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RESEARCH ARTICLE

Problem Solving Skills of Grade 9 Students in Science and their Science Academic Performance (A Proposed Differentiated Materials)

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ABSTRACT

The study determined the problem-solving skills and the academic performance in science of grade 9 students as basis for the preparation of differentiated materials on the science subject. Focusing on specific topics like electronic structure of matter, chemical bonding, carbon compound and mole concept, it involved the participation of 52 grade 9 students. The findings showed that the level of problem-solving skills of the Grade 9 students was generally described as above average, their academic performance in Science was found to be at the same above average level. The data led to the rejection of the hypothesis explaining a moderate relationship between the level of problem-solving skills and the academic performance of the students in the subject. A number of instructional materials were developed to address the weakness of the students in problem solving. Further studies on the problem-solving skills of the students are strongly recommended.

INTRODUCTION

The National Research Council of the National Academy of Sciences created a set of standards that will guide teachers and students in teaching and learning science, respectively. These standards known as the National Science Education Standards (NSES), envision a scientifically literate populace, where advanced skills in reasoning, creative thinking, decision making and problem solving are used not only in the academe but more importantly in the workplace.

The NSES is similar to 2002 Basic Education Curriculum (BEC) in Science of the Department of Education. They both outline what the students are expected to know, understand and are able to do at the end of every grade level. These requirements or competencies are all aimed for the students to be scientifically literate. To achieve this goal, both NSES and the BEC have provisions on science skills.

However, despite this urgent need for science literacy, the 2000 National Assessment of Educational Progress (NAEP) Science Assessment results provide alarming evidence that most of the students are not well prepared for the challenges ahead. The NAEP results indicate that the vast majority of the students are learning very little science.

They are taught to memorize facts and vocabulary and solve problems but almost never to connect the knowledge into coherent picture of the physical world. To address this concern, Nelson (2007) listed some key research and strategies so that widespread science literacy can be achieved. The list includes: 1.) coherent learning goals, and 2.) curriculum materials and assessments aligned with learning goals, among others. It is in the assessment aspect that this study is concerned with Standardized test is an integral part of any sciences.

Science, being such, involves problem solving. However, most students find the task of solving chemical problems a difficult one. Hence, innumerable studies have been conducted to address this problem.

However, most students find the task of solving chemical problems a difficult one. Also, extensive work has been done to develop problem solving ability among students especially because problem solving is a higher order cognitive skill that is important in achieving a scientific literate society. Alongside is the dire need of an assessment instrument aligned with the learning goals.

Moreover, science teachers expect their students to be able to solve quantitative problems, and this has become the basis of success of students in science. If this is an inevitable scenario, then how can science be measured and how can it be validated that the students are indeed succeeding in this task? The present study attempted to answer these questions.

The problem-solving component of science underscores the need for reasoning abilities defined by Piagetians. These reasoning abilities are divided into categories: correlational, combinational, probabilistic, and proportional logic. In addition to these are the abilities to identify and control variables.

In this light, Roadrangka, Yeany, and Padilla constructed the GALT test (Group Assessment of Logical Thinking), a paper – and – pencil test that measures logical reasoning abilities.

Accordingly, a sufficient number of studies have been undertaken and have demonstrated the predictive value of the GALT. Bunce and Hutchinson (2008) believed “the GALT would successfully correlate with a student’s ability in an introductory chemistry course”. The validity and reliability of the GALT have been established by researchers like Bitner and Roadrangka as cited by Bunce and Hutchinson. Hence, this study used the GALT as criterion to establish the concurrent validity of the researcher made test.

Meanwhile, no local study has developed a test to measure the validity of standardized test in high school chemistry. This situation, therefore, necessitated the development of one.

MATERIALS AND METHODS

Research Design

This study made use of the descriptive, research design. It determined the relationship between the problem -solving ability and the students’ academic achievement in science.

The problem- solving ability in science focused on the: 1) electronic structure of matter, 2) chemical bonding, 3) carbon compounds and 4) mole concept.

Research Locale

The study was conducted in Balayan a first class municipality in the Province of Batangas, Philippines. According to the 2010 Philippine census of population and housing., it has a population of 81,805 people.

Balayan is bounded by Tuy on the north; Calatagan and Lian on the west, Calaca on the east and the Balayan bay on the south. The town is rich in resources like sugarcanes, coconut and corn. Significant events for which this town is known are the parade of lechon (every June 24) and the feast of Immaculate Conception celebrated every December 8 of the year. Widely known products originating from the area include the bagoong Balayan. This study was conducted in Balayan National High School in the school year 2014-2015.

The Balayan National High School was founded during the year 1986, the population today of the school is 4000 students. The BNHS always doing well in academic performance. Many times, the students of BNHS won the medal as champion in science quiz regional category and 1st place in other quiz bee and activities. The National Achievement Test status of the BNHS is very satisfactory.

Respondents of the Study

The researcher used the convenience sampling in selecting the respondents. A total of 20 boys and 32 girls who were available at the time of the data collection served as the respondents.

