Vol 12(1) (2023): 25-37
DOI: http://dx.doi.org/10.24235/sc.educatia.v12i1.13706

SCIENTIAE EDUCATIA: JURNAL PENDIDIKAN SAINS

https://www.syekhnurjati.ac.id/jurnal/index.php/sceducatia

Innovative Strategies in Science Education: Implementing the POE Model to Enhance Elementary School Students' Science Process Skills

Reni Ramdayani[a*], Kurnia Marifatul Latifah[b], Yurniwati[c], Taofik[d]

[a] Department of Elementary School Teacher Education, Faculty of Education, State University of Jakarta, Indonesia
[b] Department of Elementary School Teacher Education, Faculty of Education, State University of Jakarta, Indonesia
[c] Department of Elementary School Teacher Education, Faculty of Education, State University of Jakarta, Indonesia
[d] Department of Elementary School Teacher Education, Faculty of Education, State University of Jakarta, Indonesia

*Corresponding author: Jl. Rawamangun Muka Gd. Dewi Sartika Universitas Negeri Jakarta, Indonesia. E-mail address: reniramdayani1@gmail.com

article info

Article history:
Received: 22 May 2023
Received in revised form: 24 May 2023
Accepted: 20 June 2023
Available online: 30 June 2023

Keywords:
Force
Motion
POE model
Realistic media
Science process skills

abstract

Effective science learning is designed and implemented for students who experience pressure in science process skills (SPS). Therefore, this study aims to analyze the use of the POE (Predict-Observe-Explain) learning model to improve the Science Process Skills of Elementary School students. The research method used is Classroom Action Research (CAR) with the Kemmis & Taggart model consisting of planning, action, observation, and reflection. Data collection techniques were carried out through observation and tests, with the number of research subjects being 27 (15 women and 12 men). Then the data were analyzed descriptively. The analysis results in cycle I indicate an average value of 62%. In cycle II, there was an increase with an average value of 85%; in cycle III, there was a more significant increase with an average value of 96%. From these results, the POE model effectively improves students' science process skills, so this study contributes to developing innovative and effective science learning approaches. Thus, the results of this study have an important impact on the world of education, showing that using the POE model with realistic media can improve students' science process skills. This study also provides a basis for further research to delve deeper into the application and effectiveness of the POE model in other learning contexts and with different variations of realistic media.

1. Introduction

Natural Science is one subject matter that must be learned in elementary schools. Natural Science is developed through scientific activities such as observing, testing, and communicating an event. The characteristics of natural science are always related to real biological phenomena (Hardiman et al., 2022; Ndjangala et al., 2021; Sutadji et al., 2021). In learning Natural Sciences in Elementary Schools, knowing should emphasize mastery of concepts or principles and the process of discovery (Murniarti et al., 2019). Discovery activities can be obtained by carrying out experiments or trials (Bahtiar et al., 2022; Hariyanto et al., 2022; Usman et al., 2022). With this, students can improve their thinking processes to see natural phenomena around them. Effective Natural Science learning is learning designed and implemented with student orientation emphasizing science process skills through observing, assessing, researching, analyzing, and clarifying (Çoruhlu et al., 2023; Hacıeminoğlu et al., 2022; Irwanto, 2023; TAS, Erol, Guler, 2022; Felitasari & Rusmini). Student-oriented learning means that students independently find the knowledge that must be obtained, and the teacher becomes a facilitator (Usman et al., 2022). Learning Natural Sciences must be able to answer problems that occur in natural events which will change at any time. Thus, Natural Sciences cannot be separated from their essence. Namely, there is a process for students to make observations.

Science learning in elementary schools focuses on students with a foundation of thinking and acting based on meaningful scientific understanding (Agus Kurniawan et al., 2023; Idris et al., 2022; Yang et al., 2023). The three science competencies that must be achieved are products, processes, and attitudes necessary to students (Hacıeminoğlu et al., 2022; TAS, Erol, Guler, 2022; Zorluoğlu et al., 2022). Science process skills need to be developed from elementary school because students' cognitive abilities are still developing, so they can practice and improve these skills (Wang et al., 2023; Yang et al., 2023). Science process skills is a scientific method that involves discovering through experimentation. In addition, Science Process Ability includes understanding, developing, reflecting, and formulating knowledge through experience in the learning process (Mulhayatiah et al., 2023; Widodo & Hazimah, 2022). These skills are essential for students because they encourage direct involvement in learning and motivate students in their curiosity. Science process skills have essential aspects: observing, hypothesizing, predicting, investigating, interpreting findings and drawing conclusions, and communicating (Aflah et al., 2023; Damopolii et al., 2020, Irnin et al., 2019). So that someone who has high science process skills shows indications that in the learning process, students' insights and abilities develop because they are motivated by their curiosity through experimental activities or experiments that connect students' experiences directly to observe, hypothesize, predict, investigate, interpret findings and draw conclusions, and communicate based on the results of their observations in class. Thus, science process skills can improve learning outcomes, and students will be active in the learning process (Çoruhlu et al., 2023; Firdaus et al., 2020).

