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An Investigation into the Effects of Problem Solving Method in Teaching Grade Ten Chemistry

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Abstract

This research is to investigate the effects of problem solving method in Grade Ten students' learning in chemistry subject. An experimental research was used with (160) Grade Ten students from two types of combinations, science combination and arts-science combination at No.3. Basic Education High School. The results were analysed by using the independent samples *t*-test. There was a significant difference between the experimental group and control group in both combinations of the students. Results showed that the mean score of the experimental group is higher than that of the control group. Examination of means and *t*-test ($t = 2.398$, df = 78, MD = 0.25, $P < 0.05$) indicated that there was a significant difference between the two groups. Thus, it can be said that the scores obtained from the application of the problem solving method are higher than those from the traditional method of teaching. Problem solving in any area is a very complex process. It involved an understanding of the language in which the problem is stated, the interpretation of what is given in the problem and what is sought, and understanding of the science concepts involved in the solution. Students can learn facts and concepts quickly by their own efforts.

Key words: problem solving method, science concept, student achievement.

Introduction

Life is full of problems and man is able to solve them successfully only if he has proper experience and the art of overcoming difficulties in life. In every-day life, every person confronts with difficulties and solves a lot of problems. Thus, the interest for problem solving in the learning process is inevitably developed in society.

The main aim of education is all round holistic development of the students. In the pursuit of this goal, teachers play a significant role. Teaching has always been considered to be essential for preservation and development of all intellectual life. Teachers are considered to be the major transmitter of accumulated knowledge and experience of human race from one generation to the next. Thus, teachers determine to a great extent the character, capacity and

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destination of a nation. Well-qualified teachers can choose the most appropriate teaching method to meet the needs of his individual students.

In problem solving method a systematic and orderly process is adopted. The process begins with the difficulty or problem. The student is then made to think out all the possible situations of the confronted problem on the basis of what the student knows.

Aim of the Study

The major aim of this study is to investigate the effects of problem solving method in teaching Grade Ten chemistry.

Research Hypotheses

(1)There is a significant difference in the achievement of learning chemistry concepts between Grade Ten students who receive instruction through the steps of problem solving method and those who receive traditional instruction.

(2) If there is asignificance of the three levels of cognitive domain, on what level questions do they differ such as knowledge, comprehension and application?

Definition of the Key Terms

Problem solving is the result of the application of knowledge and procedure to a problem situation and proposes four stages; (a) definition of the problem (b) selection of appropriate information (c) combining the separate pieces of information and (d) evaluation of the solution (Waddington, 1992).

Traditional method includes lecture method and demonstration method.

Lecture method

The expository lecture is the traditional lecture that treats a single question or problem, typically with a hierarchical organization of major and minor points. This approach allows teachers to present broad concepts and factual information efficiently but runs the risk of reducing students to passive spectators (Davis, 1993).

A demonstration has been defined as the process of showing something to another person or group (Trowbridge &Bybee, 1990).

Review of Related Literature

Problem solving is the ability to combine previously learned principles, procedures, declarative knowledge, and cognitive strategies in a unique way within a domain of content to solve previously unencountered problems. This activity yields new learning as learners are more able to respond to problems of a similar class in the future. This type of problem solving is often described as "domain-specific" or "semantically rich" problem solving because it emphasizes learning to utilize principles in a specific content area (Smith and Ragan, 1999).

The requirements of problem solving are (1) a situation exist where in a goal is to be achieved and (2) learners are asked to be considered how they would attain the goal (Cruickshank, 1999). There are two different types of problems. One type, which is often encountered when studying mathematics or science, is a "well-structured" problem that 'can be solved by recalling and applying a mathematical or scientific procedure (Cruickshank, 1999). Second type of problem is "ill-structured". It occurs more often in daily living, and comes up when studying people oriented subjects like psychology or education. With these problems, no specific, simple procedure exists that can be applied to obtain a finite solution. Teachers face ill-structured problems when they expect students to achieve or to behave a certain way and they do not.

The problem-solving decision-making sequence begins by helping students identify a problem. To help students recognize a problem, use the sequence. Use children's **Experiences** to make them aware of **Discrepancies,** which should lead them to raise **Questions**and the questions, will help them define the problem.

Once students have identified a problem by constructing a precise question, they can proceed with problem solving using the model. The model is organized into a sequence of steps with specific tasks for each step. Once students learn the tasks for each step, they will be able to use them, either consciously or automatically, to solve problems.

