



Developing Problem Solving Skills in Chemistry through the Algorithm Approach

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Abstract: This study aimed to develop problem-solving skills in chemistry using the algorithm approach, with the goal of providing problem-solving exercises to enhance students' ability to solve chemistry-related problems. It examined how science teachers used the algorithm approach to teach chemistry topics such as empirical and molecular formulas, the law of conservation of mass, and gas laws, and the difficulties they encountered in using the algorithm approach in teaching Chemistry. The study also identified and compared students' problem-solving skills before and after applying the traditional and algorithm approaches in teaching. Statistical treatments applied were frequency, percentage, weighted mean, independent t-test, and Hake factor test.

Based on the findings, the teachers strongly agreed that the algorithm approach can be utilized by engaging students in procedural approaches in solving stoichiometry-related problems, and they often encountered difficulties in utilizing the algorithm approach in teaching Chemistry, such as a one-trial-then-quit mentality of the students, lack of critical thinking ability, and lack of prior knowledge of the students in Chemistry concepts. Results also showed an increase in students' problem-solving skills from basic to mastery level with the traditional teaching method and from basic to advanced level with the algorithm approach. In addition, students showed no significant differences in performance on the pretest, but significant differences were observed on the post-test. The Hake factor test revealed that the control group had a medium gain, while the experimental group had a high gain after instruction, implying that the algorithm approach was more effective than the traditional lecture method.

Keywords: Problem Solving Skills, Chemistry, Algorithm Approach, Experimental.

1. Introduction

Chemistry is one of the fundamental sciences in the 20th century supplying key materials and principles that are interwoven throughout today's technology, natural sciences and culture. It deals with the properties of and interactions between matter and energy. Chemistry is known as the central science because it touches all other natural sciences like biology, physics, geology, and more. Traditionally, it is divided into subdisciplines such as organic, inorganic, physical, biological, theoretical, and analytical but these distinctions blur as it is increasingly appreciated how all of science, let alone chemistry, is interconnected.

In the light of learning chemistry, students expect to appreciate the world on the macro-scale such as synthesis of medicine, plastics or biomolecules while learning the underlying principles occurring on the molecular level and gain an understanding of how to collect, organize and interpret chemical data. They also anticipate to learn to critically analyze chemical information and use sophisticated instrumentation equipment to investigate the world around them. Students are also presumed to apply the principles of chemistry to solve qualitative and quantitative problems. The ability of problem solving in various learning contexts is essential in developing the students' knowledge in innovative and creative ways and gaining insight. Students' experiences in problem solving expose them to real life situations, thus preparing them to face the

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challenge of the real world which is the primary focus of science education.

However, studies have shown that many secondary and higher education students have problems based on deficiency of information and skill in problem solving stage particularly in the field of chemistry. As it is, it is seen as a difficult field by students, teachers and researchers. Students have difficulty in this field because of the abstract nature of chemistry topics and there are lots of chemistry languages that are different from the language used in daily life. And whenever problem solving activities in chemistry are given to the students, whispers and puzzled faces outshine the class implying that they don't have a clue on what to do. Preparing the students to become effective problem solvers in chemistry is a difficult goal to achieve. Studies in problem solving show that even after instruction, many chemistry students have still difficulty solving problems and continue to use novice problem solving techniques rather than more advanced problem-solving techniques.

In upper secondary education, chemistry is usually presented as a simplified and reduced version of college general chemistry. It contains quantitative and qualitative aspects of chemical reactions that need to be understood in order to solve chemistry-related problems. Researchers in science education contend that such a situation and process is not correct since science education in school aims to develop scientific literacy which is sufficient to make the future citizen able to understand and participate in decision making on crucial social and economic matters (Stamovlasis, 2005). A main feature of the way school chemistry should be taught and tested all over the world is that the emphasis should be often placed on learning rules which students showed respond with success to examination questions, including relatively complicated computational problems or exercises.

Traditionally the subject is taught in a teacher-centered classroom with compartmentalized curriculum with students working independently to memorize facts. The teacher operated as the "sage on the stage," the giver of all knowledge. Teachers are keepers of knowledge and uniformly provide content to students. And the lessons are focused on the lower level of Bloom's Taxonomy such as knowledge, comprehension and application.

This study presupposes that for the students to achieve better problem-skills in chemistry, they have to be exposed to different types of teaching approaches. The teacher should be able to make a wise choice of the type of approach that should be utilized under varying learning conditions. Algorithm approach is one of the teaching approaches that may be used in science education. It describes and demonstrates specific procedures and situations that can help students understand why particular algorithms are relevant and effective in certain situations. Indeed, the purpose of this approach is to reduce the load on working memory and save time. It is used by chemists to unit conversions, such as converting feet into inches or inches into centimetres, in stoichiometry questions, in writing Lewis structures, and in the step-by-step process often used to predict the shape of a molecule from its Lewis structure.

An algorithm features a set of steps of operations to solve a problem performing calculation, data processing, and automated reasoning tasks. In science education, an algorithm is the best way to represent the solution of a particular problem in a very simple and efficient way. The important aspects of algorithm design include creating an efficient algorithm to solve a problem in an efficient way using minimum time and space.

The researcher as a chemistry teacher is witness to much difficulty in solving chemistry-related problems. From this observation, the researcher felt that there is a need to teach problem-related topics in chemistry to science, technology, engineering and mathematics (STEM) students applying the algorithm approach to develop their problem-solving skills. Considering that in the later years, they will be having higher success and later be the future professionals in the field in engineering, mathematician, medicine and the like, it is but of importance that early on, they be taught the higher order thinking skills. It was along this concern that this study was conducted.

2. Objectives of the Study

This study aimed to develop problem solving skills in chemistry of the senior high school students using the algorithm approach.

Specifically, this study aims to:

1. determine how is algorithm approach utilized in teaching chemistry;
2. describe the problem-solving skills of students in the control and experimental groups in the following units of study:
 - 2.1 Empirical and Molecular Formula
 - 2.2 Law of Mass Conservation
 - 2.3 Stoichiometry
 - 2.4 Gas Laws
3. determine the significant differences in the performance of the two groups of respondents in the pretest and posttest; identify the difficulties encountered in utilizing the algorithm approach in teaching chemistry; and,
4. prepare problem solving exercises integrating the algorithm approach.

3. Materials and Methods

This experimental research used pretest-posttest and control and experimental group design. Experimental designs provide control of when and to whom the measurement is applied. The design allows the researcher to control the assignment to the treatment condition using some criterion other than random assignment. It is a commonly used experimental design because of its strength in controlling threats to internal validity (Levy and Ellis, 2011).^[2]

The researcher decided to use experimental research because the availability of participants was limited and the number of population in the school was appropriate with the number of sample expected by the researcher. Moreover, the researcher decided to choose experimental design because the participants were organized well in the class where randomization was not possible. In addition, the researcher applied the pre-and posttest design approach to a experimental design. The researcher

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assigned intact groups the experimental and control treatments, administered a pretest to both groups, conducted experimental treatment activities with the experimental group only, and then administers a posttest to assess the differences between the two groups.

