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Improving the Least Mastered Competencies of Grade 11 Students in General Chemistry using Electronic Strategic Intervention Material (E-SIM)

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ABSTRACT

Students perceive chemistry as a complex subject resulting in low academic performance. Education systems shall support students in bridging the gap between traditional learning and online set-up using technology-based materials. The Electronic Strategic Intervention Material (E-SIM) is a new learning method to help improve the learner's performance in the least mastered competencies. This study focuses on determining how the E-SIM for "Ganyan Ang Bonding" (in English: Bonding Goes Like This) topic will improve the Grade 11 students' knowledge about chemical bonding. The researchers used a one-group pretest-posttest control design. The population was pooled using simple random sampling and out of the randomly selected sections, twenty-two students were qualified after the voluntary response sampling. Pretest and posttest, which underwent validation, were given before and after the intervention respectively. The material was validated by experts prior to its utilization. The analysis showed a 0.01 normalized gain score, which is confirmed by the paired sample t-test with a result of -3.17 and p-value of 0.0023, hence presenting that there is a significant increase between the pretest and posttest scores. The student perception survey was used to further determine the efficiency of the material, which showed that the students perceived the E-SIM as an effective tool as review material.

Keywords: *electronic strategic intervention material; competency; chemistry; chemical bonding*

INTRODUCTION

Many students perceive chemistry as a complex and challenging subject, resulting in low academic performance and failure to accomplish learning competencies in General Chemistry. The perception of the students on chemistry indicates that academic achievement in General Chemistry is relatively low (DepEd, 2019). According to reports of the Program for International

Student Assessment (PISA) 2018, the Philippines ranked Level 1, with a mean of 357 and standard deviation of 75, on performance in science. It was also noted that even the highest-performing students in the Philippines, alongside Kosovo and Morocco, only scored around the OECD average (Schleicher, 2018). Moreover, as noted by Dacumos (2016), despite the importance of science education, students exhibit negative responses as they never perceived it as an enjoyable way for them to grasp significant concepts; thus, resulting in low academic achievement. Through a research article the Ely (2019), it was concluded that through the Chemistry Achievement Test (CAT), the level of mastery in chemistry competencies is generally average mastery. The ninth grade students who have a lesson in chemical bonding, mole concept, and carbon compound achieve the lowest score in MPS. Mainly, chemistry is considered to be one of the most significant fields that help learners comprehend their environment. However, it is also a challenging subject since chemistry topics are usually linked to the structure of matter and other chemical terms. The chemistry curriculum integrates many abstract concepts, which is essential to learning since it is the basis for further knowledge in other fields of science. Moreover, it also discusses that learners must involve themselves more than once in these concepts. With the possible growing learning in chemistry, it is essential to review chemical concepts in different aspects (Ely, 2019).

Based on the related literature by Ely (2019), it was noted that chemical bonding is one of the most difficult concepts in General Chemistry. Chemical bonding requires intellectual thought since it also needs a broad understanding of abstract concepts. It is also considered to be fundamental to learning chemistry. Understanding chemical bonding is primary in learning the nature of chemistry like chemical reactions, thermodynamics, molecular structure, chemical equilibrium, and physical properties. Knowledge in chemical bonding theories can also be obtained by learning about reactivity, spectroscopy, and organic chemistry (Pabuçcu, A. & Geban, Ö, 2012). It is considered to be a prerequisite of the concept behind hydrocarbons.

Due to the advancing technology, Pinar (2021) has learned that the utilization of technology-based instructions, if given the proper dissemination of information, can provide students a more significant opportunity to learn a specific competency. It can also strengthen the idea of the relationship of learning in terms of collaboration, participation, engagement, and in-depth learning acquisition. The education system should have the ability to provide students with a high level of support to fill the large gap between the online distance learning setup and the face-to-face learning environment. Online learning uses new learning modalities such as self-learning modules and incorporating technology as a viable mode of enhancing students' competencies. This resulted in reconstructing learning materials to deliver prowess within the new learning modalities. It was also stated that because of the unique challenges brought by the sudden transition of a mode of learning, the design and implementation of online distance learning should still adhere to an effective learning process for the students.

The Electronic Strategic Intervention Material (E-SIM) is described as the newest learning method recommended by the DepEd to lessen academic underachievement by increasing the learners' performance in the least mastered competencies and skills (De Jesus, 2019). Arpilleda (2021) stated that these materials serve as additional learning material that is used for the mastery of the least-learned competencies of students. Students use these intervention materials to study and explore independently with the help of simple interactive discussion and activities. This study aims to create an E-SIM to test how this will improve the least mastered skills of Grade 11 science high school students in General Chemistry.

As shown in the research paradigm (Figure 1), implementing the "Ganyan ang Bonding" (in English: Bonding Goes Like This) E-SIM may significantly increase students' knowledge of the topic and their mastery of their LMC in chemical bonding.