1. **Planning:** Planning is the initial step in the model for problem solving. In the planning step, a problem solver uses a sequence of focus questions to construct and organize the precise questions. Students should be taught that when they construct a plan, they must always assume that the plan may have to be revised in light of new information. Good planning is an essential component of effective problem solving.

2. **Obtaining data:** The problem solver gathers data that may have an impact on the solution to the problem. Quantitative as well as qualitative data may be needed.

3. **Organizing data:** The problem solver establishes some pattern of order or form with the data obtained.

4. **Analyzing data:** This step requires the problem solver to seek apparent patterns and relationships in the data to recognize characteristics that suggest cause and effect and to state inferences.

5. **Generalizing and/or synthesizing from data:** Here the problem solver creates conclusions or alternative choices (potential solutions to the problem) to use in the next step, decision making.

6. **Decision making:** In the decision-making step, a problem solver uses a sequence of focus questions to arrive at a decision.

At each step in the problem-solving sequence, students engage in the following tasks.

1 **Questions:** The problem solver should construct precise questions that will help clarify the problem and the steps that must be taken to solve it. Students should view each precise question as a little piece of the problem to be solved.

2. **Skills:** The problem solver can get answers to precise questions by applying appropriate skills or processes. Students should be taught to select and apply the best skills or processes for the specific task implied by the questions.

3. **Products:** The problem solver creates a tangible product by applying the appropriate skills or processes to the specific task. For example, by applying the skill of recording data, the problem solver may create the tangible product of a chart or graph. Tangible products contain answers to questions (Carin&Sund, 1989).

Theoretical Consideration

A basic assumption of constructivism is that people are active learners and must construct knowledge for themselves. To understand material well, learners must discover the basic principles for themselves. Constructivists differ in the extent to which they ascribe this function entirely to learners. Some believe that mental structures come to reflect reality, whereas others (radical constructivists) believe that the individual's mental world is the only reality. Constructivists also differ in how much they ascribe the construction of knowledge to social interactions with teachers, peers, parents, and others.

Constructivism also has influenced educational thinking about curriculum and instruction. It underlies the emphasis on the integrated curriculum in which students study a topic from multiple perspectives. Constructivist ideas also are found in many professional standards and affect design of curriculum and instruction, such as the learner-centered principles (Schunk, 2004).

Role of the Teacher

Whatever the activity, it is important to keep in mind the need to teach the skills of group functioning. The process of guiding student growth in participatory experiences is a major responsibility of the teacher. The teacher must come to know each student well, must be constantly aware that participatory skills must be learned, and must be perceptive in guiding group activities.

The teacher's role is significant at every stage of the process. It begins with a commitment to the value of and need for group instructional procedures. The attitude of teacher is important. The effective teacher knows that skills of group work must be taught, and so builds upon students' present levels of experience and skill. The effective teacher understands the difference between the kind of verbal noise that signifies purposeful group activity and the type of noisy interaction that suggests group disintegration. The effective teacher is aware of the many decisions involve in the group techniques and has the data and insights upon which to make such decisions.

In this role, the teacher must raise problems, issues, and questions designed to catch the pupils' interest, start them thinking, and encourage them to investigate. While the pupils are investigating, the teacher should guide their search by helping them clarify their problems, map out their procedures, order their thinking, come to logical conclusions, and, finally, test and apply their conclusions.

In addition, to stimulate independent resource thinking the teacher should also; check the pupils' data-gathering techniques; ask thoughtful questions; ask for interpretations, explanations, and hypotheses; question the interpretations, explanations, and hypotheses at which the pupil arrives; ask pupils what their data and information imply; ask pupils to check their thinking and their logic; confront pupils with problems, contradictions, fallacies, implications, value assumptions, value conflicts, and other factors that may call for a reassessment of their thinking and positions (Callahan & Clark, 1988).

Method and Procedures

A quantitative research method was used in this study. A true experimental research was used to compare students' chemistry achievement between two groups: Experimental group and Control group.

Sample

The sample for the experimental design was randomly selected at No.3, B.E.H.S, Tamwe in Yangon Region. Population and sample size aregiven in Table 1.