The researcher used two classes treated as experimental and control class. Experimental class was the class where algorithm approach was applied and control class was the class where the traditional method of teaching was used.

The participants of the study were two heterogeneous sections of Grade 12 STEM (Science, Technology, Engineering and Mathematics) students who were enrolled in General Chemistry during the first semester of school year 2018-2019 at Palahanan National High School and eight chemistry teachers from public senior high schools in San Juan, Batangas.

The researcher used purposive sampling technique in the selection of the participants from the science teachers teaching chemistry subject in public senior high schools in San Juan and students taking general chemistry 1 in STEM strand. STEM 1 consisting of 17 students were exposed to algorithm approach. STEM 2 consisting of 18 students were exposed to traditional method.

Pretest results were analyzed to establish the comparability of the two groups of participants before subjecting them in the actual instruction. Pretest results revealed that there was no significant difference in the performance of the two groups of participants. To further strengthen the comparability of the two groups of participants, the general weighted average on applied and core science subjects in Grade 11 were also analyzed. Data are presented in Table 1.

Range of GWA	Control Group STEM 2	Experimental Group STEM 1	Total
92-94	9	9	18
89-91	7	7	14
86-88	1	0	1
83-85	0	0	0
80-82	0	1	1
77-79	1	0	1
Total	18	17	35

$$\bar{x}_2 = 3.00$$

$$\bar{x}_1 = 2.83$$

On the other hand, this study was organized and conducted on the following bases: first, the control and experimental groups were both enrolled in the same academic track. Second, they were also exposed to the same curriculum with the same number of units. With this, they used the same curriculum guide and learning competencies.

Data Gathering Instrument

The main data gathering instruments used in this study were self-constructed test and questionnaire.

Self-constructed test (Pretest and Posttest). This test was designed by the researcher to assess the performance of the two study groups before and after the experiment was conducted. The final version of the test consisted of 30 items multiple choice type test items with four plausible options, and five Chemistry-related problems each covering the chosen topics in General Chemistry 1 such as empirical and molecular formula, law of conservation of mass, stoichiometry, and gas laws. All these topics were discussed during the period of the experiment. The test constructed covered different levels of understanding such as knowledge, understanding, application and analysis based on Bloom's Taxonomy of objectives. A table of specification was made based on the scope of the study to ensure proper distribution of test items (refer to Appendix D). The content of this instrument was submitted to two chemistry instructors and one chemical engineer from San Juan Senior High School, and three science instructors of Batangas State University for comments and suggestions. Their suggestions and comments served as bases for the improvement of the items before this was subjected to a pilot test for further refinement and for determination of the test reliability.

After the test was validated, the 50-item test was pilot tested to 35 Grade 12 STEM students who had finished General Chemistry 1. The data gathered were used for item analysis. After establishing the validity of the test, it was administered analyzing and checking, the test was administered to the control and experimental groups.

Scoring of self-constructed test. To determine the ability in problem solving of the students in each topic in General Chemistry 1, their obtained raw scores were arranged with a certain number of intervals. Their obtained scores were categorized into four levels: advanced, mastery, basic, and approaching basic. This categorization of the levels of the problem solving skills was based on the achievement level descriptors adapted by the Louisiana Educational Assessment Program 2025 (LEAP 2025) (louisianabelieves.com). Such categories of the problem solving skills were classified into the following:

Advanced category. This category indicates that students create original algorithms to find solutions to multi-step problems using the full range of chemical values, and constructs structured proofs that provide full justification of each step. Students in this level use mathematical and common vocabulary correctly and provide clear and precise solutions.

a. Mastery category. This category indicates that students adapt one or more algorithms to find a solution to multi-step problems using the full range of chemical values and construct structured proofs that may lack some details. Students in this level use mathematical and commonly vocabulary correctly, but solutions may lack clarity for the external reader.

b. Basic category. This category indicates that students make a choice of algorithms to find a solution to multi-step problems or one-step problems using limited range of chemical values. Students use more than one particular case to establish a proof. Students in this level use common vocabulary to present solutions.

c. Approaching basic. This category indicates that students find single solution to one-step problems using obvious

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algorithms and a limited range of chemical values and use one case to establish a proof.
The verbal interpretations used for the students' problem solving skills in each lesson were as follows:

Raw Score Range	Verbal Interpretation
8-9	Advanced
5-7	Mastery
2-4	Basic
0-1	Approaching Basic

Empirical and Molecular Formula (Perfect Score: 9)

Raw Score Range	Verbal Interpretation
8-9	Advanced
5-7	Mastery
2-4	Basic
0-1	Approaching Basic

Law of Conservation of Mass (Perfect Score: 9)

Raw Score Range	Verbal Interpretation
11-13	Advanced
7-10	Mastery
3-6	Basic
0-2	Approaching Basic

Stoichiometry (Perfect Score: 13)

Raw Score Range	Verbal Interpretation
15-19	Advanced
10-14	Mastery
5-9	Basic
0-4	Approaching Basic

Gas Laws (Perfect Score: 19)

Questionnaire. The utilization of algorithm approach in teaching chemistry, and the difficulties encountered by the teachers in utilizing algorithm approach were determined through questionnaire. The questionnaire was composed of two parts. Part I focused on the ways algorithm approach was utilized in teaching chemistry. Part II gathered information on the difficulties encountered by the teachers in utilizing the approach.

Construction of the questionnaire. The research instrument was conceptualized through reviewing different concepts and studies about utilization of algorithm approach in chemistry and the difficulties in teaching chemistry integrating the algorithm approach. The first draft was given to the adviser for thorough examination of each item based on the statement of the problem. Modification was done to ensure that each item would yield the information needed. The researcher was advised to incorporate the suggestions and corrections. After all the corrections and suggestions from the adviser were incorporated, draft of the questionnaire was prepared.

Part I of the questionnaire was constructed based on the related literatures and other studies on the application and integration of algorithms in the field of chemistry. Part II of the questionnaire was based on some researches and true-to-life experiences of teachers in delivering science instructions inside the classroom with the integration of algorithm approach.

Validation of the questionnaire. The first draft of the questionnaire was presented in the field to the chosen science teachers, and other experts for validation. After validation, the final copy of the questionnaire was prepared and made ready for administration.

Administration of the questionnaire. Upon validation of the questionnaire, it was reproduced and readied for administration. A letter of request to distribute and asking for the approval of the principal to disseminate the instruments was done. With the request approved, the researcher administered the copies of the questionnaire to the selected chemistry teachers in senior high schools in San Juan. The teacher-respondents were given enough time to answer the questionnaire and were informed that the questionnaires would be retrieved on a specific date.

Scoring of responses. Upon one week retrieval of the questionnaires, the researcher tallied the responses of the respondents. The responses were evaluated according to the following scale and corresponding verbal interpretation:

Scale Range	Verbal Interpretation
3.50 – 4.00	Strongly Agree/Very Often
2.50 – 3.49	Agree/Often
1.50 – 2.49	Disagree/Sometimes
1.00 – 1.49	Strongly Disagree/Never

Data Gathering Procedure

Before the conduct of the study, the researcher sought the approval of the authorities concern to conduct the investigation through a letter of request. Upon the approval, all the students involved were made aware of the purpose of the study to be conducted to ensure that their participation would be voluntary.

