Predict–Observe–Explain Strategy Using Household Materials: Enhancing Grade 10 Students' Mastery of Chemical Reactions

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ABSTRACT

Public secondary schools in the Philippines often face difficulties in teaching chemistry as a result of having limited access to laboratory facilities, which hinders students' understanding of chemical reactions. Even though the Predict-Observe-Explain (POE) method has proven to be effective in the context of science education, there is still a lack of evidence on its use with everyday household materials in classrooms where resources are scarce. This study aims to fill that gap by examining how effective the POE approach is when it makes use of household materials in improving students' understanding of chemical reactions. A quantitative, quasi-experimental one-group pretest–posttest design was carried out with nineteen students who were deliberately chosen for the study. The two-week intervention involved inquiry-based learning activities that used household materials easily available to students. Students' conceptual understanding was measured using a validated 15-item achievement test that corresponds to the K to 12 Grade 10 Science Curriculum. The mean score rose from 4.84 in the pre-test to 7.58 out of 15 in the post-test. A paired-samples *t*-test showed a statistically significant improvement in performance, $t(18) = -5.60$, $p < .001$, with a large effect size (Cohen's $d = 1.285$). The results show that the POE strategy can effectively improve students' conceptual understanding of chemical reactions when it is applied with household materials and presents a novel, practical, and cost-efficient way of teaching chemistry in science classes that have limited laboratory resources. The study offers evidence in support of a contextualized and learner-centered method of teaching chemistry in educational settings with limited resources.

Keywords: *chemical reactions, household materials, inquiry-based learning, predict-observe-explain, science education*

INTRODUCTION

The Programme for International Student Assessment (PISA), set up by the Organisation for Economic Co-operation and Development (OECD), is an international assessment conducted every three years to examine the skills of 15-year-old students in reading, mathematics, and science. Rather than depending only on the ability to recall content, PISA judges students' capacity to use their scientific knowledge and skills in order to interpret real-world situations by means of scientific reasoning, problem-solving and the evaluation of evidence. In contrast to traditional examinations that stress content recall, PISA measures students' ability to apply their science knowledge and skills to real-life situations by getting them to engage in scientific reasoning, problem-solving, and the interpretation of evidence (Hartono et al., 2022). It thus acts as a useful indicator of the extent to which education systems succeed in helping students apply scientific knowledge to real-world situations rather than simply memorizing facts.

The Philippines took part in PISA for the first time in 2018, and it was found that students' scientific literacy was significantly lacking. The average science score for Filipino learners was 357 points, significantly below the OECD average of 489 points; only 22% of learners achieved the minimum level of scientific proficiency (Level 2 or higher), compared to 78% in OECD countries. The learning gaps that emerged in PISA 2018 also appeared in PISA 2022. The country showed no significant gains in science performance, as evidenced by the mean score in the science section (356) in 2022 being lower than in 2018 (357) (Bernardo et al., 2023; Cabural, 2024; Acido & Caballes, 2024). A gap of about 20 PISA points is equivalent to one year of schooling, and Filipino learners' scores indicate that they still have large learning deficits in science (Acido & Caballes, 2024).

Filipino learners' underperformance in science is attributed to multiple factors involving learners, teachers, and systemic issues. Previous research has associated low science achievement with socioeconomic disadvantage, low learner motivation, limited science self-efficacy, language barriers, insufficient teacher qualifications, poor-quality teaching materials, and inconsistencies in curricular implementation (Cabural, 2024). The problems are most evident in public secondary schools, particularly in rural and remote areas, because the lack of adequate educational resources limits access to good science education. As a result, students have fewer opportunities to gain the scientific knowledge, inquiry skills, and problem-solving abilities that the present science curriculum requires.

Chemistry is one of the most conceptually difficult subjects in secondary school science, and there are serious problems evident in it. It is essential to be able to link observable phenomena with symbolic representations and with the processes that take place at the submicroscopic level if one is to understand chemistry, although this is often a difficult task, particularly when it comes to abstract topics like chemical reactions (Rahmi & Azra, 2023; Chonillo-Sislema et al., 2024). A study carried out in the Philippines with Grade 11 students who were not following STEM tracks revealed that 88.9% of them could not achieve the competencies required in chemistry for Grades 7 to 10, with chemical reactions being regarded as one of the most difficult subjects (Melitante et al., 2025). The students themselves said that the reasons for their difficulties were the abstract character of the chemistry concepts, a lack of reinforcement activities, and the absence of hands-on experiments, thus highlighting the need for chemistry teaching to become more meaningful and contextualized.