Table 1.Population and Sample Size in 2012-2013 Academic Year

Sr.No	School	Combination	Population	Sample
1.	No.3, B.E.H.S, Tamwe	Science	247	80
2.	No.3, B.E.H.S, Tamwe	Arts - Science	147	80

Experimental Design

The design used in this study was the pretest-posttest control group design.

Instruments

(a) Pretest

Pretest was used to see if the groups were essentially the same on the dependent variable at the start of the study. Pretest included (25) items. Test items were based on Chapter (6), Chapter (7) and Chapter (8) from Grade Ten Chemistry Textbook.

(b) Posttest

Both groups were taken at the end of the study. Posttest scores were compared to determine the effect of the treatment. Posttest involved (23) items. Test items were based on Chapter (10) from Grade Ten Chemistry Textbook. Test items includes a variety of items, namely, short questions, true/false questions, multiple choices and matching which are all to test students' achievements. A table of specifications is presented as follows.

Table 2. TheTable of Specifications for Grade Ten Chemistry Question Items

No	Test Area	Knowledge Level	Comprehension Level	Application Level	Total Number of Items
1.	Pretest	48%	36%	16%	100%
2.	Posttest	34.78%	30.44%	34.78%	100%

(c)Validation of Test Items and Conducting Pilot Testing

Two expert teachers in the field were asked to examine pretest items and posttest items and rate each on their representativeness, relevance and clarity. Pilot testingwas conducted with (20) Grade Ten Students. U.L Index method (Stocklein, 1957 cited in Sevilla, et. al, 1992) is appropriate to determine the test item whether it is suitable or not.

$$D_f = \frac{P_u + P_l}{2}$$

Where D_f = Difficulty index

P_u = Proportion of the Upper 27 percent group who got the item right

P_l = Proportion of the lower 27 percent group who got the item right

Moreover, it is computed discrimination index of each item using the formula.

$$D_s = P_u - P_l$$

D_s = Discrimination index

Items with difficulty indices within 0.2 to 0.8 and discrimination indices within 0.3 to 0.8 are retained.

(d) Lesson Plan

1. Teacher's name - DawMyintMyint Aye
2. Grade - Grade Ten
3. Number of pupils - 40
4. Subject - Chemistry

5.	Date	-	2.10.12
6.	Period	-	45 minutes
7.	Learning Topic	-	Chapter 10, Oxygen and its Compounds (Properties of Hydrogen Peroxide)
8.	Previous knowledge	-	Pupils have to acquire the conceptual knowledge concerning with 1. Laboratory preparation of oxygen from hydrogen peroxide 2. Properties of oxygen 3. Action with metals and non-metals
9.	Learning Objectives	-	(a) General Objective Students will be able to apply scientific facts and thinking to solve problems (b) Specific Objectives (1) To investigate the oxidation of hydrogen peroxide (2) To find out the reaction of hydrogen peroxide with some compounds
10.	Required Apparatus and Chemicals	-	Hydrogen peroxide solution
		-	Potassium iodide solution
		-	Sulphuric acid
		-	Lead (IV) oxide
		-	Potassium permanganate solution
		-	Glass rod, Test tube, Record paper

11. Introduction - A teacher introduces the combination of hydrogen and oxygen that are formed two different hydrides, namely, water and hydrogen peroxide

12. Problem Solving Activities -

(1) Identifying the problem Pupils have to do the experiments for the chemical properties of hydrogen peroxide. They are divided into (3) groups. The first group has to take potassium iodide solution, sulphuric acid and hydrogen peroxide. The second group finds to do the reaction of lead (IV) oxide and hydrogen peroxide. The third group is to investigate potassium permanganate, sulphuric acid and hydrogen peroxide solution.

(2) Observing: Pupils have to observe the physical state of the chemicals.

(3) Ordering: The teacher has to examine the given solutions, compounds and apparatus for each group.

(4) Carrying out experiments Each group finds the results of the reaction and presents the specific findings to the teacher.

(5) Analyzing data: After doing experiments each group reports the final results and continues the discussions with the teacher.

(6) Generalizing: According to the guidance of the teacher, pupils realize the possible answers of the reactions. The teacher has to provide a brief wind-up by summarizing all the key facts.

(7) Evaluating: Finally, the teacher has to examine individually the chemical properties of hydrogen peroxide with drawing concept map and written test.