The participants were subjected to four weeks of lecture. Both groups met with the same number of hours for 16 meetings every 9:20-10:20 AM for the Experimental Group and 10:40-11:40 AM for the Control Group, from Monday to Friday. On the first week of the actual study, the Pretest was administered in both the control and experimental groups at the same time and room. It was administered before the exposure of the students in the algorithm approach to determine the students' initial level of problem solving skills.

The researcher employed the algorithm approach as a teaching method in General Chemistry 1 for the experimental group and the Traditional method for the control group. The participants attended interactive lecture engagement classes through the algorithm approach. The experimental group used drill exercises, and some worksheets focused on the chosen units of study. While the control group used the traditional learning materials and resources during the sessions. During the conduct of the study observers were invited to the experimental class. A copy of the observer's rating sheet is presented in Appendix N. This was used to ensure that algorithm approach was integrated during the instruction to the experimental class.

After the integration of the two approaches, the posttest was administered to both groups to determine their new level of performance. Results of the pretest and posttest were subsequently analyzed and interpreted. Different ways on how teachers utilize algorithm approach in teaching Chemistry, and the difficulties in teaching Chemistry integrating the algorithm approach were determine through questionnaire. Interview prompt was also conducted in order to clarify further the teachers' responses.

The gathered quantitative data was subjected for checking, scoring, analysis and interpretation with the help of the statistician. The researcher made a careful evaluation of the results of the questionnaires. Every item in the questionnaire was painstakingly analyzed and interpreted to come up with drill exercises which may be proposed to develop students' problem solving skills.

Statistical Treatment of Data

The following statistical measures were used by the researcher in analyzing the data in this study.

Frequency and Percentage. This was used to determine the participants problem solving skills in the control and experimental group in each item in the pretest, posttest.

Weighted Mean. These were used to determine the teacher-respondents' perceptions regarding the utilization of algorithm approach in teaching Chemistry, and the difficulties encountered in teaching Chemistry integrating the said approach.

Table 2
Utilization of Algorithm Approach in Teaching Chemistry

Items	Weighted Mean	Verbal Interpretation
1. engaging students to procedural approaches in solving for stoichiometry related problems	3.63	Strongly Agree
2. giving students an easier way of converting unit of measurements in Chemistry	3.50	Strongly Agree
3. providing process-based computational analysis on determining the limiting and excess reagents	3.50	Strongly Agree
4. enumerating and following standardized processes and procedures in naming hydrocarbon compounds	3.38	Agree
5. using algorithmic nonlinear model to control the pH neutralization process	3.25	Agree
6. presenting digital charts to compare the qualitative and quantitative properties of matter	3.25	Agree
7. using statistical models for the analysis and design of digital polymerase chain experiments in Chemistry	3.25	Agree
8. using molecular graphs in representing the structural formula of a chemical compound	3.13	Agree
9. providing the students with models and simulations used in explaining how variables behave under a variety of conditions, such as temperature, pressure, and volume	3.13	Agree
10. expressing solution on mole ratio and balancing equation in a sequential manner	3.13	Agree
11. providing machine-learning algorithms to study the fundamental properties of atoms, molecules and chemical reactions	2.88	Agree
12. applying constitutional graphs (corresponds to a set of isotopological compounds) in chemical nomenclature, coding, and in representing atoms and lines symbolizing covalent bonds	2.75	Agree
13. emphasizing the use of various graphical representations in analysing rate of chemical reaction	2.75	Agree
14. identifying the type of chemical reactions using mathematical patterns and representations	2.50	Agree
15. using computer simulations to calculate the structures and properties of molecules and solids	2.50	Agree
Composite Mean	3.10	Agree

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Independent t-test. This was used to determine the comparison of the performance of the students in the control and experimental groups.

Hake Factor Test. This was used for analyzing the pretest and posttest to measure the effectiveness of algorithm approach in developing problem solving skills in Chemistry.

4. Results and Discussion

1. Utilization of Algorithm Approach in Teaching Chemistry

The ways on how algorithm approach is utilized by science teachers in Chemistry is shown in Table 2.

From the table it can be seen that the teachers strongly agreed that they utilized algorithm approach in teaching chemistry by engaging the students to procedural approaches in solving for stoichiometry related problems, which has the highest weighted mean of 3.63. Result implies that for the teachers the most effective way of solving chemistry problems is by presenting it in a procedural process. From the prompt interview conducted for the teachers, if the solution in solving problem were presented step-by-step, the more the students understand the lesson. The students can easily solve the problem and understand it if presented logically. This finding runs parallel to the study of Bodner wherein he emphasized that such step-by-step approaches is useful in solving problems and in situations where each decision must be made following the same process and where accuracy is critical.^[3] In addition, he reiterated that through the use of these procedures, accuracy is increased and potential mistakes are minimized. Because the process follows a prescribed procedure, students can be sure that they will reach the correct answer each time they make solutions for problems.

It can also be gleaned from the table that the teachers strongly agreed that they utilized algorithm approach in teaching chemistry by giving the students an easier way of converting unit of measurements in Chemistry and by providing process-based computational analysis on determining the limiting and excess reagents, which both have the weighted mean of

3.50. Some students find the conversion of units difficult, whereas for others it seems to come naturally. Whether they find it difficult or not, students are often required to convert between different units, such as length, volume or mass. And in order to deepen the students understanding of what concepts in conversion are, the teachers teach proportional reasoning and provide the students easier ways on how to convert units of measurements in chemistry. On the other hand, most students find stoichiometry to be one of the most challenging topics in chemistry class. This is true especially in determining the limiting and excess reagents in an experiment. From the interview prompt conducted, in order to respond with this daunting challenge of learning stoichiometry concepts, teachers provide process-based computational analysis on determining the limiting and excess reagents, and that in the process students learned several lessons that made the rest of their chemistry work easier. These support the idea of Schmidt & Jigneus that the usage of algorithm such as the factor label approach which provides an easier way to unit conversions, and the use of the road-map approach which is focused on process-based computational analysis to stoichiometry questions help the students to perform to a great extent in their Chemistry class.^[4] He added that students who have not built algorithms for at least some of the steps in a problem, such as converting between grams and moles, will never solve the problem.

Reflected also from the table that the teachers agreed that they utilized algorithm approach in teaching chemistry through enumerating and following standardized processes and procedures in naming hydrocarbon compounds. This got a weighted mean of 3.38. This is not surprising since most of the students get confused in following several rules in naming hydrocarbon compounds. Some other teachers based the rules they teach in the class in different resources such as books and other journals in the internet which lead to students' confusion in learning the concepts. Based on the interview prompt conducted, teachers respond to this problem through enumerating and following standardized processes and procedures in naming hydrocarbon compounds. Through these standardized processes and procedures, the students were able to name several hydrocarbon compounds in minimal amount of time correctly. This conforms to the idea of Ertl that the use of algorithm with relatively simple standardized procedures with full details and examples will lead to the automatic identification of hydrocarbon compounds or functional groups in organic chemistry.^[5] It can also handle more complex functional groups and provide detailed classification of hydrocarbon compounds. He reiterated that this approach allows the analysis of functional groups in large chemical databases in a way that was not possible using other approaches.

