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Intertextual-Based Chemistry Learning in Salt Hydrolysis Concept to Improve Students' Science Process Skills

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Abstract

Teaching with multiple representations provides a rich context for helping students overcome difficulties in understanding chemical concepts. Learning models such as POE (Predict-Observe-Explain) can enhance students' science process skills. The purpose of this study was to determine the effectiveness of the POE model in learning salt hydrolysis to improve high school students' science process skills. The method used was quantitative, with questionnaires for data collection. The research findings are as follows: (1) students are more interested in the practicum method, (2) many students do not understand the equipment used in the practicum, and (3) many students have science process skills scores lower than their cognitive scores. Therefore, science process skills must be applied to students.

Keywords: *Conceptual, Intertextuality, POE Model, Process Skills in Science, Salt Hydrolysis*

Introduction

Learning is the primary function of schools, and education engages directly with students in three main areas: cognitive, affective, and psychomotor. Therefore, specific skills are required to address various chemical problems, including concepts, theories, laws, and facts (Fajrina et al., 2020). Learners' understanding of chemical concepts can be seen from their ability to demonstrate the correlation between the macro, micro, and symbolic levels. Tertiary representations help learners understand and remember what they have learned by integrating it into their conceptual knowledge (Wiji et al., 2021).

According to Fauzi et al. (2015), teaching with multi-representational presentations provides students with a rich context for understanding a concept. Showing different representations to introduce a concept can help students better understand the concepts learned. Concept mastery refers to students' understanding of a concept through skills or knowledge (Permanasari & Hamidah, 2013). A person is said to master a concept if they truly understand it, enabling them to explain it in their own words based on their knowledge (Astuti, 2017).

Learners who understand chemistry concepts can integrate different representations and life experiences (Wu, 2003). The relationship between chemical representations and everyday experiences and classroom events can be seen as an intertextual relationship (Zulfahmi et al., 2021). Intertextuality has long been regarded as a central process in forming the meaning of foreign texts (Wiji et al., 2021). To address students' difficulties in understanding chemical concepts, chemistry instruction should be macroscopic, microscopic, and symbolic to enhance and strengthen students' comprehension of the material across different texts (Pohan et al., 2020). In this sense, it is easier for students to understand that chemical expressions relate to other texts they already know.

The skills of observing, classifying, and ultimately conducting experiments are known as Science Process Skills (SPS). These skills depict students' thinking and require logical reasoning. Teachers play a central role in teaching science process skills through the science learning process (Irwanto et al., 2017). Fundamentally, students possess learning abilities such as questioning skills, hypothesis formulation, investigation (experiment planning), observation, classification, prediction, interpretation, and communication (Wulandari et al., 2022). Scientific process skills also encompass cognitive or intellectual, procedural, social, and communicative skills (Suyanti, 2018). This skill is divided into two groups: basic process skills and integrated skills (Ngozi, 2021). According to Bakri et al. (2015), skills of basic processes include observation, inference, measurement, communication, classification, and prediction, while integrated process abilities involve checking and determining operational variables, formulating hypotheses, interpreting data, experimenting, and formulating models.

According to Fajrina et al. (2020), science process skills (SPS) are among the most crucial skills for students to achieve their full potential. The concepts of SPS and mastery of science content are two sides of the same coin in science learning and thus cannot be separated (Permanasari & Hamidah, 2013). These two aspects are interconnected and mutually reinforcing. Science process skills involve all students' abilities to gain knowledge based on phenomena (Syafi'ah et al., 2022). Since process skills can be defined as an insight or inspiration for developing intellectual, social, and physical skills that stem from fundamental abilities that are principally present in students, science process skills must be applied to students.