However, the reality in the elementary school environment shows that students' science process skills, especially in learning Natural Sciences, still need to improve (Lamanauskas, 2022; Sharma & Buxton, 2018). They are evidenced by students who still need help developing science process skills, such as difficulties formulating hypotheses, identifying variables, and designing investigations (Ndjangala et al., 2021). Students still need help to group things, communicate, and be more complicated in the ability to conclude. In line with this, they have yet to be optimally achieved based on observations assembling science process skills of students in class IV at Setiabudi 01 Pagi Public Elementary School. This is indicated by students needing help in conducting experimental experiments. In addition, it is also marked by an understanding of concepts that have yet to be properly mastered. Hence, boredom and complaints occur when carrying out the process of teaching Natural Sciences. These problems are caused by a lack of practical learning because the facilities available in the learning process need to be improved. Learning that is still teacher-centered by emphasizing memorization can also be a trigger because there is no encouragement for students to solve problems, communicate, classify, and conclude during the learning process. Therefore, an effort is needed to instill science process skills as early as possible, especially in elementary school students.

Several previous studies have made efforts to develop science process skills, such as developing science process skills using the Inquiry learning model, which concludes that the findings can provide stimulation to students. Hence, they can make hypotheses and conduct experimental verification of their hypotheses (Angelia et al., 2022). In addition, the development of science process skills by applying the Project Based Learning model can affect the improvement of the learning process (Nurjanah et al., 2021). Then the following research is to develop science process skills using learning video-based media and concludes that the help of the media can train students' science process skills (Rahmawati et al., 2022). Recent research related to developing science process skills using the POE learning model, which discusses the material of light and its properties, the results of his research concluded that there is an influence on science process skills. They can create an active learning process (Utama et al., 2019). POE is a learning model that can be used to recognize students' initial ideas, provide information to teachers regarding students' thoughts, develop discussions, and motivate students to cover a concept. This is because the stages are predicting, observing, and explaining (Çoruhlu et al., 2023; Safira et al., 2020). So the POE learning model is adequate for acquiring and improving student science. In addition, this model can stimulate students to have science process skills because it can be related to conducting direct experiments or practicums, which makes students enthusiastic and excited. However, applying the POE model must be related to the student's environmental conditions so that it is not difficult and easy for students to understand the material (Maryanto & Mawartiningtyas, 2022; Mustofa et al., 2022).

This research differs from existing research because it applies the POE learning model, which emphasizes three things. First, this research focuses on improving science process skills through the POE learning model. This model engages students in predicting, observing, and explaining scientific phenomena, encouraging active involvement and developing critical thinking skills in science learning. Second, this study uses environment-based realistic teaching aids. The use of realistic teaching aids helps students experience abstract concepts through authentic experiences. In this study, these visual aids were used to facilitate students' understanding of force and motion in materials more concretely. Third, this study applies the POE learning model in style and motion material. With serious attention to this topic, this study provides in-depth insights into using the POE learning model to enrich students' understanding of concepts related to force and motion in science. Therefore, the novelty of this research lies in the use of the POE learning model to improve science process skills, the use of environment-based realistic teaching aids, and their application which is focused on force and motion material. So, this article focuses on analyzing the use of the POE (Predict-Observe-Explain) learning model, which is expected to improve the science process skills of elementary school students. So, research can significantly contribute to developing innovative and practical approaches to learning science and placing more emphasis on a more concrete environmental context at the basic education level.

2. Method

This research method uses classroom action research. The study subjects are grade IV students of Setiabudi 01 Pagi Public Elementary School located in Setiabudi, with 27 students (15 females and 12 males). The study was conducted in the second semester of the 2022/2023 academic year, with three cycles using the Kemmis & Taggart model consisting of planning, action, observation, and reflection. The classroom action research model is presented in Figure 1.