Moreover, the teachers agreed that algorithm approach was utilized in the class through the use of algorithmic nonlinear model to control the pH neutralization process, presenting digital charts to compare the qualitative and quantitative properties of matter, and using statistical models for the analysis and design of digital polymerase chain experiments in Chemistry. These got the same weighted mean of 3.25. This showed that most teachers used nonlinear and statistical models and charts in teaching chemistry concepts. This maybe because most of the students in the class are visual learners and they easily understand and analyze concepts through visual models and charts. These contribute to authentic chemistry education, and are used to explain or describe something that is not familiar like the pH neutralization process, the properties of matter, and the design of digital polymerase chain experiments in Chemistry. This finding also supports the idea of Neria and Amit that graphs, models, and simulations facilitate student's problem solving and understanding of science concepts.^[6] She also mentioned that students learned how to think more deeply and better through models. On the other hand, these results contradict the findings of Drechsler that teachers encountered difficulties in the use of models in the specific area of acids and bases.^[7] He found out that teachers often do not emphasize the different models to describe acids and bases, and this mix of models makes it complicated for students to understand the chemistry content.

On the other hand, the teachers agreed that algorithm approach was also utilized by using mathematical patterns and representations in identifying the type of chemical reactions and by using computer simulations in calculating the structures and properties of molecules and solids. These got the lowest weighted mean of 2.50. This implies that, in order to deliver the instructions and learning competencies well in Chemistry, the teachers also considered the use of mathematical patterns and

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representations, and using computer simulations to arrive at accurate solutions, and quantitative values. From the interview conducted, the availability of computer and internet in public senior high schools limit their use of this strategy. This finding confirms the study conducted by Gakunga & Mwikali that public secondary schools were less equipped with computer facilities/equipment, computer studies books and internet connectivity unlike private secondary schools.^[8] It was also mentioned in his study that students from private secondary schools were adequately exposed to projects/practical activities as a mechanism of enhancing their computer skills compared to their counterparts from public secondary schools.

As a whole, the composite mean of 3.10 indicates that the teacher-respondents agreed in most of the items used to describe the utilization of algorithm approach in teaching Chemistry. Data revealed that algorithm approach was utilized by STEM science teachers in delivering instructions and learning competencies in Chemistry.

2. Problem-Solving Skills of Students in the Pretest and Posttest in Each Unit of Study in General Chemistry 1

Problem solving skills is one of the important competencies that students need to develop in understanding Chemistry. Problem solving skills of the students in the controlled and experimental groups in the pretest and posttest in general Chemistry 1 were discussed in this study. The topics in General Chemistry 1 that were included were the empirical and molecular formula, the law of conservation of mass, stoichiometry, and gas laws. These are shown in the succeeding tables.

2.1 Empirical and Molecular Formula. Table 3 presents the level of problem-solving skills of students in the control and experimental groups in the pretest on empirical and molecular formula.

Level	Control		Experimental	
	f	P	f	P
Mastery (5-7)	1	5.56	1	5.88
Basic (2-4)	17	94.44	16	94.12
Total	18	100	17	100

$\bar{x}_C = 3.06$ (Level 2) $\bar{x}_E = 3.29$ (Level 2)
Table 3 Problem Solving Skills in the Pretest on Empirical and Molecular Formula

It can be gleaned from the table that before the instruction, the two groups of participants belonged to the basic level of problem solving skills as reflected by the frequency of 17 (94.44%) and 16 (94.12%) respectively. Only one (5.56% - 5.88%) in both groups were at the mastery level. The students got a raw score which ranged from 5 to 7 in the pretest. It appears that students have limited knowledge in writing empirical and molecular formula. It is maybe because it was not yet further discussed when they were in junior high school since it is on the latter part of the curriculum guide. The topic was not discussed during junior high school since there are lots of competencies to be tackled. It also implies that students were not able to utilize previous knowledge to predict rational answers.

Table 4 presents the level of problem-solving skills of students in the control and experimental groups in the posttest on empirical and molecular formula.

Level	Control		Experimental	
	f	P	f	P
Advanced (8-9)	0	0	13	76.47
Mastery (5-7)	15	83.33	4	23.53
Basic (2-4)	3	16.67	0	0
Total	18	100	17	100

$\bar{x}_C = 5.41$ (Level 3) $\bar{x}_E = 8.06$ (Level 4)
Table 4 Problem Solving Skills in the Posttest on Empirical and Molecular Formula

As to the performance of the students in the posttest, 15 participants (83.33%) had achieved the mastery level in problem solving. They got a raw score which ranged from 5 to 7. This signifies that most of the students were able to determine the formulas whether it is empirical or molecular, and calculate for the actual and correct formula of a substance using the traditional teaching method. This also implies that most of the participants were able to connect their prior knowledge to the present discussion on the empirical and molecular formula. They have enriched their skills in identifying and analyzing data as well as the skills in solving problems at hand. However, there were three participants (16.67%) in the control group who belonged to basic level of problem solving skills. They got grades which ranged from 2 to 4. This could be meant that the students were not able to fully comprehend ideas, and apply the knowledge that they have gained in determining the empirical and molecular formula of a given substance. It may also be perceived that students might have developed misconceptions on the concepts of the topic and there might be possibilities that student got confused of ways in finding the best solution for the problem.

As to the performance of the students with the use of algorithm approach in posttest, 13 participants (76.47%) had achieved the advanced level of problem solving skills. They got a raw score which ranged from 8 to 9. It appears that the algorithm approach used by the teacher was effective because 13 students got a perfect score of 9. Algorithm approach using experiment and drill exercises was utilized by the researcher on this topic to promote learning and develop problem solving skills. This means that this approach increased student acquisition of basic skills. These findings run parallel to the idea of Sukmadinata that drill exercises can improve the high-level of mathematical ability of the students.^[9] He added that well-designed drill exercises have positive impacts on students' learning achievement. However, four students (23.53%) attained the mastery level during the posttest. Their raw scores ranged from 5 to 7. Seemingly, these students were able to comprehend well the concepts, and practice their problem solving skills in getting the empirical and molecular formulas of compounds.

The result of posttest in the two groups revealed that most of the students learned well and ameliorated their skills in

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problem solving especially the students in the experimental group where the algorithm approach was integrated. This finding conforms with Bodner's idea that by using an algorithm, accuracy is increased and potential mistakes are minimized. He also added that the process follows a prescribed procedure and that students can be sure that they will reach the correct answer each time they solve a problem or find the best solution to a problem.

2.2 Law of Conservation of Mass. Table 5 presents the level of problem-solving skills of students in the control group and experimental groups in the pretest on the Law of Conservation of Mass topic.

