EFFECTIVENESS OF COMPARATIVE ANALOGY APPROACH IN TEACHING CHEMISTRY CONCEPTS

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Master of Arts in Teaching (Chemistry)

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by

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APPROVAL SHEET

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E.A.M.JR.

DEDICATION

This simple piece of achievement

is dedicated to the four

ladies of my life,

to all chemistry and science educators,

and to all students.

Bebot

ABSTRACT

This study aimed to determine the effectiveness of the comparative analogy approach in teaching chemistry concepts to third year high school students. The Post-test-Pre-test-Control Group method of research was employed in this study using a validated teacher made test. The reliability of the test instrument was tried out to 101 fourth year high school students. The samples were two groups of third year high school students of Samar State Polytechnic College which were chosen by purposive matching of their Science and Technology II grades and sex. In testing whether there was a significant improvement in the levels of understanding of chemistry concepts by students subjected to the comparative analogy approach per post-test – pre-test results, the computed t of 13.365 was contrasted with the tabular t value of 2.048. The computed t value was greater than the tabular t value suggesting a rejection of the null hypothesis. Thus, there is a significant improvement in the levels of understanding of chemistry concepts by the students using a comparative analogy approach of teaching. The awareness or knowledge of the two groups of students about the concepts at the start of the experiment are the same. Chemistry teachers are encouraged to use a comparative analogy approach to enhance and concretize understanding of abstract chemistry concepts.

TABLE OF CONTENTS

Chapter 1

THE PROBLEM AND ITS BACKGROUND

Introduction

The experiences of many highly industrialized countries like Japan and the United States just to name a few have shown the power of science and technology in improving the standards of living of their people and the country's economy. This could only happen in a country where science education is given the necessary attention it rightly deserves to produce scientifically cultured citizens.

Most experienced science educators are aware of the importance of science and technology education. The progress of the country like that of Japan and other industrialized countries in the near future depends a great deal on how well students learn, appreciate and use the concepts of science and technology because they are the foundation upon which economic growth proceeds.

While the present aim of science and technology education in the Philippines is to promote the well-being of every Filipino citizen and national development by becoming an industrialized country in the near future it is also equally important that citizens understand the detrimental forces caused by science and technology on the environment. It is in this sphere that the children of the country should gain an intimate knowledge and facility in the use and application of science and technology.

The irony is that the country lacks qualified chemistry teachers who can impart effectively chemical knowledge to students. Probaly due to this observations, Father Ernesto Javier (1983) was right when he said that "like the national economy" the condition of chemistry education today "is a disaster". Solicited opinions of high school graduates and even professionals will further reveal the real situation. The general consensus is that chemistry is the most difficult subject they have encountered of all the science subjects offered in high school (Linasa et. al.,1989). For this reason very few consider going into the chemistry profession. Some brave souls who venture into the chemistry profession and allied courses are usually doomed to fail in college chemistry or mathematics.

According to most students their difficulty on the subject is generally attributed to the abstract nature of chemical concepts, principles, theories and laws and the wholeness of the subject. Participants' report in Course 3122 : Selected Approaches For Effective Chemistry Teaching, SAMEO-RECSAM (1989) place this difficulty to poor English and Mathematics background among the students.

Moreover, for beginning chemistry students, to be able to understand and learn these concepts appear to be a very difficult task. These concepts, principles, theories, etc., in turn should be learned by the students not as bits of informations or isolated facts but as a system of related facts which constitute the broad body of knowledge of chemistry. For example, the concepts of the atom and molecule represent the basic theoretical frameworks or the organizing principles in the total understanding of the subject. If the student cannot grasp the abstractions, then the outcome is rote memorization minus genuine understanding which affects the learning ability of the student in later topics (Sprinthall and Sprinthall, 1987).

It is very important then that students should be taught by qualified teachers who understand the language of chemistry and the abilities of the students and their level of cognitive development. The failure and success in chemistry education depend on the hands of the teacher. It is the chemistry teacher who is the key to excellence in the subject.

In teaching chemistry, teachers must apply teaching methods and techniques that are appropriate for the topic being taught and the culture of the country concerned. What may be appropriate in one country may be inappropriate in another. This means, chemistry teaching must consider the average Filipino student in the context of his culture.

Holman (1985) related this amusing experience :

I vividly remember an occasion when, at the Bangalore conference, I was enthusiastically extolling the advantage of computer simulations in teaching chemistry to a teacher from a developing country. She listened with interest, but when I finished she politely pointed out that for her particular school the first priority, before installing computers, was to build a roof for the school.

Dawson (1991) further pointed out that science teachers in general should have confidence in his or her abilities, and should not rely only on the tried and tested approaches in science teaching, but should also try novel approaches. After all, it is the science classroom teacher more than any school official who knows best the abilities of his/her students.

Inspired by the above observations and opinions, the researcher was challenged to come up with a teaching approach referred to as the "Comparative Analogy Approach" in hastening and improving students understanding and learning of some basic chemistry concepts that considers the experiences and cognitive development of the students.

Theoretical Framework

The theory adopted by the researcher is Ausubel's (1968) theory of meaningful verbal learning called the

"Assimilation Process in the Acquisition, Retention, and Organization of Knowledge" which is also the basis of learning as conceptual change approach to teaching and learning science by Driver and Oldham (1986).

According to this theory in concept acquisition, the learner's cognitive structure at any point in time is organized in a hierarchical order so that ideas and concepts are held in such a manner that broad overall concepts have linked to them several related subsumed ideas. These in turn have their own sub-ideas and so on.

This cognitive structure determines the learner's ability to deal with new ideas and relationship. The meaning of a new concept or idea can only emerge if it ties up with existing cognitive structures of prior learning.

The most general concept of a subject will be at the apex of a body of knowledge which will be progressively differentiated into less general concepts down through the least general, most specific facts.

When a new idea or concept is presented, the learner tries to relate it to the cognitive structure already in place or any of the subsumed. If the learner cannot find a related subsumer, then the new idea is not retained for long. In this case, teachers should provide comparable examples as advance organizers prior to presenting a new concept.

Thus, if a new subsumer or advance organizer already exists for the new idea then it will be linked in by the subsumer and may be integrated into cognitive structure. If not, the new concept will be retained for a time and then lost, unless additional ideas are subsequently introduced to allow this new concept to be linked in.

Conceptual Framework

The research paradigm illustrated on page 7 (Figure 1.0) served as guide in conducting the study.

The study was founded on the assumption that students understand and learn meaningfully and are able to generate further meaning of a scientific concept if it is related to their experiences or prior learning.

Two groups of third year high school students enrolled at the Samar State Polytechnic College during the first semester of school year 1992-1993 identified as control and experimental groups served as samples of the study.

Each group was pretested to assess their knowledge about the identified areas of difficulty in chemistry using a validated test instrument. The experimental group was taught using the comparative analogy approach. The approach capitalizes on students' prior knowledge or experiences about world phenomena as examples, or advance organizers that has comparable attributes to the concept that is being

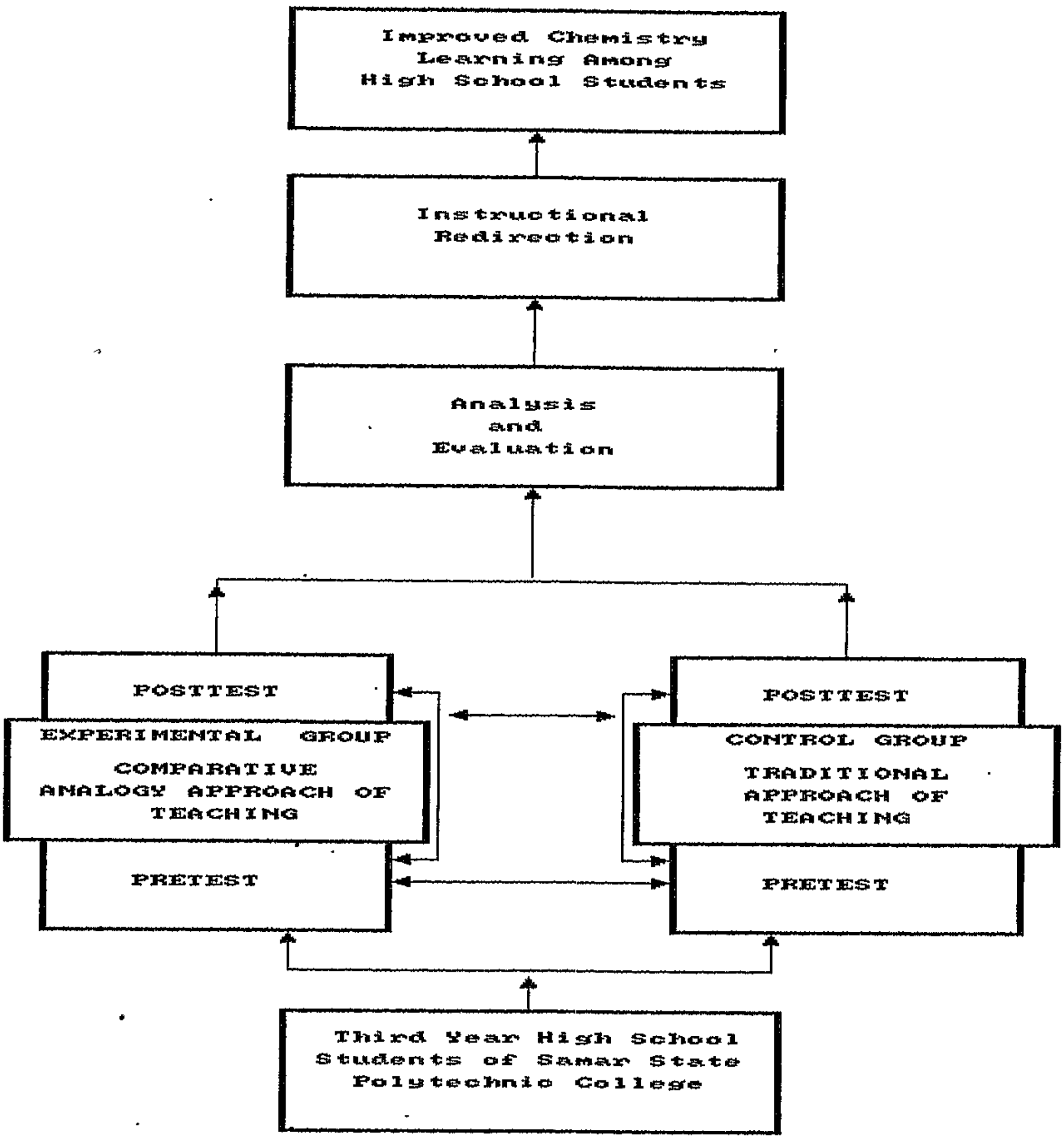

FIGURE 1.0 Schema of the Conceptual Framework showing the research subject and environment, variables involved, statistical treatment of data, and the end result of the study.

presented. The control group was taught using the traditional approach.

A posttest was administered to both groups after instruction using the same test instrument to determine the level of understanding and learning among students as a consequence of the comparative analogy approach and traditional approach of teaching chemistry concepts.

The test scores were analyzed using the appropriate statistical tool to find out any significant improvement or gain in levels of understanding in concepts acquisition.

<u>Statement of the Problem</u>

The study aimed to determine the effectiveness of the comparative analogy approach in helping high school students understand and meaningfully learn concepts in chemistry. Specifically, the study sought answer to the following questions :

1. What are the levels of understanding of chemistry concepts by the experimental group and the control group at the start of the experiment ?
2. Is there a significant difference with respect to the levels of understanding of chemistry concepts by the experimental and control group prior to the treatment ?
3. What are the levels of understanding of chemis-

try concepts by the experimental group and control group after the treatment using the comparative analogy approach and the traditional approach of teaching ?

4. Is there a significant difference in the gain of levels of understanding of chemistry concepts by the experimental group using the comparative analogy approach over that of the control group using the traditional approach of teaching ?

Null Hypotheses

The following null hypotheses were formulated based on the above specific questions :

1. There is no significant difference in the levels of understanding of chemistry concepts by the experimental group and the control group at the start of the experiment.
2. There is no significant improvement in the levels of understanding of chemistry concepts by students using the comparative analogy approach of teaching.
3. There is no significant improvement in the levels of understanding of chemistry concepts by the students using the traditional approach of teaching.
4. There is no significant difference in the gain of

levels of understanding of chemistry concepts by students subjected to the comparative analogy approach over those subjected to the traditional approach of teaching.

Significance of the Study

The significance of the study lies first in its novelty. Although it appears that comparative analogy approach of presenting abstract concepts is commonly used by textbook authors yet, up to this time no study has been made to find out its potential as a teaching method in concept building and as an alternative to the laboratory method where the latter cannot be had.

Secondly, based on the findings that the teaching approach significantly hastens and enhances understanding of abstract chemistry ideas and phenomena, the result would be very beneficial to both teachers and students because it will facilitate the teaching-learning process inside the classroom.

To the chemistry teachers, the findings of the study once adopted will place them in a better position to improve chemistry literacy by making the topics in chemistry more understandable.

Students will likewise benefit from the findings of the study in the form of improved method in chemistry instruction. Their learning will be maximized once the difficulty in concept learning is minimized or eliminated.

Parents play a vital role in the early education of their children. They can accelerate the cognitive development of their children even before formal schooling by assisting children understand abstract natural phenomena using the comparative analogy approach.

Further, the findings of the study will serve as insight to school administrators and officials in improving the chemistry curriculum by means of updating the laboratory facilities and upgrading teachers' competencies involving the comparative analogy approach.

Ultimately, this study will also be useful to other researcher in the field of science or chemistry education. They can use the findings of the study in undertaking similar study that may establish the validity of the results.

Scope and Delimitation

The concepts included in the study are : the particulate nature of matter about atoms, elements, molecules, and compounds, and the two laws of chemical change - law of definite composition and law of multiple proportions.

The experimental variable of the study was the teaching method (comparative analogy) used in presenting the above mentioned concepts. The experimental study was conducted from August to October, 1992 (Appendix E).

The subjects of the study were students of the two sections of the third year laboratory high school of Samar State Polytechnic College, Catbalogan, Samar during the school year 1992-1993.

Sex of the students was used as moderator in selecting and forming the two groups of samples. The main control variable was the students' grade in Science and Technology II. Other variables besides those mentioned were not considered. One such variable was the time element the topics under study were conducted. Since it was impossible to conduct two classes at the same time by the same person, instead the control group had their chemistry class from 8:00 to 9:00 in the morning and that of the experimental group at 9:00 to 10:00 in the morning also (Appendix R).

Definition of Terms

To facilitate the reader's comprehension, the following terms as used in the study are intended to mean as follows :

Advance organizer. A concrete information, event or situation given to the students as example by the teacher just prior to or during actual presentation of the learning material which will serve as a hook, or an anchor, or intellectual scaffolding for subsequent learning materials. When integrated into the cognitive structures becomes a subsumer (Arends,1988).

Allied courses. College courses related to B.S. in Chemistry such as B.S. Biochemistry, B.S. Chemical Engineering, B.S. Physics, B.S. Agricultural Chemistry and B.S.E. major in Chemistry.

Chemistry. A high school or college science subject which deals with the study of matter ; its composition, structure, properties, the changes that matter undergoes, and the energy involved during the change.

Chemistry profession. Refers to the four-year college degree awarded by colleges and universities on completion of full-time study program specializing in chemistry (Bachelor of Science in Chemistry).

Cognitive structure. A learner's organizational stability and clarity of knowledge in a particular subject matter field at any time (Arends,1988).

Comparative analogy approach. A teaching method in concept learning in which the teacher uses concrete comparable examples (objects, ideas, or events) as advance organizers in presenting the new concept to be learned where the basic structure of the example and the concept stand out. Further, these advance organizers must be related to the students' prior knowledge or cognitive structure.

Concept. An idea, a fact, a principle, a law, or a theory referred to in the study of chemistry.

Concept acquisition. The process of gaining concept or knowledge.

Concept learning. A concept has been learned when a learner responds to a number of stimuli (RECSAM handout).

Control group. This term refers to a group of students that is subjected to the traditional teaching of chemistry concepts.

Experimental group. This is the group of students in the study which will be subjected to the comparative analogy approach of teaching chemistry concepts.

Grade in science. Refers to the grade in Science and Technology obtained by the student at the end of the second year in high school. This is the grade found at the fourth column of the report card.