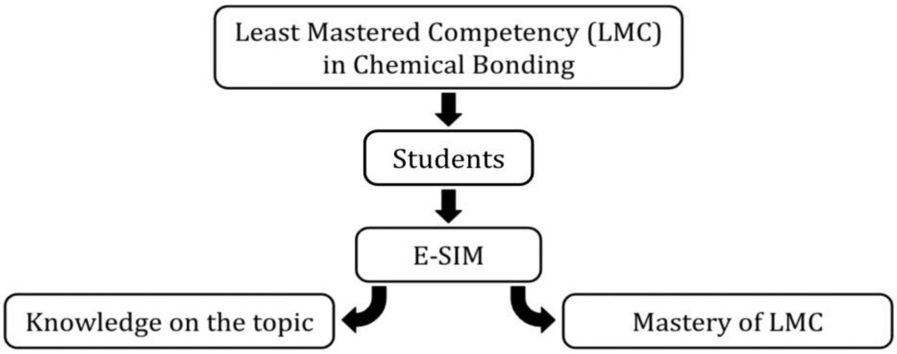

Figure 1. Paradigm

Herrera & Soriano (2016) conducted a study titled *"The efficacy of strategic intervention material (SIM) to the achievement in Physics of a selected group of Public-School Students in Las Nieves, Agusan del Norte"* which studied the effectiveness of the SIM in improving achievement of tenth grade students in physics. In this study, the SIM was found to be effective in raising the posttest results of students. The majority of SIM-related studies from various places in the Philippines show significant effects on both students and teachers. It accomplishes its purpose of developing least mastered competency in certain topics (Contreras, 2018).

Since chemistry is highly concept-based, learners and teachers must weigh its importance. According to Ely (2019), chemistry requires significant conceptual understandings. It was discussed that cognitive science disciplines could be learned effectively through active learning methods, like group works and activities. This can also boost learners' motivation and retention of information.

According to the Constructivist Theory of Jerome Bruner, learning is an active and constructive process in which learners construct new ideas, concepts, and information based upon their current and past knowledge. This theory also sets forth that an individual learns from their discovery of the environment by using their senses, which gives rise to the emerging theory of constructivism and self-learning. Pasion (2019) highlighted the need for activity-centered instructional materials in which students may instantly experience the purposeful use of all of their senses. Experiential learning is a way of accumulating knowledge or skills by firsthand and keen observations, followed by an evaluation of what has been experienced and comprehended.

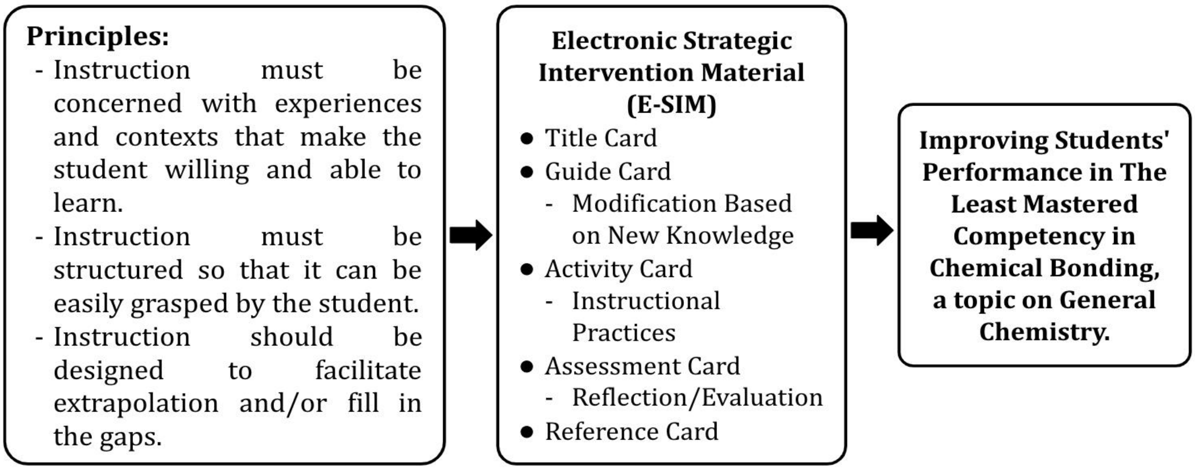

Figure 2. Theoretical Framework Based on the Constructivist Theory of Jerome Bruner

Bruner (1966) states that a theory of instruction should address four significant aspects: (1) predisposition towards learning; (2) how a body of knowledge can be structured so that the learner can most readily grasp it; (3) the most compelling sequences in which to present material;

and (4) the nature and pacing of rewards and punishments. Exemplary methods for structuring knowledge should simplify, generate new propositions, and increase the manipulation of information. The principles of the Constructivist Theory are the following: Readiness, Spiral Organization, and Extrapolation. If all these theories and principles are employed in the self-learning E-SIM on improving the least mastered competency of students in General Chemistry, see Figure 2, there shall be a significant improvement in the students' performance which can be determined by administering pretest and posttest.

The K to 12 Basic Education Curriculum of DepEd aims to provide inclusive learning to students. It ensures that all learners are given an equal chance to learn and master the most essential learning competencies at their own pace through varied learning activities. Teachers can give students the ability to concretize their learning through differentiated instructions and contextualization (De Jesus, 2019). Consequently, DepEd brought down DepEd Memorandum No. 117 s. 2005, "Strategic Intervention Materials (SIM) Training Workshop for Successful Learning," which led to the utilization of SIM as a form of remediation to increase the academic achievement of low-performing students in schools on the vision to improve students' academic performance.

This study sought to answer the following problems:
What was the learners' level of achievement per competency before and after using the "Ganyan ang Bonding" E-SIM?

1. Are there significant changes in the student's knowledge on the competency in General Chemistry before and after the utilization of the E-SIM?
2. How do the students perceive the use of E-SIM in terms of learning General Chemistry competencies?

At a 0.05 level of significance, it is hypothesized that (a) H_o: There is no significant difference between the pretest and posttest scores of the students; and (b) H_a: There is a significant difference between the pretest and posttest scores of the students.