It can be noted from the table that there were 12 participants (66.67%) in the control group who had basic level of problem solving skills. Majority of the participants got a raw score which ranged from 2 to 4 in the pretest. It appears that the students have limited knowledge in the topic. It is maybe because the concepts in the Law of Conservation of Mass were not clearly conceptualized in their previous science lessons. However, six participants (33.33%) who participated in the control group made it to the mastery level. The students got raw scores which ranged from 5 to 7. This can be an indication that few students were able to connect their prior knowledge to the questions in the topic. According to Leach and Scott prior knowledge is a foundation for subsequent learning that should be mastered before new information is to be taught.^[10] When students don't have appropriate prior knowledge, intended learning cannot take place.

Level	Control		Experimental	
	f	P	f	P
Advanced (8-9)	0	0	1	5.88
Mastery (5-7)	6	33.33	8	47.06
Basic (2-4)	12	66.67	8	47.06
Total	18	100	17	100
	$\bar{x}_C = 4.00$ (Level 2)		$\bar{x}_E = 4.82$ (Level 3)	

Table 5 Problem Solving Skills in the Pretest on Law of Conservation of Mass

Reflected also from the table that eight participants (47.06%) in experimental group belonged to the mastery and basic achievement level of problem solving skills. It can be said from the statistical data that some students could still recall the previous concepts related to the Law of Conservation of Mass while some of the students had limited knowledge in the topic. This can be attributed to the fact that this topic was included and discussed in science subject in junior high school level and even in elementary level.

Findings revealed that some of the students do not have prior knowledge regarding the law of conservation of mass, and or they were not able to utilize previous knowledge to predict rational answers. On the other hand, some of students were able to engage preconceptions in Chemistry in order to understand and solve Law of Conservation of Mass-related problems.

Table 6 presents the level of problem-solving skills of students in the control and experimental groups in the posttest on law of conservation of mass.

Level	Control		Experimental	
	f	P	f	P
Advanced (8-9)	4	22.22	14	82.35
Mastery (5-7)	14	77.78	3	17.65
Total	18	100	17	100
	$\bar{x}_C = 6.76$ (Level 3)		$\bar{x}_E = 8.24$ (Level 4)	

Table 6 Problem Solving Skills in the Posttest on Law of Conservation of Mass

It can be gleaned from the table that 14 participants (77.78%) of the control group belonged to the mastery level. They got raw scores which ranged from 5 to 7. It appears that they were able to engage and apply what they have learned using the traditional method of teaching. Participants were able to understand and solve problems related to the law of conservation of mass after the instruction. On the other hand, four participants (22.22%) of achieved the advanced level, which is the highest level of problem solving skills. This shows that students have improved skills and abilities in solving Chemistry-related problems through the traditional lecture method and gain more conceptual understanding of Chemistry after the instruction.

As to the performance of the students in the posttest under the experimental group, 14 participants (82.35%) had advanced level of problem solving skills. They got raw scores which ranged from 8 to 9. It comes out that algorithm approach was effective since majority of the students got perfect score of 9. Algorithms provided students an easier way of converting unit of measurements in law of conservation of mass such as gram to mole or mole to mole, that was highly used in learning the topic. In calculations, algorithms automate individual steps in a problem. These notions were supported by the idea of Bodner's that students who have not built algorithms for at least some of the steps in a problem, such as converting between grams and moles, will never solve the problem. Through algorithm approach, the students were able to deepen their understanding of chemistry concepts and develop their problem solving skills.

It can also be noted from the table that three participants (17.65%) attained the mastery level of problem solving skills during the posttest. Their raw scores ranged from 5 to 7. This is an indication that the students were able to conceptualized and analyzed the ideas regarding the topic. The students were also able to solve problems easily and arrive to a more precise answer following the algorithms provided in the drill exercises during the experiment.

As a whole, the results revealed that exposing the students in algorithm approach of teaching develop their problem solving skills in Chemistry than the traditional method of teaching. Students were able to solve problems easily and arrive to a more precise answer following the algorithms provided in the drill exercises during the instruction. They were able to answer almost all the questions in test correctly and find best solutions to problems with the aid of the approach. This finding conforms

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with Cherry's notion that the upside of using an algorithm to solve a problem or make a decision is that yields the best possible answer every time.^[11] This is useful in situations when accuracy is critical or where similar problems need to be frequently solved.

2.3 Stoichiometry. Table 7 presents the level of problem-solving skills of students in the control and experimental groups in the pretest on stoichiometry.

As seen in the table, nine participants (50%) of the control and experimental groups belonged to the basic level and approaching basic level based on the pretest result. The students got raw scores which

Level	Control		Experimental	
	f	P	f	P
Basic (3-6)	9	50.00	6	35.29
Approaching Basic (0-2)	9	50.00	11	64.71
Total	18	100	17	100
	$\bar{x}_C = 2.41$ (Level 1)		$\bar{x}_E = 2.24$ (Level 1)	

Table 7 Problem Solving Skills in the Pretest on

Stoichiometry

ranged from 0 to 6. It appears that the students lack prior knowledge and understanding in stoichiometry maybe because such topics in Chemistry were not discussed in a more detailed manner. Only basic concepts on stoichiometry were emphasized in the previous science lessons.

As to the performance of the experimental group in pretest, 11 participants (64.71%) got the lowest scores which classified to be at the approaching basic level. The students obtained scores which ranged from 0 to 2. This is a clear indication that students had no or little knowledge in this particular topic. It can also be noted from the table that only six participants (35.29%) belonged to the basic achievement level in the pretest. It can also be perceived from the result that the topic was not given emphasis or was not thoroughly discussed when they were in junior high school.

The results revealed that the two groups found it hard to think of rational answers to the questions in stoichiometry. This upholds the fact that many students have problems learning stoichiometry since it covers a complex mathematical concept in determining how much product will be produced or formed from a given quantity of reactants. This conforms to the idea of Schmidt and Jignéus that the concept of stoichiometry is very difficult for students to grasp and therefore discouraging. Difficulty is encountered by the students in determining the limiting reagent in a given problem, when one substance is added in excess.

Table 8 presents the level of problem-solving skills of students in the control and experimental groups in the posttest on stoichiometry.

Level	Control		Experimental	
	f	P	f	P
Advanced (11-13)	0	0	9	52.94
Mastery (7-10)	9	50.00	8	47.06
Basic (3-6)	9	50.00	0	0
Total	18	100	17	100
	$\bar{x}_C = 6.18$ (Level 2)		$\bar{x}_E = 10.71$ (Level 4)	

Table 8 Problem Solving Skills in the Posttest on Stoichiometry

It can be seen in the table that nine participants (50%) of the control group had achieved the mastery and basic achievement level of performance. They got raw scores which ranged from 7 to 10, and 3 to 6 respectively. It appears that in the administration of posttest, some of the students had applied the concepts and problem-solving strategies that they've learned during the lecture, and tried their best to cope up with the challenges brought about by the stoichiometric questions and problems. Data revealed that after the traditional method of teaching half of the students still gained the basic skills in analyzing stoichiometric questions and the skills in solving stoichiometric problems. This implies that traditional method of teaching is not enough for the students to really grasp concepts on stoichiometry.

