adequacy by the expert's perception were the indicators 1, 4 and 5, where the multimodal semiotics science learning set "aligns instructions with activities to target development of least mastered science process skills of the learners" since as seen in appendix J, the instructions were evidently presented in each learning activity sheets based on what the learners need to do and improve specific science process skills.

Moreover, the multimodal semiotics science learning set was "clearly integrates multimodal semiotics, such as visual, textual, and hands-on, in service of responding to the needs of learners at differing levels of skill" as perceived by the experts with highly acceptable. This was observed that the science learning set deals with various modes and semiotic resources involving Venn diagram in classifying, symbols for predicting, hands- on activities for controlling variables, defining operationally and experimenting as seen in appendix J.

And "presents science concepts logically so that progression is maintained from basic to more complex skills" where Science learning set consists of six (6) learning activity sheets that were logically implemented from classifying to experimenting in practicing their progression from lower level to higher level skills since it was hard for the learners to perform an experiment without the knowledge of the factors affecting climate. It was supported by the comment in the evaluation checklist of our Educational Program Supervisor in Science, Maam Rosziel Rosales, stated that "The activities are sequenced from simple cognitive skills to higher cognitive demands; developed the HOTS of learners by scaffolding simple activities to critical thinking" as seen in Appendix R.

On the other hand, the statements about the "satisfaction of the stated objectives through learning activities" and the "delivery of independent activities for the improvement of the least mastered science process skills of the learners" were found as with lowest mean frequency of 3.80 but still interpreted as highly acceptable. The possible reason is the time allotted for each learning activity. Experts have seen some of the activities cannot be accomplished on time and, the experimental activities need a group collaboration and the guide questions were answered individually. As a result, their mean score on all learning activities were almost interpreted as "proficient performance" that shows strong proficiency but still need a few improvements to achieve the advanced performance level as seen in Appendix L. It was suggested by the expert to provide time allotted for each learning activity sheets to maximize the time of the learners in accomplishing a specific task.

Table 6. Expert Respondents' Perception on the Extent of Acceptability of the designed Multimodal Semiotics Science Learning Set as to Coherence

Statements	$\bar{x}$	**SD**	**VI**
1.contains instructional material with relevant activities to the development of least mastered science process skills of the learners.	3.90	0.31	*HA*
2.activities include hands- on work of an applied nature relevant to enhancing the least mastered science process skills of the learners.	3.90	0.31	*HA*
3.includes activities aimed at enhancing creativity, critical thinking, and resourcefulness-all important components in enhancing learners' science process skills.	3.80	0.41	*HA*
4.provides information to enhance learners' understanding of core concepts in science.	3.90	0.31	*HA*
Overall	**3.88**	**0.26**	***HA***

Legend: 3.50-4.00 (HA-Highly Acceptable); 2.50-3.49(A-Acceptable)1.50-2.49 (NR-Needs to be Reworded); 1.00-1.49 (NA-Not Acceptable)

The table above depicts the expert respondents' perception on the extent of acceptability of the designed multimodal semiotics science learning set as to coherence. These indicated that the evaluation of the experts on the acceptability of the interrelation of various activities throughout Science learning set to improve the learners' science process skills were all interpreted as highly acceptable with the frequency of 3.88 indicating that the science learning set effectively aligns its components to support the development of learners' least mastered science process skills.

The high approval rating shows in "contains instructional material with relevant activities for the development of the learners" were supported by the developed learning activity sheets per least mastered science process skills with guidance of usage through lesson exemplar with teachers notes. It was observed that each learning activity sheets given to the learners had a connection with the skill that need to be developed as seen in Appendix J.

In addition, the indicator about "activities include hands- on work of an applied nature relevant to enhancing the least mastered science process skills of the learners" also showed high acceptable rating. Since most of the learning activity sheets demands the learners to illustrate first their answer then explain it through writing. Also, in the learning activity sheet no. 6 as seen in Appendix L, where learners work together for an experiment about how factors of climate such as elevation and proximity to bodies of water influences temperature. These shows a practical work and actual learning which was supported by including relevant and hands-on activities. You may refer appendix U for the photo during experiment.

Furthermore, the statement that the multimodal semiotics science learning set "provides information to enhance learner's understanding of core concepts in science" was perceived as highly acceptable. This was supported on the learning activity sheet no. 2 in Appendix J where the learners watched the video to understand the concept about factors the affects climate and the discussion found in the lesson exemplar.

However, it also presented that the only indicator with a 3.80 frequency mean stated that the science learning set "includes activities aimed at enhancing creativity, critical thinking, and resourcefulness-all essential components in improving learners' science process skills" was found as the lowest among all the indicators in terms of coherence suggesting a possible area for further improvement. It may be hard for the learners to improve creativity, critical thinking, and resourcefulness quickly; ample activities are needed to acquire all that efficiently.