The data collection technique uses observation and tests (Creswell, 2008; Prabha & Abdul Aziz, 2020; Warju et al., 2020). Hence, this observation sheet is used to observe the activities of teachers and students during the learning process. Evaluation questions in the form of tests are used to measure the Explanation of Science Process. The indicators used in this study are observing, hypothesizing, predicting, investigating, interpreting and drawing conclusions, and communicating. Subsequently, the data is analyzed descriptively using success indicators, namely the improvement in science process skills from cycle I to cycle II and cycle II to cycle III; if 80% of the total students get a score of 70, the study is declared complete

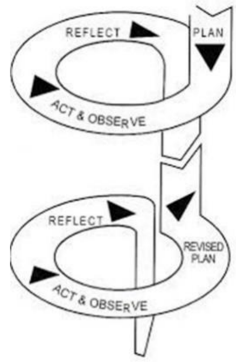

Figure 1. Classroom action research cycle according to Kemmis & Taggart (Habeb Al-Obaydi et al., 2021)

3. Result and Discussion

Cycle I

The first cycle discusses the difference between force and motion. Before learning is prepared, a learning implementation plan, student worksheets in printed form, and printed pictures of a child pulling and pushing a table and pulling a table. I also prepared six essay questions to measure students' science process skills. The teacher starts the learning process by praying, conveys the learning objectives, and continues by motivating students. The implementation of learning applies POE to teacher and student activities. In the core activity of the prediction stage, the teacher divides students into four groups (consisting of 6-7 students) and sparks students by giving initial questions about the pictures presented in the form of pushing and pulling tables. Then students give predictions about the experiments they will do. In the observation phase, the teacher explains the practical steps and directs students to experiment. The teachers explain stage directs students to discuss the results of joint experimental observations, followed by giving awards to the experimented group.

At the end of learning, students are given an evaluation. Students are allowed to ask questions regarding things that are not understood and conclude the material that has been studied. The teacher also follows up by giving assignments to review advanced material about force and motion, then closes the lesson by praying. The following results of observations of teacher and student activities are presented in Table 1.

Table 1. Teacher and student activities in cycle I

Indicator	Teacher Observation Results	Student Observation Results
Introduction	75.00	71.88
Predict	75.00	71.88
Observe	83.33	71.88
Explain	55.00	48.44
Closing	58.33	50.00
Total	69.12	66.91

Based on the observations and evaluations conducted in cycle I, the weakest indicator of science process skills (SPS) is explaining, with teacher observation results at 55.00 and student observation results at 48.44. Several factors, including a lack of student focus during the learning process, can cause this. This phenomenon can be understood because students who are too active or quiet make it difficult for the teacher to control the class and convey the material well. On the other hand, the highest SPS indicator is observing, with teacher observation results at 83.33 and student observation results at 71.88. Student activity in conducting experiments and group discussions makes them easier to observe. This condition is similar to previous research results conducted by Angelia et al., (2022), even though using a different Inquiry Learning model, the same result was found that students find it easier to observe than to explain.

Meanwhile, research by Nurjanah et al., (2021) which used the Project Based Learning method, also found that students have difficulty explaining, indicating that this may be a universal challenge in the SPS learning process. Therefore, there needs to be an improvement in learning strategies, especially in explaining, to improve students' SPS so that students can more easily understand and explain the material that has been learned. For example, providing more detailed material and concrete examples, and interactive discussions can encourage students to be more active in asking questions and explaining their understanding. The following are the results of the students' SPS tests presented in Table 2.

Table 2. Results of cycle I science process skills

Score	N	Percentage
>70	8	38.1
<70	13	61.9

Based on the reflections, things that need to be improved in cycle two can be stated, namely: a) teacher readiness in teaching; b) the language used; c) group presentation activities; d) providing learning conclusions; e) limited time; f) students' difficulties working on Student Worksheets; g) unattractive media so that students are less focused; and h) the distribution of homogeneous groups. Efforts to improve in cycle 2 are: a) Teachers are better prepared to teach and pay attention to the POE model steps, b) The language used in conveying information must be easy to understand, c) Reduce the level of difficulty in Student Worksheets, d) Material explanations and Student Worksheets need to be shortened, e) Using media that attracts students' attention, f) Change the group to be heterogeneous Therefore, it is necessary to proceed to cycle 2.