This study employs the POE (Predict-Observe-Explain) learning model to address the issue, which can optimize students' scientific process skills. According to Utama (2019), POE learning is grounded in constructivist theory, which is closely related to process skills. The POE learning model emphasizes a constructivist approach, such as prediction, where students are asked to predict a phenomenon. Additionally, it involves validating assumptions through observation, discussion, and participation in experiments or practices to obtain information and provide explanations regarding the alignment between predictions and observations (Kurniawan et al., 2022). Meanwhile, according to Rozana et al. (2018), the POE model is described as a learning model where students start by predicting solutions to problems (predict), then observe to validate predictions (observe), and finally explain their observations (explain).

According to (Wulandari et al., 2022), the advantages of the POE learning model encompass five aspects: 1) it can be used to discover students' ideas, 2) it provides information to teachers about students' thinking, 3) it fosters discussions, 4) it encourages students to explore concepts, and 5) it stimulates a desire for exploration. However, the POE learning model has its disadvantages: 1) it requires more profound preparation, especially in presenting operational physics problems to validate students' predictions; 2) it necessitates appropriate tools and materials; and 3) it demands that teachers possess specific skills and abilities, thus requiring them to perform more professionally, which assumes good intentions and motivation from teachers for the success of student learning. Teachers can select the appropriate and effective learning model to achieve educational goals (Masyitrah et al., 2021).

Many studies have been conducted to demonstrate students' understanding of salt hydrolysis. These studies indicate that many students need help to grasp the concept of salt hydrolysis. According to interviews conducted by researchers at SMA/MA Sleman, it is evident that there are still many students whose scientific process skills are lower than their cognitive scores. Therefore, this study aims to analyze "Chemistry Learning Based on Intertextuality on the Concept of Salt Hydrolysis and Enhancing Students' Scientific Process Skills."

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Method

This research is quantitative, using a questionnaire for data collection. Quantitative research is research that uses measurements, calculations, formulas and certainty of numerical data in planning, processes, building hypotheses, techniques, and analyzing data (Abdussamad, 2022). Quantitative research is conducted systematically and continuously from the beginning. Each piece of data is described with statistical measures that can be quantified and empirically tested (Waruwu, 2023). Data collection techniques or methods involve researchers using a questionnaire with a series of questions to gather information from respondents (Syahrizal & Jailani, 2023). This approach is employed to obtain data needed for the research (Djollong, 2014). The POE learning model was chosen, consisting of three stages: Predict, Observe, and Explain. This study aims to enhance high school students' scientific process skills.

The research site for the purposive sampling method is aimed at samples chosen not based on a random, stratified, or regional basis but for specific purposes. The subjects of this study are high school students in grade XI of the Science program in the second semester of the 2023/2024 academic year. The sample selected is from grade XI high school students in Sleman. The research design includes two groups, each selected randomly. One class is the experimental group, and another is the control group. The first group receives no special treatment or standard treatment (X2) as the control group, while the second group receives special treatment as the experimental group (X1).

Table 1. Research Desain

Groups	***Pre Treatment***	***Treatment***	***Post Treatment***
Experiments	Y1	X1	Y2
Controls	Y1	X2	Y2

Determining the research site by the purposive sampling method aims to select samples based on a specific purpose rather than random selection, stratification, or region. The subjects of this study were high school students in grade XI of the Science program during the second semester of the 2023/2024 academic year. The sample selected came from class XI high school students in Sleman. The research design included two groups, each of which was randomly selected. One class was the experimental group, while the other was the control group. The control group (X2) received no special or standard treatment, while the experimental group (X1) received special treatment.

The first step in the research procedure was to review the problems occurring at the school and examine previous research on learning using the POE (Predict-Observe-Explain) learning model. The second stage involved preparation, including the development of teaching materials and the creation of instruments. The third stage was validation, which involved material experts assessing content, integration, and presentation aspects and media experts validating display, typography, media organization, language, and communication aspects. The fourth stage involved determining the sample (experimental or control class) and conducting tests. Finally, questionnaires were administered to assess student responses to implementing the learning process.