The findings of this descriptive quantitative study, which aims to provide supplementary learning material, might improve the least mastered competencies of Grade 11 students in chemical bonding. Hence, offering strategic intervention materials may alleviate the deficit of learners' materials such as textbooks and activity sheets that occurred during the implementation of the K-12 Curriculum in the Philippines, which affects students' performance in class. In addition, teachers in public schools are led to fill the gaps in education, such as the critical shortcomings of learning materials, by seeking specific strategies to assist students in obtaining high-quality education and mastering the essential learning competencies (Sinco, 2018). The legislated science high school teachers will access extra teaching resources regarding chemical bonding through this E-SIM, which may provide quality education to learners. Lastly, this study may serve as a reference for future researchers conducting more research on improving students' General Chemistry competencies and the development of E-SIMs. This study can also help these researchers obtain more knowledge and different experiences on the topic as they continue their studies.

METHODOLOGY

Research Design. The researchers used a one-group pretest-posttest control design to determine the effect on the learning of Grade 11 students that used the material since the E-SIM shall serve as a re-teaching tool for randomly selected Grade 11 students. The experimental group received the researcher-made intervention material and underwent pretest and posttest to assess their knowledge before and after utilizing the material.

Phase 1: Development of General Chemistry Electronic Strategic Intervention Material (E-SIM). According to Arpilleda (2021), some phases must be considered in making an intervention material. In gathering the material and data, the researchers considered the following phases:

Preliminary phase. The researchers looked for studies that discuss the least mastered competencies in General Chemistry of Grade 11 students. Afterward, learning sources and materials were gathered as references to be used in the E-SIM.

Preparation phase. The researchers thoroughly prepared activities and tasks. Based on the DepEd SIM format, there are essential parts in the E-SIM, namely: title card, guide card, activity card, assessment card, and reference card. The E-SIM was utilized using Microsoft Powerpoint because of its features, such as hyperlinks and animations. This software was able to make the activity card interactive.

As seen in Figure 3, the title card includes the title of the material as well as the names of the developers. The guide card which comes before the title card, contains an in-depth examination of chemical bonding concepts. The steps in generating Lewis diagrams, the octet rule and its exceptions, covalent bonds, and ionic bonds are among the topics covered in this card. The concepts were taught through images and texts to assist students in grasping the topics (see Figure 4).

Figure 3. Title Card

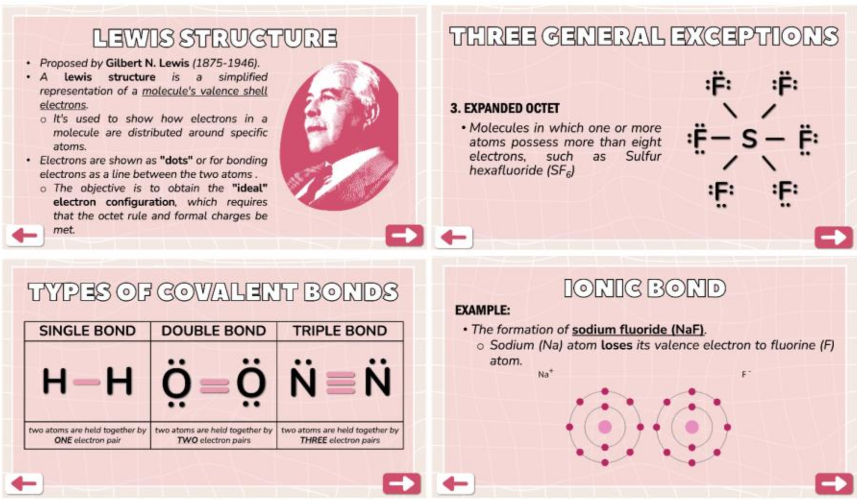

Figure 4. Guide Card

Another section of the E-SIM is the activity cards, which feature activities to help learners master the competencies in a fun and interactive way. As gleaned from Figure 5, multiple-choice questions, puzzle-solving, matching type identification, and 4-pics 1-word themed activities are given one activity for each competency. To make the activity cards interactive, all of the content in this section utilizes various diagrams and shapes combined with animations.

