The Use of Predict-Observe-Explain-Explore (POEE) as a New Teaching Strategy in General Chemistry-Laboratory

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ABSTRACT

This paper describes the fruitful interaction between educational research on discovery learning using Predict-Observe-Explain-Explore (POEE). The researcher used POEE and expository approach to know the level of achievement, attitude, and perceptions towards General Chemistry (laboratory) The study showed that the experimental group had a mean score of 25.83 in the Chemistry pretest achievement, which is higher by 3.00 than the score of the control group with 22.83. The difference had a computed t-value of 1.80, which was not significant at the 0.05 level for 10 degrees of freedom. The experimental group got a higher score in the posttest with a mean score of 33.83 while the control group obtained 25.50. The computed t-value of 3.31 is very significant for 10 degrees of freedom. In terms of attitude towards chemistry, the mean difference of 12.00 in the posttest scores is significant in favor of the experimental group, which implies that the experimental group favored Chemistry as an enjoyable subject. The relative effectiveness of the different POEE strategy in improving the students' achievement in Chemistry lies on the *Discovery learning theo*ry. The strategy focused on the inductive reasoning of the students in learning and promoting new material.

Keywords: Predict-Observe-Explain-Explore (POEE), Discovery learning theory, General chemistry (laboratory), experimental and control groups

INTRODUCTION

There are many events that surprise students and teachers as well. It is expected that one thing will happen, and something else happens instead. These events are called discrepant events. Psychological constructivists say that these events create "*cognitive dissonance*". When cognitive dissonance was created for our students, they should be ready to learn. An example of a discrepant event is that most students expect that vinegar is less dense that vegetable oil. They will pour vegetable oil and vinegar together, and record that the vegetable oil floated on the vinegar. But, the next day, the teacher can ask them what happened, they will forget it, and tell that the vinegar floated on the vegetable oil, and they will give you their theory: the vinegar is less dense, therefore it floated on the vegetable oil. Someone once said of this phenomenon: "*To see it to believe*." As a result of these observations, the predict-observe-explain teaching strategy was developed. Richard Gunstone (1989) of Australia has done a lot of research on discrepant events and

on the use of this teaching strategy to bring about conceptual change in children.
Teaching can generally be defined as content-centered, teacher-centered or student-centered. The content-centered teacher relies on facts and principles and the style of teaching is done by focusing on covering the topics, mastery of the breadth and depth of material or content, and rather less concern for the students. For such teachers, improvement of teaching would be making better lecture notes, becoming better organized and making fewer errors on content. The teacher-centered style means the instructor role is to teach the student's role to learn. The teacher is the authority, which informs, instructs, trains and evaluates. The teacher has to the expert in the subject matter and attributes failure to learn as the fault of the students, their laziness and ability to understand new materials, poor preparation in former classes. The student-centered professor focuses on active learning where the learners take opportunities to decide the aspect of the learning process, make their own time tables as to be able to follow a systematic plan for learning, identifies their learning goals and activities as they keep track of their own progress and takes care of their learning by reflecting on the errors and successes along the way to learning. For learning to active, students must do regular reading—for information and pleasure; they can clearly express themselves in written form and verbal form; they constantly upgrade their vocabulary; can accurately listen and take notes and are continuously challenged using their skills of thinking via problem solving, motivation, creativity and retaining playfulness and humor. Teachers need to introduce a new teaching strategy like the Predict-Observe-Explain (POE) that could be used in association with demonstrations, hands-on activities and laboratory experiments. This can help improve classroom practice by recognizing the learner's conception and account the meaning of a specific laboratory phenomena.

Predict-Observe-Explain (POE) is a teaching strategy that probes understanding by requiring students to carry out three tasks. First the students must predict the outcome of some event and must justify their prediction; then they describe what they see happen; and finally they must reconcile any conflict between prediction and observation. For this study the researchers used another variable which is "explore" giving it a new name via Predict-Observe-Explain-Explore (POEE). This study was based on the previous studies on Predict-Observe-Explain (POE). The researchers will improve and add another domain which is "explore", making a new name Predict-Observe-Explain-Explore (POEE).