Results

After conducting research according to procedural stages, the data analysis results of both classes' affective and psychomotor domains were analyzed using N-gain to assess improvement. The obtained analysis results are as follows:

Table 2. Improvements in Affective Domain Scores

Source of Variation	Experiment Class			Control Class		
	I	II	III	I	II	III
Max Value	91,67	95,83	95,83	75,00	83,34	95,83
Min Value	58,34	75,00	79,16	54,16	58,34	66,57
Average	75,05	85,41	87,49	64,58	70,84	81,20
Criteria	Good	Very Good	Very Good	Good	Good	Very Good

The research findings indicate that qualitatively, there was a significant improvement in the average scores of the affective domain between the experimental class using the POE (Predict-Observe-Explain) learning model and the control class using conventional methods. In the experimental class, there was a notable increase in average scores from the first to the third session, particularly in the aspect of engagement, which continued to rise to an average score of 93.33 by the third session. Meanwhile, in the control class, the average score started at 65.66 in the first session, increased to 75.83 in the second session, and rose to 80.16 in the third session. This demonstrates that the POE learning model has a more significant impact on enhancing student engagement and effective learning outcomes (Restami, 2019). According to the research results (Yani & Arjaya, 2021), POE encourages students to be more active, think critically, and participate in the learning process, resulting in a more significant increase in affective domain scores compared to conventional teaching methods in the control class.

Table 3. Average Scores for Each Affective Aspect in the Experimental Class and Control Class

Num.	Aspects	Scores			
		Experiment Class	Criteria	Control Class	Criteria
1	Student attendance in class.	3,96	Very High	3,36	Very High
2	Discipline in attire.	3,76	Very High	3,23	High
3	Student readiness to participate in the learning process.	3,76	Very High	3,23	High
4	Student seriousness in engaging in the learning process.	3,46	Very High	3,03	High
5	Responsibility towards assignments.	3,40	Very High	3,20	High
6	Attitude and behavior.	3,60	Very High	3,26	High

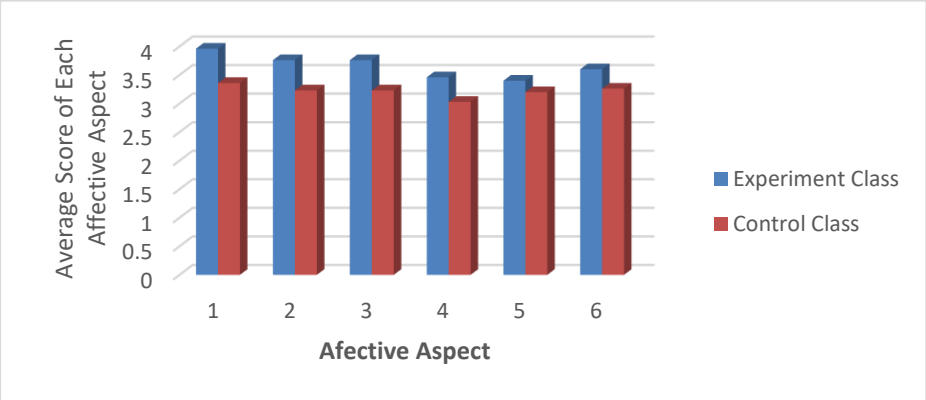


Figure 1. Diagram Comparing Average Scores for Each Affective Aspect

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Based on Table 1 and Figure 1, the average values for each aspect of student affective scores in the experimental and control classes generally fall within the same criteria. However, there is a quantitative difference between the two classes; specifically, the average affective scores in the experimental class are higher than those in the control class. This indicates that learning outcomes in the affective domain are better in the experimental class than in the control class.