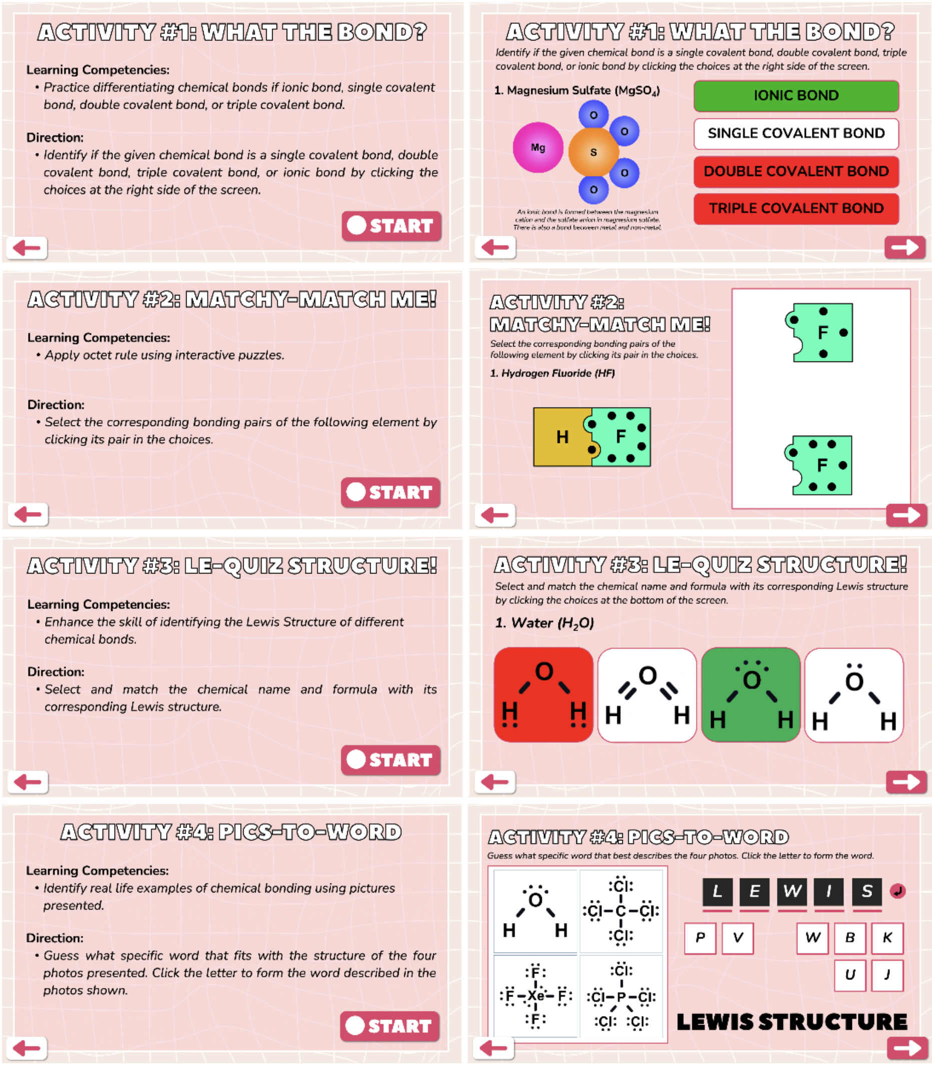

Figure 5. Activity Card

There is also an assessment card in the E-SIM—pre-assessment and post-assessment, as shown in Figure 6.1 and 6.2. These assessments are self-checked by the learners to test their knowledge before and after browsing through the guide card, activity card, and enrichment card.

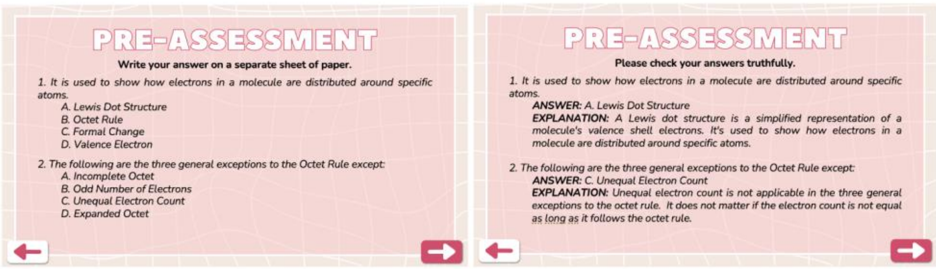

Figure 6.1. Pre-assessment Card

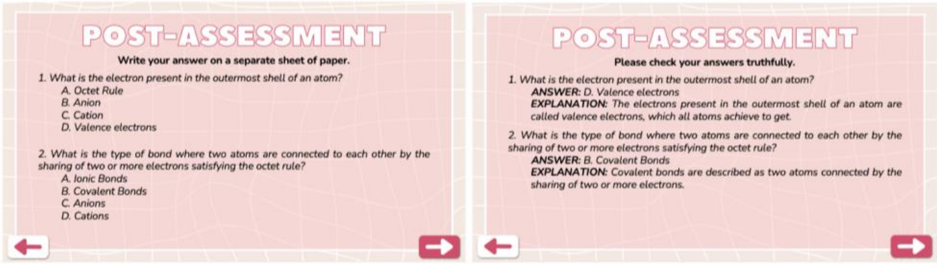

Figure 6.2. Post-assessment Card

As seen in Figure 7, an enrichment card is also present in the material. This card focuses on providing other review material (e.g. Youtube videos and interactive simulations) for the learners to have a wider understanding of the concepts of chemical bonding. The reference card contains the references used in the material (see Figure 7). This is to ensure that the concepts and information gathered in the material are cited properly.

Figure 7. Enrichment Card and Reference Card

Evaluation phase. This phase was conducted to evaluate and test the effectiveness of the material. The questions underwent face and content validity. Selected five experts in the field of chemistry and research were given an evaluation form which is entirely based on the DepEd Evaluation Rating Sheet for Non-Print Materials retrieved from the DM No. 441 s. 2019 Guidelines and Process for LRMDS Assessment and Evaluation of Locally Developed and Procured Material. The questionnaire focused on determining the accuracy of content, appropriateness of the presentation, language, and visuals to target users of the intervention material (DepEd, 2019). The evaluation sheet from the validators showed that the material passed the content quality, instructional quality, technical quality, and other factors, as shown in Table 1.

The pretest and posttest questionnaire also underwent validation by a subject teacher and a master teacher. Validator 6 focused the comments on the content validity, while Validator 7 gave suggestions mostly on the face validity of the questionnaire. With this, results from the test for face and content validity indicate that the pretest and posttest questionnaires are appropriate for the experiment.

