The Effectiveness of Predict-Observe-Explain (POE) Model in Enhancing Students' Critical Thinking Skills on Colloid Topic

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ABSTRACT

Cultivating critical thinking skills in colloidal subjects is difficult due to the intricacy of abstract concepts, even though they are pertinent to daily life. This study seeks to evaluate the efficacy of the Predict-Observe-Explain (POE) learning model in improving high school students' critical thinking skills in colloid science. This pre-experimental study employed a one-group pretest-posttest design with 36 11th-grade science students chosen via purposive sampling. The research instrument comprised an essay test formulated according to Facione's critical thinking indicators. The findings demonstrated a substantial enhancement in students' average scores, rising from 32.55 to 75.14, accompanied by a Normalized Gain (N-gain) of 0.635 (moderate). An analysis based on indicators showed that the POE model was best at helping students improve their deduction and inference skills, but it still needed work on helping them figure out how trustworthy information sources are. This study concludes that the POE model is effective in enhancing scientific argumentation; however, it necessitates supplementary scaffolding to fortify students' metacognitive skills in the validation of external information.

Keywords: *Critical Thinking; Colloid; POE Model; Chemistry Education.*

ABSTRAK

Pengembangan keterampilan berpikir kritis pada materi koloid menjadi tantangan karena kompleksitas konsep yang bersifat abstrak meskipun relevan dengan kehidupan sehari-hari. Penelitian ini bertujuan untuk menganalisis efektivitas model pembelajaran *Predict-Observe-Explain* (POE) dalam meningkatkan keterampilan berpikir kritis siswa SMA pada materi koloid. Metode penelitian yang digunakan adalah pre-experimental dengan desain one-group pretest-posttest terhadap 36 siswa kelas XI IPA yang dipilih melalui purposive sampling. Instrumen penelitian berupa tes esai yang disusun berdasarkan indikator Facione. Hasil penelitian menunjukkan adanya peningkatan skor rata-rata siswa secara signifikan dari 32,55 menjadi 75,14 dengan perolehan *Normalized Gain* (N-gain) sebesar 0,635 (kategori sedang). Analisis per indikator menunjukkan bahwa model POE paling efektif dalam melatih kemampuan deduksi dan inferensi siswa, namun masih menunjukkan capaian rendah pada aspek evaluasi kredibilitas sumber informasi. Temuan ini menyimpulkan bahwa model POE efektif dalam membangun argumentasi ilmiah, namun memerlukan integrasi *scaffolding* tambahan untuk memperkuat aspek metakognitif siswa dalam memvalidasi informasi.

Kata kunci: Berpikir Kritis; Koloid; Model POE; Pendidikan Kimia.

INTRODUCTION

The fast growth of science and technology in the 21st century, when there is too much information, has definitely caused big changes in education. Graduates need to change their skills because information is now so easy to get. To solve complicated problems around the world, you need to be able to think critically, which means being able to choose, study, and analyze data in depth. The Indonesian government has set up the Pancasila student profile in line with global standards. This profile uses critical and creative thinking skills as the main measure of graduate competency (Kemendikbud, 2022). The main point of this focus is to get young people ready to really contribute to a society based on knowledge, with a structured way of thinking and a strong dedication to new ideas (Qomariah & Supardi, 2021).

Chemistry education is important for reaching these curriculum goals, but it also has to deal with a lot of problems. Students need to be able to analyze things well because chemistry looks at abstract ideas that are very small and use symbols. Chemistry lessons that relate to real life can help students think critically (Rushiana et al., 2023), and help students learn more about science (Fauziah et al., 2024). But in real life, schools still use very different ways to teach. The old teacher-centered way of teaching chemistry is still the most common way for students to learn. This way, students sit quietly and memorize steps (Muteti et al., 2021). This clearly makes it harder to learn how to think critically and calls for more creative, flexible ways of teaching (Ali et al., 2023).