Table 4. Improvement of Psychomotor Domain Scores

Source of Variation	Experiment Class			Control Class		
	I	II	III	I	II	III
Max Value	72,22	86,11	92,67	61,11	75,00	86,11
Min Value	52,78	72,78	80,56	52,78	58,34	75,00
Average	62,50	79,45	86,61	56,94	66,67	80,56
Criteria	Good	Good	Very Good	Good	Good	Very Good

Based on Table 3, the average scores of the psychomotor domain in the experimental class are higher than those in the control class. In the experimental class, students scored 92.67 for basic competency in the psychomotor domain, reaching the excellent criteria. In contrast, the control class scored 86.11, meeting the excellent criteria. These results were obtained because before conducting the practicum, both classes explained how to use the tools and materials as the students' first introduction in the classroom before entering the laboratory.

Table 5. Average Scores for Each Psychomotor Aspect in the Experimental and Control Classes

Num.	Aspects	Score			
		Experiment Class	Criteria	Control Class	Criteria
1	Students' preparation for conducting practical work	3,00	High	3,00	Very High
2	Proficiency in using a dropper pipette	3,53	Very High	3,26	High
3	Ability to drop solutions onto a spot plate	3,96	Very High	3,36	High
4	Students' proficiency in using litmus paper	3,73	Very High	3,30	High
5	Students' ability to measure the pH of solutions using universal indicator	3,53	Very High	3,16	High
6	Proficiency in conducting experimental tasks	3,56	Very High	3,06	High
7	Cleanliness and tidiness of the experimental area	3,83	Very High	3,16	High
8	Students' ability in report writing	3,83	Very High	3,06	High
9	Students' ability in group dynamics	4,00	Very High	3,20	High

The results of the analysis of each psychomotor aspect can also be seen in Figure 2.

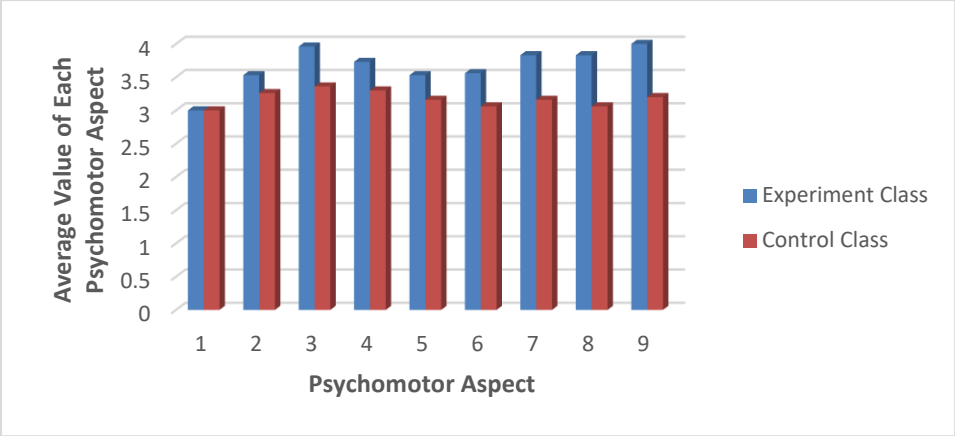


Figure 2. Comparison of Average Scores for Each Psychomotor Aspect

Table 4 and Figure 2 show significant differences between the two classes in aspects 3, 7, 8, and 9, with varying criteria. Meanwhile, aspects 1, 2, 5, and 6 show both classes performing high. However, quantitatively, the average psychomotor scores of the experimental class are higher than those of the control class. This indicates better learning outcomes in the psychomotor domain for the experimental class compared to the control class.