Table 3.The Result of Problem Solving Activities

Group	Carrying out experiments	Analyzing data	Generalizing
1.	Hydrogen peroxide reacts with acidified potassium iodide solution.	Iodine is produced. Brown colour gas is evolved.	$2KI+H_2SO_4+H_2O_2 \rightarrow K_2SO_4+I_2+2H_2O$ Potassium iodide + Sulphuric acid + Hydrogen peroxide → Potassium sulphate+Iodine+Water

Group	Carrying out experiments	Analyzing data	Generalizing
2.	Hydrogen peroxide reacts with lead (IV) oxide	Yellow precipitate is observed. Lead (IV) oxide is reduced by Hydrogen peroxide to Lead (II) oxide	$PbO_2+H_2O_2 \rightarrow PbO+H_2O+O_2$ Lead (IV) oxide + Hydrogen peroxide → Lead (II) oxide + Water + Oxygen
3.	Hydrogen peroxide reacts with acidic potassium permanganate	White precipitate is found. Violet potassium permanganate is bleached to White manganese (II) sulphate.	$2KMnO_4+3H_2SO_4+5H_2O_2 \rightarrow 2MnSO_4+K_2SO_4+8H_2O+2O_2$ Potassium permanganate + Sulphuric acid + Hydrogen peroxide → Manganese (II) sulphate + Potassium sulphate + Water + Oxygen

Concept Map

A concept map presents the relationships among a set of connected concepts and ideas. It is a tangible way to display how students' mind "sees" a particular topic. By constructing a concept map, students reflect on what they know and what they don't know. In a Concept Map, the concepts, usually represented by single words enclosed in a rectangle box, are connected to other concept boxes by arrows. A word or brief phrase, written by the arrow, defines the relationship between the connected concepts(White, 2011).

Constructing a Concept Map

(1) Brainstorming Phase:from the memory, identify facts, terms, and ideas that students think are in anyway associated with the topic. Make a list of these items and print them neatly in very brief form, i.e.a single word or short phrase. This is a brain-storming process, so write down everything that anybody in students' thinking is important and avoid discussing how important the item is. Don't worry about redundancy, relative importance, or relationships at this point. The objective here is to generate the largest possible list students can.

(2) Organizing Phase: Spread out students' concepts on a flat surface so that all can be read easily and, together, create groups and sub-groups of related items. Try to group items to emphasize hierarchies. Identify terms that represent those higher categories and add them. Feel free to rearrange items and introduce new items that students omitted initially. Note that some concepts will fall into multiple groupings. This will become important later.

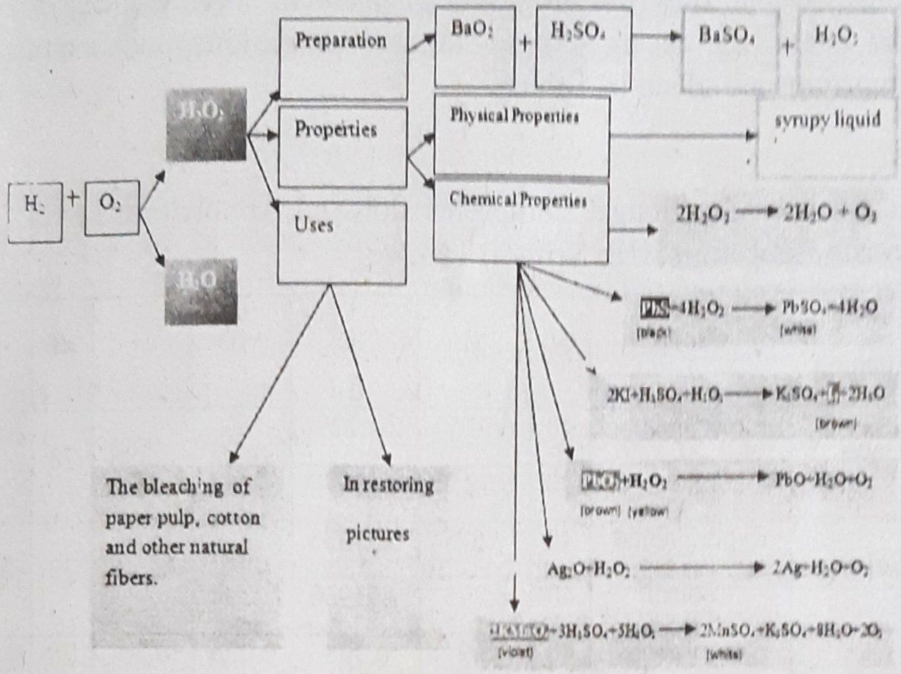
(3) Layout Phase: On a large sheet of paper, try to come up with an arrangement (layout) that best represents students' collective understanding of the interrelationships can connect among groupings. Feel free to rearrange things at any time during this phase. Use a consistent hierarchy in which the most important concepts are in the center or at the top. Within sub-grouping, place closely related items near to each other. Think in terms of connecting the items in a simple sentence that shows the relationship between them.