Cycle II

The second cycle discusses the sub-material of forces that can change the shape of objects. Before the lesson, the teacher prepares a Lesson Plan, a Student Worksheet in print form, media in the form of dried leaves and six essay questions. The teacher begins the lesson according to cycle I. The teacher checks student readiness and attendance and states the learning objectives. They are then followed by motivating the students to benefit from the material to be learned. The implementation of POE activities by teachers and students began with the prediction stage. The teacher introduced the experimental tools and materials to the students. The teacher asked the students to predict the experimental results when the paper was crumpled. During the observation stage, the teacher asked the students to use dried leaves as experimental tools. The teacher explained the practical steps in the Student Worksheet. The teacher also directed each group experimenting with dried leaves to prove their predictions. At the explanation stage, the teacher directed the students with their groups to discuss the results of their experiment and record them on the Student Worksheet. They were followed by students presenting their experimental results. The teacher rewarded each group by providing reinforcement. During the learning process, the teacher used clear and fluent language to be more easily understood by students.

At the end of the study, an evaluation was given and concluded with the closing activities. The teacher reflected and concluded with the students that the experimental results carried out with ground-dried leaves are an example of forces that can change the shape of objects. The teacher ended the lesson with prayer and greetings. Following are the results of observations of teacher and student activity cycle II presented in Table 3.

Table 3. Teacher and student activities cycle II

Indicator	Teacher Observation Results	Student Observation Results
Introduction	93.75	82.25
Predict	87.50	84.38
Observe	91.67	89.06
Explain	80.00	71.88
Closing	75.00	75.00
Total	85.29	74.26

Based on the reflection of the first cycle, improvements were made in the second cycle, and an increase was achieved with a good category. The correct approach involved the teacher presenting predictions, using clear and good language, dividing into heterogeneous groups, creating Student Worksheets in the medium category, and clear steps of POE in the learning activities could be seen. Students also followed the POE model learning activities, conducted experiments independently, and worked on worksheets and group discussions. They could observe, predict, hypothesize, and communicate their experimental results. However, some things still need to be improved; for example, one group tended to be quiet and less active because quiet students dominated. Thus, some did not work.

In the second cycle, the weakest SPS indicator was explaining, with a score of 71.88%. The highest was the introduction indicator at 93.75%. Although it has improved from the first cycle, the explaining indicator still challenges students. This might be due to some students lacking confidence in expressing their ideas and observations or having trouble formulating explanations. Moreover, some groups tended to be quiet and less active. During the explanation period, students' active participation is required to discuss and present their experimental results. Therefore, more guidance is needed from the teacher so that students can be more confident in expressing their thoughts and synthesizing their experimental results. Compared to previous studies using inquiry learning model (Angelia et al., 2022), project-based learning (Nurjanah et al., 2021), and video-based learning media (Rahmawati et al., 2022), the results of this study obtained in this cycle showed an improvement in the application of the POE learning model, as seen through the level of student activity and enthusiasm, as well as their ability to discuss and present their experimental results. This model also helped students understand shapes that can change objects' shape through direct experiments that actively involved them. Thus, they became more enthusiastic about learning. This may indicate the superiority of the POE model in the context of science process skills at the primary school level. The conclusions of the data in this study related to the number of students who passed from a minimum completeness criteria score of 70 is presented in Table 4.

Table 4. Results of science process skills cycle II

Score	N	Percentage
>70	16	64
<70	9	36

From this table, it was obtained that the science process skills of students who achieved a score of more than 70 had increased to 64. However, this level of success had yet to be achieved. So the reflections that can be put forward for improvement in cycle 3 are a) group presentations that are only representatives; b) group members lack discussion because the distribution of Student Worksheets is only 3; c) there is 1 group that tends to be quiet and less active; d) the media used is still less varied. Improvement solutions in cycle II are a) each group member must make a presentation; b) each student in the group gets a Student Worksheet; c) changing groups back heterogeneously and providing motivation to each group to be able to work together, be active in learning; d) using several media that are more interesting and challenging. So it is necessary to proceed to Cycle III.