In the experimental group, nine participants (52.94%) attained the advanced level. They got a grade which ranged from 11 to 13. It appears that the algorithm approach used by the teacher was effective because majority of the students got a perfect score. This finding runs parallel to the study of Fach that the algorithm technique using the road-map approach to stoichiometry questions and on stoichiometric problems was effective in overcoming the difficulty of most students.^[12]

Reflected also from the table that eight participants (47.06%) achieved the mastery level using the same approach. Their grades ranged from 7 to 10. This shows that the students understand the lessons and were able to find a correct solution to a multi-step problem using the full range of the approach after the instruction.

Results showed that the students in the control group were not able to fully comprehend the concepts in stoichiometry, and that they cannot create original algorithms to find solutions to multi-step problems using the full range of chemical values unlike the students in the experimental group. Students in the control group might have developed misconceptions on the ideas regarding stoichiometry, and there might be a possibility that the students were confounded with the rules used in getting the limiting and excess reagents. On the other hand, most of the students in the experimental group were able to answer all

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stoichiometric questions correctly since they were exposed to algorithm approach. They were able to analyze and think of best possible solutions to stoichiometric problems. It is good to note that algorithm approach contributed much in attaining the highest level of problem solving skills. This was supported by the notions of Fach wherein he emphasized that the execution time in solving stoichiometric problems is being reduced through the use of the algorithm approach. He also added that stoichiometric discrepancies in chemical reaction databases may also be removed through the use of this approach.

2.4 Gas Laws. Table 9 presents the level of problem-solving skills of students in the control and experimental groups in the pretest on gas laws.

It can be gleaned in the table that out of 18 participants who have been part of the control group, 14 (77.78%) got the lowest scores ranging from 0 to 4. Their problem solving skills was in approaching basic level. This shows that the students lack prior knowledge and understanding of the concepts regarding Gas Laws. On the other hand, four participants (22.22%)

Level	Control		Experimental	
	f	P	f	P
Basic (5-9)	4	22.22	0	0
Approaching Basic (0-4)	14	77.78	17	100.00
Total	18	100	17	100
$\bar{x}_C = 3.35$ (Level 1)		$\bar{x}_E = 3.18$ (Level 1)		

Table 9 Problem Solving Skills in the Pretest on Gas Laws

had the basic level of performance in the pretest. The students got scores which ranged from 5 to 9. This can be an indication that students have limited knowledge on the topic. It is maybe because such topics in General Chemistry were not tackled profoundly in the lower years. In addition, this topic has a broad coverage of concepts, laws and principles.

Table also revealed that all (100%) of the participants under the experimental group had approaching basic level in problem solving before the instruction. The students got scores at the lowest range (0-4) in the scale. It appears that the students were not able to recall their previous learnings on gas laws, and or they lack of problem solving skill necessary in solving gas laws problems. Students were not able to understand and evaluate ideas based on science concepts. This conforms to the ideas of Colley that learning for understanding such as explaining ideas in science and evaluating arguments based on scientific evidences were given less emphasis at all levels. This suggests that students may be learning science without actually understanding.^[13]

The data from the table can be an indication of the limited knowledge of the students in the topic. Students encountered misconceptions during the time that gas laws were presented to them. It is also a clear indication of poor mathematical reasoning of the students before instruction.

Table 10 presents the problem-solving skills of the controlled and experimental groups in the posttest on gas laws.

It can be gleaned from the table that 16 participants (88.89%) percent in the control group obtained the mastery level in the posttest.

Level	Control		Experimental	
	f	P	F	P
Advanced (15-19)	1	5.56	9	52.94
Mastery (10-14)	16	88.89	8	47.06
Approaching Basic (0-4)	1	5.56	0	0
Total	18	100	17	100
$\bar{x}_C = 11.06$ (Level 3)		$\bar{x}_E = 14.53$ (Level 4)		

Table 10 Problem Solving Skills in the Posttest on Gas Laws

They got a score which ranged from 10 to 14. It appears that the students were able to answer most of the items in the test correctly. The students were able to apply the knowledge that they had gained using the traditional method of teaching. The method promoted understanding of the topic and developed their ability in solving problems related to gas laws.

As to the performance of the students under the experimental group, 9 participants (52.94%) had reached the advanced level of problem solving skill in the posttest. Participants got the highest scores that ranged from 15 to 19. It comes out that algorithm approach used by the teacher was effective because most of the students got perfect score in the test. Gas laws concepts were discussed incorporating algorithms through the symbolic representation such as symbols, equations, formula and graphs. This technique makes the concepts understandable by the students. This finding is in line with the notions of Sande that the use of representations and conceptions surrounding the gas laws can be easily managed and will provide specific insight in the discipline of chemistry as well as in the subject matter knowledge for teaching the gas laws. He also mentioned that representational competence helped students achieve a deep understanding of chemical concepts.^[14]

Reflected also from the table that eight participants (47.06%) had achieved the mastery level of performance in the posttest. The students got a raw score which ranged from 10 to 14. This means that the students' skills in problem solving were enhanced through algorithm approach.

The result implies that most of the students in the two groups were able to conceptualize and analyze the concepts regarding gas laws. However, not all the participants in the control group were able to develop their skills in problem solving.

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Some remained in the lowest level of performance when they were exposed to traditional lecture method. This finding runs parallel with the findings of Kautz that students receiving traditional lecture instruction fail to develop a functional understanding of gas laws in several respects.^[15] He affirmed that students have difficulty in relating the quantities in the ideal gas law to a given physical situation and in making predictions and comparisons about one or more gas samples on the basis of the ideal gas law.

3. Differences in the Performance of the Two Groups of Respondents in the Pretest and Posttest

The differences in the performance of the respondents in control and in experimental groups in the pretest and posttest were determined in this study. Table 11 presents the differences in the performance of students in the control and experimental groups in the pretest in each topic in general Chemistry 1.

Lesson	t_c	p-value	Decision on H_0	Interpretation
Empirical and Molecular Formula	0.855	0.399	Do not Reject	Not Significant
Law of Conservation of Mass	1.566	0.127	Do not Reject	Not Significant
Stoichiometry	-0.766	0.449	Do not Reject	Not Significant
Gas Laws	-0.846	0.403	Do not Reject	Not Significant

$$\alpha = 0.05$$

Table 11 Differences in the Performance of the Two Groups of Respondents in the Pretest

It can be noted from the data that the students in the control and experimental groups did not differ in their performance in all the topics in General Chemistry 1 as reflected by the t-values which range from -0.766 to 1.566 and p-values ranging from 0.127 to 0.449. The two groups of students did not differ in their performance in all the topics covered in the pretest. Thus, the null hypothesis of no significant difference between the levels of performance of the students in the controlled and experimental groups in the pretest was accepted. This finding revealed that participants in both groups were not able to answer most of the test items correctly in the pretest. This means that participants had no or little knowledge before the instruction.