A good way to close this gap in understanding is to use a learning method called Predict-Observe-Explain (POE). This method encourages students to change their minds by making them make predictions, test those predictions by observing, and then improve their understanding by using scientific explanations.Predict-Observe-Explain (POE) is a learning method that can help you fill this gap in understanding. This method structurally encourages students to change their views by making them make predictions, test those predictions by watching what happens, and then use scientific explanations to improve their understanding (Karsli Baydere, 2021). It has been demonstrated that utilizing educational tools based on the POE framework is effective for teaching fundamental scientific skills across different educational levels (Nurika et al., 2022). Also, using POE with modern learning technologies has been shown to help students understand ideas that are hard to picture a lot (Sari et al., 2020).

This approach not only enhances what students learn but also transforms learning into an active, inquiry-based activity supported by objective evidence (Gustina et al., 2023; Wati et al., 2025). People often talk about the benefits of the POE model, but there are big problems with research when this model is used for colloidal materials. Most studies examine the POE model within the realms of static physics or environmental biology (Sari et al., 2020); Nurika et al., 2022). Colloidal materials have special properties that mix real-world usefulness with hard-to-understand ideas like Brownian motion and the Tyndall effect.

This dual nature evidently necessitates a significant degree of cognitive stimulation that has not been thoroughly investigated within the framework of the POE plan. The author has noted a scarcity of comprehensive studies that investigate the direct influence of the POE stages on the advancement of critical thinking benchmarks in colloid discussions. Consequently, this study seeks to fill this void by examining the efficacy of the POE learning plan in enhancing high school students' critical thinking skills related to colloids, thereby advancing chemistry education in Indonesia both theoretically and practically.

RESEARCH METHOD

Research Time and Location

This study was carried out at SMA Negeri 4 Pekanbaru. The collection of data occurred during the even semester of the 2017/2018 academic year.

Research Design

The study employed a quantitative methodology featuring a one-group pretest-posttest design. This design was selected to assess the efficacy of the Predict-Observe-Explain (POE) learning model by contrasting students' critical thinking skills prior to (pretest) and subsequent to (posttest) the intervention (Darmawati & Mustadi 2023). This design lets you look closely at how critical thinking skills change in a single experimental group, even though there is no control group.

Population and Sample

The research population comprised all 226 students enrolled in the 11th-grade science class at SMA Negeri 4 Pekanbaru. The sampling method employed was purposive sampling, specifically selecting the 11th-grade science class 3, comprising 36 students, as the research subjects. The teacher chose the sample because they thought the students' academic abilities were similar and the subjects were willing to use the active learning model a lot.

Research Procedure

The research methodology was executed in three methodical phases. The first step was the Preparation Stage, which included looking over material on colloid systems, making daily lesson plans, and coming up with ways to measure research. The next step was the Implementation Phase, which took place over four sessions using the POE framework for teaching and learning. The whole POE structure is used: the predicting stage to find out what students first thought, the observing stage to show what really happened, and the explaining stage to find out what students have learned (Ramdayani et al., 2023). Finally, the Assessment Phase is when you gather information from the final test results and the question-and-answer sessions.

Data Collection Techniques and Instrument

Two main ways were used to get the data: written tests and structured interviews. The written test, which had a pretest and a posttest, was meant to measure students' ability to think critically (Facione, 2023) indicators: analysis, interpretation, evaluation, and inference. At the same time, structured interviews were held with six chosen students (three with high, three with middle, and three with low ability levels) to find out how they felt about the learning process. We made sure that the measuring tools were of good quality by doing strict checks on their validity and reliability. The evaluation showed that all of the items in the instrument were valid and that the reliability coefficients met the standards set by the method (Alifah et al., 2024).

Data Analysis Techniques

Descriptive statistics were used to look at the quantitative data. Beforehand, a normality test was done to make sure the scores were spread out. We used Normalized Gain (N-Gain) analysis to figure out how much better students' critical thinking skills got. The formula was:

$$\text{N-Gain} = \frac{Score\ Posttest - Score\ Pretest}{Score\ Ideal - Score\ Pretest}$$

The computed N-Gain scores were subsequently categorized into three distinct classifications: high ($g>0.7$), moderate ($0.3\leq g\leq 0.7$), or low ($g<0.3$) classifications to evaluate the degree of enhancement. This classification, taken from (Alifah et al., 2024), serves as a standard way to measure how much students' critical thinking skills have improved. Additionally, the qualitative data derived from the structured interviews were examined through a narrative methodology. The goal of this descriptive analysis was to back up the quantitative results by giving a clear, contextual picture of the students' learning experiences that numbers alone might not be able to show.