Further difficulties are encountered when learning about chemical reactions due to environmental limitations. Since laboratory work is a basic part of chemistry, it allows students to see phenomena directly, check scientific ideas, and link theory with practical evidence. In many secondary schools in the Philippines, especially in rural and geographically isolated regions, laboratory facilities, equipment, and teaching materials are still inadequate (Pacadaljen, 2024). Consequently, practical exercises are frequently substituted by teacher demonstrations, videos, or computer simulations. Although these alternatives can show scientific concepts, they offer fewer chances for students to investigate phenomena, form scientific explanations based on evidence, and build inquiry skills through hands-on experimentation (Pacadaljen, 2024; Monta & Perdio, 2025).

The problems in question are not limited to particular areas of the Philippines, as evidence from different regions shows. In both Ilocos Norte and Bataan, studies (Gonzales et al., 2025; Monta & Perdio, 2025) have identified inadequate laboratory facilities, limited technical assistance for the laboratories, insufficient teacher training, and heavy workloads as common difficulties. Taken together, these findings indicate that improved chemistry teaching should involve pedagogical methods that promote conceptual learning and scientific inquiry yet are feasible in classrooms with limited resources. Since teaching chemical reactions it is necessary to provide students with opportunities to observe, investigate, and explain chemical phenomena in order to achieve meaningful learning, such methods are particularly important.

Given these difficulties in teaching, there is an increasing need to use teaching methods based on inquiry that are appropriate for classrooms with limited resources and which manage to get students involved. The Predict-Observe-Explain (POE) approach is a type of instructional model grounded in constructivism and helps bring about conceptual change by asking students to predict the outcomes of scientific phenomena, observe them through experimentation, and then explain the differences between their predictions and what they observe (Yang, 2023; Chen, 2025; Mirabueno & Paderna, 2023). Instead of simply receiving information, students express their existing knowledge, compare it with empirical data, and improve their understanding through discussion and reflection. Research has consistently shown that POE leads to better conceptual understanding, improved scientific reasoning, and greater academic achievement, especially in cases concerning topics that involve abstract concepts and persistent misconceptions (Ünlü, 2024; Gustina et al., 2023; Yudi et al., 2024).

Household items, since they are easily obtained, can be used in chemistry lessons to increase the effectiveness of the POE method. Things like baking soda, vinegar, and candles give students the chance to see physical and chemical changes firsthand. By using these materials, the concepts of chemical reactions can be presented in situations that are familiar to students, making them more concrete, relevant, and meaningful, and thus encouraging their active involvement in inquiry-based learning. Research shows that activities carried out outside of the normal laboratory environment can improve students' understanding of concepts, their engagement in class, and their achievement in learning (Hulu & Damarsari, 2025). As a result, using household materials with the POE approach provides a sound and practical way of teaching chemical reactions in public secondary schools that have limited resources.

Research carried out in the past has shown that the Predict–Observe–Explain (POE) method is effective in enhancing students' understanding of scientific concepts and in the benefits of carrying out science activities at home. Yet, most of the studies have been carried out separately or outside the junior high school chemistry context. Moreover, there has been only limited research into the application of the POE method using household materials for teaching chemical reactions in public secondary schools in the Philippines, a country where laboratory facilities are scarce and inquiry-based learning is restricted. In order to fill this gap, the current study examined the effectiveness of the POE strategy combined with household materials in improving students' understanding of chemical reactions. The study offers evidence for an inquiry-based, contextually relevant, and low-cost method of teaching that can help to improve science learning and increase access to education in schools which do not have sufficient laboratory resources.

STATEMENT OF THE PROBLEM

This study aimed to determine the effect of using the Predict-Observe-Explain (POE) method with materials found at home on Grade 10 learners' understanding of chemical reactions. Specifically, it sought to answer the following questions:

1. What is the level of mastery of Grade 10 students in chemical reactions before the implementation of the POE strategy using household materials?

2. What is the level of mastery of Grade 10 students in chemical reactions after the implementation of the POE strategy using household materials?

3. Is there a significant difference in the mastery of Grade 10 students in chemical reactions before and after the implementation of the POE strategy using household materials?

