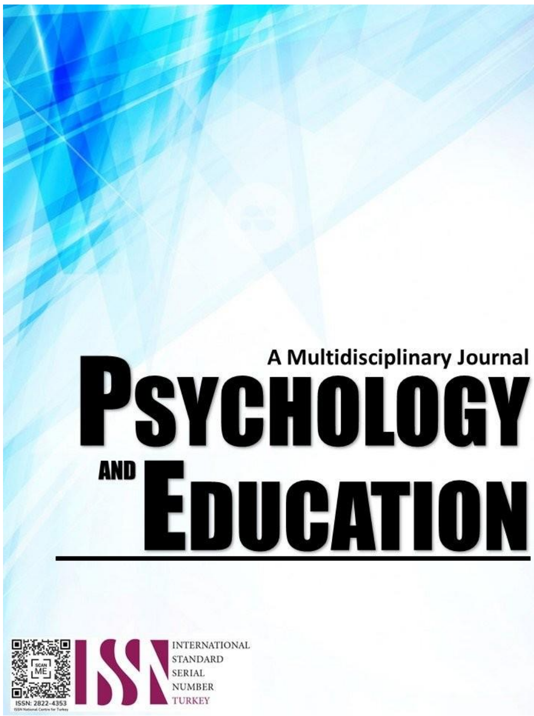
A MENTAL MODEL OF PREDICT-OBSERVE- EXPLAIN (POE) STRATEGY AS THINKING SKILL TO PROMOTE SCIENTIFIC LITERACY



PSYCHOLOGY AND EDUCATION: A MULTIDISCIPLINARY JOURNAL

2023
Volume: 13
Pages: 9-20
Document ID: 2023PEMJ1134
DOI: 10.5281/zenodo.8309759
Manuscript Accepted: 2023-30-8

Psych Educ, 2023, **13**: 9-20, Document ID:2023 PEMJ1134, doi:10.5281/zenodo.8309759, ISSN 2822-4353
Research Article

A Mental Model of Predict-observe-explain (POE) Strategy as Thinking Skill to Promote Scientific Literacy

Dolores C. Mirabueno*, Marivic S. Basilio
For affiliations and correspondence, see the last page.

Abstract

To address the aggressive reform of the Department of Education focused on improving the quality of science education at the basic levels, this mixed-method research explores how high school students exemplified the predict-observe-explain (POE) strategy as a skill or strategy in performing science experiments. A survey questionnaire was administered to determine their practice of POE strategy during the performance of the experiment. Based on the result, a mental model of the predict-observe-explain (POE) strategy was generated, which will serve as a reference for the students when they use POE as a strategy in performing science experiments as well as the teacher's reference when using POE as a teaching strategy. Previous studies on POE have primarily focused on its effectiveness as a strategy, not as a thought process; thus, this present study proposed a mental model. A mental model is an explanation of how students process the way science experiments are performed. This mental model can help students to understand science concepts and to make better decisions to develop the scientific literacy of the students.

Keywords: *POE strategy, Scientific literacy, Mental model, Thinking*

Introduction

Rooting on the Department of Education's aggressive reforms in education to improve the quality of basic education driven by the results of the Programme for International Student Assessment (PISA) in 2018, the teaching of science must be supported by a variety of pedagogical strategies that may develop students' capacity to interact critically as a citizen with scientific ideas and challenges. According to PISA 2018 Philippine National Report (2019),A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically (p. v).

The PISA 2018 Philippine National Report showed that Filipino students attained a significantly lower performance in scientific literacy than the Organization for Economic Co-operation and Development (OECD). Hence, upskilling of teachers and continuous improvement of the learning environment are the two key areas proposed by the Department of Education to improve the quality of basic education in the Philippines. This report shows how important it is to develop students' critical thinking skills anchored with how students use their thinking strategy and science process skills.

To address this gap, this study is focused on prediction-observation-explanation as a teaching strategy, science process skills, and cognitive thinking skills in performing experiments and in answering scientific inquiries. From the elaboration of the POE, the study described how high school students exemplified the predict-observe-explain (POE) strategy as a science process skill and as a thinking skill in performing science experiments. During the research process, the study was able to generate a mental model of the POE strategy as a thinking skill, which can be used as a guide when students use the POE strategy in performing the experiment and as teachers' reference when POE is used as a teaching strategy.

Many teaching strategies to increase scientific literacy promote 21st-century skills (Hanson, C. R. 2022). This should be complemented with a systematic improvement in the science curriculum and the teaching of science to develop science literacy (Klemenčič, E. et. al, 2023). Therefore, scientific literacy emphasizes inquiry using explicit instruction and scaffolding with well-designed collaborative learning opportunities that encourage students to question, explain, and elaborate their thoughts to develop their metacognitive skills (Linda Darling-Hammond, et.al, 2020). The students' scientific literacy can also be developed by using scientific activities such as problem-based learning (Nainggolan, V. A., et. al, 2021) and dialogic scientific gatherings that may enhance scientific literacy to develop analytical and critical thinking skills (Díez-Palomar, J., et. al 2022) among the students.

Similarly, the POE strategy as a teaching strategy reveals that the academic achievement of students increases and the strategy provides positive attitudes towards science (Erdem Özcan, G. & Uyanık, G., 2022). POE strategy enhances the conceptual understanding and reasoning skills of students to justify concepts based on scientific grounds and reasons (Perver, 2015). This teaching strategy, when used in pre-service science teachers, showed that they achieved high scores on the concept test and on the Course Attitude Scale (Çiğdem Çıngıl Bariş, 2022) using POE strategy. Hence, POE strategy is effective in improving conceptual understanding based on students' cognitive development (Syamsiana et al., 2018; Baltaci & Yildiz, 2018). The strategy also improved the critical thinking skills of Senior High School students using the POE model with PhET (I F Alfiyanti, et. al., 2020). These studies imply that POE as a teaching strategy can be used to improve the scientific literacy of the students.