Table 6. Improvement of SPS Domain Scores

Num.	SPS Aspect	SPS Percentage (%)						Average	
		Experiment			Control				
		Prac 1	Prac 2	Prac 3	Prac 1	Prac 2	Prac 3	EK	KO
1	Observation	73,34%	85,48%	86,29%	60,00%	62,50%	62,50%	81,70%	62,00%
2	Formulating Hypotheses	71,67%	73,38%	91,12%	58,33%	67,50%	67,50%	78,72%	64,44%
3	Planning Experiments	66,93%	96,77%	93,54%	61,16%	65,56%	65,56%	85,75%	64,09%
4	Using Tools and Materials	53,05%	85,84%	93,62%	53,06%	60,83%	60,83%	77,50%	58,24%
5	Prediction	58,87%	74,19%	89,51%	58,40%	60,83%	68,30%	74,19%	62,51%
6	Classification	51,61%	82,25%	93,54%	50,00%	68,30%	70,83%	75,80%	63,04%
7	Interpretation	58,87%	82,25%	88,70%	60,00%	70,83%	70,83%	76,61%	67,22%
8	Applying Concepts	58,87%	77,41%	90,32%	50,00%	63,30%	63,30%	75,53%	58,87%
9	Communication	59,72%	76,95%	97,78%	58,84%	64,72%	64,72%	78,15%	62,76%

Results of the analysis of each psychomotor aspect can also be seen in Figures 3 and 4.

Based on the data table, it is evident that students in the experimental class showed significant improvement in their science process skills from session 1 to session three compared to those in the control class. The differences in scores are notable, with the experimental class achieving the highest average scores in observation (81.70%), experiment planning (85.75%), and hypothesis formulation (78.72%). In contrast, the control class scored below 70% in these aspects.

Observations indicate that the experimental class was able to draw accurate conclusions. This can be attributed to pre-practicum exercises where students were tasked with predicting the material to be learned regarding salt hydrolysis and understanding related concepts. Predictive skills scored 74.19%, classification 75.80%, and concept application 75.54%, ranking lowest among all aspects.

The POE learning model proved more effective in enhancing experiment planning, hypothesis formulation, and communication skills than conventional methods in the control

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class. Factors contributing to these results include active student engagement, a more interactive classroom environment, and opportunities for participation in discussions and experiments. Additionally, POE encourages critical and analytical thinking, providing relevant firsthand experiences that lead to more significant improvements in their affective domain.

The results of the control class SPS analysis for meetings 1 and 2 towards learning can also be seen in Figure 3:

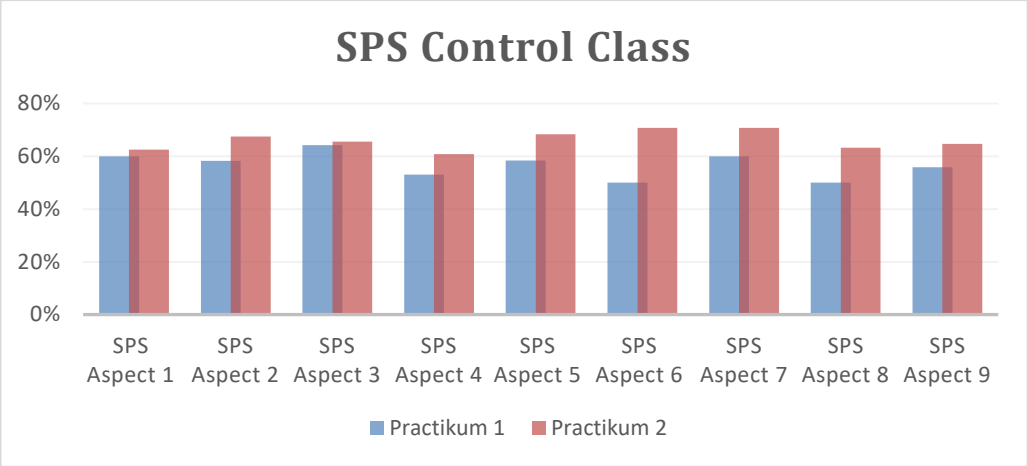


Figure 3. Comparison of Average Scores for Each SPS Control Class

The results from the diagram showing the improvement in Science Process Skills (SPS) in the control class are presented in Figure 3. There is an increase in the score for aspect 5, prediction, from 58.40% in the first practicum to 68.30%. Furthermore, aspect 6, which involves classification, shows an improvement from a score of 50% to 70.83%. Similarly, aspect 7, which focuses on interpretation, increased from a score of 60% to 70.83%. Despite these improvements, the results obtained in the control class are still significantly lower than those from the experimental class. This discrepancy is attributed to the control class only using conventional teaching methods, such as lectures. In contrast, the experimental class utilized the POE (Predict-Observe-Explain) learning model, which has been proven to enhance students' science process skills.