Progressive differentiation. It is the hierarchical arrangement of the subject matter in the cognitive structure of the student.

Purposive grouping. Refers to the method of deliberately selecting the samples by matching the average grades in Science and Technology II between students of the same sex and assigning the equivalent samples to the two groups.

Subsumer. An idea used to link a new concept or information to pre-existing segments of cognitive structure.

Third year high school students. Refers to the students officially enrolled in Samar State Polytechnic College during the school year 1992-1993 under the New Secondary Education Curriculum.

Traditional approach. Refers to the combined lecture-discussion, conventional textbook and laboratory method of teaching. This is the most and widely used method of teaching science.

Understanding. The process of acquiring or developing the meaning of various types of concepts and knowledge and the ability to use this knowledge to cope with situations (White,1988).

Chapter 2

REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents the review of some literature and studies related to the factors and problems that affect meaningful verbal learning of chemistry concepts based on the following criteria : (1) nature of the subject, (2) language difficulty of teachers and students, (3) cognitive development of the students, and (4) teaching strategies used by the teacher. These factors are very important in helping students understand and meaningfully learn the subject matter in chemistry.

Related Literature

It is a common knowledge that among the scientific and technological revolutions affecting human life in the twentieth century the chemical revolution is the most pervasive and far-reaching since the industrial revolution which began the modern world as it is known today. Yet, chemistry is the most disliked and dreaded of all the science subjects among high school and college students (Linasa et al., 1989).

On the Nature of the Subject

If it's green and slimy,

. . . . It's **biology.**

If you stub your foot against it,

. . . . It's **geology.**

If it doesn't work,

. . . . It's **physics.**

If it stinks,

. . . . It's **chemistry.**

(Charles Dawson)

Surveys have identified several factors why students dislike chemistry. The most prevalent is the difficulty in comprehending and understanding chemical concepts, principles, theories, and laws. To the students, these concepts or ideas are very abstract and have no relevance to their day-to-day activities. It is believed that deep appreciation of the subject goes hand in hand with understanding. Complimentary to the first factor is the broad scope of the subject which makes the study of chemistry more difficult. Because of its wide coverage students find it hard relating one concept to another concept. Concepts in chemistry should be learned by students not as bits of informations or isolated facts but as a system of related facts interwoven together. In the words of Keenan, Wood and Kleinfelter (1976), " Chemistry is an area of knowledge remarkable for its breadth and depth ".

The abstract nature of chemistry as a science is reflected in Dawson's (1991) description of the aim of science. According to him, the aim of science is to describe the observable world. But more importantly, science goes beyond the observable - those that cannot be seen. In trying to represent the world, human beings construct theoretical entities which have not been seen like electrons, protons, atoms, genes and black holes. Science also postulates processes which are not directly observable - electron whirling inside the atom, photosynthesis, etc. For these constructed theoretical entities and processes to be more realistic and comprehensible multitudes of symbols, diagrams, models, written descriptions and mathematical formulas are used which are in themselves abstract concepts.

The complete understanding of a concept is very important to anybody or students alike. According to Arends (1988):

> Concepts are basic building blocks for thinking, especially higher-level thinking, in any subject. Concepts allow individuals to classify objects and ideas and to derive rules and principles ; they provide the foundations for the idea networks that guide thinking. The learning of concepts is crucial in schools and in everyday life, because concepts allow mutual understanding among people and provides the basis for verbal

interaction.

To facilitate students' understanding of abstract concepts Lawther (in Skinner, 1961) suggests that teachers should teach students in such a way that students are not suddenly thrust into the abstract. Studies have shown that this order of presentation is more effective than the reverse order of presentation.

On the otherhand, the process of describing and explaining world phenomena results in the generation and accumulation of large volumes of chemical facts, theories, principles, laws and ideas (Keenan et al.,1976).

To make these large volumes of scientific informations and knowledge accessible and understadable to students, presents a major problem among authors and educators. What has been done was to divide the science of chemistry into several branches - Biochemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, Physical Chemistry, and Nuclear Chemistry. Selected topics from each of these branches are lifted and collected into a unified subject called General Chemistry. This is the kind of chemistry subject being offered to high school students and first year college students.

On Language Difficulty

According to Smith and Dechant (1961) the capacity of inventing and acquiring language is one of the most distinctive features of human development. They further explained that language plays a central role in the acquisition of scientific concepts. Human beings do not only have the ability to invent concepts in describing the world but also how to utilize the constructed concepts. Utilization of concepts is also one aspect of linguistic activity in science. They collaborated further by saying:

> Chemistry, like any science subject, has its own vocabulary and concepts. Though vocabulary tends to be precise and definite, the concepts frequently are broad and extremely difficult to derive from concrete experience. For example, atom, valence and electron are difficult to conceptualize. Whereas, one can readily learn terms such as electron orbital and energy level, a full understanding of them is beyond immediate reach.

Smith and Dechant further mentioned that vocabulary skills are basic determinants of school achievement. Vocabulary skills also correlate highly with competencies. Without understanding of words comprehension is impossible. A child with the best and voluminous vocabulary will generally have a good comprehension.

The opinion of Peterson et al. (1989) is also relevant to the above views. The use of a suitable vocabulary is a difficult problem not only by the learner but also by the teacher. New concepts should be introduced by the teacher in a language that the student, himself, can use functionally. Even simple language will not clarify a difficult idea – " The atom is the smallest particle of an element", for example, or " During chemical reaction mass is neither created or destroyed". To cite pertinent portion of their opinion :

> In chemical bonding, covalent bond can be described as 'shared electron pair' to mean that the electron pair exists in some space between the atoms in a molecule, in the everyday English language 'to share' means 'to possess or use or endure jointly'.

The implication is that chemistry teachers need to emphasize the distinction of meaning of the same words in everyday English speech and in a chemistry context.

On language difficulties in learning science, Garrison (in Skinner,1961) said that the most obvious characteristic of science information, concepts and generalizations is that they are in large measure verbal.

In his report "Project WISP : Words in Science – Philippines" submitted to the Philippine Science Education Center (now UPISMED) in 1976, Gardner supports the idea of Garrison by describing the characteristic of scientific language as :

> Scientific language is not just a collection of verbal labels for science concepts. Scientific concepts are expressed by means of propositions; these propositions, if they are to be understood, require the student to have learned the syntax of English - its grammatical structure, the way in which ideas are linked together within and between propositions - and to have learned, large body of non-technical vocabulary as well.

In the same report Gardner pointed out the sources of language difficulties of students in learning science. According to him :

> Many children in countries where English is the mother tongue have difficulty in utilizing their language as an instrument of learning for several reasons. First, the teacher is using language which is too technical or too complex to the students. Second, the typical classroom is giving students insufficient opportunity to discuss their ideas, to apply the students' out-of-school knowledge to new information. Third, in many homes, parents do not encourage reading and discussion.

If these are problems in English-speaking countries, how much more serious are they in countries like the Philippines, where the vernacular of the home generally differs from the language of instruction in the school. Students in non-English speaking countries are at a disadvantage with respect to instruction and also in reading textbooks written in English. It is expected then that Filipino students will experience considerable difficulties at school, especially in subjects like science where they are frequently presented with many new concepts often unrelated to their direct personal experiences.

This leads to the assumption that the use of the English language as a medium of instruction presents a major learning difficulty for many students. Using dialect which are understood and accepted by most individuals is one way of improving understanding concepts (Mercado, 1982). He further said that in general, the target clientele especially in the rural areas prefers the local dialect over the English language or national language. But in places where people are proficient in the English language or using varied dialects, the compromise is to use the English language.

The 1992 EDCOM Report cites that a study in 1987 made by the Institute for Science and Mathematics Education revealed that the English understanding of a sample of elementary school teachers is equivalent only to Grade 7 and several other research studies have shown that students learn more and faster when taught in Filipino or in their native language rather than in English. The report recommends the use of vernacular or dialect as medium of instruction inside the classroom and to develop right away instructional materials written in Filipino and the vernacular.

The use of Filipino or vernacular had so long ago been recommended by the Presidential Commission to Survey Philippine Education (1969) as cited below :

> The Commission believes that bilingualism in Filipino or English is both a fact of Philippine national life today, as well as a desirable condition of the contemporary world. The choice is not either Filipino or English, to the exclusion of the other in our educational system. It is recommended that Filipino be the main language of instruction at the elementary level, with the main vernacular as the medium in the first two grades. At the secondary and higher education levels, it is recommended that Filipino or English, whenever practicable, be the instructional medium.

The use of vernacular in conveying chemical concepts cannot be avoided. The English language is not complete in itself to describe the science of chemistry. To cite the inadequacy of the English language, take the definition of matter and mass. Matter is generally defined as anything that occupies space and has mass. The word mass is used in the definition to get a clearer understanding of the meaning of matter. But what is mass? Mass is the quantity of matter present in an object or material. Again, here matter is used to define the word mass. Further, mass and weight are two different physical quantities in science. However, if somebody wants to determine the weight of a certain object the verb used is "to weigh". Similarly, if it is the mass of the same object that is to be determined the verb used is again "to weigh". Whether it is mass or weight that is to be determined the sample object has to be weighed.

On Cognitive Development of the Students

A serious problem for students going into the chemistry and other natural sciences and mathematics is the requirement in these fields of specialization for a relatively high level of abstract and critical thinking. The vast majority of Filipino students simply do not possess such cognitive development. In terms of Piaget's stages of mental development, only between 3% and 20% of Filipino students have attained the formal operational stage of intellectual development (Javier,1984).

Smith and Dechant (1961) said that abstract and critical thinking is not a simple gadget that can be taught and acquired on the spot in one lesson, unit, or even in one single subject. It is somewhat a way of life. It is necessary to see abstract thinking as a developmental process in which there is a psychological learning sequence that students need to follow.

Ask high school students taking chemistry about the word "mass", ranges of different answers will be obtained. Some students may say mass is a religious activity, others will probably say it is a pile of sand and cement, etc. This is not surprising according to Smith and Dechant since the development of a concept by an individual is a cumulative process like critical thinking.

In teaching chemistry concepts, theories, etc., therefore, the teacher should be aware of the students cognitive abilities (Hernandez, 1982). The teacher has to match his teaching style to the mental capabilities of his students. The point here is not only that students learn specific vocabulary or mathematical operations underlying the concept of every scientific phenomena but should develop general capacity for thinking. Many students who enter high school have never developed good reading, comprehension and computational skills. The study of science materials requires critical thinking on specific problems followed by generalizations to related problems. What is happening in most most classrooms is that concepts are introduced and learned rotely but the relationships to existing cognitive structures or prior knowledge of the students are neglected.

For new materials to be meaningful to the students, teachers must find ways to connect or associate the new material to what students already know. The present idea of the students on a particular topic determine which new concepts are potentially meaningful (Arends,1988). The role of previous knowledge or experience is further explained by Garrison (in Skinner, 1961) when he said:

> Another fundamental in the teaching of science is to begin with the experiences of the children. Children have considerable knowledge about the environment when they enter school. They bring with them seven years of experience. The lessons in science must be in harmony with these experiences. Artificial motivation will not be necessary to enlists children's interest in science if the teacher will relate the materials to the experiences of the students. Often young children are challenged by ideas that appear commonplace or even dull to the adult. It is only when the teacher is able to view the universe from the learner's point of view, as well as his own, that he is able to enlist the interests and best efforts of the students.

Along this line, Lawther (in Skinner,1961) advises teachers to be careful not to abbreviate experience of students to verbal symbolism. He stressed further :

Teachers should bear in mind that concepts develop through numerous specific experiences from everyday life and grows slowly from the concrete, perceptual level to the abstract, relationship-of-common-elements level. Following these principles of conceptual development, the teacher can accelerate understanding of of concepts by: (1) inducing the concept with examples in which the basic relationships stand out, (2) keeping the examples as close as possible to the concrete objects and perceptual level of the everyday life of the learner, and (3) reducing the number of concepts to be covered and allowing more time and greater wealth of experience for each.

The science education literature of the late 1980's indicate the emergence of a new teaching approach in science which takes into accounts the cognitive structures of the students. The so-called constructivist theory of teaching science.

"Constructivists" as implied by Driver and Oldham (1985) "view learning as a restructuring of experiences, ideas or concepts presently held by students". The work of some notable science educators like Driver and Erickson (in Osborne and Wittrock, 1985) among others revealed that students often have views of science concepts even before formal schooling that differ from those generally accepted by science teachers. These alternative science views have been called, among other terms, as "children's science", "alternative frameworks", "alternative conceptions", and "mini-theories".

According to Osborne and Wittrock (1985), Piaget could be considered as a constructivist. Central to Piaget's theory is the idea that children's cognitive development follows a well-defined sequence of stages whereby students acquire "cognitive structures" that enable them to deal with the world.

Piaget hypothesized four factors affecting the cognitive development of a child, namely :

(1) maturation – the older a child is, the more likely that he will have cognitive structures that act in more coordinated ways,

(2) experience – the more experience that a child has with physical objects in his environment, the more likely that related understanding will develop,

(3) social interaction – the more opportunities children have to interact with peers, parents and teachers, the more viewpoints they will hear explicitly and implicitly, and

(4) equilibration – not only does a child assimilate experience into his existing mental framework, he

also accommodates the structures of his framework in response to his experience (Sprinthall and Sprinthall, 1987).

Other than experience there are still some factors that affect the cognitive development of a student which promote learning such as teaching strategies used by the teacher.

On Teaching Strategies

Many concepts are relatively concrete and easy to define (Grant, 1990). When somebody sees a car, on most occasions the individual is able to recognize it immediately because of its appearance, motion and sound. Human beings have learned to associate these characteristics to a piece of machine called automobile. However, some concepts in chemistry are abstract and very difficult to define, for example, concepts such as molecular orbitals or linear combination of atomic orbitals.

To tone down complexity of concepts models, examples, or illustrations are employed. In applying the examples to induce the concept Deese and Hulse (1967) said that the use of strategies will clearly lift concept learning out of the domain of simple discrimination learning and rote learning.

However, necessary precautions should be exercised in the use of examples, models or illustrations. Ausubel

(1968) cautions that the use of examples, models and illustrations should be intended to clarify the meaning of a concept and not to serve as superfluous padding or to generate a spurious aura of scientific authenticity. If they are permitted to become excessively detailed, complex, or esoteric, they tend to become ends in themselves, thereby obscuring rather than clarifying the concepts or ideas they exemplify.

Helping students to develop and clarify their understanding of concepts is the fundamental purpose of the teacher (Grant,1990). He further explained that it is not only the very technical concepts of science which need careful consideration but to correct misconceptions already held by students when they enter school. What college instructors complain about is not the lack of scientific knowledge of their freshman students, but the firmly held erroneous scientific concepts with which so many students possess when they enter college and which are frequently very difficult to eradicate because these concepts are already incorporated securely in the cognitive structures of the students. An awareness of these problems will assist the teacher in selecting appropriate teaching strategies – those which enable students to formulate new concepts, to challenge those which are already learned (sometimes not correctly) and to develop links between old, already learned, concepts and new concepts as they are learned.

Laya (1985) recommends the use of analogy as a teaching strategy when employing examples, models or illustrations. Analogy which shows parallelism between a new concept to be learned and an old concept already learned can be made more effective using examples that respond to the lifestyle of the students with which they are familiar . Teachers should select from students' own lives some previous knowledge or experience that exemplifies the same critical attributes of the new and old concept. For example, in schools located in the coastal areas most students are familiar at least with fishing. In such a situation, the science teacher might draw out immediate response from the student if the teacher concentrates at least initially on the marine objects. Similarly, those students in the mountain and agricultural areas would respond immediately to plants or birds.

The potential of analogy as an effective teaching strategy in problem solving is reflected in the work of Gick and Holyoak (in Anderson, 1985). With this technique, the problem solver attempts to use the structure of the solution to one problem to guide solutions to another problem. This strategy is usually employed in solving exercises in mathematics which is also applicable to chemistry teaching especially on topics where mathematics is a requirement.

A teaching strategy similar to analogy being recommended by White (1988) which does not appear to have been extensively studied is synectics. Originally devised to promote creativity in engineers, synectics can be used in secondary and at the upper levels of primary schools to induce students to think about and extend facts. One could also expect that students who frequently participated in synectics exercise come to create analogies spontaneously, and so would elaborate their knowledge habitually.