Cycle III

Cycle III, with the topic discussing force, can change the motion and acceleration of objects. Before learning, a Learning Implementation Plan is prepared, Student Worksheets in printed form, realistic media in the form of toy cars and balls, and six essay questions to measure students' science process skills. The teacher starts learning according to cycle II. The teacher conveys the topic and learning objectives. The teacher gives an apperception to trigger the material to be studied using the media of toy cars and balls—teacher and student activities in learning with POE. Predict activities are carried out by exposing students to tools and experiments. The teacher also asked the students to make predictions from what they did during the experiment with toy cars and balls. Then in the observation stage, the teacher explains the practical steps on the Student Worksheet and directs the group to carry out and observe the experiment. The group explains the stage and discusses the experiment's results with toy cars and balls on the Student Worksheets. All groups present their experimental results in turn. The teacher and other groups provide feedback and awards to groups that have performed.

At the end of learning, students are given an evaluation. The teacher and students make learning conclusions that experiments with toy cars and balls can produce a force that can change the motion and acceleration of objects. The teacher also closed the lesson by praying. The following are the results of observations of teacher and student activities is presented in Table 5.

Table 5. Teacher and student activities cycle III

Indicator	Teacher Observation Results	Student Observation Results
Introduction	100	84.38
Predict	100	90.63
Observe	100	98.44
Explain	95.00	92,19
Closing	100	100.00
Total	98.53	92.65

The learning process that integrates the Predict-Observe-Explain (POE) model has been successfully carried out in three cycles. Based on observations of teacher and student activities in Cycle III, data showed that all science process skills indicators had reached the "very good" level. The value of teacher observation reached an average of 98.53%, and the value of student observation reached an average of 92.65%, indicating that the POE learning model effectively enhances students' SPS. However, in more detail, the weakest SPS indicator in Cycle III was Introduction, with a student observation value of 84.38%. The reason why this indicator is the weakest is due to several factors. For example, students take longer to respond and adapt to the new method introduced. Moreover, students' prior knowledge of the material to be learned could also affect the assessment of this indicator.

In contrast, the highest SPS indicator is Observing, with a student observation value of 98.44%. This aligns with prior research by Utama et al., (2019) that also showed that the observation step in the POE model is very effective in enhancing students' science skills. The highest indicator likely resulted from students being directly involved in the experiments and seeing the results firsthand. Overall, this research demonstrates that the POE model can serve as an innovative strategy in science education to enhance primary school students' SPS. Thus, the teacher's role in designing and implementing learning is vital to better understanding science concepts and improving students' science process skills. The conclusion data in this study related to the number of students who pass from the minimum completeness criterion score of 70 is is presented in Table 6.

Table 6. Results of science process skills cycle III

Score	N	Percentage
>70	25	96,20
<70	1	3.80

The learning outcomes of science process skills increased by 96.20, which achieved a score of more than 70 and has reached a level of success. Although, there is still one student who has yet to be able to achieve a success rate score. However, there were no additional cycles, and the study ended in cycle III because the comparison had significantly increased. Teacher and student activities for three cycles are presented in the Figure 2.

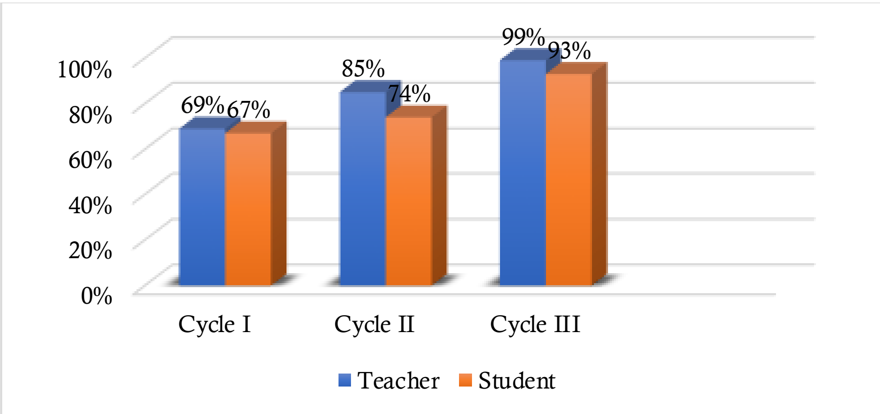

Figure 2. Teacher and student activities POE learning model cycles I, II, and III

From the picture above, the percentage of teacher and student activity has increased. The high and stable increase in activity shows that the POE (Predict, Observe, and Explain) learning model can increase the activity of teachers and students. In cycle 1, students still tend to be quiet. In cycle II, the teacher divided the groups heterogeneously. This activity makes students have good cooperation with the group. In addition, the teacher provides a variety of realistic media that supports students' activeness and understanding of the material. Using concrete, realistic media can obtain more real student learning experiences and provides opportunities for students to be actively involved (Halim et al., 2021; Rohmah et al., 2022).