The results of the experiment class SPS analysis for meetings 1 and 2 towards learning can also be seen in Figure 4:

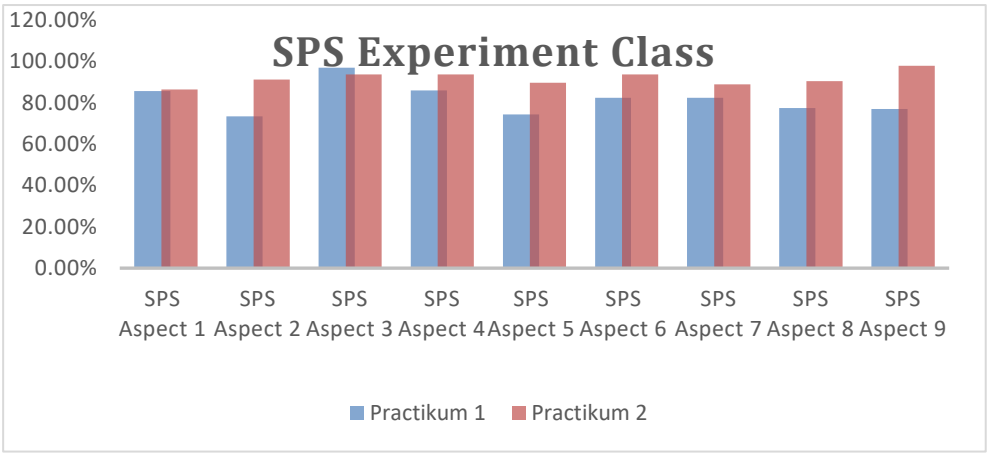


Figure 4. Comparison of Average Scores for Each SPS Experiment Class

The diagram's results showing the improvement of Science Process Skills (SPS) in the experimental class are presented in Figure 4. There is a noticeable increase in scores for aspect 5, prediction, which rose from 74.19% in the first practical session to 89.51%. Similarly, aspect 6, involving classification, increased from 82.25% to 93.54%. Furthermore, aspect 7, which focuses on interpretation, improved from 82.25% to 88.71%. Additionally, aspects related to planning experiments, applying concepts, and communication experienced significant increases from the first to the last session. Therefore, the use of the POE (Predict-Observe-Explain) learning model in the topic of salt hydrolysis enhances students' science process skills more effectively than the conventional model.

In the final session of the study, students received a review of the learning experiences from the previous three sessions. Subsequently, a questionnaire was distributed to assess student reception towards the POE learning model. The survey results are detailed in Table 6:

Table 7. Results of Student Feedback on Learning

Num.	Questionnaire Item	Responses			
		SNA (%)	NA (%)	A (%)	SS (%)
1	I feel happy and motivated to participate in chemistry lessons that apply the POE model.	0,0	0,0	66,7	33,3
2	The material on salt hydrolysis presented through the POE model is easy to understand.	0,0	10,0	70	20,0
3	The application of the POE model motivates me to generate questions actively.	0,0	13,3	66,7	20,0
4	Implementing the POE model encourages me to respond to questions or issues that arise actively.	0,0	0,0	73,3	16,7
5	Predictive activities, such as reading material and solving problems before lessons begin, greatly help me understand the topic of salt hydrolysis.	0,0	0,0	63,3	23,3
6	Observation activities or lab work assist me in answering predictions and significantly enhance my understanding of salt hydrolysis due to hands-on practice.	0,0	0,0	20,0	60,0
7	Explanation activities or conclusions at the end of lessons help me explain the differences between predictions and experimental results.	0,0	0,0	43,3	56,7
8	Applying the POE model sparks my curiosity to investigate and validate its predictions.	0,0		33,3	60,0
9	Implementing the POE model helps me improve my engagement in lessons.	0,0	0,0	53,3	46,7
10	Besides the core material on salt hydrolysis, applying the POE model also benefits other subjects.	0,0	0,0	56,7	43,3