METHODS

Research Design

The study employed a quantitative research approach using a quasi-experimental, one-group pretest-posttest design to examine the effect of the POE instructional strategy using household materials on Grade 10 students' mastery of Chemical Reactions. The study began with a pre-test to establish the learners' baseline level of mastery, followed by the implementation of the POE-based intervention and a post-test to determine changes in performance after the intervention. This quasi-experimental design was appropriate because the study used an existing classroom section rather than randomly assigning students to experimental and control groups (Al-Buraiki et al., 2025; Singh, 2021). The pre-test and post-test results were then compared to determine whether students' mastery changed significantly following the intervention (Nayeri et al., 2024; Mara, 2025).

Participants & Locale of the Study

The participants in the study were 19 students in Grade 10 from the group that had the lowest mean score on the preliminary pre-test concerning Chemical Reactions; the preliminary pre-test had been given to all of the Grade 10 classes to assess their initial level of mastery. After identifying the section with the lowest mean performance, it was purposively selected as the target group because it represented the group with the greatest identified need for instructional intervention. The 19 learners included in the study were those present during the administration of the pre-test and who participated in the succeeding intervention and post-test.

The study was conducted at Southern Samar National Comprehensive High School, located in San Lorenzo Street, Poblacion 1, Balangiga, Eastern Samar. The intervention was implemented in the participants' regular classroom during scheduled Science sessions. This classroom setting provided a familiar learning environment in which household materials could be used to facilitate hands-on observation and discussion of chemical phenomena.

Innovation, Intervention, and Strategy

This study implemented a two-week intervention in which the POE strategy was used to teach Grade 10 students to understand chemical reactions conceptually. The intervention covered three main topics: changes in matter (physical and chemical changes), types of chemical reactions, and balancing chemical equations.

The POE strategy was integrated into the 7Es model of instruction, specifically the Explore and Explain phases. In the Explore phase, students actively engaged in inquiry learning through experimentation with readily accessible materials found at home. In the Explain phase, they verbalized their observations and were guided by the teacher to form scientifically accurate concepts. This approach enabled students to engage in inquiry-based learning while also learning scientifically accurate concepts.

For this study, a systematic method was used, which involved two stages: the first concerned with preparation and the other with implementation, to promote an understanding of chemical reactions, as shown in Figure 1. In the first phase, attention was given to the instructional materials and preparation, while in the second phase, the POE strategy was put into practice.

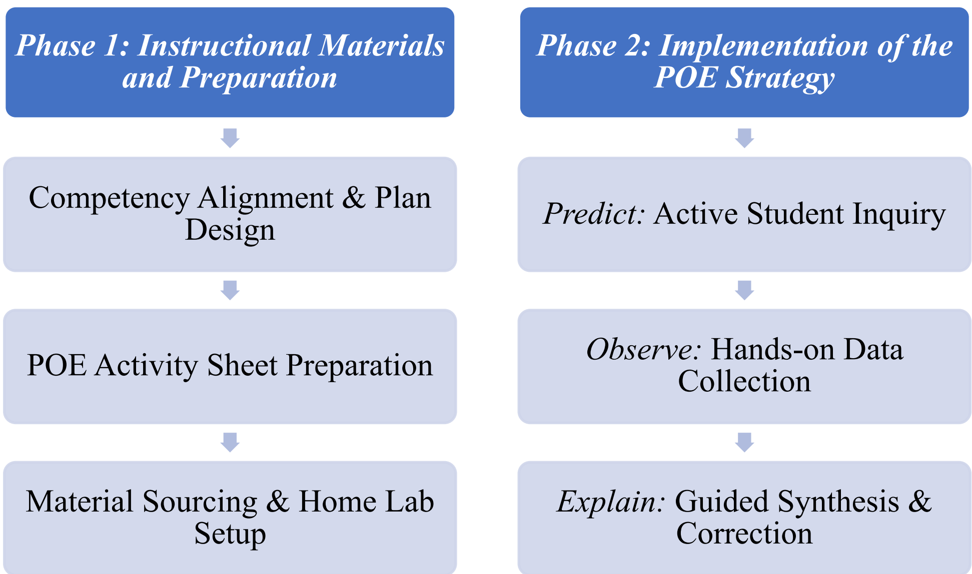

Figure 1. The POE-integrated instructional intervention process

Phase 1: Instructional Materials and Preparation

Before the intervention, the researchers developed and aligned the teaching materials to the Grade 10 Science competencies. This involved preparing lesson plans using the POE strategy and activity sheets to guide students through the various stages of POE. Each activity sheet for the hands-on experiment required students to write predictions, record observations, and construct explanations.