The division of heterogeneous groups makes student learning look more passionate. The heterogeneous distribution also encourages students to collaborate and control each other actively. By forming heterogeneous groups, it shows students have good responsibility and cooperation (Ghanbari & Abdolrezapour, 2020). The determination of group members in each cycle that was made differently made students adapt to the POE model. With heterogeneous groups, students are indirectly trained to work together and help each other with the ability to have and respect each other.

In cycle III, the teacher distributes Student Worksheets to each student. Students can actively discuss and exchange ideas without feeling too constrained by their friends. Students feel given the freedom to express their opinion and maximize their potential. Each student is given Student Worksheets to help them exchange ideas in groups to hone their critical thinking skills and export their abilities. The estuary of cycles I – III significantly influences students' science process skills. From the activities of teachers and students, there are results of students' science process skills tests for three cycles, as shown in the Figure 3.

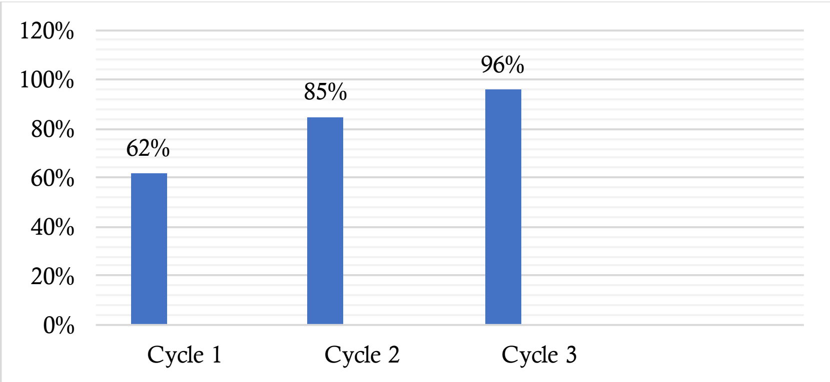

Figure 3. Results of science process skills of cycle I, II, and III students

The science process skills test results in each cycle showed a significant increase. There was an increase of 23% from cycle I to cycle II and 11% from cycle II to cycle III. This improvement is evident from the student's ability to observe activities well, make temporary hypotheses or assumptions, predict before experimenting, investigate to prove experiments, interpret data, draw conclusions, and communicate experimental results well. Through learning activities using the POE model supported by experiments, students showed high enthusiasm in following each learning and developing science process skills (Chen, 2022; Den Otter et al., 2021).

Using experimental activities in POE steps helps to improve students' thinking skills in realistically describing an event. In cycle I, students tended to be quiet, but with the division of heterogeneous groups in cycle II, students began to show good cooperation with their group members. In addition, the use of concrete and realistic learning media also supports students' involvement and understanding of the material. Through this media, students can gain more realistic learning experiences and are allowed to be actively involved in learning (Lo & Ku, 2021; Salimi et al., 2020). Therefore, using the Predict-Observe-Explain (POE) learning strategy in science process skills can stimulate students to make predictions, make observations, and explain results based on their understanding. This strategy focuses on active student involvement in the learning process, hoping they will feel more responsible for the knowledge they gain (Utama et al., 2019: Nau & Djalo, 2019). In this learning strategy, students are encouraged to formulate their predictions, make observations from experiments, and then explain their findings. This stimulates critical thinking processes and puts students in an active learning process that helps them solve problems and understand concepts better (Rahmawati et al., 2022). This learning model effectively improves student SPS because it allows students to learn in a real and relevant context.

The estuary of cycle I to III significantly affects the development of students' SPS. The research results show that by using the POE learning model with the help of experiments, students show an increased ability to observe, formulate hypotheses, predict, investigate, interpret data, draw conclusions, and communicate the results of experiments well and thoroughly. In addition, through learning carried out with enthusiasm, students become more involved in the learning process and acquire science-related skills. This aligns with previous research that shows that the POE learning model can improve students' science process skills (Utama et al., 2019). Thus, there is a significant improvement in students' SPS by implementing learning cycles involving the POE model and improving each cycle based on reflection. The results show that an active learning approach that directly involves students in the learning process and allows students to develop science process skills can positively impact science learning in elementary schools.