Table 1. Scores from the Validators' Evaluation Rating Sheet for Non-Print Materials

Validator	Factor A	Factor B	Factor C	Factor D	Summary of 'Other Comments'
	Content Quality	Instr. Quality	Tech. Quality	Other Findings	
1	39	40	51	16	The interface and the design are one of the things that the validator praised about the material. Few suggestions were made; for instance, showing more examples of atoms in the exemptions to the octet rule and correcting some grammatical errors.
2	35	38	51	14*	The title of the material and the colors are complemented by the validator. Most comments discuss the conceptual part of the material; for instance, adding more examples, diagrams, and illustrations. The Factor D failed because of the conceptual and grammatical errors.
2.1**	40	40	52	16	All comments from the first evaluation were addressed and resolved.
3	40	40	41	16	No other comments were made.
4	37	36	45	16	Guide cards can easily be followed. Activities align with the material's objectives. Few suggestions were made; for instance, interactive activities online can be utilized in the E-SIM
5	38	36	44	16	The validator suggested that simpler examples should be used.

** Failed from the Factor D: Other Findings, revisions were made accordingly.*
*** Re-evaluation scores for Validator 2.*

Phase 2: Pilot Testing and Assessing Improvement in Least Mastered Competencies in General Chemistry .

Respondents of the Study. The respondents of this descriptive quantitative study were drawn from a pool of Grade 11 students from the legislated science high school. This study was carried out after the first semester of S.Y. 2021-2022 during the COVID-19 pandemic where online sessions were predominantly conducted instead of face-to-face classes. There are five Grade 11 sections in the science high school—two sections were chosen using simple random sampling via the fishbowl method to gather sufficient numbers of respondents in total to gather richer information (De Jesus, 2019). In this sampling technique, the five sections were written down on a piece of paper and picked up randomly. From the two randomly selected sections, voluntary response sampling was used to gather respondents from the total population of Grade 11 science high school students. In addition, the students were divided by sex assigned at birth—male and female. A screening was done based on the following qualifications: (a) students from the randomly selected two sections; (b) has a working laptop/desktop; (c) has a stable internet connection at home; and (d) has a Microsoft Powerpoint Office 2016 or later. Out of 34 students who responded to the call for respondents, only 22 students qualified for the pilot testing of the intervention material, which comprises 10 male and 12 female students.

Research Instrument. The researchers used the following tools and instruments in conducting this study: the E-SIM in the least mastered competencies in General Chemistry, the pretests and posttests questionnaires, along with the survey form developed by the researchers.

Intervention material. The E-SIM was prepared by the researchers using Microsoft Powerpoint 2016. By utilizing the hyperlink, designing, and animation functions of the application, it became interactive and pleasing to the eye of the learners. The intervention material includes the following essential components: title card (Figure 3), guide card (Figure 4), activity card (Figure 5), assessment card (Figure 6.1 and 6.2), and reference card (Figure 7), which is based primarily on the DepEd SIM format.

Pretests and posttests questionnaires. The researcher-made pretest and posttest questionnaires were done through Google Forms for easy access to students. It consists of a number of questions that determine the students' achievement in terms of concepts and understanding. It is worth taking note that the pretest and posttest questions are similar to study the students' gain of knowledge. The questions were validated by the selected experts in the field of chemistry and research. In addition, the researchers developed the survey questionnaire that aimed to describe the perception of the students on the use of the E-SIM. It consists of five questions which aim to determine a student's perception on the use of the material. Each statement is rated using a 4-Point Likert Scale, where 1 means strongly disagree, 2 means disagree, 3 means agree, and 4 means strongly agree (De Jesus, 2019).

Data Gathering Procedure. Following the approval to conduct the study, an orientation for selected students was followed using the Google Meet video conferencing platform to thoroughly explain the procedures of the study. Using Google Forms, the same set of tests was given to the qualified participants accordingly. In addition, students' perceptions were also collected through the aforementioned platform after the intervention to have a proper analysis of the material.

To assure the study's ethical consideration, underage participants were asked for their assent and parental permission before the intervention using Google Forms. This form outlines all of the study's terms and conditions. This means that their responses will never be used against them, and only the researchers will have access to them. There are important questions that require a mandatory response before moving on to the next section of the survey. Moreover, respondents were briefly informed about the purpose and the main goal of the study.

The pretest was administered before the material intervention, and participants had one day to complete the evaluation using Google Forms. For the intervention proper, participants could access the intervention material in Microsoft Powerpoint format that is compiled in Google Drive for one week. Students are tasked to do self-assessments to ensure that the material can be used without the guidance of other people. After the intervention, the Google Form link for the posttest was issued to the qualified participants. To assess if there were significant differences in the mean scores on the pretest and posttest, their scores were tallied and analyzed using Google Sheets.

Data Analysis Procedure. The questions underwent face and content validity. The researchers looked for experts in the field of research and chemistry to validate the E-SIM, pretest, posttest, and survey questionnaires. The test-retest correlation was used to measure the test consistency by handing out the same test twice to the same respondents at different times to determine if the results are the same (Weir, 2005). To measure the reliability of the questionnaires, the same test was conducted on the same exact group of people. The second test was conducted after one week. With this, the correlation between the two sets of results was computed using Pearson Correlation (r).

As shown in Table 2, the pretest and posttest questionnaire pose a good reliability ($r=0.87$) in assessing student's knowledge in chemical bonding. Using the Pearson correlation table

(Ratnasari et al., 2016), the r-value presents a strongly positive correlation which makes the instrument reliable for this study.