The experiments were carefully planned using safe, inexpensive materials such as vinegar, baking soda, sugar, candles, yeast, hydrogen peroxide, warm milk, *Gumamela* extract, aluminum foil, balloons, bottles, glass jars, and tarnished coins. These materials were chosen to mimic a science laboratory, even when no science laboratory was available.

Phase 2: Implementation of the POE Strategy

The intervention was conducted through a student-centered inquiry process:

Predict. Students started with demonstrations related to chemical reactions. They were required to make predictions and explain their predictions based on what they already knew.

Observe. Students conducted experiments in small groups using familiar materials. These experiments involved: (1) illustrating physical and chemical changes using sugar, candle, baking soda, and vinegar; (2) exploring chemical reactions using yeast, hydrogen peroxide, *Gumamela* extract, and other substances; and (3) relating reactions to chemical equations. Students observed gas bubbles, color changes, temperature changes, and the formation of new substances.

Explain. During the reflection, students discussed their observations and how these related to their predictions. They then developed their own explanations, using evidence from the activity. The teacher guided the discussion through "how" and "why" questions, explained misconceptions, introduced relevant science concepts and terms, and provided examples relating chemical reactions to everyday situations. Students were also assessed during this time.

Research Instruments

The study utilized three POE-based learning plans and a researcher-developed 15-item multiple-choice achievement test administered as a pre-test and post-test. The learning plans addressed the Grade 10 Science competencies on Chemical Reactions and incorporated the POE sequence using safe and readily available household materials. The achievement test was developed from the content covered in the learning plans and aligned with the relevant competencies of the Grade 10 Science K to 12 Curriculum of the Department of Education.

The researcher-developed test underwent content validation by two experienced educators: one Teacher III with more than 15 years of experience in Chemistry instruction and one Head Teacher III responsible for instructional supervision and quality assurance. The validators evaluated the test items for clarity, scientific accuracy, appropriateness, and alignment with the intended Grade 10 Science competencies and cognitive demands. The instrument received 100% consensus approval before administration. The researchers used their comments and recommendations to revise the instrument.

Data Gathering Procedure

The researchers first obtained the school principal's permission before carrying out the study; having received this permission, the researchers then contacted the parents and the learners and secured the required informed consent. The participants were made aware of the aim of the study, the procedures that would be involved, and the fact that their participation was voluntary.

A preliminary pre-test on chemical reactions was given to all the Grade 10 classes to assess their initial level of proficiency. The mean scores of the different classes were compared, and the class which had the lowest mean score was designated as the group to which the intervention would be applied. The study participants consisted of nineteen learners from this class who were present when the pre-test was administered and who also took part in the later research activities.

The POE intervention took place during ordinary Science lessons over a period of 10 instructional days and included three lessons concerning chemical reactions. The learning activities adhered to the POE sequence by having the learners make their predictions first, then observe the chemical phenomena using safe and easily obtainable household materials, and finally explain their observations on the basis of the evidence.

The post-test was then given to the participants. The scores from both the pre-test and the post-test were recorded and compared to assess the learners' degree of mastery of chemical reactions and to find out if there was a significant difference in their performance before and after the intervention.

Ethical Considerations

The study adhered to ethical standards in order to guarantee safe practices that would protect the rights, safety, and well-being of all the participants. The researchers wrote a letter to the school principal asking for permission to carry out the study. Before the data collection took place, informed parental/guardian consent and child assent were obtained for all minor participants. Participation in the study was completely voluntary, and the students were made aware that they could withdraw at any time without suffering any academic repercussions or personal consequences. The data from the study, including the results of the pre-test and post-test, were kept with the highest level of confidentiality. In any reports or publications, no identifying information will be given.

Data Analysis

The data collected were analyzed statistically by means of various methods with the help of JASP 0.96. Descriptive statistics were applied to the students' test scores in order to find the mode, the mean, the variance, the highest and lowest scores, as well as the ranges and standard deviations. Afterwards, a paired-samples *t*-test was carried out to assess the significance of the pre- and post-test scores in the experimental group.