Lastly, in selecting appropriate teaching techniques to facilitate growth in concept learning Grant (1990) advises teachers to consider the following :

(1) the teacher's objectives,

(2) the teacher's understanding of how students learn ; and

(3) the teacher's desire to teach in a way which caters for the individual needs of the students in the classroom.

<u>Related Studies</u>

The following studies conducted were considered pertinent and relevant to the present study, hence their inclusion in this study.

Caoibes (1990) conducted a study to determine the relationship between English competency and science learning. The subjects involved in the study were 96 first year high school students of Balayan Colleges categorized according to their level of competency in English as high and low. The study made use of the descriptive method of research of the correlation type. The study revealed there is a significant relationship between English competency and ability to investigate, learning of science content, and class standing in science of students with high English competency.

Suarez (1986) found out that the most frequently used teaching method in teaching chemistry is the lecture-discussion and lecture-demonstration. The subject of her study were 16 college chemistry teachers of the Cebu State College of Science and Technology during the school year 1985-1986. The normative-descriptive type of research was used which employed questionnaires and interviews in data gathering.

Briones (1982) compared the effectiveness of the modified individualized approach and the lecture-discussion method of teaching high school chemistry. Briones experimented on 70 third year high school students during the school year 1981-1982 using a teacher-made achievement test in gathering the data. The result showed that the two methods did not differ significantly in terms of student achievement. However, the teaching methods used had other pronounced effects on students' behavior. Students subjected to the modified individualized approach became more active in classroom discussions than students subjected to the lecture-discussion approach.

Pili (1984) investigated the effects of the Piagetan-based learning cycle approach on the learning of chemical reactions and equations using a sample of 212 first year college students assigned to experimental and control groups during the latter part of the first semester of school year 1983-1984. The approach made use of concrete observations from results of laboratory activities from which to derive abstract thinking involved in writing the chemical equations. The results showed that achievement of the desired instructional objectives of chemical reactions and equations can be improved using the Piagetan-based learning cycle.

Castillo (1974) conducted an analysis survey on the effectiveness of molecular models in teaching organic chemistry. The respondents were high school chemistry teachers from randomly selected schools in Metro Manila and in the provinces. Majority of the respondents agreed that they have experienced a more effective way of communication to the students when using the models. Further, students' interest are easily aroused and a more stimulating learning atmosphere is created.

Relationship with Present Study

The present study is essentiallly similar to the works of Caoibes, Suarez, Briones, Pili and Castillo for the major reason that all studies were concerned in helping students understand and meaningfully learn the subject matter in chemistry by identifying the most effective teaching approaches and other factors that go with it.

Caoibes' study revealed that English competency of students have a significant positive relationship with learning science concepts. This finding is similar to the present study in the sense that English language used as medium of instruction affected the students' understanding and learning content areas in chemistry. The differences lie in the research design used, samples of the study, and place of study.

The study conducted by Suarez is similar to the present study in the sense that both studies identified the teaching method most frequently used in teaching chemistry. The present study did not only try to identify the teaching method but attempted to find out the effectiveness of the combined lecture-discussion and laboratory method as compared to the comparative analogy approach of teaching chemistry concepts. Both studies differ in the method of research used, the time and place of study, and samples used.

Briones' study was to find out the effectiveness of the lecture-discussion method of teaching chemistry concepts as compared with the modified individualized approach of teaching. Pili used concrete observations from laboratory activity results to induce learning of chemistry concepts. The teaching approach used was the Piagetan-based learning cycle. Castillo's survey dealt on the effect of using models in teaching. Models were used to simplify abstract chemistry concepts as a touch-and-see visual aid to the unseeable nature of chemistry concepts. The present study identified the most effective teaching method in chemistry instruction.

The main differences of the above cited studies as compared with the present study are on the particular teaching approaches used, time element, the place where the studies were conducted, the samples used, and the content areas covered in the study.

Chapter 3

METHODS AND PROCEDURES

This chapter presents the research design, description of subjects, sampling procedure, topic identification, instrumentation, data gathering and the statistical treatment of data.

Research Design

This study on the effectiveness of the comparative analogy approach of teaching chemistry concepts employed the experimental method of research using in particular the Pretest-Posttest-Control Group Design represented below as :

Purposive Grouping	Pretest	Treatment	Posttest	Difference
Experimental Group (P)	O_1	X_1	O_2	$D_{eg} = O_2-O_1$
Control Group (P)	O_3	X_2	O_4	$D_{cg} = O_4-O_3$

and

$$D_{egcgp} = O_1 - O_3$$

$$D_{egcgpp} = (O_2-O_1) - (O_4-O_3)$$

Where :

P - Purposive selection of the members of the control and experimental group.

O_1 – Pretest of the experimental group.

O_2 – Posttest of the experimental group.

X_1 – Comparative Analogy Approach of teaching chemistry concepts.

X_2 – Traditional method of teaching chemistry concepts.

O_3 – Pretest of the control group.

O_4 – Posttest of the control group.

D_{eg} – Difference between the posttest and pretest mean score of the experimental group.

D_{cg} – Difference between the posttest and pretest mean score of the control group.

D_{egcgp} – Difference between the pretest mean scores of the experimental and control group.

D_{egcgpp} – Difference between the difference of the posttest and pretest mean scores of the experimental group and the control group.

<u>Subjects of the Study</u>

The study was participated by all third year high school students taking chemistry under the New Secondary Education Curriculum (NSEC) in the laboratory school of Samar State Polytechnic College.

A total of 58 students served as samples of the study (Appendix S). This figure is actually 61.7 per cent of the total third year high school population of Samar State Polytechnic College, Catbalogan, Samar.

The age of these students ranged from 14 to 16 years old.

Sampling Procedure

Purposive sampling was employed in this study. The researcher asked from the two third year high school section advisers the subjects' previous report cards. Sex and grade in Science and Technology II in the previous year of each student served as basis in identifying equivavalent samples of the two groups - 29 students in the experimental group and another 29 students in the control group.

The Science and Technology II grades between any two students of the same sex from the two sections were correspondingly matched. Each group formed consisted of 10 males and 19 females.

The non-samples were ranked from highest to lowest based on their Science and Technology grades and were distributed betweeh the two groups finally forming two heterogeneous groups.

To reduce Hawthorne effects by samples and non-samples, the students were kept uninformed that they were participating in an experiment being conducted by the researcher.

Topic Identification

To really find out the effectiveness of the comparative analogy approach in teaching chemistry concepts, the topics discussed under the instructional phase of the study were the law of definite composition and the law of multiple proportions. These topics were identified in the study of Oliva (1991) as only partially learned by students but teachers feel competent to teach. For purposes of increasing the coverage of the study, additional topic on the particulate nature of matter - about atoms, elements, molecules and compounds was included. The additional topic was justifiable since it is a prerequisite for the total understanding of the subject matters in chemistry.

<u>Instrumentation</u>

A table of specifications of objectives on the topics particulate nature of matter, law of definite composition and law of multiple proportions were prepared (Appendix F). A table of test specifications based on the specifications of objectives were also made (Appendix G).

A multiple choice test of thirty three (33) items covering the range of the identified topics were constructed based on the table of specifications. The whole test was made up of three parts. Part I (8 items including 2 extra items) and Part III (12 items only) were of the fixed-response type and Part II (13 items including 1 extra item) was a multiple-response type of test.

Copies of the first draft of the test items were presented to knowledgeable collegues, the research adviser and chemical education expert for their opinions, comments and suggestions to improve the instrument.

With the expert's approval the first draft was revised integrating the consolidated suggestions. The revised test was tried out to 101 fourth year high school students of the Samar State Polytechnic College, Catbalogan, Samar and item analyzed to determine its difficulty indices, discrimination indices and test reliability. No other criterion was needed except that these students have taken and passed chemistry in the previous year.

Factors that may affect the result such as sitting arrangement (one seat apart), lighting (flourescent lamps on), ventilation (windows were open), use of calculators (not allowed) and discipline (no talking and cheating) during the try out were properly controlled. The time consumed by most students to finish the whole test was likewise noted and recorded.

The D-index item analysis was performed after retrieving, correcting and scoring the papers following the steps recommended by Stanley and Hopkins (1972) :

1. The scored answer sheets were arranged from the highest to the lowest score, the highest at the top and the the lowest at the bottom.

2. The high group was separated by counting 27 (0.27 x 101) answer sheets beginning from the top. Simi-

larly, the low group was separated by counting 27 answer sheets starting from the bottom.

3. The total number of correct responses per item of the high group were counted and divided by 27. This is the proportion of the students in the high group who answered the item correctly, designated as p_H. The same was done for the answer sheets of the low group, designated as p_L. Results were tabulated for easy analysis and interpretation.

$$p_H = \frac{\text{No. of correct items for the high group}}{27}$$

$$p_L = \frac{\text{No. of correct items for the low group}}{27}$$

4. The index of difficulty per item was computed by adding p_H and p_L and dividing the sum by 2.

$$p = \frac{p_H + p_L}{2}$$

5. To obtain the discrimination index per item, the p_L value was subtracted from its corresponding p_H value.

$$D = p_H - p_L$$

The accepted indices of difficulty ranged from 0.20 to 0.65. This acceptance was based on the interpretation of Ebel (1965) shown below :

Index of Difficulty	Item Evaluation
0.86 – 1.00	Very easy items
0.71 – 0.85	Easy items
0.40 – 0.70	Moderately difficult items
0.15 – 0.39	Difficult items
0.01 – 0.14	Very difficult items

Likewise, the accepted discrimination indices range was from 0.30 and above based on the interpretation of Ebel (Stanley and Hopkins, 1972) as follows:

Index of Discrimination	Item Evaluation
0.40 and up	Very good items
0.30 – 0.39	Reasonably good but possibly subject to improvement
0.20 – 0.29	Marginal items, usually needing improvement
Below 0.19	Poor items, to be rejected or improved by revision

Test items with discrimination indices below 0.30 were either rejected or improved in order to come up with a 30-item test of ratios 1:2:2 for knowledge, comprehension, and application, respectively. The final revised test was used as the pretest and posttest instrument of the study.

The interpretation of the computed r (reliability coefficient) was based on the interpretation given by Ebel shown below :

Reliability Coefficient	Degree of Reliability
0.95 - 0.99	Very high, rarely found among teacher made test
0.90 - 0.94	High, equalled by few tests.
0.80 - 0.89	Fairly high, adequate for individual measurement.
0.70 - 0.79	Rather low, adequate for group measurement but not very satisfactory for individual measurement.
Below 0.70	Low, entirely inadequate for individual measurement although useful for group average and school survey.

Data Gathering Procedure

The experimental group and control group were pretested using the final revised test fifteen days before the experimental phase. At the outset, students were informed that the test was being given for prognostic purposes to minimize getting bias results. Afterwards, the test papers were collected, scored and recorded for subsequent statistical analyses.

The researcher used comparative analogy approach to the experimental group teaching the topics on the particulate nature of matter, law of definite composition and law of multiple proportions guided by five (5) detailed lesson plans group. In the other group, (CG), traditional method of teaching was used based also on five (5) detailed lesson plans. Sample lesson plans are presented in Appendix K.

After covering the range of topics of the study, the posttest was administered to both groups using the same test instrument in the pretest. Again, answer sheets were collected, scored and recorded for statistical treatment.

Factors that may affect the result during the pretesting were also controlled during the posttesting.

Statistical Analyses

The test reliability was determined using the modified Kuder-Richardson Formula 20 given by Stanley and Hopkins as:

$$r = \frac{k}{k-1}\left[1 - \frac{6\,\Sigma pq}{(k\bar{D})^2}\right]$$

where :

r = reliability coefficient

Σ = summation

p = proportion of students who answered the particular item correctly (difficulty index).

q = proportion of students not getting the correct answer for a particular item $(1 - p)$.

k = total number of test items

$\bar{D}$ = mean of discrimination indices

The results of the pretest and posttest of the control group and the experimental group were analyzed by computing first the mean scores and standard deviations using the following general formulas :

$$1)\quad \bar{O} = \frac{\Sigma O}{N}$$

and

$$2)\quad SD = \sqrt{\frac{N(\Sigma O^2) - (\Sigma O)^2}{N(N-1)}}$$

where :

$\bar{O}$ – Mean

Σ – Summation

O – Pretest and posttest scores of the two groups or difference of the posttest and pretest of the two groups.

ΣO – Sum of the O column

ΣO^2 – Sum of the O^2 column

N – Number of students of each group

SD – Standard deviation of the posttests and pretests

To find out if there was significant difference at α (significance level) equal to .05 between the pretest and posttest mean scores within the group, the t-test formula for dependent means as follows was used :

$$3)\ t_c = \frac{\bar{D} \times \sqrt{N}}{SD}$$

where :

t_c – Computed t-value for dependent means,.

$\bar{D}$ – Average difference between the posttest and pretest of the control group (D_{cg}) or the experimental group (D_{eg}).

N – Number of students of each group.

SD – Standard deviation of the posttest and pretest of the control group or the experimental group (Walpole, 1982).

To find out if there was a significant difference at α equal to .05 between the pretest mean scores of the experimental and control groups and the mean of the difference of the pretest and posttest scores of the two groups, the t-test formula for independent means as follows was used :

$$4)\ t_c = \frac{\bar{D}}{\sqrt{\frac{(N_1-1)SD_1^2 + (N_2-1)SD_2^2}{N_1+N_2-2}(1/N_1 + 1/N_2)}}$$

where :

t_c – Computed t-value of independent means.

$\bar{D}$ – Difference of the pretest mean scores (D_{egcgp}) of the experimental and control groups or the difference of the mean difference of the posttest and pretest (D_{egcgpp}) of the two groups.

N_1 – Number of students in the control group.

N_2 – Number of students in the experimental group.

SD_1 – Standard deviation of the pretest or difference of the posttest and pretest of the control group.

SD_2 – Standard deviation of the pretest or difference of the posttest and pretest of the experimental group (Walpole).

Chapter 4

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

This chapter presents the data gathered, their analyses and interpretation of results broken down into six categories as follows: 1) profile of the subjects, 2) item analyses of test instrument, 3) comparison of pretest mean scores of the experimental group and control group, 4) comparison of the posttest and pretest mean scores of the experimental group, 5) comparison of the posttest and pretest mean scores of the control group, and 6) comparison of the posttest and pretest difference mean between the experimental group and control group.

Profile of the Subjects

The students' profile are shown in Table 1 . The table includes the students' Science and Technology II grade, sex and age.

It can be read from the table that the average age of the members of the experimental group is 14.99 years while the average age of the members of the control group is 14.88 years. The mean difference is 0.11 year.

Other things being equal, such as sex and science grade, it can be said that the members of the two groups of samples were nearly of the same age.

TABLE 1

Grade, Sex and Age of Samples

Students'			Age (No. of Years)	
No.	Sex	S and T Grade	Experimental	Control
1	F	90	15.5	15.1
2	M	90	15.5	13.9
3	F	89	15.8	15.3
4	F	88	15.2	14.8
5	F	88	15.0	14.8
6	F	87	14.5	14.7
7	F	87	15.6	13.6
8	M	87	15.5	15.1
9	F	87	15.0	14.8
10	F	87	15.6	14.8
11	F	86	15.0	15.3
12	M	86	14.9	14.9
13	F	86	14.3	14.8
14	F	85	14.6	15.3
15	F	85	14.3	14.8
16	M	85	15.0	15.4
17	F	85	14.0	14.9
18	M	84	15.3	14.3
19	F	84	15.1	14.8
20	F	83	15.5	14.3
21	M	83	15.2	16.3
22	M	83	14.6	14.1
23	F	81	14.6	15.2
24	F	81	14.2	14.7
25	F	80	14.2	14.6
26	F	79	14.7	14.8
27	M	78	15.3	15.4
28	M	77	14.7	15.2
29	M	75	15.9	15.5
TOTAL			434.60	431.50
MEAN			14.99	14.88

Item Analyses of Test Instrument

The item analyses of the first draft of the test instrument which was tried out to 101 fourth year highschool students of Samar State Polytechnic College is presented in Appendix L.

Difficulty indices ranged from 0.20 to 0.63, providing a wide range of difficulty. Of the original 33 items, 20 items were identified to be moderately difficult (MD) and 13 were difficult items (D).