Specifically, this investigation will sought to answer the following questions:

1. Is there a difference between the achievement test scores in General Chemistry (laboratory) of students taught using the POEE approach and those using the expository approach?
2. Is there a difference between the attitude test scores in General Chemistry (laboratory) of students taught using the POEE approach and those using the expository approach?
3. What were the perceptions of both groups on the use of POEE and expository approach?

This research was designed to be used by students working by groups to elicit and promote discussion about students' pre-instructional General Chemistry (laboratory) conceptions. The collaborative use of the POEE approach tasks in this program should promote a student's conceptual development in the domain of Chemistry by one or more of the following:

a. articulation and/or justification of the student's own ideas
b. reflection on the viability of other students' ideas
c. critical reflection on the student's own ideas
d. construction and/or negotiation of new ideas

The research also provides students with an opportunity to engage in 'science talk' (Lemke, 1990) and a means of developing science discourse skills (exploration, justification, negotiation, challenge etc.)

The challenging, real world contexts that will be presented in this research should stimulate students' intrinsic interest and curiosity in various mechanics related events and related principles. Hence POEE approach will create student awareness and appreciation of the integral relationship between Chemistry and students' everyday lives.

The POEE approach will elicit views of the students regarding its effectiveness and efficiency. These pre-instructional conceptions can be used to guide future learning episodes. Unlike traditional whole class, instructor-led POEE demonstrations, the program should provide an opportunity for the teacher to engage in small group discussions with students as they engage in the POEE tasks. The research should also provide a stimulus for later whole class discussions. Indeed, the instructor version of the program contains the 'correct science views' for each POEE task.

While research literature reports numerous studies dealing with students' understanding of various chemical concepts, attention has to be paid to research that promotes effective teaching strategies to minimize the misconceptions or alternate frameworks. Treagust (1987), identified studies on approaches to helping students and teachers diagnose misconceptions), Nidderer (1987), a teaching strategy based on students' alternative frameworks, theoretical concepts and examples and Rosenquit (1987) conceptual approach to teaching kinetic theory. Teachers were introduced to a teaching strategy called Predict –Observe-Explain that could be used in association with demonstrations or hands-on activities. Teachers participated in four workshops where they were shown what POE strategy is and how it could be used in a science classroom to probe student understandings of chemical concepts.

Predict-Observe-Explain (POE) is a teaching strategy that probes understanding by requiring students to carry out three tasks. First the students must predict the outcome of some event and must justify their prediction; then they describe what they see happen; and finally they must reconcile any conflict between prediction and observation. Champagne, Klopfer and Anderson (1979) were the first to design this strategy as 'demonstrate-observe-explain' to probe the thinking of first year physics students at the University of Pittsburg . Gunstone and White (1981) reworked the 'DOE' idea into 'POE'. Research studies, which used POE with secondary science children to probe children's understanding of science concepts, have been reported (White & Gunstone, 1992; Liew & Treagust, 1995, 1998; Tao & Gunstone, 1997). Palmer (1995) used the POE strategy with pre-service students.

Over the last two decades a vast body of evidence in the literature has echoed the need for science educators to understand the students' understanding of science concepts, processes and phenomena as a prerequisite to improving teaching and learning in science (Liew & Treagust, 1998). Ausubel's theory of learning takes into account what the learner already knows (Treagust, Duit & Fraser, 1996). Traditional teaching strategies generally do not recognize the learner's conceptions and often fail to take into account the meaning of specific words as used and understood by classroom teachers and students (Mansfield & Happs, 1996). To help the teachers improve their classroom practice various strategies like concept mapping, problem solving, and co-operative learning should be modeled in teacher development programmes and their effectiveness evaluated. Another technique developed by White and Gunstone (1992) has been widely used with student groups, is the Predict-Observe--Explain learning / teaching sequence. In Predict-Observe –Explain strategy students are required to predict the outcome of an event or experiment. The experiment is then performed and observations made by students are probed. When predictions and observations are inconsistent with each other the students' explanations are explored.