This is also supported by the basic principles of Piaget and Vygotsky's constructivist learning theory supports the implementation of POE steps in learning. Piaget argued that knowledge results from active interaction between individuals and their environment, and the learning process occurs when students reconstruct their knowledge through new experiences (Santrock, 2020). In the context of POE, students must make predictions, make observations, and explain their findings based on their initial knowledge, which is an active interaction with learning materials. Meanwhile, Vygotsky emphasized the importance of social interaction in learning (Rohaendi & Laelasari, 2020). The POE strategy encourages cooperation and communication between students, where they can construct understanding and knowledge about the concept being studied together. Thus, the principles in Piaget's and Vygotsky's learning theories support the implementation and benefits of the POE learning strategy in improving students' SPS.

4. Conclusion

Based on research findings, using the predict-observe-explain (POE) learning model effectively enhances elementary school students' science process skills. This is because, through this learning model, students are allowed to directly conduct prediction, observation, and explanation processes which can train and improve their science process skills. However, the process of explaining still proves to be a challenge for students, necessitating the enhancement of strategies in learning, particularly in the explaining process. In addition, using concrete and realistic learning media can also support a more effective learning process and increase students' activity and understanding of the materials studied. Therefore, the POE learning model can be a reference in developing future learning methods to enhance students' science process skills.

References

Aflah, A. N., Ananda, R., Surya, Y. F., Syafari, O., & Sutiyan, J. (2023). Upaya meningkatkan kemampuan berpikir kreatif menggunakan model project based learning pada siswa sekolah dasar. *Autentik: Jurnal Pengembangan Pendidikan Dasar*, *7*(2), 57–69.

Agus Kurniawan, D., Purnama Wirayuda, R., Ardina Putri, W., Febri Setiya Rini, E., Aktapianti Br Ginting, A., & Ratnawati, T. (2023). Impact of science process skills on thinking skills in rural and urban schools. *International Journal of Instruction*, *16*(2), 803–822. www.e-iji.net

Angelia, Y., Supeno, S., & Suparti, S. (2022). Keterampilan proses sains siswa sekolah dasar dalam pembelajaran ipa menggunakan model pembelajaran inkuiri. *Jurnal Basicedu*, *6*(5), 8296–8303. https://doi.org/10.31004/basicedu.v6i5.3692

Bahtiar, Ibrahim, & Maimun. (2022). Analysis of students' scientific literacy skill in terms of gender using science teaching materials discovery model assisted By Phet Simulation. *Jurnal*

Pendidikan IPA Indonesia, *11*(3), 371–386. https://doi.org/10.15294/jpii.v11i3.37279

Chen, J. C. (2022). Developing a cycle-mode POED model and using scientific inquiry for a practice activity to improve students' learning motivation, learning performance, and hands-on ability. *Interactive Learning Environments*, *30*(7), 1252–1264. https://doi.org/10.1080/10494820.2020.1716023

Çoruhlu, T. Ş., Çalık, M., Nas, S. E., & Bilgin, B. (2023). Improving science process skills of students with mild intellectual disabilities. *Journal of Baltic Science Education*, *22*(2), 323–336. https://doi.org/10.33225/jbse/23.22.323

Creswell, J. W. (2008). *Educational research: Planning, Conducting and evaluating, quantitative and qualitative research* (3rd ed.). Pearson Education.

Damopolii, I., Keley, U., Rianjani, D. T., Nunaki, J. H., Nusantari, E., & Kandowangko, N. Y. (2020). Potential of inquiry-based learning to train student's metacognitive and science process skill. *Jurnal Ilmiah Peuradeun*, *8*(1), 83. https://doi.org/10.26811/peuradeun.v8i1.351

Den Otter, M. J., Dam, M., Juurlink, L., & Janssen, F. (2021). Two design principles for the design of demonstrations to enhance structure–property reasoning. *Education Sciences*, *11*(9), 1–19. https://doi.org/10.3390/educsci11090504

Felitasari, A., & Rusmini, R. (2022). Development of e-worksheet assisted by liveworksheets to improve science process skills and collaboration on chemical equilibrium materials. *Scientiae Educatia: Jurnal Pendidikan Sains,* *11*(1), 10-23. http://dx.doi.org/10.24235/sc.educatia.v11i1.10235

Firdaus, F., Subchan, W., & Narulita, E. (2020). Developing STEM-based TGT learning model to improve students' process skills. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(3), 413–422. https://doi.org/10.22219/jpbi.v6i3.12249

Ghanbari, N., & Abdolrezapour, P. (2020). Group composition and learner ability in cooperative learning: A mixed-methods study. *Tesl-Ej*, *24*(2), 1–18.