The results of the analysis of students' responses to the learning can also be seen in the figure 5:

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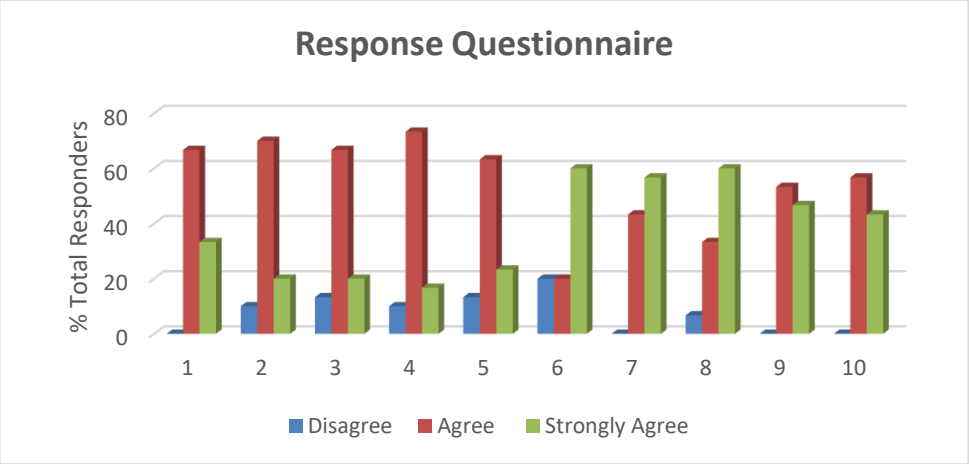


Figure 5. Diagram of Learner Response Questionnaire

Based on Table 6 and the diagram in Figure 5, students responded positively to using the POE (Predict-Observe-Explain) model in learning. The questionnaire analysis of students' responses in the experimental class, which utilized the POE learning model, indicated a favorable reception. Specifically, in one response, 26 students stated that preliminary activities, such as reading materials and solving problems before the commencement of learning, aided their understanding of salt hydrolysis. This suggests that engaging with the material and solving problems beforehand enhances students' initial comprehension, making the subsequent presentation of the material more accessible.

Furthermore, in another response, 28 students reported that the POE learning model effectively captured their attention during lessons, as they could directly engage with the material through practical activities. Based on the students' initial responses, 20 agreed, while ten strongly agreed. Thus, 30 students expressed happiness and motivation to participate in chemistry lessons that employed the POE learning model.

Discussion

The feasibility of the learning devices is based on the results of expert validator assessments of the Learner Worksheet content/material products. Based on the results of expert validation, the material is declared valid with revisions. To access the learning LKPD, please visit the following link: http://bit.ly/46bOIPL. The diversity of student characteristics is a unique aspect that needs to be understood by teachers. The interaction between the learning model and learning style affects understanding chemical concepts and science process skills (Pamungkas et al., 2017). The most significant effect was the interaction between the POE learning model and practicum (Samudera et al., 2017). The research found that students with difficulty understanding material concepts can be identified quickly using the POE model. The speed at which students with difficulty understanding concepts are diagnosed allows immediate intervention during the observation and explanation stages. Explaining concepts becomes more accessible for students with difficulty learning during these stages because it uses concepts familiar to their lives.

Based on the data presented in Table 5, it is evident that students experienced significant improvement in their science process skills, especially in the experimental class that used the POE (predict-observe-explain) learning model. The observation sheet data analysis showed that the prediction aspect scored 74.19%, falling into the excellent category. After analyzing the

observation sheets from the first and second practicums, it was found that students experienced a significant improvement in their science process skills, particularly in the experimental class. This improvement is attributed to using the POE (predict-observe-explain) learning model.