The indices of discrimination ranged from 0.15 to 0.75. In order to come up with a 30-item test instrument with an item ratio of 1:2:2 for knowledge, comprehension and application, respectively; items with discrimination indices greater than 0.30 with functional distracters were accepted without the need for further improvement. Two (2) test items under Part I of the instrument (Items 4 and 5) with above 0.30 discrimination indices were improved due to nonfunctional distracters. Another two (2) items (Items 18 and 30) were improved for low discrimination indices which was attributed to ambiguous statements or questions. Item 1 and 6 were rejected as extra items of Part I due to poor discriminating power among the eight (8) items. Item 28 of Part III was rejected as extra item due to its similarity with item 29. All in all, 26 items were retained, 4 items were improved and 3 items were rejected.

The modified Kuder-Richardson Formula 20 was applied to determine the test reliability using as data the computed indices of discrimination and difficulty indices of the retained and to be improved test items. The test reliability coefficient was computed to be 0.80 (Appendix M). The test instrument was interpreted as highly reliable for group measurement.

As a whole, the test instrument was composed of moderately difficult items as reflected by its computed difficulty index mean of 0.42. With a calculated discrimination index mean of 0.45, the test is interpreted as being made up of very good items. The final form of the test instrument is presented in Appendix I.

Comparison of Pretest Mean Score of the Experimental Group and Control Group

Table 2 displays the statistical treatment result of the pretest scores of the experimental group and control group. The computations of the means and t-test are reflected in Appendix N.

The data and results displayed in Table 2 are clear and straightforward. Inspection of the mean scores shows that students' achievement in each of the experimental group and control group are essentially equivalent. The pretest mean score of the experimental group is 7.793 and the control

TABLE 2

Data and Result of the Pretest Mean Scores of the Experimental Group and Control Group

Students	Experimental		Control		Difference
	Pretest O_1	O_1^2	Pretest O_3	O_3^2	D_{egcgp} $O_1 - O_3$
1	10	100	12	144	-2
2	10	100	10	100	0
3	10	100	9	81	1
4	8	64	7	49	1
5	7	49	12	144	-5
6	8	64	8	64	0
7	9	81	11	121	-2
8	11	121	8	64	3
9	3	9	6	36	-3
10	14	196	11	121	3
11	8	64	11	121	-3
12	10	100	11	121	-1
13	9	81	7	49	2
14	8	64	8	64	0
15	10	100	7	49	3
16	3	9	8	64	-5
17	5	25	9	81	-4
18	11	121	12	144	-1
19	8	64	6	36	2
20	7	49	4	16	3
21	6	36	7	49	-1
22	7	49	8	64	-1
23	6	36	6	36	0
24	7	49	9	81	-2
25	3	9	6	36	-3
26	8	64	5	25	3
27	8	64	8	64	0
28	7	49	5	25	2
29	5	25	6	36	-1
TOTAL	226	1942	237	2085	-11
MEAN	7.773		8.172		-0.379

COMPUTED t : 0.596

TABULAR t : 1.960 at $\alpha = 0.05$, df = 56 group's mean is 8.172 with a mean difference of 0.379.

To determine the significance of the difference between the pretest mean scores of the two groups, a two-tailed t-test for independent means was determined.

The computed t value of 0.596 is smaller than the tabular t value of 1.960 at 0.05 significance level with 56 degrees of freedom. The smaller value of the computed t compared to the tabular t value supports the observations that there is no significant difference in the levels of understanding of chemistry concepts by the experimenetal group and control group at the start of the experiment per pretest results. This leads to the acceptance of null hypothesis 1.

Null Hypothesis 1:

> **There is no significant difference in the levels of understanding of chemistry concepts by the experimental group and the control group at the start of the experiment.**

Comparison of the Posttest and Pretest Mean Scores of the Experimental Group

Table 3 presents the results of the statistical analysis done on the posttest and pretest mean scores of the experimental group. The t-value was computed using the t-test for dependent means. The calculation is presented in Appendix O.

TABLE 3

Data and Result of the Posttest and Pretest of the Experimental Group

Students	Posttest O_2	Pretest O_1	Difference $D_{eg} = O_2 - O_1$	$(D_{eg})^2$
1	25	10	15	225
2	19	10	9	81
3	21	10	11	121
4	21	8	13	169
5	17	7	10	100
6	19	8	11	121
7	14	9	5	25
8	21	11	10	100
9	15	3	12	144
10	17	14	3	9
11	15	8	7	49
12	24	10	14	196
13	17	9	8	64
14	17	8	9	81
15	16	10	6	36
16	15	3	12	144
17	13	5	8	64
18	15	11	4	16
19	13	8	5	25
20	9	7	2	4
21	15	6	9	81
22	17	7	10	100
23	16	6	10	100
24	12	7	5	25
25	12	3	9	81
26	15	8	7	49
27	14	8	6	36
28	15	7	8	64
29	8	5	3	9
TOTAL	467	226	241	2319
MEAN	16.103	7.793	8.310	

COMPUTED t : 13.365

TABULAR t : 2.048 at $\alpha = 0.05$, df = 28

It can be read from the table that the posttest mean score of 16.103 is higher by 8.310 compared to the pretest mean score of 7.793. It can be said that there is a significant improvement in the level of understanding of chemistry concepts by the experimental group due to the experimental treatment.

To check the finding statistically, a two-tailed t-test for dependent means was applied. The computation yielded a t value of 13.365 which is greater than the tabular t-value of 2.048 at 0.05 significance level with 28 degrees of freedom. Hence, null hypothesis 2 is rejected.

Null Hypothesis 2:

There is no significant improvement in the level of understanding of chemistry concepts by students using the comparative analogy approach of teaching.

The rejection of the above null hypothesis is interpreted that there is a significant improvement in the level of understanding of students who were treated with the comparative analogy approach of teaching chemistry concepts based on the statistically proven positive significant difference in their posttest and pretest mean scores.

The significant improvement could be attributed to the lectures and comparative analogy approach through the use of comparable examples as advance organizers.

Comparison of the Posttest and Pretest Mean Scores of the Control Group

Table 4 shows the results of the statistical treatment between the posttest and pretest mean scores of the control group. The mean and t-test computations are presented in Appendix P.

As can be observed from the above table, the posttest mean score of 13.276 is definitely higher than the pretest mean score value of 8.172. The mean difference is 5.103. As a consequence, the computed t value of 8.839 is significantly higher than the two-tailed tabular t value of 2.048 at 0.05 significance level with degrees of freedom equal to 28. Based on these results, null hypothesis 3 of the study is rejected.

Null Hypothesis 3:

There is no significant improvement in the levels of understanding of chemistry concepts by the control group using the traditional method of teaching.

The rejection is interpreted that there is a significant improvement in the level of understanding by the students of the control group following the traditional method of teaching chemistry concepts.

This significant improvement could be attributed to the lectures and laboratory activities.

TABLE 4

Data and Result of the Posttest and Pretest of the Control Group

Students	Posttest O_4	Pretest O_3	Difference $D_{cg} = O_4 - O_3$	$(D_{cg})^2$
1	16	12	4	16
2	19	10	9	81
3	10	9	1	1
4	13	7	6	36
5	14	12	2	4
6	13	8	5	25
7	17	11	6	36
8	15	8	7	49
9	18	6	12	144
10	18	11	7	49
11	17	11	6	36
12	12	11	1	1
13	14	7	7	49
14	12	8	4	16
15	15	7	8	64
16	18	8	10	100
17	15	9	6	36
18	21	12	9	81
19	10	6	4	16
20	9	4	5	25
21	16	7	9	81
22	9	8	1	1
23	11	6	5	25
24	8	9	-1	1
25	7	6	1	1
26	9	5	4	16
27	12	8	4	16
28	7	5	2	4
29	10	6	4	16
TOTAL	385	237	148	1026
MEAN	13.276	8.172	5.103	

COMPUTED t : 8.839

TABULAR t : 2.048 at $\alpha = 0.05$, df = 28

Comparison of the Posttest and Pretest Difference Mean Between the Experimental Group and Control Group

Table 5 reflects the posttest-pretest difference means of the experimental group and that of the control group. The table also shows the number of hours missed by the student samples of each group from start to finish of the experimental study. The computation of the means and the t value is shown in Appendix Q.

Inspection of the entries of the table will reveal that 7 students in the experimental group and 6 students in the control group missed one or several class sessions. In terms of the number of hours missed, it is the experimental group which incurred the highest with 9 hours and 6 hours for the control group. The experimental group is at a disadvantage. Yet, it can be gleaned from their posttest-pretest difference mean that the experimental group performed better than the control group. The average posttest-pretest difference of the experimental group is 8.310 compared with that of the control group of 5.103. The mean difference of the means is 3.207. In other words, the comparative analogy approach of teaching the chemistry concepts was more effective than the traditional approach as shown by the superiority of the means of the students in the experimental group.

To statistically check this findings, a two-tailed t-test was carried out. The computation yielded a t value of

TABLE 5

Data and Result of the Posttest-Pretest Difference Between the Experimental Group and Control Group

Students	Experimental			Control			Difference
	D_{eg} O_2-O_1	D_{eg}^2	Hours Missed	D_{cg} O_4-O_3	D_{cg}^2	Hours Missed	D_{egcg} $O_2O_1 - O_4O_3$
1	15	225		4	16		11
2	9	81		9	81		0
3	11	121		1	1		10
4	13	169	1	6	36		7
5	10	100		2	4		8
6	11	121		5	25	1	6
7	5	25		6	36		-1
8	10	100		7	49		3
9	12	144		12	144		0
10	3	9		7	49		-4
11	7	49	2	6	36		1
12	14	196	1	1	1		1
13	8	64		7	49	1	1
14	9	81		4	16		5
15	6	36		8	64		-2
16	12	144		10	100		2
17	8	64		6	36	1	2
18	4	16	1	9	81		-5
19	5	25		4	16		1
20	2	4		5	25	1	-3
21	9	81		9	81		0
22	10	100		1	1		9
23	10	100		5	25		5
24	5	25	1	-1	1		6
25	9	81		1	1		8
26	7	49		4	16	1	3
27	6	36	2	4	16		2
28	8	64		2	4		6
29	3	9	1	4	16	1	-1
TOTAL	241	2319	9	148	1026	6	93
MEAN	8.310			5.103			3.207

COMPUTED t : 3.773

TABULAR t : 1.960 at $\alpha = 0.05$ with df = 56

3.773 which is significantly greater than the tabular t value of 1.960 at 0.05 level of significance with 56 degrees of freedom. Hypothesis number 4 is therefore rejected.

Null Hypothesis 4:

> **There is no significant difference in the gain of levels of understanding of chemistry concepts by students subjected to the comparative analogy approach over those subjected to the traditional approach of teaching.**

Based on the above results, it is safe to infer that the experimental group experienced a more significant learning than the control group in terms of levels of understanding of the chemistry concepts presented as reflected by the significantly greater posttest-pretest difference mean of the former. It clearly shows that the comparable examples given to the experimental group just prior to the actual presentation of the learning materials enhanced the understanding of the students about the concept, hence they scored higher in the posttest than the control group did. The examples used in the analogy provided a general framework or reference points that aided the students in assimilating and organizing the concepts into a logical pattern.

The above result supports the theory that understanding of chemistry concepts is more likely to occur and retained longer if students learn ideas within a meaningful verbal context with the use of comparable examples as advance organizers which is an integral component of the comparative analogy approach of teaching.

Chapter 5

SUMMARY of FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter contains the summary of findings, conclusions and recommêndations of the study.

Summary of Findings

Based on analyses and interpretation of the data gathered, the following findings are established :

1. There is no significant difference in the levels of understanding of chemistry concepts between the experimental group and the control group at the start of the experiment per pretest as indicated by the insignificant difference of their pretest mean scores. The t-test for independent means yielded a computed t value of 0.596 which is significantly lower than the tabular t value of 1.960.

2. In testing whether there was a significant improvement in the level of understanding of chemistry concepts by students subjected to the comparative analogy approach per pottest-pretest results, the computed t of 13.365 was contrasted with the tabular t value of 2.048. The computed t value was greater than the tabular t value suggesting a rejection of the null hypothesis. Thus, there is a significant improvement in the level of understanding of chemistry

concepts by the students using the comparative analogy approach of teaching.

3. The t-test for significant difference between posttest and pretest mean scores of the control group yielded a higher computed t value of 8.839 against the tabular t value of 2.048 indicating the rejection of null hypothesis 3. Thus, there is a significant improvement in the levels of understanding of chemistry concepts by the students using the traditional approach of teaching.

4. To determine the significant difference in the gain of levels of understanding by the students subjected to the comparative analogy approach over those of the traditional approach of teaching, the mean posttest-pretest difference of the experimental group was compared to the mean posttest-pretest difference of the control group. The computed t of 3.773 was significantly higher than the tabular t value of 1.960 in favor of the experimental group. Hence, there is a significant difference in the gain of levels of understanding of chemistry concepts by the students subjected to the comparative analogy approach over those of the traditional method of teaching.

<u>Conclusions</u>

As a consequence of the above findings, the following conclusions were made :

1. The awareness or knowledge of the two groups of students about the chemistry concepts at the start of the treatment were the same.

2. The group subjected to the comparative analogy approach learned the concepts on the particulate nature of matter and the two laws of chemical change.

3. The group subjected to the traditional approach of teaching in the same learning content learned the concepts.

4. The comparative analogy approach is more effective than the traditional approach. The former enhanced, reinforced and concretized the understanding of chemistry concepts.

Recommendations

In view of the foregoing findings and conclusions, the following proposals are highly recommended :

1. Chemistry teachers are encouraged to use comparative analogy approach to enhance and concretize understanding of chemistry concepts.

2. Teachers are advised to use comparable examples that are more or less within the students' level of understanding and experiences for maximum effectiveness of the comparative analogy approach.

3. Comparative analogy approach is highly recom-

mended in the absence of laboratory materials when a laboratory activity is required in presenting a concept, especially in barangay high schools where availability of laboratory materials are often times not available.

4. Chemistry teachers are encouraged to use combined traditional and comparative analogy approach to reinforce the former.

5. Self-instructional materials or modules be developed on the use of the comparative analogy approach.

6. SSPC Research Center should promote the comparative analogy approach during science seminars and in-service trainings. It is well documented that research findings in science education take a considerable time to be applied in the classroom.

7. Similar studies should be conducted using other control variables, moderators, content topic and experimental design to fully substantiate the validity and potentials of the comparative analogy approach.

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A P P E N D I C E S

APPENDIX A

Republic of the Philippines
SAMAR STATE POLYTECHNIC COLLEGE
Catbalogan, Samar

February 28, 1992

The Dean of Instruction & Related Services
Samar State Polytechnic College
Catbalogan, Samar

S i r :

In my desire to start writing my thesis proposal, I have the honor to request approval of one of the following research problems, preferably problem no. 1.

1. EFFECTIVENESS OF COMPARATIVE ANALOGY APPROACH IN TEACHING CHEMISTRY CONCEPTS
2. A COMPARATIVE STUDY OF STUDENTS' PERCEPTION OF A CHEMISTRY TEACHER
3. EVALUATION OF AN EXISTING MODULE ON THE MOLE CONCEPT

I hope for your early and favorable action on this request.

Very truly yours,

emalindog
ESTEBAN A. MALINDOG, JR.
Graduate Student

Recommending Approval :

TERSITO A. ALIPOSA, Ph.D./ Ed.D.
Chief, Research/Extension/Publication

APPROVED :

SENECIO D. AYONG, D.P.A./ Ed.D.
Dean, Instruction and Related Services

APPENDIX B

Republic of the Philippines
SAMAR STATE POLYTECHNIC COLLEGE
Catbalogan, Samar

August 21, 1992

The President
Samar State Polytechnic College
Catbalogan, Samar

Sir :

I respectfully request permission to utilize the Third Year High School students of the college as subjects of my study entitled "EFFECTIVENESS OF COMPARATIVE ANALOGY APPROACH IN TEACHING CHEMISTRY CONCEPTS" for a duration of one (1) month to start on September 1992.

Hoping for your early and favorable consideration on this matter.

Respectfully yours,

Esteban A. Malindog, Jr.
Graduate Student

Recommending Approval :

TERESITA T. NEYPES
Head, Teachers Education

Approved :

BASILIO S. FRINCILLO
College President

APPENDIX C

Republic of the Philippines
SAMAR STATE POLYTECHNIC COLLEGE
Catbalogan, Samar

September 23, 1992

The President
Samar State Polytechnic College
Catbalogan, Samar

Sir :

In my desire to write my thesis and finish my master's degree, may I hereby respectfully apply for study leave good for one year starting this second semester, school year 1992-1993.