(4) Linking Phase: Use lines with arrows to connect and show the relationship between connected items. Write a word or short phrase by each arrow to specify the relationship. Many arrows can originate or terminate on particularly important concepts.

(5) Finalizing the Concept Map: After students have agreed on an arrangement of items that coveys their understanding, they need to convert the concept map into a permanent form that others can view and discuss. Be creative in a constructive way through the use of colors, fonts, shapes, border thickness, etc. to communicate their understanding. In reviewing the concept map, the following attributes should be considered-

- Accuracy and Thoroughness. Are the concepts and relationships correct? Are important concepts missing? Are any misconceptions apparent?
- Organization. Was the concept map laid out in a way that higher order relationships are apparent and easy to follow? Does it have a little?
- Appearance. Was the assignment done with care showing attention to details such as spelling and penmanship? Is it neat and orderly or is it chaotic and messy?
- Creativity. Are there unusual elements that aid communication or stimulate interest without being distracting?

The Concept Map of Hydrogen peroxide



Results

A study was conducted to test the effects of problem solving method for two periods of two weeks (from 1st October to 12th October) in No.3, B.E.H.S, Tamwe. The mean scores of the pretest arepresented in Table 4.

Table 4. Mean Scores of Pretest

Subject Combination	Group	N	Mean
Science	Experimental	40	6.750
	Control	40	6.750
Arts-Science	Experimental	40	6.665
	Control	40	6.665

The findings for pretest showed no significant difference in prior knowledge related to the dependent variable.

Firstly, students based on pretest were randomly assigned two groups; experimental group and control group. On 1st October, 2012, the lesson (Oxygen and its Compounds, Chapter 10) was taught to two groups such as science combination and arts-science combination. The data from the posttest were recorded systematically. Then, the data were analyzed using the independent samples *t*-test to describe the effect of problem solving method. The results of the *t*-test, the mean scores, standard deviations and mean differences of both groups are given in Table5.

Table 5 Mean, and *t*-test at Knowledge, Comprehension and Application Level in No.3, Basic Education High School, Tamwe

Level	Subject Combination	Group	N	M	SD	MD	*t*	df	Sig(2 tailed)
Knowledge	Science	Experimental	40	6.9750	0.4229	0.25	2.398	78	0.019*
		Control	40	6.7250	0.50574				
	Arts-Science	Experimental	40	7.675	0.57233	0.9	6.748	78	0.000***
		Control	40	6.775	0.61966				
Comprehen-sion	Science	Experimental	40	6.9	0.308	0.025	0.35	78	0.728
		Control	40	6.875	0.3349				
	Arts-Science	Experimental	40	6.95	0.221	0.475	5.44	78	0.000***
		Control	40	6.475	0.506				
Application	Science	Experimental	40	8.05	0.714	0.2	1.234	78	0.221
		Control	40	7.85	0.736				
	Arts-Science	Experimental	40	8.125	0.723	0.975	5.367	78	0.000***
		Control	40	7.15	0.893				

Note: $p^*<0.05, p^{***}<0.001$

Results show that the mean score of the experimental group on knowledge level question is higher than that of the control group. Examination of means and *t*-test (t = 2.398, df = 78, MD = 0.25, $p<$ 0.05) indicated that there was a significant difference between the two groups. Thus, it can be said that the scores obtained from the application of the problem solving method are higher than those from the traditional method of teaching for science students.

Results also indicated that the mean score of the experimental group on knowledge level question is higher than that of the control group. The*t*-value proved that there was a significant difference between the two groups (t =

6.748, df = 78, MD = 0.9, $p < 0.001$) (see table 5). Thus, it can be said that the average scores of the students for the application of problem solving method are higher than those obtained by using the traditional method for arts-science students.