Table 2. Test-Retest Correlation

Item Number	Pretest	Posttest
1	16	20
2	14	10
3	18	19
4	10	11
5	10	13
6	9	10
7	13	15
8	22	22
9	9	12
10	15	15
r		**0.87**

The data gathered from the questionnaire was consolidated and analyzed by the researchers with the aid of Google Forms and Spreadsheets. Spreadsheets are a typical form of application for a variety of purposes, including data collecting. The most obvious benefit is that many individuals are familiar with spreadsheets. A spreadsheet also has a number of tools and capabilities for data analysis and processing (Nurdiantoro, et al., 2017).

Statistical Treatment. The assumption of normality must be checked before analyzing data when comparing the means of two or more groups because the validity of the results will rely on the test of normality (Banda, 2018). There are a variety of methods to be used in order to test the assumption of normality. The simplest way is to visually inspect the data using the histogram tool. The data is considered or accepted as normal if the shape looks symmetrical and bell-shaped (Ghasemi, 2012). Another way to tell if the data is normally distributed is the Shapiro-Wilk Test for Normality which is usually used when the sample size is less than 50 (Banda, 2018).

Several stats were used in this study to evaluate the acquired information. A total of 22 respondents participated. Since this study is interested in the difference between two variables for the same subject, a paired sample t-test was used for the pretest and posttest regardless of the sample size. The pretest and posttest data were evaluated using mean, standard deviation, and MPS. The same method was also used for the student perception survey (SPS). A Likert Scale ranging from 1 to 4 (1 - Strongly Disagree, 2 - Disagree, 3 - Agree, 4 - Strongly Agree) was used to determine the perception of the students. The 4-point scale has its own respective ranges and interpretations as shown in Table 3 (Pimentel, 2019).

Table 3. 4-Point Likert Scale Range Interpretation

POINT	SCALE RANGE	DIFFERENCE	INTERPRETATION
1	1.00 - 1.75	0.75	Strongly Disagree
2	1.76 - 2.51	0.75	Disagree
3	2.52 - 3.27	0.75	Agree
4	3.28 - 4.00	0.72	Strongly Agree

RESULTS AND DISCUSSION

This section analyzes the knowledge acquired before and after intervention, followed by an analysis of the student's achievement per competency, and the student's perception survey.

Test for Normality and Equal Variance. Since only a small sample size (N=22) was gathered, determining the distribution of the pretest scores was important for choosing the appropriate statistical method. For the statistical test of normality assumption, the Shapiro-Wilk Normality Test (Shapiro and Wilk, 1965 as cited by Acharya, et al., 2018) and histogram were performed. The pretest scores were used as a direct measure of the level of knowledge of students prior to the intervention. With this, the Shapiro-Wilk Test did not show evidence of non-normality (W=0.945, p-value=0.2511), with all the pretest data sets as acceptable at $p<0.05$ level as shown in Table 4.

Table 4. Test for Normality—Shapiro-Wilk Normality Test

Parameter	Value
Sample Size	22
W	0.945
P-value	0.2511**
***Note:** *p<0.10, **p<0.05, ***p<0.01*	

On the other hand, histogram is also one way to test for normality of a data. It is easy to visualize the distribution of the data using this. To establish the histogram, the frequency of pretest data (see Table 5) was used. As shown in Figure 8, it presents a potentially symmetrical shape, which indicates that the data gathered from the pretest are normally distributed.

Table 5. Frequency of Pretest Data

SCORE	FREQUENCY
1	0
2	0
3	1
4	2
5	4
6	4
7	8
8	2
9	1
10	0

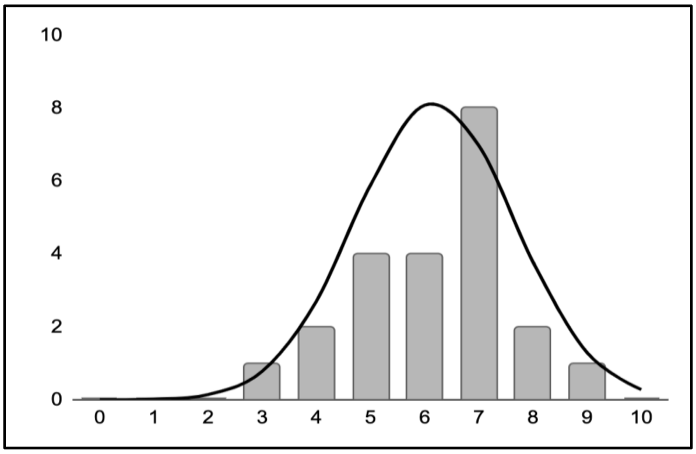

Figure 8. Frequency Distribution Histogram of the pretest Data

Based on the findings and after the visual examination of the histogram, as shown in Figure 8, the paired sample t-test was the appropriate statistical test to use.

Students' Achievement before and after Intervention. Based on the gathered data during the pilot testing of the E-SIM and assessing the improvement in the least mastered competency of students, the researchers found the following:

Students' Achievement on tests Before Intervention. A pretest was given to the students before the implementation of the intervention material to establish their level of performance in chemical bonding. The scores were tallied and analyzed. The frequency distribution of the scores for each item is shown in Table 6. The mean, standard deviation, and MPS were used to interpret the data.