Efforts to address the low performance in scientific literacy in PISA 2018 results were done by the academic community and as part of this initiative, this study was able to generate a mental model of a thinking skill based on the POE strategy. This model of a thinking skill interweaves POE strategy and scientific literacy, which can be useful in the teaching and learning process in the performance of the experiment. A learning model on thinking skills can be used by teachers to foster scientific literacy and critical thinking skills among students (Vieira, R. et. al 2014). Moreover, implementing an inquiry learning model that will develop science literacy improves the critical thinking skills of the students (Sutiani, A. et. al, 2021); thus, the teachers will teach students how to think scientifically (McBain, B, et. al, 2020).

Research Questions

This study aimed to determine the extent on how POE strategy is exemplified by the high school students during the performance of science experiments. Specifically, this study sought to answer the following questions:

1. What is the extent on how the respondents exemplified the POE strategy during the performance of science experiments in terms of the following:
   1.1 Typologies,
   1.2 Processes,
   1.3 Structures?
2. Based on how the respondents understand the POE strategy, what is the model of their POE strategy as a thinking model?
3. How is POE strategy able to increase the scientific literacy of the students?

Literature Review

POE Teaching Strategy

The curriculum of basic education in the Philippines forges creative and critical learners. In Southeast Asia, Indonesia's 2013 curriculum aims to make individuals and citizens who are creative, critical, and functional members of the society (Syamsiana, Suyatno & Taufikurohmag, 2018); Laos's revision of their education in 2008 intends to provide necessary knowledge for continuing education or profession (Khanthavy & Yuenyong, 2009); the Philippines' K-12 curriculum targets to offer concepts and skills mastery, lifelong learners development, tertiary education preparation, and middle-level skills development (Official Gazette of the Republic of the Philippines, n.d.). Common to these curricular aspirations is the capability of educational systems to mold learners to be competent in terms of knowledge and skills; to help develop all-rounded learners who can actively participate in the economic reconstruction of the society (Sreerekha, Arun Raj & Swapna, 2016); and to depict the sentiment of modernizing the society by developing Science and Technology. The curricular paradigm is to focus on significant and long-term change as the educational energy is to go beyond students' knowledge (Sales, Avilla & Camacho, 2015).

High levels of technological and high proficiency of scientific understanding are important curricular considerations, which become the advantages of academic enrichment. The scientific-oriented thinking process needs to use scientific concepts that will explain the observation to further reinforce new knowledge (Teerasong, Chantore, Ruenwongsa, & Nacapricha, 2010). Through these efforts of enhancing and innovating pedagogy that adapts to the present needs of society and learners, POE teaching strategy responds to this call. It is effective in improving conceptual understanding based on students' cognitive development (Syamsiana et al., 2018; Baltaci & Yildiz, 2018). POE highly demands active and creative participation from students during the learning process because the POE allows students to explore initial ideas, generate dialogue between students and teacher, investigate concepts, and awaken curiosity (Irfan, 2017).

POE strategy enhances the understanding of scientific ideas in two ways: common sense interpretation where learners use sensed impressions and form interconnecting concepts and interpretation to explain the world around them ("Using POE Sequences," n.d.). Through experimentation enforced by POE, a problem is presented in which learners are asked to provide possibilities, probe the truth by experimentation, and explain the phenomenon (Irfan, 2017; Hilario, 2015). Hence, POE allows learners to explore prior knowledge and actively navigate learning during the learning process.

The first phase of POE strategy is prediction. It uncovers students' predictions and their reasons for making these about the phenomenon being examined (Sreerekha et al., 2016; Costu, Ayns, & Nïaz, 2012; Syamsiana et al., 2018). The primary concern is to allow students to elaborate on how they make sense of the situation. This phase is done by students initially listing all their predictions and then selecting the most sensible and reasonable prediction (Hilario, 2015). Cinici and Demir (2013) identified prediction as to when students become dissatisfied with their present knowledge about the phenomena. This elicitation of students' ideas is important for the teachers and the students in building academic rapport. This phase is essential to teachers because it will give teachers insights into how students think, while students will be conscious of their thinking ("Using POE Sequences," n.d.); neurons communicate with each other and create an understanding (Syamsiana et al., 2018); prediction phase recognizes that nonscientific conceptions have potential impacts on learning (Cinici & Demir, 2013). Thus, prediction becomes a cognitive structure that is placed when prior information is invested in connection to the new information.

The second phase of POE strategy is observation. Students describe, build, and discover new concepts based on what they have seen in the demonstration-observation practice, and read in books (Sreerekha et al., 2016; Costu et al., 2012; Syamsiana et al., 2018). They record observations and repeat the activity when necessary to identify if their prediction is correct or otherwise (Hilario, 2015). In particular, students are trying to verify the intelligibility, awareness of the new concept and plausibility, and capacity of the new concept to answer the problem (Cinici & Demir, 2013). They perform the experimentation in groups to help their groupmates who find challenges in understanding the concept. According to John, there are two levels of cognitive development: the level of actual development, the ability to independently finish tasks; and the level of potential development, the ability to dependently finish tasks with peers (as cited in Syiamsiana, 2018). If there is a demonstration of the experiment, teachers are encouraged to let students help out and write their observations ("Using POE Sequences," n.d.).

The third phase of POE strategy is explanation. Students must reconcile the conflict between prediction and observation to explain the event (Sreerekha et al., 2016; Costu et al., 2012; Syamsiana et al., 2018), and deconstruct the process that happened (Khanthavy & Yuenyong, 2019). They detail the alterations in the variables, and point out discrepancies between what was initially predicted and what occurred (Hilario, 2015); these student explanations are either field experience or research findings; the former focuses on the conducted field testing, the latter traces resemblances between the experience and findings ("Using POE Sequences," n.d.).