I hope for your kind and favorable consideration on this matter.

Respectfully yours,

Esteban A. Malindog, Jr.

Recommending Approval :

TERESITA T. NEYPES
Head, Teachers Education

BERNARDO S. OLIVA, Ph.D.
Vice President fo Academic Affairs

Approved :

BASILIO B. FRINCILLO
College President

APPENDIX D

Repbulic of the Philippines
SAMAR STATE POLYTECHNIC COLLEGE
Catbalogan, Samar

February 3, 1993

The Dean
School of Graduate Studies
Samar State Polytechnic College
Catbalogan, Samar

Sir :

I have the honor to apply for Final Oral Defense of my Thesis entitled "EFFECTIVENESS OF COMPARATIVE ANALOGY APPROACH IN TEACHING CHEMISTRY CONCEPTS" on a date convenient for your office.

Thank you.

Very truly yours,

Esteban A. Malindog, Jr.
Applicant

Recommending Approval :

COSETTE C. OLIVA, Ph.D.
Faculty Adviser

Approved :

DOMINADOR Q. CABANGANAN, Ed.D.
Dean of Graduate School

Date of Oral Defense : February 17, 1993

Time : 2:00 P.M.

APPENDIX E

CALENDAR OF EXPERIMENTAL ACTIVITY

EXPERIMENTAL GROUP	Mo / Date	Yr / Day	CONTROL GROUP
	Aug	92	
Pretesting	17	Mon	Pretesting
Resectioning	28	Fri	Resectioning
	Sept	92	
Lesson Plan 1E	14	Mon	Lesson Plan 1C
Lesson Plan 1E	15	Tue	Lesson Plan 1C
No Class (Meeting)	16	Wed	No Class (Meeting)
Lesson Plan 1E	17	Thu	Lesson Plan 2C
Lesson Plan 2E	18	Fri	Lesson Plan 2C
No Classes	19	Sat	No Classes
No Classes	20	Sun	No Classes
Lesson Plan 2E	21	Mon	Lesson Plan 3C
Lesson Plan 3E	22	Tue	Lesson Plan 3C
No Class	23	Wed	No Class
Lesson Plan 4E	24	Thu	Lesson Plan 4C
Lesson Plan 4E	25	Fri	Lesson Plan 4C
No Classes	26	Sat	No Classes
No Classes	27	Sun	No Classes
Lesson Plan 5E	28	Mon	Lesson Plan 5C
Lesson Plan 5E	29	Tue	Lesson Plan 5C
Standby	30	Wed	Standby
	Oct	92	
Posttesting	1	Thu	Posttesting

APPENDIX F

TABLE OF SPECIFICATIONS

TOPIC / OBJECTIVES	COGNITIVE K	C	A	Total	%
	No. of Test Items				
1.0 Particulate Nature of Matter					
1.1 Distinguish :					
1.1.1 an atom from an element	2			2	8%
1.1.2 an element from a compound	2	2		4	13%
1.1.3 a molecule from a compound	2	2		4	13%
2.0 Laws of Chemical Change					
2.1 Distinguish from each other :					
2.1.1 Law of Definite Composition		4		4	13%
2.1.2 Law of Multiple Proportions		4		4	13%
2.2 Solve problems involving :					
2.2.1 Law of Definite Composition			6	6	20%
2.2.2 Law of Multiple Proportions			6	6	20%
TOTAL	6	12	12	30	
PERCENT	20%	40%	40%		100%

Legend : K – Knowledge, C – Comprehension, A – Application

APPENDIX G

TEST SPECIFICATIONS

TOPICS / OBJECTIVES	K	C	A	Total
	No. of Test Items			
1.0 Particulate Nature of Matter				
1.1 Distinguish :				
1.1.1 an atom from an element	2			2
1.1.2 an element from a compound	2	2		4
1.1.3 a molecule from a compound	2	2		4
2.0 Laws of Chemical Change				
2.1 Distinguish from each other :				
2.1.1 Law of Definite Composition		4		4
2.1.2 Law of Multiple Proportions		4		4
2.2 Solve problems involving :				
2.2.1 Law of Definite Composition			6	6
2.2.2 Law of Multiple Proportions			6	6
TOTAL	6	12	12	30

Legend : K – Knowledge, C – Comprehension, A – Application

APPENDIX G (Continuation)

TEST SPECIFICATIONS

TOPICS / OBJECTIVES	COGNITIVE			
	K	C	A	Total
	% of Test Items			
1.0 Particulate Nature of Matter				
1.1 Distinguish :				
1.1.1 an atom from an element	8%			8%
1.1.2 an element from a compound	6%	7%		13%
1.1.3 a molecule from a compound	6%	7%		13%
2.0 Laws of Chemical Change				
2.1 Distinguish from each other :				
2.1.1 Law of Definite Composition		13%		13%
2.1.2 Law of Multiple Proportions		13%		13%
2.2 Solve problems involving :				
2.2.1 Law of Definite Composition			20%	20%
2.2.2 Law of Multiple Proportions			20%	20%
TOTAL	20%	40%	40%	100%

Legend : K - Knowledge, C - Comprehension, A - Application

APPENDIX H

ITEM SPECIFICATIONS

ITEM NO.	COGNITIVE LEVEL (Objective) No.	TYPE OF TEST
1	K (1.1.1)	FR
2	K (1.1.1)	FR
3	K (1.1.2)	FR
4	K (1.1.2)	FR
5	K (1.1.3)	FR
6	K (1.1.3)	FR
7	C (1.1.2)	MR
8	C (1.1.2)	MR
9	C (1.1.3)	MR
10	C (1.1.3)	MR
11	C (2.1.1)	MR
12	C (2.1.1)	MR
13	C (2.1.1)	MR
14	C (2.1.1)	MR
15	C (2.1.2)	MR

ITEM NO.	COGNITIVE LEVEL (Objective) No.	TYPE OF TEST
16	C (2.1.2)	MR
17	C (2.1.2)	MR
18	C (2.1.2)	MR
19	A (2.1.1)	FR
20	A (2.2.1)	FR
21	A (2.2.1)	FR
22	A (2.2.1)	FR
23	A (2.2.1)	FR
24	A (2.2.2)	FR
25	A (2.2.2)	FR
26	A (2.2.2)	FR
27	A (2.2.2)	FR
28	A (2.2.2)	FR
29	A (2.2.2)	FR
30	A (2.2.2)	FR

Legend : K – Knowledge, C – Comprehension, A – Application
FR – Fixed Response, MR – Multiple Response

APPENDIX I

GENERAL DIRECTIONS

This test is divided into three (3) parts. Read carefully the directions before answering each part.

Each test item has four choices, only one of which is the correct answer. Read the question or statement/ statements of each item carefully and after you have decided which is the best answer, encircle the letter corresponding to it. There are 30 items for the whole test. Be sure to answer all items. You have one (1) hour to finish answering the test.

If you wish to change your first answer for another, put a cross (X) on your first answer and encircle another letter.

You can use the sides of the questionnaire for any computation you might want to do.

Name : ______________________ Date : ______________

Year/Section : ______________

PART I

Directions : This section consists of 6 items (item 1 to item 6). Each item has four (4) choices, only one of which is the correct answer. Read each item carefully and encircle the letter corresponding to the answer which you think is correct.

1. All matter is composed of fundamental and indivisible particles having definite masses that are nearly alike for a given element. This fundamental particle is called

   a. atom c. molecule
   b. element d. compound

2. The simplest form of matter composed of only one kind of atom is

   a. a molecule c. a compound
   b. an element d. a pure substance

3. Atoms of an element may combine chemically with other atoms of an element forming

   a. elementary particles c. a compound
   b. a molecule. d. an atom

4. When an element combines chemically with another element, the product formed is

   a. an atom c. a compound
   b. a molecule d. an elementary particle

5. The smallest particle of a compound that exhibit its characteristic properties is called

   a. an elementary particle c. an atom
   b. a molecule d. an element

6. Which of the following pairs of substances have similar chemical properties ?

   a. O atom and C atom
   b. C element and O element
   c. CO_2 molecule and CO_2 compound
   d. O_2 molecule and CO_2 molecule

PART II

Directions : Each question (items 7 to 18) of this part is followed by three statements or ideas, combinations of which correspond to the correct answer. Analyze the statements carefully and encircle the letter which you think corresponds to the correct choice.

7. Which statements are true about an element and a compound ?

   I – An element may combine chemically with another element to form molecules of a compound.
   II – Compounds are chemical combination of elements.
   III – An element is a group of nearly the same atoms, similarly, a compound is a group of nearly the same molecules.

   a. I and II
   b. II and III
   c. I and III
   d. All of the above

8. Which statements are false about an element and a compound?

   I – An element is the smallest particle of a compound.
   II – Each element in a compound have the same properties.
   III – A compound is a group of similar elements.

   a. I and II
   b. II and III
   c. I and III
   d. All of the above

9. Which statements are true about a molecule and a compound ?

   I - The molecule is the smallest particle of a compound.
   II - The compound is the smallest particle of a molecule.
   III - The characteristic or properties of a compound is demonstrated by its individual molecule.

   a. I and II c. I and III
   b. II and III d. All of the above

10. Given that the correct formula of iron oxide is FeO, which statements are true about iron oxide ?

   I - FeO is a compound formed by the chemical combination of the elements iron and oxygen.
   II - FeO expresses the composition of iron oxide compound.
   III - FeO expresses the composition of iron oxide molecule.

   a. I and II c. I and III
   b. II and III d. All of the above

11. When iron chemically combines with sulfur to form a compound, it is found that 1.0 g of sulfur always combines with 1.75 g of iron. If 10 g of sulfur and 175 g of iron are used in making the compound, which statements are possible ?

   I - All of the sulfur will be consumed in forming the product but not all of the iron.
   II - There is more than enough iron that is needed to combine with all the surfur.
   III - There is more than enough sulfur that is needed to combine with all the iron.

   a. I and II c. I and II
   b. II and III d. All of the above

12. Every 3 parts by mass of carbon, 4 parts of oxygen by are needed for complete reaction to form carbon monoxide. If 3 g of carbon and 4 g of oxygen are placed inside a closed container for reaction, which statements are possible ?

I – The total mass of the system will remain the same.
II – The total mass of the reactants (carbon and oxygen) is equal to the mass of the product (carbon monoxide) formed.
III – Carbon and oxygen will all be consumed.

a. I and II
b. II and III
c. I and III
d. All of the above

13. Determine which of the following statements describe the Law of Definite Composition ?

I – In forming the compound AB, a fixed mass of element A will always combine with a fixed mass of element B.
II – In compounds, elements combine in a fixed mass ratio.
III – Different atoms combine in varying ratios in forming molecules of compounds.

a. I and II
b. II and III
c. I and III
d. All of the above

14. Determine which of the following statements explain the Law of Definite Composition ?

I – Compounds have definite compositions because atoms of elements combine in a definite ratio forming a compound.
II – The ratio of the masses of an element combining with a definite amount of another element in forming several compounds vary in simple whole numbers.
III – Each atom of an element has a definite mass, therefore, the masses of the elements in a compound have also a definite ratio.

a. I and II
b. II and III
c. I and III
d. All of the above

15. Which of the following pairs of chemical systems shows the Law of Multiple Proportions ?

I. CO_2 and NO
II. NO and NO_2
III. CO_2 and CO

a. I and II
b. II and III
c. III and I
d. All of the above

16. Identify the statements which describe the Law of Multiple Proportions ?

I - When two elements combine to form more than one compound with the amount of one element remaining fixed, the ratios of the other elements are in simple whole numbers.

II - Two different atoms may chemically combine forming two different molecules of varying ratios.

III - Elements A and B may chemically combine to form compounds AB and A_2B. The mass ratio of A in compound AB and compound A_2B is 1:2 if the mass of B is held constant.

a. I and II
b. II and III
c. I and III
d. All of the above

17. Which of the following ideas are true about the Law of Multiple Proportions ?

I - Masses of elements that combine to form a compound are in definite ratio.

II - Two elements may combine to form several compounds.

III - The ratio of masses of elements forming different compounds vary.

a. I and II
b. II and III
c. I and III
d. All of the above

18. Which observations agree with the Law of Multiple Proportions ?

I - The mass ratio of oxygen combining with a fixed amount of hydrogen in the compounds water and hydrogen peroxides is always 1:2.

II - A compound of carbon and oxygen when decomposed will always produce 3 parts carbon and 4 parts oxygen by mass.

III - N and O, can form three different compounds : NO, NO_2, and N_2O. In these compounds, the mass of oxygen combining with a fixed mass of hydrogen are in the ratio of 2:4:1, respectively.

a. I and II
b. II and III
c. I and III
d. All of tne above

PART III

Directions : For each problem, select the correct answer by encircling the corresponding letter. You may use the space at the sides for your computations.

19. Upon applying heat, 68.4 g of sugar separated completely into carbon and water. The reaction produced 14.4 g of carbon. What is the mass of water produced ?

a. 14.4 g c. 54 g
b. 28.8 g d. 82.8 g

20. Analysis shows ammonia to contain 14 g of nitrogen for every 3 g of hydrogen. How many grams of nitrogen are combined with 0.15 g of hydrogen in 0.85 g of ammonia ?

a. 0.70 g b. 1.0 g c. 11.0 g d. 17.0 g

21 - 24. Items 21, 22, and 23 are based on the following informations :

Lead and oxygen combine at a mass ratio of 13:2 to form lead oxide. Available are 30 g of lead and 4 g of oxygen.

21. What mass of lead oxide is produced ?

a. 15 g b. 30 g c. 34 g d. 45 g

22. What is the mass of the limiting reagent ?

a. 2 g c. 13 g
b. 4 g d. 30 g

23. How many grams is the unreacted excess reagent ?

a. 2 g c. 13 g
b. 4 g d. 30 g

24. What is the limiting reagent ?

a. lead c. both lead and oxygen
b. oxygen d. All of the above

25-27. Items 25, 26, and 27, are based on the following information :

2.016 g of hydrogen (H) combines with 16.000 g of oxygen (O) to form water (H_2O). The same amount of hydrogen will combine with 32.000 g of oxygen forming hydrogen peroxide (H_2O_2).

25. What is the mass ratio of oxygen combining with the same amount of hydrogen in the two compounds ?

a. 1:1
b. 1:2
c. 2:2
d. 2:3

26. How many grams of water will be formed in the above amount of hydrogen and oxygen ?

a. 2.176 g
b. 18.016 g
c. 34.016 g
d. 64.000 g

27. What is the mass ratio of hydrogen combining with the same amount of oxygen in the two compounds ?

a. 1:2
b. 2:2
c. 2:1
d. 2:3

<u>28-30</u>. Items 28, 29, and 30 are based on the following information :

Carbon and oxygen can form carbon monoxide and carbon dioxide compounds. The mass ratio of carbon to oxygen in carbon monoxide is 3:4. The mass ratio of carbon to oxygen in carbon dioxide is 3:8 .

28. How many grams of oxygen is needed to combine completely with 6.0 g of carbon to produce carbon monoxide ?

a. 4 g b. 6 g c. 8 g d. 16 g

29. How many grams of oxygen is required to combine completely with the same 6.0 g of carbon to produce carbon dioxide ?

a. 4 g b. 6 g c. 8 g d. 16 g

30. What is the mass ratio of oxygen combining with the same amount of carbon in the two compounds ?

a. 1:1 b. 1:2 c. 3:4 d. 3:8

APPENDIX J

KEY TO CORRECT ANSWERS

PART I	PART II	PART III
1. a	7. d	19. c
2. b	8. d	20. a
3. c	9. c	21. b
4. c	10. d	22. b
5. b	11. a	23. b
6. c	12. d	24. b
	13. a	25. b
	14. c	26. b
	15. b	27. c
	16. d	28. c
	17. c	29. d
	18. c	30. b

APPENDIX K

LESSON PLAN 4E (EXPERIMENTAL GROUP)

I TARGET

At the end of the lesson, students should be able to :

Solve problems involving the Law of Definite Composition.