Table 6. Pretest Results

Item Number	Frequency	Percentage
Mean		13.60
Standard Deviation		4.30
MPS		136

According to the data acquired during the pretest (M=13.60, SD=4.30), the students showed poor performance in the pretest and an intervention is required to improve their least mastered competencies in chemical bonding. These findings are similar to the findings of De Jesus (2019), which indicate that students' low performance on the pretest presupposes an intervention to improve their level of achievement on a specific topic in science.

Comparing Students' Achievement on tests Before and After Intervention. Table 7 presented the comparison of students' pretest and posttest scores. The table presented that ten out of 22 students have increased their scores before and after the intervention, seven students maintained, and five students have decreased. It was noted that most students improved their knowledge on chemical bonding after the exposure to E-SIM.

Table 7. Tabulation of Students' Pretest and Posttest Scores

Student	Pretest	Posttest
1	6	6
2	5	9
3	4	4
4	6	7
5	7	9
6	8	9
7	7	7
8	6	7
9	7	8
10	7	6
11	7	7
12	5	9
13	9	9
14	3	7
15	6	8
16	4	4
17	5	4
18	7	5
19	8	5
20	7	7
21	7	4
22	5	6

Table 8.1 shows the comparison of the frequency distribution of pretest and posttest scores of students per item. In the majority of the item numbers, the frequency of students who got correct answers has increased. Table 8.2, on the other hand, compares the mean, standard deviation, and MPS of the pretest and posttest scores. Further, the mean, standard deviation, and MPS in posttest scores are higher than in pretest scores.

Table 8.1. Frequency of Students and Percentage of Pretest and Posttest Results

	Pretest		Posttest	
Item Number	**Frequency**	**Percentage**	**Frequency**	**Percentage**
1	16	0.73	20	0.91
2	14	0.64	10	0.45
3	18	0.82	19	0.86
4	10	0.45	11	0.50
5	10	0.45	13	0.59
6	9	0.41	10	0.45
7	13	0.59	15	0.68
8	22	1.00	22	1.00
9	9	0.41	12	0.55
10	15	0.68	15	0.68

Table 8.2. Mean, SD, MPS, and Normalized Gain Score of Pretest and Posttest Results

	Pretest	Posttest
Mean	13.60	14.70
Standard Deviation	4.30	4.32
MPS	136	147
Normalized Gain Score	0.01	

The next step was to use the students' pretest and posttest scores to calculate the gain in the knowledge from the intervention material. Because the pretest and posttest scores are dependent, a student's t-test for paired samples was used to verify that learning occurred during the pilot testing of the material. Table 9 presents the results obtained.

Table 9. Comparison of Pretest and Posttest scores—gain in knowledge

	Pretest	Posttest
Mean	6.18	6.68
Variance	2.16	3.18
Observations	22	22
Hypothesized Mean Difference	0.00	
df	21	
t Stat	**-3.17**	
P(T≤t) one-tail	0.00	
t Critical one-tail	**-1.72**	

Table 10. Significant difference between the Pretest and Posttest results

	M	SD	t-value	*t-crit*	df	*p*-value	Decision
Experimental Group							
Pretest VS Posttest	-0.5	0.74	-3.17	-1.72	21	0.0023	Reject H_o

It can be seen from Table 10 that under the experimental group, pretest and posttest scores pose a significant difference (t-value=−3.17 < t-crit=−1.72). Meanwhile, the pretest (M=6.18, SD=1.47) and the posttest (M=6.68, SD=1.78) of the experimental group showed a significant difference in the test results before and after using the E-SIM. After achieving poorly in the pretest, the students understood the concepts in chemical bonding with the use of the guide cards, activity cards, and enrichment cards provided in the intervention material without the guidance of a teacher or instructor, which led to an improvement in the performance of the students. This indicates that there is an improvement in the performance of students after the utilization of E-SIM. Further, the significant increase in the mean score of the students manifests the effectiveness of the material. All of these findings are similar to De Jesus (2019) and Arpilleda (2021), where the use of an intervention material has significantly improved the level of achievement of learners as indicated on the increase of mean scores of the students.

With these findings, the experiment may be considered valid and there is a significant difference between the pretest and posttest scores—the posttest scores are higher than the pretest scores. Further analysis can proceed to evaluate the next research question, which is to assess the pretest and posttest scores of the group in each learning competency.

Students' Achievement Per Competency. Each learning competency, as presented in Table 11, has two to three questions on each test to determine the student's mastery per competency given on the "Ganyan ang Bonding" E-SIM. The students' achievement per competency was determined by computing and comparing the frequency of students who got correct answers and mean data from the pretest and posttest results.

Table 11. Frequency of Students and Mean of Pretest and Posttest Result per Learning Competency

Learning Competency	Item No.	Pretest		Posttest	
		Frequency	Mean	Frequency	Mean
1. Identify ionic bond, single covalent bond, double covalent bond, and triple covalent bond.	1, 3, & 8	56	18.67	61	20.33
2. Apply the octet rule in the formation of molecular covalent compounds.	4 & 7	23	11.50	26	13.00

As gleaned from Table 11, the data poses a significant increase of the mean in the competencies: identifying bonds, pretest (M=18.67) and posttest (M=20.33); applying octet rule, pretest (M=11.50) and posttest (M=13.00); and learning real life examples of chemical bonding, pretest (M=11.330) and posttest (M=13.33). Meanwhile, the competency of drawing Lewis structure of molecular covalent compounds states that there is a decrease between the data with pretest (M=11.50) and posttest (M=10.00). These data implied that the students understood the majority of the learning competencies with the use of E-SIM on their own. It also implies that there is a significant increase in the performance of the students in the learning competencies after the utilization of E-SIM. All of these findings are consistent with Cordova, et al. (2019)'s study, who found that using an intervention material enhanced students' level of achievement in these learning competencies significantly, as implied by an increase in mean scores.