On one hand, for students, this phase is a reconfiguration of sensing the world, which is also called accommodation, a process that involves replacement or reorganization of learners' concepts to more scientific ones (Cinici & Demir, 2013). Perceptions are questioned and tested by an environment that allows exploration not only by himself but also with others. This is fruitfulness, the final condition of conceptual change (Cinici & Demir, 2013). On the other hand, for teachers, this phase is the scientific explanation established by scientists. The inclusion of information from students' short and long-term memory is necessary to organize their self-conceptual understanding (Syamsiana et al., 2018).

Scientific literacy

Scientific literacy according to OECD (2007), is the ability to understand, explain, and apply science in order to solve problems such as COVID-19, wildfires, and other 2020 headlines (Levy & Schweingruber, 2020). Problems that require scientific understanding, explanation, and application made scientific literacy vital not just for professionals, but also for students and other sectors of society. Being a scientific literate would help solve scientific problems, which is a good basis for students to have a more authentic challenge to prepare them for real-life problem solving scenarios. With that, there is an importance to enhance the scientific literacy of the students and one way to do it is to use the POE or Predict-Observe-Explain strategy.

Two groups of respondents [21 teachers and 203 Senior High School students] from the study of Olivia (2019) entitled Predict-Observe-Explain (POE) Strategy: Basis for Enhancing the Performance of Students in Science, believed that the use of predict-observe-explain strategies strengthened the cognitive, psychomotor, and affective development of the students. The evaluations of educators and students diverge when it comes to assessing the efficacy of predict-observe-explain strategies in enhancing students' cognitive advancement. With that it is narrowed that the use of POE as an approach in science lessons depends on the assessments and materials given by the teachers to the students. Textbooks that pay attention to the content of science literacy will, of course, influence the students' science literacy. Other factors that affect students' science literacy include: 1) learning models, 2) learning media, 3) worksheets, and 5) evaluation tools based on science literacy (Rusilowati et al., 2019). As part of the learning media, in the study of Nadiah (2021), it is concluded that the use of video-based POE enhanced the scientific literacy of students, particularly in chemistry's concept of salts. The findings showed that students' scientific literacy on salts had increased post-intervention, their metacognition had improved regardless of their opinions, and students' misconceptions of salts had been revealed, indicating that video-based POE is an efficient constructivist learning approach that fosters metacognition and, in turn, increases scientific literacy.

In addition, the effectiveness of POE depends on how the teacher implements the strategy. The teacher should make use of students' views or misconceptions to plan teaching sequences. The teacher needs to help students harmonize the disparity between their predictions and observations. Students at first were scared to express their views in writing, what if they wrote a wrong answer. 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.

Methodology

To determine if the students exemplified the predict-observe-explain (POE) strategy as a skill or strategy in performing science experiments, the researchers used a survey questionnaire administered to the high school students and asked them to indicate their practice of POE strategy during the performance of the experiment.

Participants

This research was conducted in public and private schools in Metro Manila and its nearby areas in the Philippines during the fourth quarter of the school year 2022-2023. The study used random sampling to select the participants; thus, one hundred seventy-two (172) high school students from eight (8) public and private high schools participated in the study.

Instruments of the Study

The research instrument consisted of questions with a scale from 0 to 4 (zero for not exemplified, 1 for the least exemplified, and 4 for the most exemplified). Part 1 of the survey questionnaire is about prediction strategy with four (4) questions for the typology, four (4) questions for the process, and five (5) questions for the structure of the prediction strategy. At the end of part 1, students were asked how they practiced prediction as a science strategy/skill in performing the experiment. Part 2 of the survey questionnaire is about observation strategy with four (4) questions for the typology, five (5) questions for the process, and four (4) questions for the structure of the observation strategy. At the end of part 2, students were asked how they practiced observation as a science strategy/skill in performing the experiment. Part 3 of the survey questionnaire is about explanation strategy with five (5) questions for the typology, six (6) questions for the process, and eight (8) questions for the structure of the explanation strategy. At the end of part 3, students were asked how they practiced explanation as a science strategy/skill in performing the experiment. The last part of the questionnaire is for the students to share their perspectives on how they exemplified prediction, observation, and explanation skills during experimentation aside from those listed on the questionnaire.

Procedure

This research employed a mixed-method design where both qualitative and quantitative data were gathered and analyzed to answer the research questions. The research tool used in this study was based on the typology, processes, and structures of POE as a strategy/skill in performing the experiment adapted from the study of Mirabueno (2022). Figure 1 shows the three stages of how POE strategy/skill is being used during the performance of the experiment. The typologies, processes, and structures of POE were then converted to a survey instrument and this was administered to students in Grade 10 and students from the science, technology, engineering, and mathematics (STEM) strand.

The quantitative data were analyzed using descriptive statistics. The qualitative data were analyzed by grouping the common responses of the students to determine the other ways they practice prediction, observation, and explanation as a strategy or a science process skill.

Psych Educ, 2023, **13**: 9-20, Document ID:2023 PEMJ1134, doi:10.5281/zenodo.8309759, ISSN 2822-4353
Research Article

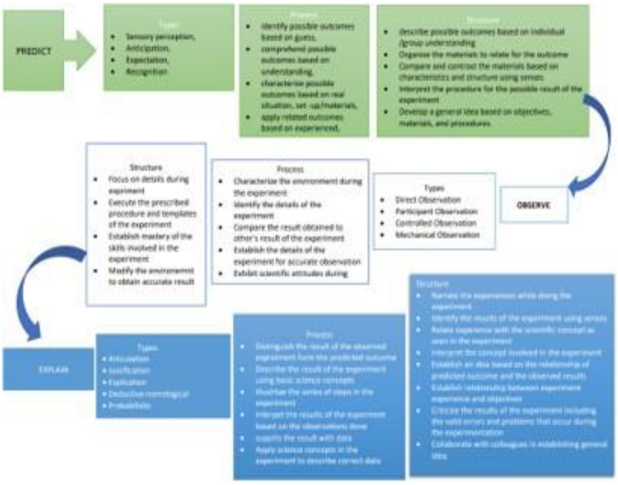


Figure 1. *Typology, Processes, and Structures of POE Strategy*

Ethical Considerations

Prior to the data collection, the respondents accomplished an informed consent form to signify their agreement for voluntary participation in this research. This process ensured appropriate research ethics protocols during the collection and analysis of data.