II LEARNING TASKS

A. Subject Matter : Law of Definite Composition
   1. Concept
      a. Definite Composition

   2. Skills
      a. Identifying similarities and differences
      b. Analysis
      c. Problem solving

B. Materials : Teaching aids

C. References : a. Practical Chemistry for Secondary Schools, pp. 33-36

D. Time Allotment : 2 hours (2 days)

III TEACHING STRATEGY

TEACHER ACTIVITY	STUDENT ACTIVITY
1. Preparation	1. Preparation
Today, we will take up another lesson. Our new lesson is about the law of definite composition. Before proceeding to the new lesson, let us review our past lessons because they are still a part of today's lesson and succeeding lessons. We have learned from Dalton's Atomic Theory that an atom can chemically combine with another atom forming a molecule. Further, when an atom combines with another atom, they do so in a fixed ratio of small whole numbers such as one is to one, one is to two, two is to one, etchetera, when forming molecules. The fixed ratio is reflected in the formula of a molecule or compound. Given the formula of water as H-2-O, suggests that to form a molecule of water we really need two hydrogen atoms and one oxygen atom.	Students listen and pay attention to the lecture of the teacher and actively participate in class discussion by raising their hands or when called upon.

1.1 Advance Organizer

Let us consider again the match sticks as atoms. Every triangle formed by combining the black sticks and red stick is equivalent to a molecule. To form the triangle we need two black sticks and one red stick. The ratio in terms of the number of pieces of black sticks to the number of pieces of red stick is two is to one.

If we have six pieces of the black sticks and two pieces of the red sticks, how many triangles will be formed ?

"Two triangles."

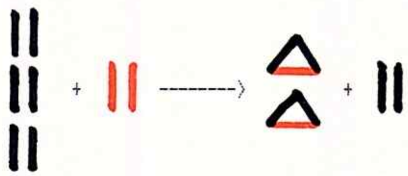
To form the triangle :

ratio: 2 1 1

Given :

6 blacks and 2 reds

Solution :



Limiting reagent - substance or material that limits the formation of the desired product.
- substance or material that is present in short supply.

Excess reagent - substance or material that is in excess or over-supply.
- substance or material that is present more than what is needed.

Limiting reagent = red stick
Excess reagent = black stick

Very good. We can make two triangles. It's very easy. Every two black sticks requires one red stick to form a triangle composed of two black sticks and red stick. Since we have two red sticks it needs four black sticks.

Notice class that all of the red sticks were used up and there are remaining black sticks. We consider the red stick as the limiting reagent. A limiting reagent is a substance that limits the formation of the desired product or it is the material that is in short supply.

On the otherhand, the black stick is called the excess reagent. It is the substance that is in excess or more than enough than what is required.

Now let us try this. How many triangles can be formed from one thousand black sticks and one thousand one hundred forty red sticks ?

Drawing the sticks on the board will require a wider space. Counting by memory the right combinations may be cumbersome. We might even get lost on the process of counting and we have to go back again.

We can solve the problem with ease by applying the appropriate mathematics taking into consideration the fixed ratio in forming the triangle.

Here, we will apply the method of ratio and and proportion.

To form a triangle of 2 blacks and 1 red :

black stick + red stick ---------> triangle

2 B   1 R   1 B_2R

Given :

1000 blacks sticks and 1140 red sticks

Find : a) the limiting reagent

b) the excess reagent

c) no. of triangels that can be formed

Solution :

B + R -------> T

ratio 2 : 1 : 1

a) For B = 1000 ----- ? R

let x = no. of red sticks that can combine completely with the 1000 black sticks to form the triangles.

By ratio and proportion,

B : R = B : R   or $\frac{B}{R} = \frac{B}{R}$

1000 B : x = 2 B : 1 R $\frac{1000\ B}{x} = \frac{2\ B}{1\ R}$

(2 B)x = (1 R)(1000 B)

$\frac{(2\ B)x}{(2\ B)} = \frac{(1\ R)(1000\ B)}{(2\ B)}$ 2 B(x) = (1000 B)(1 R)

$$x = \frac{(1)(1000)}{2} \ R$$

x = 500 R ------> available R is 1140 pieces

Therefore, limiting reagent is the black stick.

b) The excess reagent is the red stick

c) Number of triangles that can be formed,

B	+	R	------>	T
1000		500		x

By ratio and proportion, in terms of black sticks :

$$\frac{1000B}{x} = \frac{2B}{1T}$$

$$x\ (2B) = 1000B\ (1T)$$

$$\frac{x\ (2B)}{2B} = \frac{1000B\ (1T)}{2B}$$

$$x = \frac{1000\ (1)}{2} \ T$$

x = 500 Triangles

or, in terms of the red stick:

500 R : x = 1 R : 1 T

$$x\ (1R) = 500\ R\ (1T)$$

$$\frac{x\ (1R)}{1R} = \frac{500\ R\ (1T)}{1R}$$

$$x = \frac{500\ (1)}{1} \ T$$

x = 500 Triangles

Knowing that 1000 pieces of black sticks require 500 red sticks, we count 500 red sticks from the available 1140 red sticks. Using our fingers, we pick one stick at a time until we have the 500 red sticks.

If we are given one billion of the black sticks and one billion also of the red sticks, its not a problem how to determine the number of black and red sticks that will be used in forming the triangles. We just apply ratio and proportion. How many triangles will be formed ?

"One half billion."

Very good. One billion black sticks will require one half billion of the red sticks because the ratio is two black for every one red.

However, to count one by one half billion of the red stick from the one billion red sticks will take us months or longer. Probably, by the time we are through counting, we are physically and mentally exhausted.

The point here is that atoms are very very small. Actually, a group of similar atoms to be considered as an element, large enough to be observed, takes several billions of atoms. If we want to produce one cup of water from hydrogen atoms and oxygen atoms, we will need billions of billions of the hydrogen and oxygen atoms. If we are to count the number of atoms needed in making the water, before we can drink the water, there is a great probability that we are already long dead and yet we have not gone half way through. It is not even possible to pick the atoms one by one because of their very very very small size.

However, knowing the constant mass of each stick or atom we can obtain the correct number of sticks at a shorter time with less effort by weighing.

Let us say, each red stick weighs 0.5 gram and each black stick weighs 1.0 gram. What will be the mass of one thousand one hundred forty red sticks?

"Five hundred seventy grams."

One thousand one hundred forty of the red sticks is equivalent to 570 grams. We multiply one thousand one hundred forty by the mass which is 0.5 gram. Similarly, 600 grams of red sticks is equivalent to 1200 pieces. We divide 600 grams by 0.5 gram per stick. How many grams are one thousand black sticks?

"One thousand grams."

Yes. The total mass of the black sticks is 1000 grams.

2. Presentation

2.1 The Law of Definite Composition

In 1799, after numerous experiments, a French chemist by the name of Joseph Proust (1754 - 1826) formulated the law of constant proportion otherwise known as the law of definite composition. The law states that elements combine in a fixed mass ratio to form a com-

2. Presentation

Students pay attention to the lecture and participate by raising their hands or when called upon.

pound.

The law as stated is similar to Dalton's number 4 assumption, atoms combine in a fixed ratio of small whole numbers such as one is to one, one is to two, two is to one, etchetera, when forming molecules.

The two statements differ only in two minor aspects. What are these two differences ?

"Dalton's assumptions speak of atoms and molecules. While the law is about elements and compounds."

Very good. The two statements differs in the use of the terms atoms, elements, molecule, and compound.

Another difference between the two statements?

"The assumption of Dalton deals on the number ratio of atoms combining with another atom while the law deals on the mass ratio between combining elements."

Excellent. The law of definite composition tells us that the fixed ratio is in terms of mass while in Dalton's assumption it is in terms of the number of atoms or number of pieces just like in a formula.

atom	+	atom	--->	molecule
atom	+	atom	--->	molecule
atom	+	atom	--->	molecule
(billions)		(billions)		(billions)
element	+	element	--->	compound

Instead of counting billions of sticks or billions atoms or billions of elements, it is much easier to weigh them.

We can therefore restate the law as, atoms of an element can chemically combine with other atoms of another element forming molecules of a compound in a fixed mass ratio of small whole numbers, or an atom chemically combine with another atom in a fixed mass ratio of small whole numbers when forming a molecule.

Noting that a symbol can also stand for an atom or an element, and a formula for a molecule or compound, another way of stating the law is, two elements, A and B, can chemically combine in a fixed mass ratio forming the compound AB, or two atoms, A and B, can chemically combine in a fixed mass ratio forming the molecule AB.

2.2 Advance Organizer

We go back to our atomic sticks. Again, we assume that each black stick weighs 1 gram and each red stick weighs 0.5 gram. Since the triangle is made up of two black sticks and one red stick, the mass of the triangle is 2.5 grams. Let us work together on the one thousand black sticks and one thousand one hundred forty red sticks.

Problem:

1000 pcs black sticks x 1 g/pc = 1000 g blacks

1140 pcs reds x 0.5 g/pc = 570 g reds

Find:
a) the limiting reagent
b) the mass of the excess reagent
c) the mass of the triangles formed

Solution:

To form the triangle,

$$B + R \longrightarrow T$$
$$2\text{ g} \quad 0.5\text{ g} \quad 2.5\text{ g}$$

From given data,

$$B + R \longrightarrow T$$
$$1000\text{ g} \quad 570\text{ g}$$

a) For B = 1000 g ------> ? R

Let x = mass of the red sticks needed to combine with 1000 g of the black sticks.

By ratio and proportion :

$$\frac{1000\text{ g B}}{x} = \frac{2\text{ g B}}{0.5\text{ g R}}$$

$$\frac{(2\text{ g B})\,x}{2\text{ g B}} = \frac{(1000\text{ g B})(0.5\text{ g R})}{2\text{ g B}}$$

$$x = \frac{(1000)(0.5)}{2}\text{ g R}$$

x = 250 g R ===> since there are 570 g of R, Therefore, limiting reagent is the black stick.

To check :

$$\text{no. of red sticks} = \frac{250\ g}{0.5\ g/stick} = 500 \text{ red sticks}$$

b) Excess reagent is the red stick.

mass of excess red = 570 g - 250 g

= 320 g

$$\text{or, no. of extra red sticks} = \frac{320\ g}{0.5\ g/stick} = 640 \text{ reds}$$

c) Mass of triangles formed = mass of blacks used + mass of reds used

= 1000 g + 250 g

= 1250 g

$$\text{or, no. of triangles} = \frac{1250\ g}{2.5\ g/stick} = 500 \text{ triangles}$$

---

3. Application

Now, let us substitute atoms for sticks through this problem.

3. Application

Students participate in the drill by rasing their hands or when called upon.

Problem:

Analysis shows that water contains 11.1 g of hydrogen for every 88.9 g of oxygen. a) How many grams of hydrogen are needed to react completely with 16 g of oxygen ? b) If 10 g of oxygen are made to react with 5 g of hydrogen, which substance is the limiting reagent? c) Which substance is the excess reagent and how much is the excess? d) How many grams of water will be produced in b ?

Solution :

$$H \quad + \quad O \longrightarrow H_2O$$

11.1 g   88.9 g

$$\text{mass ratio} = \frac{H}{O} = \frac{11.1\ g}{88.9\ g} = \frac{1\ g\ H}{8\ g\ O}$$

a) H + O ——> H_2O

? 16 g

Let x = mass of hydrogen needed to react completely with 16 g of oxygen

By ratio and proportion :

$$\frac{x}{16\ g\ O} = \frac{1\ g\ H}{8\ g\ O}$$

$$x(8\ g\ O) = (16\ g\ O)(1\ g\ H)$$

$$x = \frac{(16\ g\ O)(1\ g\ H)}{8\ g\ O}$$

$$x = 2\ g\ H$$

b) H + O ——> H_2O

5 g 10 g

For H = 5 g ——> ? O

Let x = mass of oxygen required to combine completely with 5 g of hydrogen.

By ratio and proportion :

$$\frac{5\ g\ H}{x} = \frac{1\ g\ H}{8\ g\ O}$$

$$x\ (1\ g\ H) = (5\ g\ H)(8\ g\ O)$$

$$x = \frac{(5\ g\ H)(8\ g\ O)}{1\ g\ H}$$

x = 40 g O ——> available oxygen is only 10 g.

Therefore, the limiting reagent is oxygen.

c) Excess reagent is hydrogen

For O = 10 g ---> ? H

Let x = mass of hydrogen needed to combine completely with 10 g of oxygen.

By ratio and proportion :

$$\frac{10\ g\ O}{x} = \frac{8\ g\ O}{1\ g\ H}$$

$$(8\ g\ O)x = (10\ g\ O)(1\ g\ H)$$

$$x = \frac{(10\ g\ O)(1\ g\ H)}{8\ g\ O}$$

x = 1.25 g H ---> available H is 5 g.

Excess H = 5 g - 1.25 g = 3.75 g

d) Mass of water formed = mass of H reacted + mass of O reacted

= 1.25 g + 10 g
= 11.25 g

4. Evaluation : To be deferred until all identified topics of the experimental study had been covered.

IV AGREEMENT

1. Answer/solve the following questions. To be submitted in a one whole sheet of paper.

   1. On analysis, a compound is found to consist of 40 g of A and 120 g of B. a) How many grams of B are required to form the compound if there are 15 g of A? b) If 40 g of B are

mixed with 12 g of A and allowed to react, which substance is the limiting reagent? How many grams of compound will be formed?

2. Sodium and chlorine combine at a mass ratio of 2:3 to form table salt. Available are 20 g of chlorine and 8 g of sodium. a) What is the limiting reagent? b) How much is the excess reagent? c) What mass of table salt is produced?

3. How do we account the constancy in mass ratio when elements combine forming a compound?

2. Read and study Law of Multiple Proportions

a. Write in half sheet of paper the statement of the law.

Reference : Practical Chemistry for Secondary SChools pp. 36-38

APPENDIX K (Continuation)

LESSON PLAN 4C (CONTROL GROUP)

I TARGET

At the end of the lesson, students should be able to :

Solve problems involving the Law of Definite Composition.

II LEARNING TASKS

A. Subject Matter : Law of Definite Composition
1. Concept
a. Definite Composition

2. Skills
a. Following rules
b. Observing
c. Analyzing
d. Problem Solving

B. Materials : Glasswares and chemicals

C. References : Practical Chemistry for Secondary Schools, pp. 33-36

D. Time Allotment : 2 hours (2 days)

III TEACHING STRATEGY

TEACHER ACTIVITY	STUDENT ACTIVITY
1. Preparation	1. Pre-Instruction
Our lesson for today is not entirely new. It is about the law of definite composition. But before we go into it, let us review our previous lessons. We have learned that compounds are chemical combinations of elements. Or, a molecule is a chemical combination between atoms. Dalton's Atomic Theory further assumed that when an atom chemically combines with another atom, they do so in a fixed ratio of small whole numbers such as 1:1, 1:2, 2:1, etc. This fixed ratio is reflected in the formula of the molecule of the compound. To check this fixed ratio between combining atoms or elements, you are going to perform the activity which I assigned to you yesterday.	Students listen to the teacher and perform the activity later.

What is the title of the activity ?

"Electrolysis of water."

In the activity, you are going to decompose water into its constituent elements by the passage of electricity. After a certain period of time, you have to stop the supply of electricity and measure the volume and masses of the gases produced. From the measured height and mass, you will be able to determine the fixed ratio between the two gases that combined forming water.

Further, this activity will demonstrate the method of identifying the elements that make up water.

Each group will be given different sizes of pair of test tubes. And while the experiment is on progress, I will go around to tell you when to stop the supply of electricity. You can now proceed to the activity.

2. Presentation

2. Presentation

Let us discuss now the results of your experiment.

Students listen to the lecture-discussion and actively participate by raising their hands or when called upon.

What happened in the two electrodes inside the test tubes several minutes after closing the circuit ?

"Bubbles were formed at the two electrodes."

Yes, bubbles were formed at the two electrodes. You probably noticed that the rate of formation of the gases at the two electrodes were different.

In which electrode was the formation of gas faster?

"Gas formation was more faster at the negative electrode."

Good. Gas production at the negative electrode was more faster than at the positive electrode.

What gas was produced at the negative electrode ?

"Hydrogen gas."

How did you know it was hydrogen ?

"By placing a lighted wood splinter near the mouth of the test tube containing the gas, a popping sound was produced.

Very good. The gas was hydrogen since it produced a slight popping sound upon ignition. The popping sound upon ignition is a positive test for the presence of hydrogen gas.