Students' Responses on Students' Perception Survey. As presented in Table 12, the students' perception about the *"Ganyan ang Bonding"* E-SIM was determined using a SPS. The survey contains five statements that the students rated using a 4-Point Likert Scale.

Table 12. Student's Perception Survey

Statements	Mean	SD	Interpretation
1. The activities provided in the E-SIM were effective and interactive, which aided in the achievement of the material's objectives.	3.55	0.67	Strongly Agree
2. The illustrations used in the guide cards helped me visualize the topics about chemical bonding.	3.73	0.46	Strongly Agree
3. The E-SIM helps me have a better understanding about chemical bonding that was not understood during regular classroom teaching.	3.73	0.46	Strongly Agree
4. The E-SIM was well-organized in terms of time frame, assessment, and information access.	3.64	0.58	Strongly Agree
5. The E-SIM was interesting to repeat and review.	3.77	0.43	Strongly Agree

The high mean scores presented in Table 12 indicate that most students strongly agreed that the activities provided in the E-SIM were effective and interactive (M=3.55, SD=0.67), the illustrations used were helpful in visualizing the topics (M=3.73, SD=0.46), and it helped in having a better understanding of chemical bonding (M=3.73, SD=0.46). Furthermore, most students strongly agreed that the utilized E-SIM was well-organized (M=3.64, SD=0.58), and is an interesting review material (M=3.77, SD=0.43). These data implied that the E-SIM was effective for students.

The pretest and posttest findings, which were provided in frequency and percentage distributions, mean, standard deviation, normalized gain score, and p-value, revealed that after using the E-SIM, the Grade 11 students performed better in chemical bonding. This also proved that following the intervention, the students had gained overall knowledge and mastered the majority of the learning competencies. When the E-SIM is utilized as a teaching tool in chemical bonding, greater perception survey ratings may lead to higher improvements. The result of the SPS is the same with the findings of De Jesus (2019), where the students' response also showed that the E-SIM was helpful for most students and suggested that the E-SIM should be utilized frequently.

It can be deduced from this that there is a concrete manifestation of Jerome Bruner's Constructivist Theory, in which learners generate new ideas and concepts based on their present and previous knowledge. Pasion (2019) also emphasized the need for activity-based learning materials that allow learners to immediately experience the intentional use of all of their senses. Experiential learning is a method of gaining knowledge or skills by personal and perceptive observations, followed by an assessment of what has been learned. There are similar findings from the research of Limbago-Bastida & Bastida (2022) which discussed that the use of intervention material in the classroom has contributed to greater learning of concepts among students in science.

After the utilization of the E-SIM, students' performance had led to significant improvement from pretest to posttest. This finding can also be supported with the studies of De Jesus (2019), Cordova, et al. (2019), Sinco (2020), and Arpilleda (2021), which all highlighted that the use of intervention materials improved the performance of students in science subjects. The findings of Limbago-Bastida & Bastida (2022) and Dacumos (2016) stated that intervention materials are helpful in mastering competency-based science skills. Overall, this implies that the use of the E-

SIM as a remediation tool has a significant impact on the learner's performance in General Chemistry. These studies also showed that learners who are exposed to intervention materials have a better potential of increasing or enhancing their performance in the subject.

This study's findings are an extension of previous research about the use of E-SIM since they are congruent with their findings. This lends credence to the notion that intervention materials aid in increasing students' educational achievement to deliver high-quality education. Furthermore, the findings of this study contribute to the ongoing study and analysis of the E-SIM's effectiveness. The general public's awareness of the usefulness of E-SIM can help to strengthen the support from educational institutions. The results offered in this study can also be utilized to guide future development and implementation of E-SIM for students in other subjects and topics in a school setting.

The study was limited to Grade 11 students from the legislated science high school only, so the findings are not generalizable with other grade levels. In addition, the E-SIM only focuses on chemical bonding and the software used is only bound to Microsoft Powerpoint which is sometimes prone to software malfunctions. Finally, larger sample sizes for the participants of the study should be explored further.

CONCLUSIONS

Based on the analysis of the study identifying whether the intervention material can improve the mastery of the students in chemical bonding, it is concluded that there was a slight increase in student's achievement before and after the intervention, with a normalized gain score of 0.01. The objectives of the study were validated since the analysis of the data showed that there is a significant difference (*p-value*=0.0023) between the pretest and the posttest scores, with posttest posing a higher average. Therefore, it is deduced that the intervention material is an effective tool in enhancing the knowledge of the students about chemical bonding.

In terms of improving the knowledge of Grade 11 students in General Chemistry, the E-SIM has shown great potential. The scope of this intervention material is confined to one subject and topic area only; therefore, further studies on the use of E-SIM in other topics or subjects are advised in studying its effectiveness. The assessment tools, pretest and posttest, employed in this study only included multiple-choice questions; however, using a more comprehensive set of questions, such as identification, matching-type, and essay questions, might better capture the students' learning. Also, the respondents of this study have been limited to small sample size, having a wider population is advised to validate the impact of E-SIM. Because the scope of this study is limited, further study and implementation of the E-SIMs are strongly recommended to fully evaluate the suitability of incorporating E-SIM as an instrument in school learning.

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