Results

The Prediction Strategies of High School Students in Performing Science Experiments

Table 1. *Prediction Strategies of High School Students based on Typology*

Types of Prediction	*Mean*
Sensory perception is using senses, chance, and intuition.	3.023
Anticipation is visualizing possible action/outcome.	3.244
Expectation is the reasonable outcomes based on prior knowledge.	3.047
Recognition is noticing details close to prior experience.	3.012

Table 1 presents the prediction strategies of high school students based on typology. Typology is a classification of prediction, observation, and explanation as science process skills and as strategies for performing the experiment based on how the chemistry stakeholders used them (Mirabueno, 2022). The types of prediction strategies/skills are sensory perception, anticipation, expectation, and recognition.

The data show that the anticipation strategy is exemplified by most students in predicting the outcomes of the experiment having a mean of 3.244, followed by expectations (M= 3.047) and the least exemplified strategy is recognition strategy with a mean of 3.012.

Table 2. *Prediction Strategies of High School Students based on Process*

Process of Prediction	*Mean*
Identify possible outcomes based on guess.	2.727
Comprehend possible outcomes based on individual/ group understanding.	3.041
Characterize possible outcomes based on real situation, set-up, materials, or sample.	3.262
Apply related outcomes based on experiences.	3.186
Theorize the reason for the outcomes based on associated and applicable theories.	2.936

The findings show that when high school students anticipate possible and expected outcomes of an experiment, most students characterize possible outcomes based on real situations, set-ups, materials, and samples (M=3.262). Some students responded that when they predict outcomes, they base it on prior research and observations, and not by guessing (M=2.727).

Based on the data gathered on the structure of prediction, results show that most of the students develop a general idea based on objectives, materials, and procedures (M=3.244). On the contrary, the least focused science process skill is the interpretation of the procedure for the possible result of the experiment (M= 3.017). Considering the responses of the students when they were asked to describe how they practiced prediction based on structure, the following were identified: 1) identify the components of the experiment such as the variables, research questions, and the procedure of the experiment; 2) record predictions and compare them with the actual results; 3) test multiple experiments related to the subject topic; and 4) list facts that hinder the experiment.

Table 3. *Prediction Strategies of High School Students based on Structure*

Structure of Prediction	*Mean*
Describe possible outcomes based on individual/group understanding.	3.093
Organize the materials to relate for the outcome.	3.110
Compare and contrast the materials based on characteristics and structure using senses.	3.047
Interpret the procedure for the possible result of the experiment.	3.017
Develop a general idea based on objectives, materials and procedures.	3.244

The Observation Strategies of High School Students in Performing Science Experiments

Observation refers to the skill or strategy of the chemists, teachers, and students in describing what is happening during an experiment (Mirabueno, 2022). It includes recording the behavioral patterns of the study's subject during the experiment. Furthermore, it refers to their capability to determine the result of the experiment. Table 4 shows the types of observation being exemplified by the high school students.

Data showed that the controlled strategy is the most exemplified type of observation strategies among the high school students with a mean of 3.291. It is also seen that mechanical observation is the least exemplified observation among the students.

Table 4. *Observation Strategies of High School Students based on Typology*

Types of Observation	*Mean*
Direct observation happens at the moment of the experiment.	3.279
Participant observation is firsthand knowledge of the event or behavior being investigated.	3.180
Controlled observation follows set guidelines and procedures.	3.291
Mechanical observation uses other media or machines.	3.029

Table 5. *Observation Strategies of High School Students based on Process*

Process of Observation	*Mean*
Characterize the environment during the experiment.	3.151
Identify the details of the experiment.	3.436
Compare the result obtained to other's result of the experiment.	3.250
Establish the details of the experiment for accurate observation.	3.355
Exhibit scientific attitudes during observation.	3.174

In terms of the process of observation, Table 5 shows that most students tend to identify the details of the experiments (M= 3.436). In addition, some students mentioned that when they observe, they make sure that the materials needed for their observation are ready and available. Moreover, students believe that during observation, they need to have an open mind, a clear and focused research question, and an unbiased observation. Lastly, how members behave during the experiment and how they communicate the findings to others are being observed.

Table 6. *Observation Strategies of High School Students based on Structure*

Structure of Observation	*Mean*
Focus on details during experiment.	3.436
Execute the prescribed procedure and templates of the experiment.	3.291
Establish mastery of the skills involved in the experiment.	3.163
Modify the environment to obtain accurate result.	3.151

It is evident that the students focus on the details of the experiment (M=3.436) rather than modifying the environment to obtain accurate results (3.151). Based on the student's responses, the details of the experiment are very important to be able to explain the observations made and to draw out conclusions. They claimed that students should possess an enormous amount of knowledge to identify the experiment's weaknesses and strengths, determine the variables that may affect the results of the experiment, choose the observation method, and develop the capacity to learn.

Psych Educ, 2023, **13**: 9-20, Document ID:2023 PEMJ1134, doi:10.5281/zenodo.8309759, ISSN 2822-4353
Research Article

The Explanation Strategies of High School Students in Performing Science Experiments

Explanation refers to the ability of the chemists, teachers, and students to form relationships and synthesize the reason for the behavior of the study's subject after the experiment. It also describes scientific concepts and theories involved in the experiment. In this stage, the learners explain their observations and make connections between their observations and scientific concepts. Table 7 presents the findings on the explanation strategies exemplified by the high school students based on typology.