Studies on chemical education have been described respectively (Anderson & Renstrom, 1982; Pella & Voelker, 1967; Cosgrove & Osborne, 1981; Mitchell & Gunstone, 1984; Garnett & Treagust, 1992a; 1992b; Tan, 2000). Anderson (1986b), Ben Zvi, Elyon and Silberstein, (1987) cited in Tan (2000) found that students cannot understand the interactive nature of a chemical reaction, the concept of atoms rearranging and yet retaining their identity.

According to Watson, Prieto and Dillon in Tan (2000), students make no mention of atomic or molecular particles in their explanation of chemical reaction; "students tend to explain phenomena using macroscopic properties". Yaroch (1985), Ben-Zvi et al (1987), Hesse and Anderson (1992) cited in Tan (2000) found that students did not have a sound understanding of what chemical equations represent.

Now, the researchers will try to attempt the use of POEE as new mode of teaching General Chemistry (laboratory). This idea was taken from previous research on Predict-Observe-Explain (POE).

Theoretical Framework

According to Liew and Tregust (1995), it was Jerome Bruner in 1966, which influenced in the definition of Discovery learning, which uses a cognitive psychology as a base. Discovery learning is an approach through which students interact with their environment by exploring and manipulating objects, wrestling with questions and controversies, or performing experiments. The idea is that students are more likely to remember concepts they discover on their own. Teachers have found that discovery learning is most successful when students have prerequisite knowledge and undergo some structured experiences.

According to Lardizabal, Bustos, Bucu, and Tangco (2000), discovery approach refers to an inductive method of guiding students to discuss and organize ideas and processes by themselves. It means helping students use ideas already acquired as a means of discovering new ideas. It is a process by which the students under subtle direction go through the logical process of observation, comparison, abstraction, and generalization.

METHODOLOGY

This study is an interpretive attempt to generate understanding of chemical concepts. The distinctive characteristic of the interpretive approach is its concern with generating understanding about the significance of what is happening in particular social setting, such as a classroom, from the perspectives of the participants, namely the teacher and the students (Liew & Treagust, 1998). Data sources in this study include the students' written POEE responses, in-class discussions with students and interviews with individual students and teachers. Both quantitative and qualitative data was analyzed to answer the questions posed in this research. The research design is: as follows:

O_{e1}	X	O_{e2}
– · – · – · – · – · – · –		
O_{c1}	~X	O_{c2}

Fig. B The Research design

where:

Oe_1 -- pretest score (experimental group)
Oe_2 -- posttest score (experimental group)
Oc_1 -- pretest score (control group)
Oc_2 -- posttest score (control group)
X -- treatment using POEE
~ X – treatment using traditional method

-------------- the samples are intact groups and are not randomly selected

The teacher-researcher implemented the new teaching strategy (POEE). The study will focus on the use of POEE to enhance the students' understanding of General Chemistry (laboratory).

Instruments

The following instruments were used in collecting data:

1. *Chemistry Achievement test*

This instrument was a teacher-made examination composed of 50 items covering topics on Mixtures, Compounds, Acid-base concepts, Types of Chemical Equations, Balancing REDOX Equation, Stoichiometry, Gases, and Solutions,. It will be administered before and after the study.

2. *Chemistry Attitude scale*

This instrument is an adaptation of an existing instrument by Ibe (1985), the reliability of which is 0.92. For this study it was field tested at FEU involving 10 students and it garnered a reliability index of 0.83. This is a ten (10) item of the Likert-scale type, fifty percent positive statement and the other fifty percent will be negative. Its purpose is to measure the student's attitude in General Chemistry before and after undergoing the study. For the interpretation of the response in each statement, the following scores was used:

Mean Range	Verbal interpretation
4.21-5.00	Strongly agree
3.41-4.20	Agree
2.61-3.40	Not sure

1.81-2.60	Disagree
1.00-1.80	Strongly disagree

3. *Perception Towards POEE Approach*

This instrument was adapted and edited from Pandey (1991), it consist of five (5) questions in which the students answered the following questions such as:

a. What can you say about POEE approach?
b. Did you have a hard time in doing the different POEE activities?
c. What were the reactions of your group members in doing POEE?
d. Are you in favor of using POEE activities in teaching Chemistry?