RESULTS AND DISCUSSION

This part shows the research results and analysis in a way that is both organized and connected. The discussion will be divided into stages to meet the research goals. To start, there will be a quantitative analysis of how students' critical thinking skills have improved in general. The presentation will now move on to a more detailed look at each sub-indicator and how well students did based on their ability groups. Finally, this part will end with a critical look at the research's methodological limitations.

1. Improvement in Students' Critical Thinking Skills

Quantitative research findings indicate an enhancement in students' critical thinking abilities following engagement in POE-based learning. Table shows descriptive statistical data that summarizes the average scores on the pretest and posttest, as well as the Normalized Gain (N-Gain).

Table 1. Average Results of the Pretest, Posttest, and N-Gain for Critical Thinking Skills

n	Ideal Score	Pretest	Posttes	N-Gain	Category
36	100	32,55	75,14	0,635	Currently

Table 1 shows that the students' average score went up a lot, from 32.55 on the pretest to 75.14 on the posttest. When this increase was looked at using Normalized Gain, the average score was 0.635, which is in the "moderate" range. This finding directly addresses the primary research question regarding the efficacy of the POE learning model in enhancing students' critical thinking skills. The POE model syntax, which was 93.75% effective (in the "very good" category), helped students become active knowledge builders, which is why this intervention worked. The Predict stage compels the activation of pre-existing knowledge, the Observe stage offers empirical validation, and the Explain stage cultivates skills in evidence-based argumentation. This process is consistent with research indicating that the POE model is well-structured to cultivate and enhance students' critical thinking abilities autonomously (Alfiyanti et al., 2020).

The N-Gain score of 0.635 in the "moderate" category is a strong and realistic result for teaching methods that focus on higher-order thinking skills. The high level of syntax implementation (93.75%) is important because it shows that the "dose" of intervention was given correctly, which lets the POE syntax based on constructivism work its best. This model naturally causes cognitive dissonance at the Observe stage, when students are faced with real-world data that may go against what they thought would happen. The reconciliation process at the Explain stage is the primary cognitive "exercise." These results not only corroborate the study (Alfiyanti et al., 2020) but also back up the results of larger meta-analyses like those by (Gustina et al., 2023), which also identify the significant positive influence of POE on critical thinking skills.

2. Analysis of Improvement per Critical Thinking Sub-Indicator

According to (Ni'mah, 2022), According to Watson Glaster, critical thinking indicators have five main stages that are all connected to each other. The first step is "Recognition of Assumptions," in which students respond to and question their own assumptions and gather keywords that are related to the problem. Next, students look at arguments objectively by judging the quality of the supporting evidence and the information, and then they use deduction to come up with different answers. The process moves on to the information stage, where more data is collected and logical arguments are put together. This leads to a conclusion (inference) that helps people make good decisions and is backed up by solid proof.

Table 1 shows improvements in critical thinking skills, and these can be looked at more closely for each sub-indicator. While the overall data indicates a positive trend, a comprehensive analysis identifies specific cognitive domains in which students demonstrated the most significant enhancement. Figure 1 shows a comparison of the average scores from the pretest and posttest for the five critical thinking sub-indicators to show how the students' learning has changed over time. This picture clearly shows the difference between initial skills and proficiency after the intervention in all areas that were tested.

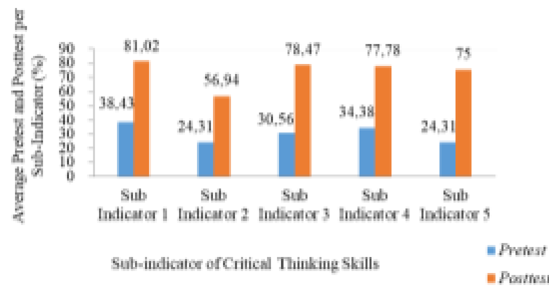

Figure 1. Results of Pretest and Posttest Critical Thinking Skills per Sub-Indicator

We do an N-Gain analysis on each sub-indicator to learn more about which areas of critical thinking skills have improved the most. This breakdown makes it easier to evaluate how well students are doing by separating the skills they have mastered from those that need more practice. The data shows the exact areas of cognition where interventions work best by organizing improvement metrics. Figure 1 shows the full results of the analysis.