The result showed that the mean score of the experimental group on the comprehension level question is higher than that of the control group. Examination of means and t-test ($t = 0.35$, df = 78, MD = 0.025) indicated that there was no significant difference between the two groups at science students.

At comprehension level, the result showed that the mean score of the experimental group is higher than the control group. The t-value proved that there was a significant difference between the two groups ($t = 5.44$, df = 78, MD = 0.475, $p < 0.001$) (see table 5). Thus, it can be said that the average scores of the students for the application of problem solving method are higher than those obtained by using the traditional method for arts-science students.

At application level, result indicated that the mean score of experimental group is higher than that of the control group. Examination of means and t-test ($t = 1.234$, df = 78, MD = 0.2) showed that there was no significant difference between the two groups. Thus it can be said that the scores obtained from the application of the problem solving method is lower than those from the traditional method of teaching in accordance with the application level questions at the science students.

Result described that the mean score of the experimental group is higher than the control group. The t-value proved that there was a significant difference between the two groups ($t = 5.367$, df = 78, MD = 0.975, $p < 0.001$) (see table 5). Thus, it can be said that the average score of the students for the application of problem solving method are higher than those obtained by using the traditional method.

It can be concluded that there was a significant difference in problem solving method from traditional method in teaching chemistry on the knowledge, comprehension and application levels question for arts-science students.

Discussion and Conclusion

Discussion

Problem solving in any area is a very complex process. It involves an understanding of the language in which the problem is stated, the interpretation of what is given in the problem and what is sought, and understanding of the science concepts involved in the solution, and the ability to perform mathematical operations if these are involved in the problem. It is found that many students have misunderstood the meaning of common words such as oxidation and oxidizing agent. Slight changes in the way a problem is worded may make a difference in whether a student is able to solve it correctly. Although teachers would like students to solve problems in whatever way they are framed they must be cognizant of the fact that these subtle changes will make a difference in students' success in solving problems. From several research studies on problem solving in chemistry, it is clear that the major reason why students are unable to solve problems is that they do not understand the concepts on which the problems are based.

However, the world increasingly needs more students highly trained in science, mathematics, and engineering. Students should frequently learn as much from many lab activities as teachers expect. Teachers must make the students to increase interest in chemistry teaching. Students must pay the most attention to things that are relevant to their lives. In schools, the teachers tend to emphasize teaching pupils what to think rather than how to think. Recently, the teaching of thinking has become a national issue. The teaching of thinking is an important issue. Well-developed thinking skills are useful in almost every life situation. The teacher should teach how chemistry influences our society, or better living through chemistry. Teaching method will be chosen to focus more on what chemistry has to offer for next generation. Effective problem solvers are confident in their use of knowledge and processes. They are willing to take on challenge and persevere in their questions to make sense of a situation and solve a problem. They are curious, seek patterns and connections and are reflective in their thinking. Problem solving habits of mind prepare individuals for real problems, situations requiring effort and thought, lacking an immediately obvious strategy or solution. To develop problem solving habits of mind, students need experiences working with situations that they "problematize with the goal of understanding and developing solution methods that making sense for them." Teachers' view of problem solving is that multiple ways exist to solve a problem and that problem solving is a process of exploring, developing methods, discussion method, and generalizing results. Problem solving method requires independent efforts on the part of students to find out the solution of the problems. It demands from them to be trained in the scientific procedure, scientific thinking and problem solving.

Conclusion

Methods are used by teachers to create learning environments and to specify the nature of the activity. Teachers carefully choose tasks that require students to engage in thinking and problem solving. Then, teachers draw out students' thinking through their questioning, and finally encourage reflection and sense making. Problem solving method is in fact necessary for teachers and students at all stages.

One of the main objectives of any problem solving methods will be to support the expression of the creative and critical thinking for the person who has the problem as well as all the participants. Recent researches have shown that chemistry plays an important role in developing solutions to environmental problems like conservation, energy, climate change and nuclear issues. Strengthening chemistry through research and development is necessary to allow us maintaining a comfortable life in harmony with the environment and nature. It is important that students learn chemistry, and knows how it can bring better in our health and environment when used properly.

Students can share their ideas and thinking, and finally they have an opportunity to reflect on what has been shared, explore whether they can create general statements or formulas, and generally construct their own meaning of the information. To improve the teaching of science, teachers have to explore various aspects of teaching school chemistry worldwide.

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