Table 7. *Explanation Strategies of High School Students based on Typology*

Types of Explanation	*Mean*
Articulation describes the behavior, situation, action, and environment.	3.023
Justification identifies the cause of behavior, situation, action, and environment.	3.157
Explication discusses how an event, behavior, or action came to be.	3.122
Deductive-nomological identifies patterns to create higher generalization and draws key ideas from cause and effect.	3.017
Probabilistic presents statistical probability, current, and recurrent data.	3.186

The table shows that learners used a probabilistic explanation (M=3.186) rather than a deductive-nomological explanation (M=3.017).

Table 8. *Explanation Strategies of High School Students based on Process*

Process of Explanation	*Mean*
Distinguish the result of the observed experiment from the predicted outcome.	3.291
Describe the result of the experiment using basic science concepts.	3.000
Illustrate the series of steps in the experiment.	3.320
Interpret the results of the experiment based on observations done.	3.331
Support the results with data.	3.448
Apply science concepts in the experiment to describe correct data.	3.122

Data shows that when students explain the result of the experiment, discussion is supported with the data they gathered during their observation (M= 3.448). It is also seen that some students when they explain the result of their experiments, they base their explanation using their knowledge of the basic science concepts (3.000).

Table 9. *Explanation Strategies of High School Students based on Structure*

Structure of Explanation	*Mean*
Narrate the experience while doing the experiment.	3.063
Identify the results of the experiment using senses.	3.134
Relate experience with the scientific concept seen in the experiment.	3.064
Interpret the concept involved in the experiment.	3.186
Establish an idea based on the relationship of predicted outcome and the observed results.	3.198
Establish relationship between experiment experience and objectives.	3.134
Criticize the results of the experiment including the valid errors and problems that occur during experimentation.	3.221
Collaborate with colleagues in establishing general idea.	3.378

For the structure of explanation, collaborating with colleagues in establishing general ideas got the highest mean (M=3.378). However, some students when they explain the result of the experiment they tend to narrate the experience while doing the experiment (M= 3.063).

Discussion

The aim of this study is to determine the extent of how POE strategy is exemplified by the high school students during their performance of science experiments. Specifically, it sought to know the extent on how the respondents exemplified POE strategy in terms of topology, process and structures. With the students' responses, a thinking model is proposed which can be utilized by science teachers in increasing or enhancing the scientific literacy of the students.

The Prediction Strategies of High School Students in Performing Science Experiments

Prediction as a strategy is often used in performing experiments. It serves as a hypothesis about the outcomes of the experiment that can be tested. This guides students in determining the expected results of the experiment. Mirabueno (2022) classified prediction strategy based on typology, process, and structure. First, typology is a science process, skills, and strategies based on how the chemistry stakeholders used them. Second, the process is a series of actions and steps in performing the experiment using prediction, observation, and explanation, and lastly, the structure is the arrangement of interrelated patterns which focuses on how deeply stakeholders must think to answer and complete the experiment.

The anticipation strategy is exemplified by high school students in giving their predictions based on typology. According to Dean (2021), anticipation is the act of using information about the past and present to make predictions about the future. Students' prior knowledge is activated, the subject is highlighted, and the concepts they are already familiar with are revealed (White & Gunstone, as cited by Erdem, et.al, 2022). White and Gunstone as cited by Furgani, et.al (2018) stated that prediction required extended knowledge of the problem to solve the given problem. This implies that teachers should provide information about the experiment, events, and the topic to be researched, requiring the students to provide their predictions and explanations.

Most high school students characterize possible outcomes based on real situations, set-ups, materials, and samples. This process of prediction enables students to associate scientific information with natural events they encounter in their daily lives (Erdem, et. al, 2022). The use of prior knowledge in making predictions provides the foundations of a new understanding; thus, connecting ideas that they already know will allow them to create more complex concepts. This implies that teachers should include activities that activate prior knowledge to enhance comprehension and foster a deeper understanding of the concepts. The use of authentic activities can be considered to validate their overall learning.

This structure of prediction activates the student's prior knowledge, leaves the formulation of the solution to the conflict to the student, and tries to ensure that the student follows the method without skipping the stages of the method (Kearney, as cited by Erdem, et. al, 2022). This result can be associated with the student's response that prediction can be done by widening their imagination. This response implies that for the students to have a better understanding of the topic, they need to focus on the most important aspects of the experiment based on prior knowledge, real-life situations, and organized information to develop a general idea.

The Observation Strategies of High School Students in Performing Science Experiments

Based on topology, most high school students use the controlled observation strategy more than the participant observation type. According to Mcleod (2023), researchers cannot openly take notes with covert observations because this would blow their cover. As a result, they must wait until they are alone and rely on their memory, which can be problematic because they may forget specifics and are unlikely to remember direct quotations. It can be challenging to obtain time and privacy for recording. In a controlled experiment, the students tend to control the environment by strictly following the set guidelines and procedures of the experiment and carefully monitoring and recording what happens in the experiment. These actions allow the students to establish the cause-and-effect relationship that becomes their basis for drawing the conclusion. This implies that when students are in control of the environment, then they will likely develop higher order thinking skills.

In terms of the observation of high school students based on structure, most students tend to identify the details of the experiments instead of characterizing the environment of the experiment. This process of observation involves using the senses in formulating the hypothesis or identifying the outcome, listening to the instructions of the teacher, drawing out the possible outcomes based on prior knowledge and experience, and supporting the observations with critical thinking skills. In addition, some students mentioned that when they observe, they make sure that the materials needed for their observation are ready and available. Moreover, students believe that during observation, they need to have an open mind, a clear and focused research question, and an unbiased observation. Lastly, how members behave during the experiment and how they communicate the findings to others are being observed. This process of observation implies that when learners observe, they focus more on the objectives and procedures to better understand the general idea. Once the information is obtained, students sum up their observations and their prior knowledge in making inferences to obtain information. (Furgani, et.al ,2018).