The result implies that although the learning activity sheets foster these cognitive abilities, teachers could be making science learning sets more interesting, challenging or flexible to maximize learners' improvement through the department's help in providing teachers training in ensuring that teachers are equipped with innovative approaches. According to the study of Kramer et al (2024), professional development that incorporates cognitive science principles has a slight but statistically significant positive influence on students' subject learning, especially for higher-achieving students.

Coherence is essential to ensure that all of the science learning set components, from pre-performance assessment to execution of the learning materials to post-performance assessment, work harmoniously in achieving the learning objective, which is to improve the learners' least mastered science process skills.

Table 7. Expert Respondents' Perception on the Extent of Acceptability of the designed Multimodal Semiotics Science Learning Set as to Appropriateness

Statements	$\bar{x}$	**SD**	**VI**
1.provides directions with clear, concise, and understandable by the Grade 9 learner and accessible to all learners.	3.95	0.22	*HA*
2.contains learning objectives that are achievable within the given instructional framework and are measurable through pre- and post-performance assessments.	3.85	0.37	*HA*
3.provides a variety of activities that target specific science process skills.	4.00	0.00	*HA*
4.includes activities that promote the expansion of the learners' scientific vocabulary to improve their describable and explainable capability regarding scientific phenomena.	3.90	0.31	*HA*
5.provides numerous activities to interest learners and involve them in science out of curiosity and to attain understanding.	3.95	0.22	*HA*
6.strengthens the learners' science process skills through relevant interactive activities.	3.90	0.31	*HA*
7.assists in better comprehending the lesson, adding clarity and insight into the concepts and skills of science that are being tackled.	3.90	0.31	*HA*
Overall	**3.92**	**0.18**	***HA***

Legend: 3.50-4.00 (HA-Highly Acceptable); 2.50-3.49(A-Acceptable)1.50-2.49 (NR-Needs to be Reworded); 1.00-1.49 (NA-Not Acceptable)

Table 7 displayed the expert respondents' perception on the extent of acceptability of the designed multimodal semiotics science learning set as to appropriateness. The evaluation shows that the Multimodal Semiotics Science Learning Set is well-suited for Grade 9 learners as perceived by the experts that all the indicators were highly acceptable with overall mean of 3.92.

The highest-rated indicator which is "providing various activities targeting specific science process skills" with a mean of four (4), suggests that the Multimodal Semiotics Science Learning Set was effective in engaging students through skill-based learning with practical and critical thinking exercises with used of various modalities as seen in Appendix J. Each learning activity sheets focused on enhancing the learners' least mastered science process skills such as classifying, predicting, controlling variable, defining operationally and experimenting skills. Through the use of multimodal semiotics helped learners to thinks critically and creatively as supported by Kokkinaki (2024), stated that developing multimodal interpretation of learners can critically analyze and explain the aesthetic experience and codes of signals generated through visual stimuli.

Furthermore, multimodal semiotics science learning set provides directions with clear, concise, and understandable by the Grade 9 learner and accessible to all learners. As observed in the objectives written per learning activity sheets, wherein the familiar words were used in order to understand easier by the learners such as compare the difference between climate and weather and identify the factors affecting climate as observed in Learning activity sheet 1 in Appendix L.

In addition, multimodal semiotics science learning set provides numerous activities for the interest of learners through the use of interactive tasks with the integration of images, symbols and textual representations that involved them in the topic out of curiosity leads to strengthens the learners' science process skills. As manifested in all the learning activity sheets in the whole process of teaching and learning and can be seen in the lesson exemplar in Appendix J, it seems that it was appropriate to their capacity to understand the topic. Wherein the learning material assisted the learners in predicting the influence of the factors affecting climate in temperature and precipitation through illustrating different symbols as noticed in Appendix L in learning activity sheet no. 3. And letting the learners to define the specific concept through drawing and explaining it after were incorporated in Appendix L in learning activity sheet no. 4 that developed scientific vocabulary led to strengthen students' conceptual understanding of the factors affecting climate and different climatic phenomenon since they already know the definition of those concepts after the discussion.

The second indicator related to measurable learning objectives had the lowest mean of 3.85 but still within the highly acceptable range, it is suggested that the future improvements on designing science learning set might concentrate on improving the alignment of objectives with the assessment methods such as in the pre- and post- performance assessment. It may limit the questions with multiple choices for better alignment of learning objectives to assessment. Just like in experimenting, it may encourage teachers to allow learners to separately grade them using a rubric by performing simple experiments. The reason why in this study, experimental set-ups and variables were the concept of the assessment, it was due to the limited time allotted. It will consume more time if it is not pen- and paper assessment.