Instrumentation

To achieve the goal of this research study, a researcher- made test on problem solving developed. This instrument underwent a validation process on content. A couple of sample questions follow hereof.

1. The glowing charcoal that cooks inihaw na isda and chicken/pork barbecue consists of almost entirely of the element carbon. Charcoal burns slowly in oxygen of open air, and the heat given off cooks the food. When charcoal burns in an enclosed space such as a closed room, there may not be enough oxygen to convert the entire carbon to carbon dioxide. This is why we grill over charcoal outdoors to have a sufficient supply of oxygen.

- a. What is the balanced chemical equation for the recution of carbon and oxygen?
 - b. Based on the balanced chemical equation, give the relationship in terms of the number of moles of carbon and oxygen.
 - c. If you are going to use 3 kg of charcoal, how many grams of oxygen will charcoal consume?
- Atomic mass: C= 2; O= 16

2. Jenny works part-time in a coffee shop. She observes that a typical cup of coffeeweighs about 240g, while a teaspoon of sugar ($C_{12}H_{22}O_{11}$) weighs about 5g. one day a customer orders a typical cup of coffee sweetened with two teaspoons of sugar. Jenny calculates for the molarity of the sugar in the cup of coffee in her chemistry class assuming a density of 1.0g/ml.
 - a. What do you have to compute for in the problem?
 - b. What is the approximate molarity of sugar in the coffee/?
 - c. What will happen to the molarity of sugar in the coffee in additional teaspoon of sugar is mixed to the coffee solution? Why?

Atomic Mass: C= 12; H= 1; O= 16

Table 1. Scoring Rubrics. In scoring the results, the Problem-Solving Ability Rubric was developed and used. This scoring rubric proved the concepts, strategies and mathematics used by the students in understanding the relationships among chemical concepts.

Level of Performance	Problem Comprehension	Understanding Relationship Among Chemical Concept	Understanding Associated Chemical Concepts
	What do you have to compute for in the problem?		
	The concentration of sugar in the cup of coffee	What will happen to the molarity of sugar in the coffee if an additional teaspoon of sugar is mixed to the coffee solution? Why?	What is the approximate molarity of sugar in th coffee?
		The molarity will increase since the amount of solute is increased	The concentration of sugar in the cup of coffee is approximately 0.1M.
5	Identifies what is to be computed for in the problem	Solution includes atleast 4 relevant relationships among the chemical concepts (e.g., molarity, electron structure, carbon compound)	Evidence that the student has a misconception
4	Supports answer with computation	Gives correct relationship between molarity and amount of solute	Fails to consider a relevant concept needed to solve the problem correctly
3	Identifies what is to be solved but fails to give an accurate answer	Solution includes 3 relevant relationships among chemical concepts	Evidence that the student has a misconception
2	Does not answer support with computation	Gives correct relationship between molarity and amount of solute but fails to explain correctly	Fails to consider relevant concept needed to solve the problem correctly
1	Fail to give an accurate answer and/or solution to either question	Solution includes 1 or 2 relevant relationships among chemical concepts	Evidence that the student has survive his conceptions

Table 2. Guide in Interpreting the Scores. Interpreting the scores was guided by the matrix below:

Scale	Mean Ranges	Rating/ Interpretation
5	4.21 – 5.00	High
4	3.41 – 4.20	Above Average
3	2.61 – 3.40	Average
2	1.81 – 2.60	Below Average
1	1.00 – 1.80	Poor

Data Gathering Procedure

The prepared test materials were administered to the samples as proctored by the respective Science Teachers. Results were scored and subjected to statistical treatment.

Statistical Treatment of Data

The following tools were used in this study.

1. Weighted Mean – it was used to described and analyze the scores of the respondents in problem solving and the academic grades in Science.
2. Pearson product moment of correlation was calculated to measure the relationships between problem solving skills and the grades of the students in Science.

RESULTS AND DISCUSSION

This part includes the presentation of data obtained from the response of the various data gathering instruments given by the researcher. The discussion is the same as when stated in the specific problems.

Level of Problem-Solving Skills of the Grade 9 Students in Science

Table 3. Problem Solving Skills of Grade 9 Students.

Variable	Mean Scores of the Respondents	Interpretation
Electronic Structure Matters	3.29	Average
Chemical Bonding	3.28	Average
Carbon Compound	3.50	Above Average
Mole concept	3.45	Above Average
General Average	3.41	Above Average

Table 3 shows the problem-solving skills of Grade 9 students in Science with a general average of 3.41, the students are able to solve Science problems at the above average level.

Obviously, the task of solving the problems is difficult, but if the students are trained on how to solve problems, step –by-step, they eventually develop the skill and their reasoning ability. Polya's (2007) simple steps of solving when properly taught provides a great help to the students. The steps consist of (1) reading the problem, (2) understanding it well, (3) defining the problem, and (4) selecting the appropriate information. Making the proper connections between the different parts of the problem enables the students to use the appropriate strategies and come up with a reasonable answer.