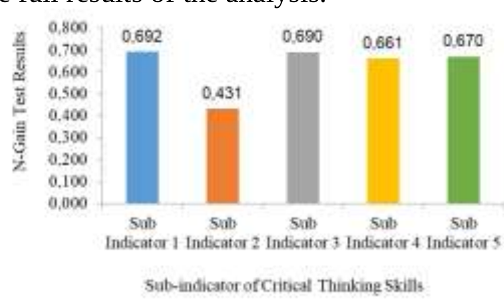

Figure 2. Comparison Chart of N-Gain Values per Critical Thinking Sub-Indicator

The graph in Figure 2 shows that the POE learning model's main strength is that it teaches students how to make simple explanations and draw conclusions. The highest N-Gain score (0.692) for the sub-indicators of answering clarification and challenging questions and the second-highest score (0.690) for the sub-indicators of deducing and considering the results of deduction show this. These results suggest that utilizing the observe-and-explain syntax facilitates students in transforming empirical data from practical work into coherent arguments. This process is a key part of learning how to think critically.

These study results are in line with those of (Safitri et al., 2024), who discovered that the POE model can greatly enhance students' critical thinking abilities. The sub-indicator that looked at how reliable a source is had the lowest improvement, with an N-Gain of 0.431. This low score shows that the POE model, which focuses on the internal inquiry process through observation and explanation activities, still needs to teach students how to think about and judge information from outside sources. Consequently, further teacher intervention is required, including discussions regarding the validity and reliability of information sources, to facilitate optimal development in this area. which also showed that the POE model makes students' critical thinking skills much better.

The analysis indicates that the elevated N-Gain values in the deduction and clarification dimensions validate the POE model's efficacy in instructing the fundamental elements of scientific argumentation. The observe stage gives proof, and the explain stage gets students to make claims and come up with reasons. The findings of these studies show that these skills are an important part of science process skills (Safitri et al., 2024).

POE is a model for inquiry that looks at internal validation, which is data from experiments. This model is not meant to be used for external validation, which means checking data from outside sources. This discovery is very important for the problems we face in the digital age, where it's important to be able to judge outside sources. As pointed out by (Putri et al., 2024), Digital literacy and critical thinking skills are now closely linked to each other. This means that the model needs to be changed, for example, to POE-W (Write) or POE-R (Read), where students have to compare what they find with outside sources and judge how reliable those sources are. Research has shown that this method works to connect POE to writing skills for making arguments (Pitaloka et al., 2024).

3. Analysis of Critical Thinking Achievement Based on Student Groups

This study performed a thorough analysis of students' critical thinking abilities using the stratification of academic ability levels, which were divided into high, medium, and low groups, in addition to reviewing general data improvements. This method was used to account for the diversity of student characteristics, allowing data interpretation to take into consideration the dynamics that took place at each distinct level of cognitive ability in addition to the overall class average. learning intervention is administered, the specific analysis at this early stage seeks to map the differences in abilities between groups and diagnose the initial conditions (entry behavior). order to guarantee that the original data is transparently described before being compared with the final results, this mapping is essential. Figure 3 shows a graphic representation of the pretest results for each ability group category.