Table 12 presents the differences in the performance of the students in the controlled and experimental groups in the posttest.

Lesson	t_c	p-value	Decision on H_0	Interpretation
Empirical and Molecular Formula	8.814	0.000	Reject	Significant
Law of Conservation of Mass	5.036	0.000	Reject	Significant
Stoichiometry	11.663	0.000	Reject	Significant
Gas Laws	4.099	0.000	Reject	Significant

$$\alpha = 0.05$$

Table 12 Differences in the Performance of the Two Groups of Respondents in the Posttest

The table shows that there are significant differences between the performance of the control and experimental groups in selected topics in General Chemistry 1. As reflected by the computed t-value which ranges from 4.099 to 11.663. The two groups of participants differed in their performance in the posttest. These observed differences can be explained by the scores of the two groups of participants in the posttest. It is good to note that the performance of the students in the experimental group which were exposed in algorithm approach is better as compared to the performance of the students in the control group which were exposed in the traditional lecture method. The participants in the experimental group were able to reach the advanced level of problem solving skills while the participants in the control group were in the mastery level of performance in problem solving.

The low performance of the control group may be attributed to the fact that in traditional teaching process, the teacher is the center, and the teaching process emphasizes system and completion but few thinking spaces for students. The knowledge is limited, the resource is scarce, and the learning is passive but the knowledge is well-formed and departed from real life. This confirms the idea of Liu and Long that in traditional method of teaching, the main experience of the students is insufficient or they lack subjective experience, which will restrict the effectiveness of learning strategy teaching. This finding also runs parallel to the notions of Kautz that students receiving traditional lecture instruction fail to develop a functional understanding of lessons in Chemistry in several respects.

On the other hand, participants' problem solving skills were developed after exposure to algorithm approach. Results imply that after the integration of algorithm approach students were able to create original algorithms to find solutions to multi-step problems using the full range of chemical values, and use mathematical and common vocabulary correctly, and provide clear and precise solutions. They were also able to arrive at the correct answers with a minimal amount of time in computing. This supports the idea of Bodner that by using an algorithm accuracy is increased and potential mistakes are minimized because the process follows a prescribed procedure where a student can

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be sure that he will reach the correct answer each time.

Ensuring the effectiveness of a new method adapted in teaching is one important role a teacher must not forget. Comparing the new method to other existing method of teaching will help the teacher in making decisions concerning the effectiveness of the new one. To further assess the effectiveness of the two instructional methods used in this study, average normalized gains (commonly referred to as the Hake Factor, g) were also calculated for each group. The average gains are reported in Table 13, along with average pretest and posttest scores.

Lesson	Group	Pretest	Posttest	g	Interpretation
Empirical and Molecular Formula	Control	0.34	0.60	0.40	Medium Gain
	Experimental	0.37	0.90	0.84	High Gain
Law of Conservation of Mass	Control	0.45	0.75	0.55	Medium Gain
	Experimental	0.54	0.92	0.82	High Gain
Stoichiometry	Control	0.19	0.48	0.36	Medium Gain
	Experimental	0.17	0.82	0.79	High Gain
Gas Laws	Control	0.18	0.58	0.49	Medium Gain
	Experimental	0.17	0.76	0.72	High Gain

Table 13 Average Normalized Gains for the Two Groups of Respondent

The table reveals that the control group was in the medium gain in all the topics covered in the study while the experimental group was in the high gain category after instruction. This is reflected by the normalized gain values ranging from 0.36 to 0.55 for the control group, and 0.72 to 0.84 for the experimental group. This only means that algorithm approach is more effective in teaching empirical and molecular formula in Chemistry than the traditional lecture method. This runs parallel to the notions of Schmidt & Jigneus that concepts discrepancies can be reduced through the use of the algorithm approach. With the use of algorithm approach in solving problems, the students would be able to easily run calculations about chemical reactions, and understand the relationships that exist between products and reactants which leads to effective teaching-learning process.

This result further supports the idea of Liu and Long that the traditional lecture method offers few thinking spaces for students wherein the knowledge is limited, the resource is scarce, and the learning is passive and departed from real life.^[16] Furthermore, the main experience of the students in this method is insufficient and lacks in subjective experience which restricts the effectiveness of learning strategy teaching. From then, many students lose interest in Chemistry because their initiative and enthusiasm cannot be fully exerted in class. The result also conforms the notions of Cherry that the development of an algorithm approach is a key step in solving a problem. It helps the students solve a problem or make a decision that yields the best possible answer every time. And that, algorithm approach is useful in situations when accuracy is critical or where similar problems need to be frequently solved.

4. Difficulties Encountered in the Utilization of Algorithm Approach

Difficulties in teaching are inevitable factors that hinder the effective teaching-learning process inside a classroom. In science education, teachers faced the difficulties in making the students understand the science concepts and develop their scientific skills such as the problem solving skills. The difficulties encountered by teachers in teaching Chemistry integrating the algorithm approach are presented in Table 13.

Table 14
Difficulties in the Utilization of Algorithm Approach
in Teaching Chemistry

Items	Weighted Mean	Verbal Interpretation
1. A one-trial then quit mentality of the students	3.38	Often
2. Lack of critical thinking ability of the students	3.25	Often
3. Lack of prior knowledge of the students in Chemistry concepts	3.25	Often
4. Lack of training in the use of algorithm approach	3.13	Often
5. Lack of students' interest in Chemistry	3.13	Often
6. Difficulty in following long and complex procedures	3.00	Often
7. Insufficient time in monitoring and evaluating the result/output of the activities in Chemistry using the algorithm approach	2.88	Often
8. Unavailability of instructional materials needed in using the approach	2.88	Often
9. Poor performance of the students in problem solving	2.88	Often
10. Inadequate skills and knowledge on the integration of algorithm approach in the lesson	2.75	Often
11. Students are too much dependent to teachers	2.75	Often
12. Lacking enough time in solving worded problems with the use of algorithm	2.63	Often
13. Difficulty in understanding and interpreting flowcharts, graphs and models	2.63	Often
14. Differences in the students' level of understanding	2.50	Often
Composite Mean	2.93	Often

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It can be noted from the data that the 'one-trial then quit mentality' of the students was the most commonly experienced problem by the science teachers obtaining the highest weighted mean of 3.38. It is a clear indication of the unwillingness of the students nowadays in doing their best in their school tasks particularly in problem solving. They just try it once, and stop when they fail. This supports the findings of Roediger and Arnold that most of the time students tend to practice their one-trial then quit mentality in solving problems. This hinders students in generating effective solutions for the problems.^[17] The students become demotivated in analyzing and evaluating the problems at hand.