4. *POEE Sheet*

This instrument is used to determine how students predicted, observed, explained and explore each laboratory experiment. The teacher-researcher who implemented POEE in class teaches two science classes one with 45 students and the other with 43 students. In one of the topic, students were first taught how to classify chemical reactions into reaction types, using pen and pencil exercises. The students were given worksheets with the POEE tasks to be performed in class and were guided by the teacher on how to complete the worksheets.

Procedure

The prediction

A student is presented with a description of a situation and asked to predict what will happen when a specified change is made. This prediction is made from a list and it is important that the student feels able to select a sensible prediction - pure guessing is not at all useful. The prediction phase can have two parts. First, the student selects a prediction, and second, selects a likely reason.

The observation

The students perform the changed situation, then must record observations and repeat the activity when necessary and followed by the teacher and checks observation. The demonstration stage is an important component at this stage and is carried out carefully so that the students observed the results very well. One of the predicted outcomes may have turned out correct, or more often than not, none of them was correct.

The explanation

It is recommended that a summary detailing the alterations in variable values and the resulting changes in the situation be provided on the explanation screen. This summary will aid the student in explaining any discrepancy between what was predicted and what occurred.

The explanation can be written on the computer screen or on paper. What is critical is that the student has the opportunity to read a model answer. It is recommended that this model answer be tailored to the prediction that the student selected.

This explanation phase can be designed to occur after the student has observed the specified change being made, but before the student has the opportunity to experiment by changing variable values.

The exploration

Students from the experimental group were asked to research the topics in the different experiments. They were also asked to explain the applications of each concept to everyday living, in hospitals, industries, pharmaceuticals, communities, and even at home.

Statistical Treatment

The t-test for independent samples was used to determine the difference between the pretest, posttest, and gain scores of the experimental and control groups as well as their attitude towards General Chemistry (Laboratory), before and after intervention. The respondents were matched based on the results of their pretest scores and attendance. In particular, the group leaders of each section represents the major participant of this action research.

RESULTS AND DISCUSSION

Participants

The subjects were two sections of first year college students of Far Eastern University enrolled in N3A1Y or General Chemistry. The group leaders of each section were the major participants of this research paper since they are ones who collected, collated and composed the POEE activity of each experiment.

Achievement test and Attitude scale towards Chemistry

To determine the impact of POEE in Chemistry as new strategy in learning Chemistry, an Achievement test was given to the experimental and control groups. It was administered before and after the study was conducted. The results were compared using t-test for independent samples and it was tabulated below:

Table 1: Comparison of the Pretest and Posttest Achievement test Mean Scores Between the Two Groups

Test	Group	N	Mean	Standard deviation	Mean diffrence	df	t-value	Significance
Pretest	Expt'l.	6	25.83	1.67	3.00	10	1.80	**NS**
	Control	6	22.83					
Posttest	Expt'l.	6	33.83	2.52	8.33	10	3.31	**S**
	Control	6	25.50					

***critical value at 0.05 level of significance at 10 degrees freedom is 2.23**

The study showed that the experimental group had a mean score of 25.83 in the Chemistry pretest achievement, which is higher by 3.00 than the score of the control group with 22.83. The difference had a computed t-value of 1.80, which was not significant at the 0.05 level for 10 degrees of freedom.

The experimental group got a higher score in the posttest with a mean score of 33.83 while the control group obtained 25.50. The computed t-value of 3.31 is very significant for 10 degrees of freedom. The experimental group were able to understand the concepts and principles behind each experiment. In doing this, they were actively involved in predicting, observing and explaining the laboratory results, while one or two of their members will do research works to complete the POEE task given to them. Students remember the essentials of chemistry concepts when they are guided during the course of each experiments.

The relative effectiveness of the different POE strategy in improving the students' achievement in Chemistry lies on the *Discovery learning theo*ry. The strategy focused on the inductive reasoning of the students in learning and promoting new material.