How about the gas at the other electrode ? What gas was it?

"The gas produced at the positive electrode was oxygen."

Yes, the other gas which was produced at the positive electrode was oxygen. The glowing splinter glowed more intensely when inserted inside the test tube containing oxygen gas. Oxygen gas supports combustion.

From these observations, what conclusion can you make regarding the composition of water ?

"Water is a compound made up of the elements hydrogen and oxygen."

Very good. Recall that it is not only heat that can cause decomposition between elements in a compound. Electricity can also cause decomposition between elements in a compound. The passage of electricity to effect a chemical change is called electrolysis.

Again, water is made up of hydrogen and oxygen. The question now is, do elements of hydrogen and oxygen combine at different ratios to form the compound water? To answer this, we have to determine the volume ratio and mass ratio of hydrogen to oxygen obtained from your activity.

For a constant diameter test tube, the height ratio is proportional to volume ratio. Also, for gases, volume ratio is proportional to number ratio - the number of atoms.

By the way, each group were given two different sets of test tubes and stopped the supply of electricity at different intervals of time. It is expected therefore that you will obtain different results of the amount of hydrogen and oxygen gases generated.

Group leaders, write on the board your results. We will compare all your results.

	(HYPOTHETICAL RESULTS) Height in cm		Number ratio
	H	O	H/O ratio
Group 1	6.7	3.4	1.97/ 1 ---> 2/1
Group 2	5.2	2.0	2.08/ 1 ---> 2/1
Group 3	7.6	3.7	2.05/ 1 ---> 2/1
Group 4	6.4	3.3	1.94/ 1 ---> 2/1

As reflected on the board, you have different results. These are due to different sizes of the test tubes used and the time of using the electricity. Notice class that by dividing the height of hydrogen by oxygen, the quotient, rounded off to the nearest whole number is two. The quotient was supposed to be exactly two. This discrepancies are attributed to what we call experimental errors or uncertainties.

What is the significance of this number?

"It means that in water, there are two hydrogen and one oxygen elements."

Good. This number tells us that for every two hydrogen will require 1 oxygen to form a compound of water. Or, if we have 8 hydrogen, 16 oxygen is needed for complete reaction between the two atoms or elements to form water.

Now, what is the formula of water?

"H-2-O."

Very good. Again, do not forget that a formula represents the name of a compound at the same time it tells us the composition of a compound.

All your observations and results confirm the validity of Dalton's Atomic Theory. Atoms of elements really combine at a fixed number ratio forming molecules of a compound. Again, this fixed number ratio is evident in the formula.

Now let us focus our attention to the next set of data. Notice again that you have different results. This is attributed to the different sizes of the test tubes and masses of the stoppers. However, rounding off the numbers to the nearest whole number we will obtain a mass ratio of 1 is to 8. This ratio is not the same as the number ratio. It is not evident in the formula unlike the number ratio.

(HYPOTHETICAL RESULTS)

	Mass in grams		Mass ratio
	H	O	H/O
Group 1	0.25	1.95	1/7.8 - 1/8
Group 2	0.27	2.21	1/8.2 - 1/8
Group 3	0.30	2.37	1/7.9 - 1/8
Group 4	0.21	1.76	1/8.4 - 1/8

If we have 2 grams of hydrogen, this amount will require 16 g of oxygen to form water. No more, no less.

This fixed mass ratio is embodied in the law usually called the law of definite composition.

In 1799, after numerous experiments, the same as you did, a French chemist by the name of Joseph Froust formulated the law of definite composition. There are several versions of it, but put simply the law states that atoms of elements combine at a fixed mass ratio forming molecules of compounds.

Noting that a symbol can stand for an atom and an element, and a formula can stand for a molecule and a compound, another way of stating the law is : two atoms, A and B, can chemically combine at a fixed mass ratio forming the molecule AB, or two elements, A and B, can chemically combine at a fixed mass ratio forming the compound AB.

3. Application

We will now solve problems by applying the principle of the law of definite composition.

When solving problems related to this law, two important terms should be clearly understood. The substance that limits the reaction in forming the desired product is called a limiting reagent. On the otherhand, a substance that is present more that what is needed is called the excess reagent.

3. Application

Students participate in solving the sample problem.

Problem 1:

Analysis shows that water contains 11.1 g of hydrogen for every 88.9 g of oxygen. a) How many grams of hydrogen are needed to react completely with 16 g of oxygen ? b) If 10 g of oxygen are made to react with 5 g of hydrogen, which substance is the limiting reagent ? c) Which substance is the excess reagent and how much is the excess ? d) How many grams of water will be produced in b?

Solution:

$$H + O \longrightarrow H_2O$$

11.1 g   88.9 g

$$\text{mass ratio} : H/O = 11.1\text{ g H} / 88.9\text{ g O} = \frac{1\text{ H}}{8\text{ O}}$$

a) $$H + O \longrightarrow H_2O$$

?   16 g

Let x = mass of hydrogen needed to react completely with 16 g of oxygen.

By ratio and proportion :

$$\frac{x}{16\text{ g O}} = \frac{1\text{ g H}}{8\text{ g O}}$$

$$x\,(8\text{ g O}) = 16\text{ g O}\,(1\text{ g H})$$

$$x = \frac{16\text{ g O}\,(1\text{ g H})}{8\text{ g O}}$$

$$x = 2\text{ g H}$$

b) $$H + O \longrightarrow H_2O$$

5 g   10 g

Trial 1: H = 5 g ⟶ ? O

By ratio and proportion:

$$\frac{5\ g\ H}{x} = \frac{1\ g\ H}{8\ g\ O}$$

$$x\ (1\ g\ H) = 5\ g\ H\ (8\ g\ O)$$

$$x = \frac{5\ g\ H\ (8\ g\ O)}{1\ g\ H}$$

$x = 40$ g O ----> available oxygen is only 10 g.

Therefore, the limiting reagent is oxygen.

c) Excess reagent is hydrogen.

Trial 2: O = 10 g -----> ? H

By ratio and proportion:

$$\frac{10\ g\ O}{x} = \frac{8\ g\ O}{1\ g\ H}$$

$$x\ (8\ g\ O) = 10\ g\ O\ (1\ g\ H)$$

$$x = \frac{10\ g\ O\ (1\ g\ H)}{8\ g\ O}$$

$x = 1.25$ g H -----> available hydrogen is 5 g.

Excess Hydrogen = 5 g - 1.25 g

= 3.75 g

d) Mass of water formed = mass of H reacted + mass of O reacted

= 1.25 g + 10 g

= 11.25 g

We will take this last problem.

Problem 2:

Ammonia has a composition of 82% nitrogen and 18% hydrogen by mass. How much ammonia can be produced from 10 g of nitrogen and 10 of hydrogen?

Solution:

Basis: 100 g ammonia

mass of nitrogen = 0.82 (100 g) = 82 g

mass of hydrogen = 0.18 (100 g) = 18 g

nitrogen + hydrogen -----> ammonia

82 g   18 g   100 g

$$\text{ratio} = \frac{N}{H} = \frac{82\text{ g}}{18\text{ g}} = \frac{4.56}{1}$$

given : 10 g H + 10 g N ---> ammonia

Trial 1: H = 10 g -----> ? N

By ratio and proportion:

$$\frac{10\text{ g H}}{x} = \frac{1\text{ g H}}{4.56\text{ g N}}$$

$$x\ (1\text{ g H}) = 10\text{ g H}\ (4.56\text{ g N})$$

$$x = \frac{10\text{ g H}\ (4.56\text{ g N})}{1\text{ g H}}$$

x = 45.6 g N ----> available is 10 g nitrogen.

Therefore : Limiting reagent is nitrogen.

Trial 2: N = 10 g ---> ? H

By ratio and proportion:

$$\frac{10\ g\ N}{x} = \frac{4.56\ N}{1\ H}$$

$$x\ (4.56\ N) = 10\ g\ N\ (1\ H)$$

$$x = \frac{10\ g\ N\ (1\ H)}{4.56\ N}$$

x = 2.19 g H ---> available H is 10 g.

Product formed = H used + N used

= 2.19 g + 10 g

= 12.19 g of ammonia formed

4. Evaluation : To be deferred until all the identified topics of the experimental study had been covered.

V. AGREEMENT

1. Answer/solve the following questions. To be submitted in a whole sheet of paper.

   1. On analysis, a compound is found to consist of 40 g of A and 120 g of B. a) How many grams of B are required to form the compound if there are 15 g of A? b) If 40 g of B are mixed with 12 g of A and allowed to react, which substance is the limiting reagent? How many grams of the compound will be produced?

   2. Sodium and chlorine combine at a massratio of 2:3 to form table salt. Available are 20 g of chlorine and 8 g of sodium. a) What is the limiting reagent? b) How much is the excess reagent? c) What mass of table salt is produced?

   3. How do we account the constancy in mass ratio between elements when forming compounds ?

2. Read and study the Law of Multiple Proportions

   a. Write in a half sheet of paper the statement of the law.

Reference : Practical Chemistry for Secondary Schools pp. 36-38

Activity 2-E (Part B)

Electrolysis of Water

Materials :

- 250 ml 10 % sodium hydroxide solution
- distilled water
- wood splinter
- 2 400 ml beaker
- alcohol burner
- 4 test tubes (same diameter) with rubber stoppers
- 2 electrodes
- 2 dry cells
- 2 one-holed wooden test tube rack
- balance
- connecting wires
- iron stand with clamps

Procedure :

1. Fill the beaker with 10% sodium hydroxide solution.
2. Attach wires to the electrodes.
3. Attach wires to the power source and put the assembled electrodes inside the beaker containing the solution.
4. Stir solution for 10 minutes using the electrodes by holding the wires. (Avoid hands getting wet with the solution, or immediately wash hands with plenty of water until slippery feel is remove.)
5. Disconnect wires from the power source.
6. Fill separately two test tubes with the solution to the brim.
7. Carefully place test tubes upside down into the beaker containing the solution. Be sure that no bubbles form in the test tubes, otherwise repeat the procedure. See to it that each electrode is inside the test tube.
8. Attach wires to power source.
9. As soon as one of the test tubes is filled entirely with gas, disconnect wires from power source.
10. Measure the height of each gas in the two test tubes. The height of the gas can be related to the volume of the gas provided that the two test tubes have the same diameter.
11. Remove the test tubes but keep them inverted. Stopper right away.
12. Label which battery ends they came from.
13. Get the test tube filled with gas from the negative

electrode. Hold the test tube upright. Remove stopper and put immediately a lighted wooden splinter near its mouth. Describe what happens.

14. Get the test tube filled with gas from the positive electrode. Put a glowing splinter near its mouth. Observe what happens to the glowing splinter. Describe what you see.
15. Determine the masses of the two wooden racks.
16. Using another set of test tubes, fill the tubes with the solution to the brim and stopper them. Be sure no bubbles are formed inside the tubes.
17. Wash sides with water, wipe dry and weigh each test tube assembly and record the masses.
18. Proceed to procedures 7, 8, 9, 11.
19. Wash sides with water, wipe dry and insert test tubes in upright position to the wooden racks. Slowly remove the stoppers to let the collected gas escape.
20. Weigh each test tube in the rack together with the stopper. Record the masses.
21. Determine the mass of gas collected in each test tube as follows :

Mass of gas collected = (Mass in P-17 + Mass in P-15) - - Mass in P-20

DATA AND RESULTS:

A - HEGHT RATIO

Test tubes	Electrode collected	Height in cm
Test tube 1		
Test tube 2		

B - MASS RATIO

	Test tube 1	Test tube 2
1. Mass of wooden racks (P-15)	________	________
2. Mass of test tube, stopper, solution (P-17)	________	________
3. Mass of test tube, stopper, remaining solution (P-20)	________	________
4. Mass of gas collected	________	________

APPENDIX L

Item Analyses On The Test Instrument Administered To 101 Fourth Year Student Of Samar State Polytechnic College

Item No.	a		b		c		d		KEY	p_H	p_L	Difficulty index	Item Evaluation	Discrimination	REMARK	q	pq
	H	L	H	L	H	L	H	L									
1	8	4	10	10	4	8	5	5	a	0.30	0.15	0.22	D	0.15	Rejected		
2	22	2	1	10	3	7	1	8	a	0.82	0.07	0.44	MD	0.75	Retained	0.56	0.2464
3	3	14	19	3	4	3	1	7	b	0.70	0.11	0.41	MD	0.59	Retained	0.59	0.2419
4	2	6	24	10	0	4	1	7	b	0.89	0.37	0.63	MD	0.52	Improved	0.37	0.2331
5	1	9	5	7	21	6	0	5	c	0.78	0.22	0.50	MD	0.56	Improved	0.50	0.2500
6	1	7	9	8	13	3	9	4	c	0.48	0.11	0.30	D	0.37	Rejected		
7	2	8	16	4	6	10	3	5	b	0.59	0.15	0.37	D	0.44	Retained	0.63	0.2331
8	1	7	1	6	23	6	2	8	c	0.85	0.22	0.54	MD	0.63	Retained	0.46	0.2484
9	5	10	2	4	4	6	16	7	d	0.59	0.26	0.42	MD	0.33	Retained	0.58	0.2436
10	6	9	7	4	5	8	12	3	d	0.44	0.11	0.28	D	0.33	Retained	0.72	0.2016
11	2	8	1	9	22	5	2	5	c	0.82	0.19	0.50	MD	0.63	Retained	0.50	0.2500
12	7	7	2	11	4	5	14	4	d	0.52	0.15	0.34	D	0.37	Retained	0.66	0.2244
13	13	2	6	10	5	8	3	7	a	0.48	0.07	0.28	D	0.41	Retained	0.72	0.2016
14	4	10	5	8	16	5	2	4	c	0.59	0.19	0.39	D	0.40	Retained	0.61	0.2379
15	24	8	1	6	1	5	1	8	a	0.89	0.30	0.60	MD	0.59	Retained	0.40	0.2400
16	1	3	3	7	17	8	6	9	c	0.63	0.30	0.47	MD	0.33	Retained	0.53	0.2491
17	2	6	15	4	8	11	2	6	b	0.56	0.15	0.36	D	0.41	Retained	0.64	0.2304
18	4	6	7	8	7	10	9	3	d	0.33	0.11	0.22	D	0.22	Improved	0.78	0.1716
19	6	9	16	4	1	9	4	5	b	0.59	0.15	0.37	D	0.44	Retained	0.63	0.2331
20	2	9	1	7	23	10	1	1	c	0.85	0.37	0.61	MD	0.48	Retained	0.39	0.2379

APPENDIX L (Continuation)

Item No.	a		b		c		d		KEY	p_H	p_L	Difficulty index	Item Evaluation	Discrimination	REMARK	q	pq
	H	L	H	L	H	L	H	L									
21	1	9	3	6	20	7	3	5	c	0.74	0.26	0.50	MD	0.48	Retained	0.50	0.2500
22	19	4	4	8	3	8	1	7	a	0.70	0.15	0.42	MD	0.55	Retained	0.58	0.2436
23	3	7	20	7	2	9	2	4	b	0.74	0.26	0.50	MD	0.48	Retained	0.50	0.2500
24	4	6	17	9	6	8	7	4	b	0.63	0.33	0.48	MD	0.30	Retained	0.52	0.2496
25	5	7	13	3	2	5	7	12	b	0.48	0.11	0.30	D	0.37	Retained	0.70	0.2100
26	2	5	20	8	3	7	2	7	b	0.74	0.30	0.52	MD	0.44	Retained	0.48	0.2496
27	1	10	18	4	4	8	4	5	b	0.67	0.15	0.41	MD	0.52	Retained	0.59	0.2419
28	0	4	22	11	3	9	2	3	b	0.82	0.41	0.62	MD	0.41	Rejected		
29	2	6	2	8	19	6	4	7	c	0.70	0.22	0.46	MD	0.48	Retained	0.54	0.2484
30	2	8	8	10	9	2	8	7	c	0.33	0.70	0.20	D	0.26	Improved	0.80	0.1600
31	4	5	3	8	17	8	3	6	c	0.63	0.30	0.47	MD	0.33	Retained	0.53	0.2491
32	5	6	2	10	4	5	16	6	d	0.59	0.22	0.40	MD	0.37	Retained	0.60	0.2400
33	1	5	13	1	10	9	3	8	b	0.48	0.04	0.26	D	0.44	Retained	0.74	0.1924
TOTAL												12.65		13.45			6.9597
MEAN												0.42		0.45			