Focusing on the details of the experiment rather than modifying the environment to obtain accurate results are shown in the presentation of data obtained from the SH. Based on the student’s responses, the details of the experiment are very important to be able to explain the observations made and to draw out conclusions. They claimed that students should possess an enormous amount of knowledge to identify the experiment's weaknesses and strengths, determine the variables that may affect the results of the experiment, choose the observation method, and develop the capacity to learn. More so, students should focus on the details of the experiments to be modified, follow the process and procedures, have a clear mind, and be attentive to the process. These actions imply that when the students are focusing their attention on the details of the experiments, it minimizes the chances of committing errors and allows accurate data to be obtained. Also, when the procedure of the experiment is well-documented, others may perform the same experiment and correlate the obtained results with the original findings. In addition, focusing on the details just like focusing on error finding promotes transparency and accountability in science (Brown et al., 2018).

The Explanation Strategies of High School Students in Performing Science Experiments

Explanation refers to the ability of the chemists, teachers, and students to form relationships and synthesize the reason for the behavior of the study's subject after the experiment. It also describes scientific concepts and theories involved in the experiment. In this stage, the learners explain their observations and make connections between their observations and scientific concepts.

Probabilistic is an explanation that involves the use of probabilities and frequencies; thus, it is used to explain events that are uncertain or random. If the students use probabilistic explanations, it means that they can better understand the uncertainty and randomness that is inherent in many situations (Berkovittz & Huneman, 2015). This capacity will help them to develop a clearer understanding of events.

It is also shown that students explain the results of their experiments by supporting their data with their observation data. This result means that learners' reports are data-driven. During the observation phase, the following actions were noted from the responses of the students: 1) focus on the details of every step of the experiment, 2) communicate ideas with clarity, evidence, and coherence, 3) use analogies, concept maps, visual aids, feedback, and vocabularies, 4) support the result with analytical, observational, and theoretical attitude, 5) read and review the literature to support the explanation and to verify the observations made, and 6) describe the event using senses, sort ideas and summarize the information. These responses imply that when the students explain the results of the experiments, they tend to justify their predictions, analyze what they have observed, and reconcile the conflict between their prediction and observation.

When the students were asked how they practice explanation, the following responses were deduced: 1) practice and familiarize the experiment for a better understanding, 2) visualize the experiment to predict an outcome, 3) search from the internet related-experiments as a reference, 4) articulate the purpose of the experiment, the audience, the related concepts, experiences 5) brainstorm on the limitations, errors and uncertainties met in the performance of the experiment, 6) explain confidently the result of the experiment in public. The gathered strategies will likely help teachers provide a more stable and organized science class that enables individuals to work more effectively and effectively as they perform their science experiments. This will provide the s students with a framework to follow to achieve the set goals. Putting together all the gathered data, a mental model was generated based on the perspectives of the students on how POE is used as a strategy or as a skill. This mental model is based on the most exemplified typology, process, and structure of prediction, observation, and explanation obtained through the highest mean gathered.

A Mental Model of Thinking Skill based on Students' Perspectives of the POE Strategy

Mental models are important components of learning which facilitates a student's early knowledge to build up the next new knowledge and achieve a complete and more scientific understanding (Hamid, 2017, as cited by Jasdilla, 2019). The learning process being facilitated by using mental models teaches the brain how to think in new ways (Clear, n.d.); hence, the POE strategy presented through a mental model can help increase the level of scientific literacy of the students. Capitalizing on the responses of the students in the POE survey, a mental model in POE was conceptualized.

The mental model of POE strategy is based on the highest mean in each item about prediction, observation, and explanation strategies. For the prediction strategy, results showed that when students used prediction as a strategy/skill in performing an experiment, the students' type of prediction strategy exemplified was anticipation, that is, to visualize the outcome of the experiment. Since the prediction strategy is based on visualization, the students' process of prediction strategy is to visualize the possible outcomes of the experiment based on the real situations, set-ups, materials, or samples. By visualizing the possible outcomes of the experiment, the students' structure of the prediction strategy is to develop a general idea based on objectives, materials, and procedures. This mental model of prediction strategy can be used as a teaching strategy in conducting science laboratory experiments because visualization plays a central role in learning science through metacognition, which enables the students to show metavisual capability (Gilbert, 2005). The typology, process, and structure of prediction strategy contained in this mental model show that students practice metacognition and visual capability in order to predict the outcome of the experiment. By doing so, the critical thinking skills of the students are developed, which may lead to understanding science, as it requires good thinking, especially critical thinking (Listiani, 2022). Hence, thinking about thinking is being practiced by the students during the visualization of the predicted outcome of the experiment, which may help in the development of the scientific literacy of the students.

Observation is a fundamental skill in science, especially when performing an experiment, because it is the foundation of the scientific method to acquire reliable data and knowledge. Hence, observation strategy is a crucial skill that a learner must develop to properly connect the prediction to the explanation when using the POE strategy. Looking at the middle part of the mental model of the POE strategy, the type of observation strategy exemplified by the students is controlled observation, as students follow the procedures and guidelines of the experiment. The process of observation exemplified by the students is identifying the details of the experiment, while the structure of observation exemplifies focusing on the details of the experiment. Since observation skill is essential for data collection and testing of inferences/hypotheses, the thinking model of the POE strategy shows that the generation of ideas during the conduct of the experiment can be done by following the guidelines/procedures and that the identification of the details of the experiment can be achieved by focusing on the details of the experiment. This series of actions, when done properly, can serve as the scaffolding process so that students can observe and later on ask questions properly, Wakhidah (2022). By applying this approach, the teachers can help the students hone their observation skills to make evidence-based decisions from the gathered data, formulate scientific knowledge and understanding, and even improve the experimental design as a form of advancement and innovation.