RESULTS & DISCUSSION

In this section, the data collected are given, examined, and interpreted with a view to assessing the effectiveness of the POE strategy when using household materials in improving the mastery of chemical reactions on the part of Grade 10 students.

Students' Pre- and Post-Intervention Performance in Chemical Reactions

Table 1. Level of mastery of Grade 10 students in the chemical reaction topic before the implementation of the POE strategy.

Test	*n*	*Mean*	*Mode*	*Var*	*SD*
PRE	19	4.84	3	3.03	1.74

The pre-test scores of the Grade 10 students on chemical reactions, as shown in Table 1, indicate that their initial understanding of the subject was quite limited, with the mean score being 4.84. A majority of the students obtained marks at the lower part of the scale, as shown by a mode of 3 and a standard deviation of 1.74 points, which shows a moderate amount of variation around this low mean. In addition, even the highest-achieving students in the class showed limited achievement before instruction, with a range of 5 points (2-7).

These baseline findings are consistent with the literature on the challenges in chemistry education. Nabua et al. (2025) and Matrido and Nabua (2026) found that, consistently, the mean score of secondary school students is low in chemical reaction competencies and, in most cases, these competencies are not at the expected level of mastery. In line with this, Sayre et al. (2025) and Tajures and Nabua (2026) reported that chemical reactions are one of the topics least mastered by high school students, causing student scores to be positively skewed, with the majority of students grouped in lower levels of mastery.

Table 2. Level of mastery of Grade 10 students in the chemical reaction topic after the implementation of the POE strategy.

Test	*n*	*Mean*	*Mode*	*Var*	*SD*
POST	19	7.58	8	2.70	1.64

As shown in Table 2, students' achievement improved markedly after implementing the POE strategy using contextualized household materials. The mean score after the post-test increased to 7.58 (from 4.84), and the mode improved to 8, indicating that almost all students improved their conceptual mastery. At the same time, score variability decreased (SD = 1.64), and the minimum score rose to 5, showing a more uniform level of performance in the cohort.

The fact that there is such a great improvement shows that the POE method works when common, everyday materials are used. With regard to its structure, POE fosters deep learning because it allows students to make predictions and then compare these with the real observations, leading them to revise their mental model rather than just memorizing it (Islamiyah et al., 2022; Baydere, 2021; Jere & Mpeta, 2024). This point is even more strongly supported by further learning that involves anchor-supported inquiry, which connects macroscopic phenomena with the symbolic concepts of chemistry (Fatihah et al., 2022; Widhiyanti et al., 2025). Since the concrete experiences have been based on materials that are commonly found in households, the abstract reactions may have become more accessible, which in turn has made chemistry more relatable and easier to deal with—especially in school settings where laboratory chemicals are not easily available in areas with limited resources. The combination of these two approaches has helped to reduce achievement gaps by changing passive learners into active investigators (Ozcan & Uyanik, 2022; Chen, 2025; Zulhelmi et al., 2023).

Effectiveness of the POE Strategy Using Household Materials on Students' Performance

Table 3. *Paired Samples t-Test on the difference between pre-test and post-test scores in the chemical reaction topic.*

	Test	*n*	*M*	*SD*	*r*	*t*	*df*	*p*	*d*
Scores	PRE	19	4.84	1.74	.21	-5.60	18	< .001	1.285
	POST	19	7.58	1.64					

Note: α = 0.05 level of significance

Table 3 summarizes the statistical results of the paired-samples t-test to determine the impact of the Predict-Observe-Explain (POE) strategy. The analysis revealed a statistically significant increase from pre-test (M = 4.84, SD = 1.74) to post-test scores (M = 7.58, SD = 1.64), $t(18) = -5.60$, $p < .001$. The calculated effect size (Cohen's $d = 1.285$) is considered a significant educational effect, well above typical high-impact intervention thresholds. This size corresponds to the overall effect size of $g = 0.98$ for science instruction using POE, reported in a meta-analysis by Ünlu (2024), which showed that teaching science using POE produced meaningful gains, not marginal ones. This was also supported by Mustofa et al. (2024) and Rante & Allo (2024), who found that structured inquiry teaching produced meaningful rather than marginal gains.