Science learning set are guaranteed to be in line with students' cognitive abilities, instructional objectives, and academic standards when instructional design was appropriate. The multimodal semiotics high acceptability across all indicators confirms how well it promotes scientific understanding. Giving students precise instructions to all learning activity sheets improves accessibility for all students, which was essential for encouraging self-directed learning with the help of visual, verbal and textual representations. Rutgers New Jersey Agricultural Experiment Station (2024) highlights that the use of visuals helps learners in understanding tasks, instructions and how it will be explained by their own.

Table 8. Test of Difference on the learners' Basic Science Process Skills before and after the use of Multimodal Semiotics Science Learning Set

Basic Science Process Skills	**Pre-Performance**		**Post-Performance**		**T**	**df**	**Sig. (2-tailed)**
	Mean	**SD**	**Mean**	**SD**			
Observing	3.65	1.10	3.69	0.92	.312	64	.756
Classifying	2.29	1.39	3.52	1.54	5.564	64	.000
Communicating	2.78	1.27	3.17	1.31	2.016	64	.048
Measuring	3.05	1.19	3.18	1.14	.894	64	.375
Inferring	3.03	0.97	3.11	1.16	.361	64	.719
Predicting	2.00	1.31	2.98	1.12	4.721	64	.000

Legend: p- value<0.05- significant; p- value>0.05- not significant

Table 8 depicted that there is a significant difference between the pre- and post- performance assessment of the respondents on basic science process skills in terms of classifying, communicating and predicting. It suggests that the exposure of multimodal semiotics in a science learning activity sufficiently addressed the specific skills that need to be enhanced due to the emphasis of the utilization of multimodal semiotics. It helped learners boost their active participation in the whole teaching and learning process. Where they gained better understanding of the difference between weather and climate, factors affecting climate and various climatic conditions through the help of video, organizing ideas using Venn diagram and making illustrations based on the influenced of temperature and precipitation in given factors. It was supported by the activity scores of the learners on their learning activity sheets wherein the focused science process skills such as classifying and predicting were interpreted as proficient performance with the mean score of 25, 24, and 24 respectively among sixty-five (65) learners that demonstrated a strong proficiency with a few small areas for development to achieve advance proficiency based on the rubrics as seen in appendix L.

As for the communication, since after making illustrations of the concept that need to be analyzed in the different learning activities, the explanation of it in textual form helped them to also developed their communication skills in expressing their ideas and understanding on the topic. Physicists can utilize various scientific problems, concepts and ideas meaningfully if the scientific language is mastered (Tumanggor et al, 2021).

However, other basic science process skills found no significant difference between the pre- and post- performance assessment such as observing, measuring and inferring skills. This indicates that even those skills were not part of the focused developed multimodal semiotics science learning set, there are slight improvement in observing to "Proficient mastery" level but still under the same level of mastery which is "Basic mastery" level for both measuring and inferring. This implies that the learners from the beginning of the study already have these skills but needs further improvement using the multimodal semiotics science learning set. As seen in Appendix U, learners used their senses by watching a video presentation to describe climate and weather and identify the factors affecting climate. They can also solve the problems based on the concept of the factors that affects climate due to the data provided since they know about the concept, there thinking was to relate the given information for them to answer the question correctly as seen on their answer in post-performance assessment in Appendix O and assess the statements about the factors affecting climate and how these factors influence climate change whether it is correct or incorrect. Since inferring was based on the facts, their understating about the topic was used to support their answer and through the illustration and symbols used in the assessment.

Various modalities with semiotic resources played an important role, which enhanced the learners' basic science process skills. It involved presenting lessons by using a combination of multiple representations in the same lesson that was found necessary to enhance the basic science process skills of the learners. Therefore, it was suggested that this technique be used to develop the educational goal (Gizaw & Sota, 2023).

Table 9. Test of Difference on the learners' Integrated Science Process Skills before and after the use of Multimodal Semiotics Science Learning Set

Integrated Science Process Skills	**Pre-Performance**		**Post-Performance**		**T**	**df**	**Sig. (2-tailed)**
	Mean	**SD**	**Mean**	**SD**			
Controlling Variables	1.48	1.21	2.98	1.04	8.655	64	.000
Defining Operationally	2.11	1.37	3.98	1.17	8.900	64	.000
Formulating Hypotheses	3.05	1.53	3.58	1.56	2.279	64	.026
Experimenting	2.57	1.58	3.14	1.20	2.737	64	.008
Interpreting Data	3.08	1.28	3.77	1.32	3.554	64	.001
Formulating Models	2.94	1.49	3.65	1.24	3.527	64	.001

Legend: p- value<0.05- significant; p- value>0.05- not significant

Table 9 shows that there is a significant difference between the pre- and post- performance assessment of the learners on all the Integrated Science Process Skills in terms of controlling variables, defining operationally, formulating hypotheses, experimenting, interpreting data, and formulating models. Based on the mean score of the learners on their pre-performance assessment, it shows that controlling variables, defining operationally and experimenting where found out with least mastered science process skills that the learners need to be improved since it scored with less than 60 percent of the total score. This was supported by DepEd Order No. 8, s. 2015- "DepEd Grading System Guidelines" indicated that 60 percent was the minimum grade required to pass a learner in a specific learning area. Applying this standard to a 5-item test, each question represents 20% of the total score; a learner must correctly answer at least 3 out of 5 questions to meet the passing requirement.