Another difficulty often experienced by the teachers in the utilization of algorithm approach in teaching Chemistry is the lack of critical thinking ability of the students, and the lack of prior knowledge of the students in Chemistry concepts. These got the same weighted mean of 3.25. Results suggest that poor performance of the students in science education was brought about by the lack of prerequisite skills such as learning how to think critically and use or connect their previous knowledge to the present ideas and concepts. Students' critical thinking attuned to thinking that to solve problems, analyze issues or make decisions while learners' prior knowledge provide them with information about what sorts of problem features are important. Learners with greater prior knowledge conceptualize key problem features more accurately than learners with less prior knowledge. According to Fung, the major difficulty in educating for critical thinking is lack of a synthesized understanding about what is meant by the term, and what an effective critical thinking program should involve.^[18] He also added that in learning to think in a better way, students will be better prepared to cope with challenges in their lives, both in and out of school. On the other hand, Leach and Scott affirm that prior knowledge is a foundation for subsequent learning that should be mastered before new information is to be taught. They highlighted the idea that intended learning cannot take place if students don't have appropriate prior knowledge.

Lack of training in the use of the approach and the students' lack of interest in Chemistry were the difficulties often encountered by the teachers in the utilization of algorithm approach. These items got the same weighted mean of 3.13. It can be deduced from the data that though our government allocates funds for training teachers, there are still instances wherein they fail to provide adequate training to teachers, leaving them unable to accommodate increasingly rigorous instructional goals of public schools. On the other hand, results also highlighted the importance of the students' interest in their academic performance inside the classroom. There are many students who do not know what actually their goal is so they tend to opt for wrong streams related to studies, and they lose interest in the related subjects. These results affirm the findings of the study of Leach & Scott that insufficient in-service training of the science teacher on the different approaches and strategies in teaching science subjects, and the lack of motivation and low self-confidence of the students in learning were some of the main problems that should be overcome for a sustainable and proper science education. These findings are further parallel to the findings of Adu-Gyamfi that the factors that contribute to students' lack of interest in science include higher demands of students' time in learning science integrating the approach, less practical nature of science teaching and learning, and too broad nature of science content.^[19]

Insufficient time in solving worded problems with the use of algorithm and difficulty in understanding and interpreting flowcharts, graphs and models are often encountered by teachers in teaching Chemistry integrating the algorithm approach. These difficulties obtained the same weighted mean of 2.63. Since algorithm approach makes use of certain procedures and steps in formulating solutions, teachers find it difficult to apply this approach in complex problems which require very long steps to arrive at the correct answer. This result conforms to the notions of Miller & Ranum that difficulty in using algorithm approach in teaching chemistry often arises to the fact that there are complex and intractable problems with complex solutions that there is no algorithm that can solve it in a realistic amount of time.^[20] He also added that it is important to be able to distinguish between those problems that have solutions, those that do not, and those where solutions exist but require too much time or other resources to work reasonably. On the other hand, algorithm approach also uses representations such as flowcharts, graphs and models for the topics to be easily understood by the students. But people vary widely in their ability at spatial tasks, some can understand and interpret a flowchart or a model, and some are not capable of doing it so. In some cases, students get confused of the data being shown in each representation leading them to misconception and inability to understand and interpret each type of representations.

Differences in the students' level of understanding was also the problem often experienced by the teachers in the utilization of the algorithm approach in teaching Chemistry. This got the lowest weighted mean of 2.50. This implies that differences in the students' level of understanding was not really a problem for the teachers. Teachers did not find it difficult to address the differences in students' level of understanding. It is a clear manifestation that teachers are good in selecting appropriate strategies and designing instructions that are suited to students' level of understanding.

A composite mean of 2.93 signifies that the problems indicated in the study were often met by the science teachers in the utilization of algorithm approach in teaching Chemistry. According to the science teachers during the prompt interview conducted by the researcher, the difficulties that they often encounter in the utilization of algorithm approach in teaching Chemistry are directly related to the process of integrating the approach in teaching Chemistry topics, and to the performance of the teachers and the students during the incorporation of the said approach. Teaching is getting more and more complex and challenging these days, and this may result to such difficulties that adversely affects the teaching-learning process.

5. Proposed Problem Solving Exercises Integrating the Algorithm Approach

The problem solving skills must have developed in order to cope with the learning demands of higher education. This mathematical skill must cognitively solidify in the early stages of secondary education particularly in senior high school level to ensure that the learning in other subject areas in the advanced level is not hampered by high-ability mathematical inadequacies and are thus maximized. One way of doing this is by providing problem solving exercises that will help learners master materials at their own pace. Exercises are usually repetitive and are used as a reinforcement tool. Effective use of exercise and practice depends on the recognition of the type of skill being developed, and the use of appropriate strategies to develop these

competencies.

The proposed problem solving exercises in this study are sets of work sheets and games designed to develop problem solving skills of the students in Chemistry. Activities that promote active learning, critical thinking and raise interest in learning Chemistry. These problem solving exercises can also be used by teachers to understand students' prior knowledge, outcome of learning, and the process of learning. These work sheets which were developed for Chemistry lessons in Grade 12 STEM aimed to develop the ability of the students in solving Chemistry-related problems.

Through the repetitive practice, the students engage with and develop their skills, knowledge and understandings in Chemistry in different ways. The worksheet has the following parts namely the title, the introduction, the general objective, the guidelines, the sample and the answer key.

The problem solving exercises were anchored on the analysis made by the researcher on the performance of the students with and without the integration of algorithm approach on the four units of studies in General Chemistry, namely the empirical and molecular formula, law of conservation of mass, stoichiometry, and gas laws. The difficulties often encountered by science teachers in the utilization of algorithm approach in teaching Chemistry were also considered in conceptualizing and developing the drill exercises. Furthermore, the content standards and performance standards as well as the learning competencies prescribed in the DepEd's General Chemistry 1 curriculum guide for senior high school were also given consideration in developing these exercises. The drill exercises can be used as a tool to assess students' mastery of the lesson, and as an application of the problem solving skills.

The topics which were found to be the most difficult among the General Chemistry 1 lessons by the student-respondents in the control and experimental groups were also considered in the preparation of the output such as on lesson regarding empirical and molecular formula, law of conservation of mass, stoichiometry and gas laws. Practice exercises were given in the form of games and work sheets. Appropriate learning approaches and strategies were also integrated in the worksheet in order to improve the ability of the high-level mathematical thinking of the students

5. Conclusion and Recommendation

From the findings of the study, the following conclusions were drawn:

1. The algorithm approach was utilized successfully in teaching Chemistry topics.
2. Control and experimental groups showed equal performance in the pretest but differences were found on the posttest.
3. Integration of the algorithm approach positively affects the problem solving performance of the students.
4. The teacher-respondents encountered difficulties in utilizing algorithm approach in teaching Chemistry.
5. The proposed problem solving exercises integrating the algorithm approach can be used as supplementary materials in developing the problem solving skills of the students.

In the light of the conclusions of the study, the following are recommended:

1. The proposed problem solving exercises integrating algorithm approach may be reviewed and tried out in teaching General Chemistry 1 to develop the problem solving skills of the students.
2. Algorithm approach may be tried out in other disciplines of science such as physics and biology to further test its effectiveness.
3. The treatment period should be lengthened and the researcher may consider a great number of subjects wherever possible.

Similar study may be done focusing on other year levels with concern on developing not only the problem solving skills but also other skills required by the 21st century learner.

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