TEST RELIABILITY = 0.80

Note : D – Difficult item

MD – Moderately difficult item

APPENDIX M

<u>Computation of Reliability Coefficient</u>, r :

$$r = \frac{k}{k - 1} \left[1 - \frac{6\ \Sigma pq}{(kD)^2} \right]$$

$$r = \frac{30}{30 - 1} \left[1 - \frac{6(6.9587)}{(30 \times 0.45)^2} \right]$$

$$r = \frac{30}{29} \left[1 - \frac{41.7522}{182.25} \right]$$

$$r = \frac{30}{29} \left[1 - 0.23 \right]$$

$$r = \frac{30}{29} \left[0.77 \right]$$

$$r = 0.80$$

APPENDIX N

Computation of Means and t-value :

$$\bar{O} = \frac{\Sigma O}{N}$$

$$\bar{O}_1 = \frac{226}{29} \qquad \bar{O}_3 = \frac{237}{29}$$

$$\bar{O}_1 = 7.793 \qquad \bar{O}_3 = 8.172$$

$$SD^2 = \frac{N(\Sigma O^2) - (\Sigma O)^2}{N(N-1)}$$

$$SD_1^{\,2} = \frac{29(1942) - (226)^2}{29(29-1)} \qquad SD_2^{\,2} = \frac{29(2085) - (237)^2}{29(29-1)}$$

$$SD_1^{\,2} = \frac{56318 - 51076}{812} \qquad SD_2^{\,2} = \frac{60465 - 56169}{812}$$

$$SD_1^{\,2} = 6.456 \qquad SD_2^{\,2} = 5.291$$

$$SD_1 = \sqrt{6.456} \qquad SD_2 = \sqrt{5.291}$$

$$SD_1 = 2.541 \qquad SD_2 = 2.300$$

$$t_c = \frac{O_1 - O_3}{\sqrt{\dfrac{(N_1-1)SD_1^{\,2} + (N_2-1)SD_2^{\,2}}{N_1+N_2-2}\left(1/N_1 + 1/N_2\right)}}$$

(APPENDIX N (Continuation)

$$t_c = \frac{7.793 - 8.172}{\sqrt{\dfrac{(29-1)(6.456) + (29-1)(5.291)}{29 + 29 - 2}\left(\dfrac{1}{29} + \dfrac{1}{29}\right)}}$$

$$t_c = \frac{-0.379}{\sqrt{\dfrac{180.787 + 148.120}{56}(0.069)}}$$

$$t_c = \frac{0.379}{\sqrt{5.873\ (0.069)}} \quad \text{(Disregard sign)}$$

$$t_c = \frac{0.379}{0.636}$$

$$t_c = 0.596$$

Walpole, page 481, Table A.5, at $\alpha = 0.05$ and $df = 56$:

$t_{tabular}$ = 1.960 (two - tailed)

APPENDIX O

Computation of Means and t-value :

$$\bar{O}' = \frac{\Sigma O}{N}$$

$$O_1 = \frac{226}{29} = 7.793$$

$$\bar{O}_2 = \frac{467}{29} = 16.103$$

$$D_{eg} = \frac{241}{29} = 8.310$$

$$SD^2 = \frac{N(\Sigma O^2) - (\Sigma O)^2}{N(N-1)}$$

$$SD_1^{\,2} = \frac{29(2319) - (241)^2}{29(29-1)}$$

$$SD_1^{\,2} = \frac{67251 - 58081}{812}$$

$$SD_1^{\,2} = 11.293$$

$$SD_1 = \sqrt{11.293}$$

$$SD_1 = 3.360$$

$$t_c = \frac{D_{eg} \times \sqrt{N}}{SD_1}$$

APPENDIX O (Continuation)

$$t_c = \frac{8.310 \times \sqrt{29}}{3.360}$$

$$t_c = 13.365$$

Walpole, page 481, Table A.5 at $\alpha = 0.05$ with df = 28 :

$t_{tabular} = 2.048$ (two - tailed)

APPENDIX P

Computation of Means and t-value :

$$\bar{O} = \frac{\Sigma O}{N}$$

$$\bar{O}_3 = \frac{327}{29} = 5.503$$

$$\bar{O}_4 = \frac{385}{29} = 13.276$$

$$\bar{D}_{cg} = \frac{148}{29} = 5.103$$

$$SD^2 = \frac{N(\Sigma O^2) - (\Sigma O)^2}{N(N-1)}$$

$$SD_2{}^2 = \frac{29(1026) - (148)^2}{29(29 - 1)}$$

$$SD_2{}^2 = \frac{29754 - 21904}{812}$$

$$SD_2{}^2 = 9.668$$

$$SD_2 = \sqrt{9.668}$$

$$SD_2 = 3.109$$

$$t_c = \frac{D_{cg} \times \sqrt{N}}{SD_2}$$

APPENDIX P (Continuation)

$$t_c = \frac{5.103 \times \sqrt{29}}{3.109}$$

$$t_c = 8.839$$

Walpole, page 481, Table A.5 at $\alpha = 0.05$ with $df = 28$:

$$t_{tabular} = 2.048 \quad \text{(two - tailed)}$$

APPENDIX Q

Computation of Means and t-value :

$$\bar{D} = \frac{93}{29} = 3.207$$

$$SD^2 = \frac{N(\Sigma O^2) - (\Sigma O)^2}{N(N-1)}$$

$$SD_1^2 = \frac{29(2319) - (241)^2}{29(29-1)} \qquad SD_2^2 = \frac{29(1026) - (148)^2}{29(29-1)}$$

$$SD_1^2 = \frac{67251 - 58081}{812} \qquad SD_2^2 = \frac{29754 - 21904}{812}$$

$$SD_1^2 = 11.293 \qquad SD_2^2 = 9.668$$

$$SD_1 = \sqrt{11.293} \qquad SD_2 = \sqrt{9.668}$$

$$SD_1 = 3.360 \qquad SD_2 = 3.109$$

$$t_c = \frac{D_{eg} - D_{cg}}{\sqrt{\frac{(N_1-1)SD_1^2 + (N_2-1)SD_2^2}{N_1+N_2-2}\left(1/N_1 + 1/N_2\right)}}$$

$$t_c = \frac{8.310 - 5.103}{\sqrt{\frac{(29-1)(11.293) + (29-1)(9.668)}{29 + 29 - 2}\left(\frac{1}{29} + \frac{1}{29}\right)}}$$

APPENDIX Q (Continuation)

$$t_c = \frac{3.207}{\sqrt{\frac{316.109 + 270.645}{812}(0.069)}}$$

$$t_c = \frac{3.207}{\sqrt{10.478\ (0.069)}}$$

$$t_c = \frac{3.207}{0.850}$$

$$t_c = 3.773$$

Walpole, page 481, Table A.5, at $\alpha = 0.05$ with df = 56

$t_{tabular}$ = 1.960 (two -tailed)

APPENDIX R

SAMPAGUITA (EXPERIMENTAL CLASS)

MORNING SESSION

ORIGINAL			REVISED	
TIME	SUBJECT	TEACHER	SUBJECT	TEACHER
7:00 - 7:40	PEHM III*	MRS. M. REPOSO	ENGLISH IIII*	MRS. I. CUNA
7:40 - 8:20	MATH III	MRS. G. ESPAÑO.	MATH III	MRS. G. ESPAÑO
8:20 - 9:00	SOCIAL STUDIES III	MRS. C. DABUET	SOCIAL STUDIES III	MRS. C. DABUET
9:00 - 10:00	CHEMISTRY	ENGR. E. MALINDOG, JR.	CHEMISTRY	ENGR. E. MALINDOG, JR.

AFTERNOON SESSION

ORIGINAL			REVISED	
TIME	SUBJECT	TEACHER	SUBJECT	TEACHER
1:00 - 1:40	VALUES III	MR. V. VILLEGAS	VALUES III	MR. V. VILLEGAS
1:40 - 2:20	ENGLISH III*	MRS. I. CUNA	PEHM III*	MRS. M. REPOSO
2:20 - 3:00	FILIPINO III	MRS. S. CORDUNA	FILIPINO III	MRS. S. CORDUNA
3:00 - 5:00	SHOP III		SHOP III	
	AUTOMOTIVE TECH.	MR. L. CREBELLO	AUTOMOTIVE TECHNOLOGY	MR. L. CREBELLO
	FOODS TECHNOLOGY	MRS. M. CONDE	FOODS TECHNOLOGY	MRS. M. CONDE

ORCHIDS (CONTROL CLASS)

ORIGINAL SCHEDULE

MORNING SESSION			AFTERNOON SESSION		
TIME	SUBJECT	TEACHER	TIME	SUBJECT	TEACHER
7:00 - 7:40	MATH III	MRS. G. ESPAÑO	1:00 - 3:00	SHOP III	
				WOOD WORKING	MR. G. DAGUMAN
7:40 - 8:00	VACANT			FOODS TECHNOLOGY	MRS. M. CONDE
8:00 - 9:00	CHEMISTRY	ENGR. E. MALINDOG, JR.	3:00 - 3:40	FILIPINO III	MRS. S. CORDUNA
9:00 - 9:40	ENGLISH III	MRS. I. CUNA	3:40 - 4:20	VALUES III	MR. V. VILLEGS
9:40 - 10:20	SOCIAL STUDIES	MRS. C. DABUET	4:20 - 5:00	PHEM III	MRS. M. REPOSO

APPENDIX S

SAMPAGUITA (EXPERIMENTAL CLASS)

No. of Students : 47

No. of Samples : 29

Chemistry Schedule : 9:00 - 10:00 A.M.

Original Students

(1.) Araya, Japar
2. Cananua, Expedito
(3.) Chua, Peter
(4.) Farfaran, Mariano Jr.
5. Mabansag, Albino
6. Mabulac, Melvin
7. Orale, Reynold
(8.) Pabunan, Leonardo
9. Picson, Gary
(10.) Sipin, Dominador
11. Yboa, Michael Angelo
12. Arcales, Emelinda
(13.) Bael, Virginia
14. Basal, Emeliana
(15.) Cabanganan, Geline
16. Daca, Anna Lou
(17.) Diocton, Clarifil
18. Gonzales, Maryjane
(19.) Marquez, Rica
(20.) Oñez, Lucille
21. Pagli-awan, Gwen Ferlyn
22. Sison, Renee
23. Tan, Myra
(24.) Villanueva, Mae Smile
(25.) Ventures, Mary Jean

From Orchids

(26.) Aragon, Pablo
27. Bautista, Erwin
28. Corrales, Rodolfo
(29.) Lampitoc, Christopher
30. Lauzon, Randy
(31.) Nacionales, Reynour
32. Piczon, Leandro III
(33.) Uy, Florencio
(34.) Valles, Paul
(35.) Baco, Cristina
(36.) Bartolome, Barbara
(37.) Borja, Ruth
(38.) Daganzo, Haileen
(39.) Deang, Antoniette
(40.) Gonzales, Geraldine
41. Molito, Ahmie
(42.) Nabablit, Domenda
(43.) Parambita, Jocelyn
(44.) Radaza, Anna Lou
45. Rama, Rutchelle
(46.) Terado, Janice
(47.) Villarin, Charlene

Legend : (no.) - actual samples

APPENDIX S (Continuation)

ORCHIDS (CONTROL CLASS)

No. of Students : 47

No. of Samples : 29

Chemistry Schedule : 8:00 – 9:00 A.M.

Original Students	From Sampaquita
1. De los Reyes, Geoffrey	25. Añonuevo, Lino
(2.) Gayda, Gibson	26. Carilla, Bryan
3. Grefaldeo, Alvin	(27.) Correche, Sonny
(4.) Labine, Manuel Jr.	(28.) Cugtas, Nelson
(5.) Lamograr, Dino	29. Daco-ag, Melvin
6. Mabansag, Eric	30. Jaboli, Samuel Jr.
7. Noroña, Shamel	31. Matilla, Anthon Niño
8. Ramos, Conrad	(32.) Roque, Alvin
(9.) Ramos, Lisandro	(33.) Sapitin, Silver
(10.) Rodriguez, Rodrigue	(34.) Topacio, Ronald
(11.) Bacarro, Haidee	35. Cinco, Rio
(12.) Bao, Cherish Joy	(36.) Cugtas, Rona Flor
(13.) Baston, Jennifer	(37.) Daguman, Ma. Dolores
14. Daganzo, Zenaida	38. Gabiana, Jasmenia
(15.) Escareal, Dyesebel	(39.) Gacelos, Rosario
(16.) Jaboli, Joan	(40.) Josol, Sharon
(17.) Mabansag, May Ritchell	(41.) Llana, Ma. Sylvia
18. Papauran, Rowena	(42.) Mencias, Melinda
19. Quebec, Nevada	(43.) Ramirez, Sharon
20. Salcedo, Mary Joy	44. Rayandayan, Jesebel
(21.) Sultan, Keath Francis	(45.) Ruedas, Rhonalie
22. Tan, Madonna	(46.) Oliva, Jill
(23.) Tapia, Rosita Abegail	(47.) Ortiz, Daisy
(24.) Villa, Marianne	

Legend : (no.) – actual samples

C U R R I C U L U M   V I T A E

PERSONAL DATA

NAME	: ESTEBAN A. MALINDOG, JR.
ADDRESS	: Brgy. San Pablo, Catbalogan, Samar
DATE OF BIRTH	: October 7, 1957
PLACE OF BIRTH	: Wright, Samar
CIVIL STATUS	: Married
WIFE	: Juliana Moldez Malindog
CHILDREN	: Jules Ayla, Danil Ayn, Magan Ali

EDUCATIONAL BACKGROUND

Elementary	Catbalogan III Elementary School Catbalogan, Samar 1970
Secondary	Samar School of Arts and Trades Catbalogan, Samar 1974
College	Cebu Institute of Technology Cebu City 1979 B.S. Chemical Engineering
Graduate	De La Salle University Taft Avenue, Manila 1981 – 1982 M.S. Chemistry (22 units)
	Samar State Polytechnic College Catbalogan, Samar 1991 – 1993 MAT Chemistry

LICENSURE EXAMINATION / ELIGIBILITIES

Chemical Engineers' Board Examination, Manila, 1979, Passed

Career Service Professional Examination, Catbalogan, Samar, 1987, Passed

Professional Board Examination for Teachers, Catbalogan, Samar, 1992, Passed

SCHOLARSHIP GRANT

Graduate School of Education Scholarship Grantee, De La Salle University, Taft Avenue, Manila, 1982

WORK EXPERIENCE

Laboratory Analyst	Marcelo Steel Corporation Punta, Sta. Ana, Manila 1980 - 1982
Part-time Instructor	College of Engineering Technological Institute of the Philippines Quiapo, Manila 1980 - 1982
Part-time Lecturer	Chemistry Department De La Salle University Taft Avenue, Manila 1982
Laboratory Supervisor . . .	Nonoc Mining and Ind'l. Corporation - Surigao Nickel Refinery Nonoc Island, Surigao City 1982 - Present (on indefinite shutdown after the Feb. 1986 EDSA Revolution)
Chemist	Oman Mining Company Sultanate of Oman Jan. - Mar. 1990 (on leave at SSPC)
Instructor 1	Samar State Polytechnic College Catbalogan, Samar 1987 - Present

TRAININGS, SEMINARS AND WORKSHOPS

Fire Prevention and Control Seminar, Philnico Mining and Industrial Corporation, Surigao City, April 16 - 21, 1990

Computer Operation Specializing in Wordstar, Lotus 123, and Dbase III+, Samar State Polytechnic College, Catbalogan, Samar, 54 hours, July - October, 1990

Teachers Industry Attachment Program for Related Tool/ Subject Teachers, Institute of Vocational Training and Development, National Manpower and Youth Council, Cebu City, October 19 - 26, 1990

SEDP Mass Training of Secondary Schools Teachers in Science and Technology III, DECS, Catbalogan, Samar, April 7 - 21, 1991

KAPNAYAN '91, UPLB Chemical Society, UP at Los Baños, Laguna, November 12 - 16, 1991

11th Regional Science and Technology Camp, Dolores, E. Samar, February 3-7, 1992

Seminar-Workshop in Interactive Exhibits Approach in Teaching Science, DOST-DECS, Tacloban City, February 20-22, 1992

LIST OF TABLES

Tables

LIST OF FIGURES

Figure