To determine the significant difference between the two groups, an Attitude scale towards Chemistry was given before and after the study. The t-test for independent samples was used to determine the level of acceptance.

Table 2: Comparison of the Pretest and Posttest Attitude Mean Scores Between the Two Groups

Test	**Group**	**N**	**Mean**	**Standard deviation**	**Mean diffrence**	**df**	**t-value**	**Significance**
Pretest	Expt'l.	6	22.00	2.62	0.17	10	0.06	**NS**
	Control	6	22.17					
Posttest	Expt'l.	6	45.00	3.67	12.00	10	3.27	**S**
	Control	6	33.00					

***critical value at 0.05 level of significance at 10 degrees freedom is 2.23**

The total mean score before intervention is 22.00 and 22.17 for the experimental and control groups respectively. It means that both groups generally agreed about their attitude towards Chemistry and there is no significant difference between the two groups. But after the POEE strategy was implemented to the experimental group, the mean score increased to 45.00, while the control group has 33.00. After computing t-test, it was found that the experimental group had a significant difference over the control group with a t-value of 3.27. This means that the items under the indicators: interest, usefulness, security, enjoyment, independence and motivation are more favorable to the experimental group rather than the control group. This shows that the experimental group liked the active and discovery-based approach, which helped them gain a deeper understanding of the material presented during the experiments.

The study showed that using POEE strategy in learning Chemistry improved students' achievement and attitude. It also improved the understanding of material and developed confidence. The positive impacts of POEE strategy were established not only by an Achievement test but also with an Attitude scale.

Perception Towards the use of POEE in Chemistry (Laboratory)

To further explore the effects of POEE as a new strategy in Chemistry particularly in the laboratory, the teacher-researcher asked questions to the group leader particularly in the experimental group regarding their perceptions. Some of the questions relevant to this paper are given below:

a. What can you say about POEE approach?
b. Did you have a hard time in doing the different POEE activities?
c. What were the reactions of your group members in doing POEE?
d. Are you in favor of using POEE activities in teaching Chemistry?

The effectiveness of POEE depends on how the teacher implements the strategy. The teacher should make use of students' views or misconceptions to plan teaching sequence. The teacher must be able to assist the students reconcile the inconsistency between the students' predictions and observations.

Based on the answers of the group leaders, POEE is an important tool in learning since it gives a sense of freedom among them. It encouraged them to discover and test generalizations and to search out new ways of solving problems. At the same time, it gives more permanent, meaningful and useful learning since they were actively involved in performing the different experiments.

Also, according to them they were first scared to express their views in writing, what if they wrote a wrong answer and predictions. The students do need to be encouraged to take charge of the learning and not look up to the teacher as the fountain of knowledge. But instead, the students just took the risk in doing the experiments and discourage fears among them. It is evident that teacher will play a minimal role in the POEE, leaving students to do most of the discovery and inquiry.

The use of POEE has implications on curriculum developers and inset planners, to make materials available so that teachers could continue using POEE in their teaching. As the use of POEE is entirely new in the Philippine, schools teachers do need support and teaching materials for all topics in the syllabus. Even though a POEE may be designed with an intention to provide an obvious and clear observation outcome there will still be a variation in students' observations. The most important part of the POEE strategy is explaining any differences between the students' prediction and observation. And also, how students can apply the concepts learned in everyday living.

The results imply that POEE tasks can be used by teachers to design learning activities and strategies that start with students' view points rather than the teacher's own perspective. Using POEE may appear to be a slow way of teaching but can enhance students' critical thinking skills.

It is recommended that the POEE methods be used in teaching some concepts in chemistry particularly in the laboratory part should be further explored to assess possible relationship between the content and complexity. At the same time, students in the laboratory classes should be given activities that will give them unlimited opportunities to work independently, participate actively and apply theories into practice. The textbook used in this research must be refined and adapted for the use of science students in Far Eastern University to integrate different POEE strategy and approach in laboratory activities. The Head of the Chemistry Department should form a committee to revise the existing textbook and integrate POEE as a new teaching strategy.

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