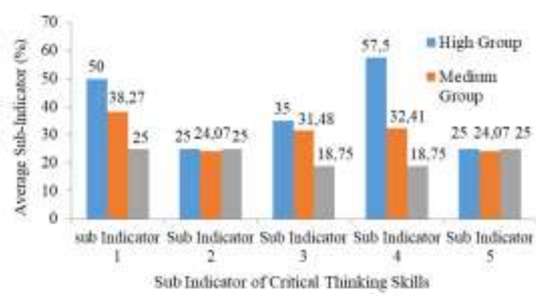

Figure 3. Pretest results

it can be seen that in the initial condition pretest) number of metrics, the students' achievements across the three groups were still inconsistent and low. high group initially performed better on sub-indicators 1 (answering questions) and 3 (deducing), they still needed to improve on other sub-indicators. The distribution of student achievement in the three groups is still uneven and comparatively low on several indicators, according to Figure 3's initial data (pre-test). The achievements on other sub-indicators were still subpar, necessitating substantial improvement, so this superiority was not all-encompassing.In particular, the high group did initially perform better on sub-indicators 1 (question answering) and 3 (deducing). achievements on other sub-indicators were still subpar, necessitating substantial improvement, so this superiority was not all-encompassing.

Additionally, a Similar analysis was done on the posttest data to see how the POE model affected the three groups. Figure 4 displays the posttest results for each group's students' critical thinking abilities.

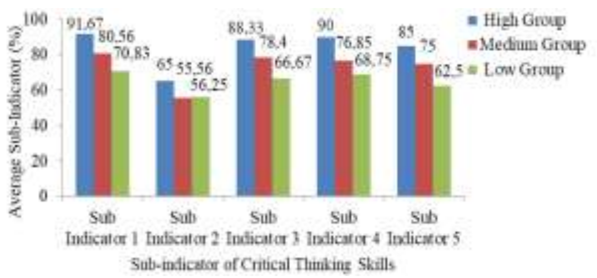

Figure 4. Critical Thinking Achievement of Each Student Group on All Sub-Indicators (Posttest)

Following participation in POE learning, all three student groups exhibit a noticeable increase (Figure 4). It is evident that on four of the five sub-indicators, high group received an excellent category (score > 80). Significantly, the medium and low groups demonstrated a notable improvement in ability, with their posttest results surpassing the high group's pretest results on numerous indicators. These results support the POE model's efficacy in enhancing critical thinking abilities across a range of student skill levels.

The results shown in Figure 4 have significant pedagogical ramifications, especially the fact that the medium and low groups' posttest scores were higher than the high group's pretest scores. This demonstrates how well the POE model serves as cognitive scaffolding. This model gives high-ability students challenges to express and validate their ideas. However, the structured syntax of POE (Predict, then Observe, then Explain) offers a clear "recipe" or cognitive workflow for scientific information processing for students of medium and low ability. They are able to "catch up" as a result, proving that POE is a reliable model for differentiated instruction in diverse classrooms (Rushiana et al., 2023).

4. Research Limitations

Even Although these results are encouraging, it's crucial to talk about the study's limitations in order to properly interpret them. A one-group pretest-posttest design without a The control group was employed. It is well known that this design is extremely vulnerable to internal validity threats like testing effect, maturation, or history (Bierer et al., 2025). In particular, the observed rise in scores (from 32.55 to 75.14) may have been impacted by outside circumstances that occurred between the pretest and posttest, students' normal cognitive development, or better performance as a result of test familiarity. Isolating the pure effect of the POE intervention is impossible without a control group.

CONCLUSION

High School students' critical thinking abilities with regard to colloid materials are effectively enhanced by the use of the Predict-Observe-Explain (POE) learning model. The average student score increased from 32.55 on the pretest to 75.14 on the posttest, indicating a moderate Normalized Gain (N-Gain) score of 0.635. By motivating students to actively expand their knowledge, the percentage of POE model steps that were implemented greatly improved learning outcomes.

POE model had the biggest impact on students' capacity to offer clear explanations (clarification) and intriguing conclusions, according to an analysis of the sub-indicators. thinking abilities were successfully developed through the phases of directly witnessing evidence (observing) and rearranging comprehension (explaining), enabling them to connect everyday observations to intricate chemical theories. However, this study revealed that students' ability to evaluate the credibility of information sources was still lacking, highlighting the necessity of incorporating digital literacy into the creation of future learning models.

Pedagogical perspective, the POE model functions as a thinking scaffold appropriate for students of all academic skill levels. to the study's findings, students with average and below-average skills actually made significant progress, even outperforming the early achievements of bright students. As a result, the POE model is strongly advised for use in chemistry classes with students of different skill levels that emphasize the development of higher-order thinking abilities.

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