In terms of controlling variables, they improved their mastery level by allowing the learners to be exposed on the different variables in a visual, verbal and kinesthetic representations. In Appendix J Learning activity sheet no. 5, activity no.6, it aimed to determine the variables involved in the given scenario. The learners were created illustrations based on the text then wrote its independent, dependent and controlled variables for better understanding of the topic about factors affecting climate and how these influences climate change. Then interchangeably, in Appendix J, learning activity sheet no. 5, activity 7, learners were asked to make their own scenarios showing the relationship of various variables. By doing this, it enhanced their scientific knowledge and retained the necessary information as the repetitive actions were implemented. As the study of Yasar et al. (2022), examined how retrieval practices affected the ability to think computationally and scientifically. The researchers discovered that giving students repeated exercises, like quizzes and self-assessments- improved their memory and comprehension of difficult ideas that fosters long- term memory and deeper understanding.

In terms of defining operationally, learners explained their illustrations for better learning using their own scientific understanding on each factor of climate and climatic phenomenon. Where they exposed to illustrate their answer on the specific concept and afterward, explained it through writing as seen in appendix O. Their critical thinking was boosted when analyzing what to draw for a particular climatic condition and factors and how they are explained to the class. A recent study by Kim et al. (2022) showed that students' critical thinking skills improved through creative activities like making illustrations. Their analysis indicated that analyzing provides various conditions to produce their artwork, where they engage through a process of evaluation of information, synthesis, and critical assessment as they examine different climatic conditions.

Moreover, in experimenting, learner's skill in following an experiment's procedure, analyzing and thinking of various experimental setups was performed efficiently. It can be inferred that upon the application of their learning in the manipulation of variables and defining with the use of multimodal semiotics in their learning activity sheet no. 6 as seen in appendix J about experimenting. Learners enhanced their said skill and can now think scientifically about other experimental setups in determining the relationship of each same variable. Having been exposed to hands-on activity in manipulating and analyzing the variables during the experiment and answering the guide questions through visual and textual form assisted them in better understanding the relationship of factors affecting the climate to temperature and think other experimental setups as their scores in learning activity sheet 6 that falls under proficient performance with the mean score of twenty-two (22) as seen in Appendix L based on the rubrics provided.

Even the targeted science process skills of the multimodal semiotics science learning set are controlling variables, defining operationally, and experimenting, still, the improvement of other integrated science process skills was evident. This was due to the use of multimodal semiotics in the whole teaching and learning process makes learning more engaging and motivating due to various learning styles that cater developed science learning sets, like visual, verbal and kinesthetic learning styles. This was supported by the study of Yeo et al (2022) that showed how the utilization of various representations in science teaching such as visual and textual representations helped learners to understand and think critically not only the specific science concepts but also the overall learning experience.

Overall, Ortiz (2021) stated in her study, that multimodal representation in science education greatly enhanced the scientific skills of the learners. A more inclusive and productive learning environment resulted from the integration of multiple modes of representation and catered to various learning preferences of the learners. This suggests that multimodal semiotics can be an effective pedagogical approach in science education, promoting comprehensive skill development beyond the primary areas of focus.

6. Conclusion

The study revealed a significant difference between the pre-performance and post-performance assessments of the respondents in basic science process skills—specifically in classifying, communicating, and predicting—following exposure to the Multimodal Semiotics Science Learning Set. This improvement can be attributed to the integration of diverse learning activities incorporating visual, verbal, and textual representations, which enhanced students' engagement and conceptual understanding.

However, no significant difference was observed in the areas of observing, measuring, and inferring. This result suggests that many learners had already acquired these foundational skills prior to the intervention, and these were not the primary focus of the learning set. Consequently, the null hypothesis was only partially rejected.

In contrast, the study found a statistically significant difference in all integrated science process skills between the pre- and post-performance assessments. These skills include controlling variables, defining operationally, formulating hypotheses, experimenting, interpreting data, and formulating models. The improvement is attributed to the multimodal semiotics-based activities, which employed visual, verbal, and kinesthetic strategies within the learning tasks, thereby promoting deeper understanding and enhanced application of scientific concepts. Therefore, the posited null hypothesis was not sustained.

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