Explanation strategy is a skill of the students to convey science concepts/ideas generated from the experiment in a logical and coherent manner. It shows the ability of the learners to make complex science concepts more understandable and accurate. This is shown in the last part of the mental model of the POE strategy. The type of explanation strategy is probabilistic, which presents statistical probability and current and recurrent data. This means that when students are conveying their ideas generated from the experiment, they base them on the current or recurrent data. They also extend their ideas to some possibilities based on what the data expressed. The process of the explanation strategy is to support the result with the data. This process of explanation is aligned with the structure of explanation that for the students to generate scientific ideas, they need to collaborate with their group mates and cooperate with their teachers. The structure of the explanation is to collaborate with colleagues in establishing general ideas. This structure of explanation supports the findings of Aldresti (2018) that teachers are facilitators of learning by asking leading questions in the discussion phase to deepen the understanding of the students and to explain science concepts comprehensively.

Conclusion

The findings of this study can enhance the scientific literacy of high school students through the POE strategy by actively engaging students in the scientific process of doing an experiment. Scientific literacy involves making predictions of possible outcomes of the experiment, observing if the predicted outcomes are happening during the experiment, and providing explanations based on evidence and reasoning. The result of the study shows that all typologies of POE, as well as the processes and structures of POE, were exemplified by the students to some extent. Those typologies, processes, and structures of POE that were most exemplified by the students became the basis of the mental model of the POE strategy. This study was able to generate other processes and structures of POE that can be included in the list of the prediction, observation, and explanation strategy/skill to further understand how POE can be used as a strategy or as a skill. By using the types, processes, and structures of the POE strategy/skill and the mental model of the POE strategy, the following are its possible effects to the students: 1) encourages active learning, 2) develops critical thinking skills, 3) enhances problem-solving skills, 4) supports the scientific method, 5) and helps in understanding science concepts and its retention. Therefore, the result of this study is highly recommended to be applied by the science teacher to promote the development of scientific literacy among students to address the result of PISA 2018. For future research, the actual application of the POE strategy and the mental model of POE strategy can be used to teach laboratory courses and survey the actual experiences of the students with the use of these approaches.

Acknowledgements

The authors would like to thank the students from the eight (8) public and private schools who participated in this study, as well as their teachers and administrators who allowed the researchers to conduct this study in their schools.

References

Aldresti, F., Rahayu, S., & Fajaroh, F. (2018). The Influence of Inquiry-based Chemistry Learning with The Context of Socio-Scientific Issues on High School Students' Scientific Explanation Skills, 23(2), 139-146

Baltaci, S. &Yildiz, A. (2018). Using predict-observe-explain (POE) strategy for the software-aided solutions of geometrical location problems. Journal of Kirsehir Education Faculty. 1891-1909. doi:10.29299/kefad.2018.19.03.003

Bonnie McBaina, Andrew Yardyd, Frances Martinb, Liam Phelana, Ian van Altenaa, Jill McKeowend, Claire Pembertond, Hollie Tosec, Lindsey Fratuse, Michael Bowyera (2020). Teaching Science Students How to Think. International Journal of Innovation in Science and Mathematics Education, 28(2), 28-35, 2020

.Brown, A. W., Kaiser, K. A., & Allison, D. B. (2018). Issues with data and analyses: Errors, underlying themes, and potential solutions. Proceedings of the National Academy of Sciences of the United States of America, 115(11), 2563–2570. https://doi.org/10.1073/pnas.1708279115

Cinici, A. & Demir Y. (2013). Teaching through cooperative POE tasks: a path to conceptual change. The Clearing House. 1-10. doi:10.1080/00098655.2012.712557

Çiğdem Çıngıl Bariş (2022) The effect of the 'Predict-Observe-Explain (POE)' strategy in teaching photosynthesis and respiration concepts to pre-service science teachers, Journal of Biological Education, DOI: 10.1080/00219266.2022.2047097

Costu, B., Ayns, A., &Nïaz, M. (2012). Investigating the effectiveness of a POE-basedteaching activity on students' understanding of condensation. SpringerScience+Business Media. 47-67. doi:10.1007/s11251-011-9169-2

Deans C. (2021). Biological Prescience: The Role of Anticipation in Organismal Processes. Frontiers in physiology, 12, 672457.https://doi.org/10.3389/fphys.2021.672457

Díez-Palomar, J., Font Palomar, M., Aubert, A., & Garcia-Yeste, C. (2022). Dialogic Scientific Gatherings: The Promotion of Scientific Literacy Among Children. SAGE Open, 12(4). https://doi.org/10.1177/21582440221121783

Erdem Özcan, G. & Uyanık, G. (2022). The effects of the "Predict-Observe-Explain (POE)" strategy on academic achievement, attitude and retention in science learning. Journal of Pedagogical Research, 6(3), 103-111. https://doi.org/10.33902/JPR.202215535

Eva Klemenčič, Mateja Ploj Virtič & Janja Majer KovačičThe Role of Teacher Education in the Science Literacy Development, Athens Journal of Sciences 2023, 10: 1-22 https://doi.org/10.30958/ajs.X-Y-Z

Dandy Furqani1, Selly Feranie & Nanang Winarno (2018). The Effect of Predict-Observe-Explain (POE) Strategy on Students' Conceptual Mastery and Critical Thinking in Learning Vibration and Wave DOI: 10.17509/jsl.v2i1.12879

Gilbert, J.K. (2005). Visualization: A Metacognitive Skill in Science and Science Education. In: Gilbert, J.K. (eds) Visualization in Science Education. Models and Modeling in Science Education, vol 1. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3613-2_2

Hanson, C. R. (2022). Developing Scientific Literacy to Promote 21st-Century Skills in Students [Master□s thesis, Bethel University]. Spark Repository. https://spark.bethel.edu/etd/863

Hilario, J.S. (2015). The use of predict-observe-explain-explore (POEE) as a newteaching strategy in general chemistry-laboratory. International Journal of Education and Research. 3(2). 37-48.