Polya further refined the above steps for a much clearer system in solving problems. These steps include (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back to evaluate the results of having implemented the plan. It is possible that the Grade 9 students in this study have had developed the above skills. It may be that the Science Teachers have been able to help the students in making meaningful connections between and among concepts (Noh and Scharmann,2009).

2. Level of Academic Performance in Summative Tests in Science of the Grade 9 Students.

Table 4. Level of Academic Performance in Science.

Academic Level	Chemistry		Physics		Biology	
	F	&	F	%	F	%
Above Ave. (85-94)	43	82.69	40	76.92	48	92.30
Average (70-84)	9	17.30	12	23.07	4	7.69
Below Ave. (55-69)	0		0		0	
Total	52	100	52	100	52	100

The academic performance of the students as revealed by the data in Table 4.2 indicates in general that majority of the participants demonstrate above average level in Science. This is true across the three subjects, i.e., Chemistry, Physics, and Biology. Across the three subjects, the above-average performance in Biology was found highest (92.30 percent). Physics was lowest as exhibited by only 76.92 percent. The above average performance in Chemistry was shown by 82.69 percent. Problem solving involves a great deal of Mathematical knowledge and skills (Mc Allister, 2009). Considering the above findings, it is understandable that among the three areas, Physics was found to be the most difficult with much-laden mathematical concepts, followed by Chemistry. Biology is least barded in mathematics.

3. Relationship between Problem Solving Skills and Academic Performance in Science.

Table 5. Relationship between Problem Solving Skills and Academic Performance in Science.

Variable	df	Coefficient of Correlation	Tabular Value
Problems Solving Skills and Academic Performance in Science	50	0.30	0.27

Decision Rule: Reject H_0

Interpretation: Significant (Moderate Correlation).

The test of relationship revealed a significant correlation ($r = 0.30$) at 0.05 margin of error. The figure suggests a moderate relationship between problem solving skills and academic performance in Science. This coefficient of correlation is supported by the figures in Table 4.1 which show the general average of 3.41 in different tests. Although the said figure falls under the above average category, it is much closer to being average and/or marginal. The result maybe a function of the nature of the tests and/or some aspects related to the grades awarded by the teachers.

1. Proposed Lesson Exemplar

The researcher developed a sample lesson exemplar on Chemistry topics in the areas of electronic structure of matters, chemical bonding, carbon compounds, and mole concept. This sample can be duplicated in other topics covered in the course/subject.

Proposed Lesson Exemplar on Chemistry Topics

A. Electronic Structure of Matter

- Element A has an atomic number of 11, then answer the five questions: a.) write the electron configuration of this element, b.) Hund's rule, c.) atomic orbital, d.) position in the periodic table and e.) the period.
- Write complete electron configurations for the following atoms:
 - F
 - V
 - Cu
 - Cr
 - Kr
- Sketch the plum pudding theory and explain how it was discovered.
- Why does Bohr's model of the atom call as solar system? Explain
- Write the Hund's Rule or Arrow method of the following:
 - Ne

- b. Ar
- c. Kr
- d. Rb
- e. Mg

B. Chemical Bonding

1. Show the ionic bonding of the following elements, there must be 5 bonding for these, Ca, K, Na, Cl and F. Draw the shape of CCl_4 (Carbon Tetrachloride)
2. Write the Lewis symbol of the following.
 - a. Ne b. Al c. As d. In e. Cs
3. Show the Lewis Structure, write the correct chemical formula and identify the type of chemical bonds of the following;
 - a. Rb and I c. Ba and S e. P and Cl
 - b. O and O d. Cs and Br
4. With the use of an arrow show the complete transfer of electrons of: Rb and F, Ca and Cl, Li and Br, then, write an explanation on how the transfer completed.

C. Carbon Compounds

Write the condensed and structural formula of the following: (5 pts each number)

- a. 3 nonyne
- b. Undecane
- c. Pentanol
- d. 2,3 dimethyl hexanes
- e. Heptanol

D. Mole Concept

1. Ammonium nitrate (NH_4NO_3 Molar Mass = 80.06g/mole) is a substance use to produce dinitrogen monoxide (N_2O), a dental anesthetic. Determine the mass percent of N in ammonium nitrate.
2. How many percent of Carbon is present in CaCO_3 ?
3. Suppose you were asked to prepare 750-g chocolate mousse which is 35% chocolate, 30% cream and 20% milk, 10% sugar and 5% butter, how much cream do are you going to use?
4. The presence of SO_2 in the atmosphere causes acid rain. How many percent of sulfur is present in SO_2 (Molar Mass = 64.07g/mole)?
5. Ethyl butanoate ($\text{C}_3\text{H}_7\text{COOC}_2\text{H}_5$) is the substance responsible for the aroma of pineapple. What is the molar mass of ethyl butanoate?

CONCLUSION

The moderate correlation between problem solving skills and academic performance in Science can be raised to a higher level. The study offers the following conclusions:

1. Problem solving skills can be developed among the students if their critical thinking skills are given enough focus.
2. Academic performance in Science is found to be low in the areas involving heavily on mathematics, particularly in the areas of Physics and Chemistry.

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