The observation sheet data analysis showed that the prediction aspect scored 74.19%, falling into the excellent category. After analyzing the observation sheets from the first and second practicums, it was found that some students needed help with predicting and estimating the pH of the solution. This difficulty may be due to a need to understand acid-base chemistry and pH in solution, negatively affecting their prediction ability. This finding aligns with Yani and Arjaya (2021), who noted that such issues arise when students connect previously learned concepts through self-reflection. This process enhances understanding and recall and fosters student engagement in discussing observations while working in groups. It also allows students to interact with classmates, openly considering different points of view from both peers and teachers.

Regarding the prediction skill, analysis of the observation sheet data revealed an average percentage of 81.70%, categorized as very good. The observation sheets indicated that students were proficient in observing changes in litmus paper and universal indicators. Observers noted that students could observe color changes in litmus paper and universal indicators effectively, possibly because they were briefed on using them before the lab activity. According to the researcher's observations, students performed optimally during lab sessions by correctly using their senses for observations, ensuring smooth processes. In the third session, they predicted pH differences theoretically and practically. The experimental class achieved an excellent score of 75.80%, while the control class scored 63.04%, indicating significant differences influenced by their respective learning models. The POE model encourages questioning and opinion expression, enhancing understanding, as Fernanda et al. (2019) noted, where group interactions during the Explain stage promote critical thinking through peer discussions and Q&A activities.

The basis of classification skills (explain stage) is the ability to identify differences and similarities between various observed objects (Andriyani et al., 2021). The results of the analysis and observation of the classification aspect show that the observation sheet data for the experimental class has a percentage value of 75%, categorized as good. In contrast, the control class results show a poor value in the classification aspect, with a percentage of 63%. The POE model encourages questioning and expressing opinions, thereby improving understanding, as noted by (Fernanda et al., 2019), where group interaction during the Explain stage fosters critical thinking through peer discussions and question-and-answer activities. The application of the POE model positively impacts students' understanding of concepts and activities in learning, as they can present previously held concepts (prediction stage), search for and process data (observation stage), and provide explanations related to prediction answers with observation results (explanation stage) (Juniwati, 2020).

Research on applying the POE (Predict-Observe-Explain) model in chemistry learning demonstrates its relevance to previous studies highlighting improvements in students' science process skills. According to (Yunita, 2014), the POE model significantly enhanced students' science process skills regarding the human digestive system. Students taught using the POE model exhibited better science process skills compared to those who learned through conventional methods. Supporting these findings, Hidayah & Yuberti (2018) reported a t-test result showing a t-value of 5.367, higher than the critical t-value of 1.992 at the 0.05 significance level, indicating a significant effect of the POE model. Furthermore, Pohan et al. (2020) observed that after applying intertextual-based learning with the POE model on salt hydrolysis material, students' science process skills increased from an average of 74.31% to 81.11%. The analysis revealed a higher N-gain value for the experimental class, which was 92.28 and classified as

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effective, compared to the control class, which had an N-gain value of 77.46, also classified as adequate.

Conclusion

Improving students' scientific process skills in chemistry learning using the POE model is superior to conventional learning models. Affective and psychomotor assessments indicate that the POE model is more effective, supported by statistically significant test results. Students' scientific process skills, such as observation, questioning, hypothesis formulation, experiment planning, use of tools/materials, prediction, classification, interpretation, application of concepts, and communication of results, also show more significant enhancement in the experimental class. In conclusion, the POE learning model significantly enhances students' scientific process skills compared to conventional models.

Acknowledgment

All authors contributed to the conception and design of the research. From the initial stages to completion, including preparation of materials, data collection, analysis, data presentation, and final editing, these tasks were performed by Izzatul and guided by Setia Rahmawan. Therefore, each author played a role and contributed to the manuscript's completion.

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