Irfan, M. (2017). Development of learning model "PODE" (predict, observe, discuss,explain) in the primary school. International Journal of Social Science and Humanities Research. 5(3). 491-498.

Ivayuni Listiani, Herawati Susilo, Sueb (2022). Relationship between Scientific Literacy and Critical Thinking of Prospective Teachers. Al-Ishlah: Jurnal Pendidikan Vol.14, 1 (April, 2022), pp. 721-730 ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v14i1.1355

James Clear (n.d.) Mental Models: How to Train Your Brain to Think in New Ways. Retrieved May 11, 2023, https://jamesclear.com/feynman-mental-models

Jasdilla L., Fitria Y., and Sopandi W., (2019).Predict Observe Explain (POE) strategy toward mental model of primary students: Journal of Physics: Conference Series, Volume 1157 022043, DOI 10.1088/1742-6596/1157/2/022043

Khanthavy H. &Yuenyong, C. (2019). The grade 1 student's mental model of force andmotion through predict-observe-explain (POE) strategy.

Linda Darling-Hammond, Lisa Flook, Channa Cook-Harvey, Brigid Barron & David Osher (2020) Implications for educational practice of the science of learning and development, Applied Developmental Science, 24:2, 97-140, DOI: 10.1080/10888691.2018.1537791

Levy, A., & Schweingruber, H. (2020, November 5). Start Young, Start Now: Key actions to Improve Scientific Literacy. EDC. https://www.edc.org/blog/start-young-start-now-key-actions-improve-scientific-literacy

Mcleod, S., PhD. (2023). Observation method in psychology: naturalistic, participant and controlled. Simply Psychology. https://www.simplypsychology.org/observation.html

Mirabueno, D.C. (2022). Competency standards based on chemistry stakeholders' typology, structure, and process of prediction, observation, and explanation. [Unpublished doctoral dissertation]. University of the Philippines, Diliman Quezon City, Philippines.

Mthembu, Z. (2001). Using the Predict-Observe-Explain Technique to Enhance the Students' Understanding of Chemical Reactions (Short Report on pilot study). University of Natal.

Nainggolan, V. A., Situmorang, R. P., and Hastuti, S. P. (2021). Learning Bryophyta: Improving students' scientific literacy through problem-based learning. JPBI (Jurnal Pendidikan Biologi Indonesia), 7(1), 71-80. doi:https://doi.org/10.22219/jpbi.v7i1.15220

Official Gazette of the Republic of the Philippines. (n.d.). What is K-12 Program?Retrieved April 10, 2019 fromhttps://www.officialgazette.gov.ph/k-12/

Oliva, L. a. M. (2019, January 18). Predict-Observe-Explain (POE) Strategy: Basis for enhancing the performance of students in science. https://ojs.aaresearchindex.com/index.php/AAJMRA/article/view/12058

Organization for Economic Cooperation and Development. (2007). Assessing scientific, reading and mathematical literacy: A framework for PISA 2006. Retrieved November 2008 from http://www.oecd.org/dataoecd/63/35/37464175.pdf

Perver, S. (2015). Predict Observe and Explain (POE): A teaching strategy for enhancing conceptual understanding of enzymes in grade 9 students in a private school of Karachi, Pakistan (Unpublished master's dissertation). Aga Khan University, Karachi, Pakistan.

PISA 2018 National Report of the Philippines (2019). Retrieved April 15, 2023 from https://www.deped.gov.ph/wp-content/uploads/2019/12/PISA-2018-Philippine-National-Report.pdf

Rusilowati, A., Astuti, B., & Rahman, N. H. A. (2019, March 1). How to improve student's scientific literacy. Journal of Physics. https://doi.org/10.1088/1742-6596/1170/1/012028

Sales, P.B., Avilla, R. A., & Camacho, V.M.I. (2015). Predict-explain-observation-explain (PEOE) approach: tool in relating metacognition to achievement in chemistry. Electronic Journal of Science Education. 19(7). 1-21.
Sreerekha, S., Arun Raj, R., & Swapna, S. (2016). Effect of predict-observe-explainstrategy on achievement in chemistry of secondary school students. Innoriginal.1(1). 1-5.

Syamsiana, F., Suyatno, &Taufikurohmah, T. (2018). The effectiveness of using POE (predict-observe-explain) strategy on students' learning result of reaction rate chapter in sma. JPPS (JurnalPenelitian Pendidikan Sains). 7(2). 1507-1512.

Sutiani, Ani; Situmorang, Manihar; Silalahi, Albinus. Implementation of an Inquiry Learning Model with Science Literacy to Improve Student Critical Thinking Skills. International Journal of Instruction, v14 n2 p117-138 Apr 2021

Vieira, Rui & Tenreiro-Vieira, Celina. (2014). Fostering Scientific Literacy and Critical Thinking in Elementary Science Education. International Journal of Science and Mathematics Education. 14. 10.1007/s10763-014-9605-2.

Teerasong, S., Chantore, W., Ruenwongsa, P, &Nacapricha, D. (2010). Development ofa predict-observe-explain strategy for teaching flow injection at undergraduate chemistry. The International Journal of Learning. 17(8). 137-150.

Using POE Sequences. (n.d.). retrieved July 31, 2023 from https://us.corwin.com/sites/default/files/upm-binaries/50697_Using_POE_Sequences.pdf.
Wakhidah N., Laelasari, I. (2022) Observing Skills And Questioning Skills: Are They Correlated In The Learning Process?. Thabiea : Journal of Natural Science Teaching, 5(2), 131-144.

Affiliations and Corresponding Information

Dolores C. Mirabueno, PhD
De La Salle-College of Saint Benilde – Philippines

Marivic S. Basilio, EdD
De La Salle-College of Saint Benilde - Philippines