Interestingly, a weak positive correlation was found between paired pre/post-test scores ($r = .21$). As Badong (2024) pointed out, weak paired correlations mean that the initial score level explains little to no variance in post-test scores. The strategy did not target high-performing students; rather, it had students build on their current understanding to move to the next level. The intervention benefited not only high-achieving students but also students with varying levels of starting knowledge. Together with the literature review already done, these indicators all indicate that linking abstract concepts to observable phenomena is effective for performance improvement, particularly in an equitable way (Fuadliyah & Yasin, 2025; Yang, 2023; Damayanti et al., 2025).

The findings also highlight the practical value of using commonly available household materials in POE-based instruction. In the present study, household materials provided an accessible way to support inquiry-based learning while reducing dependence on specialized laboratory equipment. This feature makes the instructional approach particularly applicable to resource-constrained school settings. Although the large effect size and statistically significant *t* value provide encouraging evidence of substantial improvement following the intervention, these findings should be interpreted with caution. Because of the small number of participants (N = 19) and the lack of a comparative group, the results can only be generally applied to a limited extent, and it is not possible to draw definite conclusions regarding the causal effect of the POE strategy. It is therefore suggested that further studies carried out in classroom settings should include larger samples, comparative groups, and longer intervention periods in order to verify and extend these findings.

CONCLUSION

The study investigated how effective the POE strategy is when using ordinary household materials in helping Grade 10 students to master the topic of chemical reactions. More precisely, it looked at the students' level of mastery before and after they had carried out a learning program based on the POE approach and checked whether there was a significant difference between their performance on the pre-test and the post-test. The research was aimed at dealing with the problems caused by a lack of laboratory facilities and the need for teaching methods that make abstract chemical concepts more concrete, relevant, and accessible.

The results showed that the students had a low level of mastery of chemical reactions prior to the intervention; after the POE strategy was carried out using household materials, their mastery increased, since there was a statistically significant difference between the scores on the pre-test and the post-test. The results indicate that the activities involving prediction, observation, and evidence-based explanation helped to improve students' conceptual understanding. It therefore follows that the POE strategy, when accompanied by readily available household materials, has the potential to serve as an effective method for enhancing students' understanding of chemical reactions.

The fact that students' understanding has improved can be explained by the active and inquiry-based character of the POE strategy.

Rather than viewing learners as passive recipients of information, the strategy prompts them to make predictions, compare their ideas with observable evidence, and then formulate explanations on the basis of their observations. This method is in agreement with the theory which holds that meaningful learning takes place when students actively interact with phenomena and link their previous conceptions to new evidence. The results therefore offer practical support for the use of POE when teaching abstract scientific concepts, particularly since students are given the opportunity to experience and explain the phenomena directly.

The fact that everyday household items can be used shows that it is possible to achieve meaningful science learning even in situations where laboratory facilities are limited. The results indicate that advanced laboratory equipment is by no means the only means of offering genuine, inquiry-based science experiences. By choosing materials that are safe, locally available, and appropriate, it is possible to use them as practical resources for helping to explain scientific concepts and for connecting what is taught in class to the phenomena that students encounter in their daily lives. This idea is especially important for science teachers in areas with limited resources, since it highlights the importance of being resourceful and of taking into account the local context when designing effective learning experiences.

The study also indicates that science lessons which make use of materials locally available can help to create a more learner-centered and context-specific science curriculum. It is advised that teachers incorporate prediction, observation, and explanations based on evidence into their regular science teaching, especially when dealing with topics which students generally find abstract or hard to visualize. School administrators may support these practices by helping to design lessons together and by encouraging the responsible and safe use of locally available resources. Nevertheless, the findings should be seen as evidence of the improvement that was observed after the intervention, not as definite proof that the POE approach by itself caused the improvement.

Future research could build on these

findings by employing larger and more diverse samples, such as those comprising students from different schools and various grade levels, and by using experimental or quasi-experimental designs that include control groups. The research might also lengthen the intervention period and add delayed posttests to examine how well conceptual understanding is retained over time. Furthermore, future studies might look at outcomes other than achievement, for example, scientific reasoning, engagement, motivation, attitudes towards science, and inquiry skills. However, the present study had some limitations, namely its small sample size, its one-group pretest–posttest design, the short duration of the intervention, and the main emphasis on achievement in the topic of Chemical Reactions. Overcoming these limitations in future research would help to strengthen the evidence on the effectiveness, sustainability, and wider applicability of the POE strategy when household materials are used in science education.

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