Hacıeminoğlu, E., Yıldız, N. G., & Şeker, R. (2022). Factors related to cognitive reasoning of pre-service teachers' science process skills: role of experiments at home on meaningful learning. *Sustainability (Switzerland)*, *14*(13). https://doi.org/10.3390/su14137703

Halim, A., Mahzum, E., Yacob, M., Irwandi, I., & Halim, L. (2021). The impact of narrative feedback, e-learning modules and realistic video and the reduction of misconception. *Education Sciences*, *11*(4), 1–14. https://doi.org/10.3390/educsci11040158

Hardiman, B., Reynolds, J., Pizzica, J., & Renshaw, A. (2022). Re-orientating experiences: Considerations for student development through virtual mobility in STEM. *Journal of Applied Learning and Teaching*, *5*(1), 52–59. https://doi.org/10.37074/jalt.2022.5.1.20

Hariyanto, Amin, M., Mahanal, S., & Rohman, F. (2022). Analyzing the contribution of critical thinking skills and social skills on students' character by applying discovery learning models. *International Journal of Education and Practice*, *10*(1), 42–53. https://doi.org/10.18488/61.v10i1.2907

Idris, N., Talib, O., Razali, F., Kamaruddin, H., & Hassan, N. M. H. N. (2022). Undergoing science experiment in hybrid learning. *ASM Science Journal*, *17*(1), 1–10. https://doi.org/10.32802/ASMSCJ.2022.1173

Astuti, I., Putra, I., & Bhakti, Y. (2018). Developing practicum module of particle dynamics based on scientific methods to improve students' science process skills. *Scientiae Educatia: Jurnal Pendidikan Sains,* *7*(2), 183-196. http://dx.doi.org/10.24235/sc.educatia.v7i2.2513

Irwanto, I. (2023). Improving preservice chemistry teachers' critical thinking and science process skills using research-oriented collaborative inquiry learning. *Journal of Technology and Science Education*, *13*(1), 23. https://doi.org/10.3926/jotse.1796

Lamanauskas, V. (2022). Natural science education in primary school: Some significant points. *Journal of Baltic Science Education*, *21*(6), 908–910. https://doi.org/10.33225/jbse/22.21.908

Maryanto, A., & Mawartiningtyas, A. F. (2022). Development of science student worksheet based on predict-observe-explain (POE) to improve critical thinking skills for junior high school students. *AIP Conference Proceedings*, 1–6. https://doi.org/10.1063/5.0115932

Mulhayatiah, D., Kharisma, F. E., Junissetiawati, D., Yuningsih, E. K., & Pitriana, P. (2023). Science process skills through cores and papers analysis of pedagogical content knowledge. *The 4th International Conference On Life Science And Technology (ICoLiST)*, 1–8. https://doi.org/10.1063/5.0118321

Murniarti, E., Solihatun, S., & Rangka, I. B. (2019). Assessing competency levels of students on learning of energy and weather concepts using partial credit model. *Journal of Physics: Conference Series*, *1318*(1), 1–8. https://doi.org/10.1088/1742-6596/1318/1/012086

Mustofa, B., Mardiyana, & Slamet, I. (2022). Improving problem solving ability with predict observe explain learning module. *AIP Conference Proceedings*, 1–8. https://doi.org/10.1063/5.0117124

Nau, G., & Djalo, A. (2019). The effect of practical-based jigsaw strategy on science process skills of students. *Scientiae Educatia: Jurnal Pendidikan Sains, 8*(2), 196-206. http://dx.doi.org/10.24235/sc.educatia.v8i2.5168

Ndjangala, M. N. N., Abah, J., & Mashebe, P. (2021). Teachers' views on challenges affecting learners' performance in natural science. *International Journal of Evaluation and Research in Education*, *10*(1), 48–56. https://doi.org/10.11591/ijere.v10i1.20732

Nurjanah, N., Cahyana, U., & Nurjanah, N. (2021). Pengaruh penerapan online project based learning dan berpikir kreatif terhadap keterampilan proses sains siswa kelas IV pada pelajaran IPA Di SD Nasional 1 Kota Bekasi. *Buana Pendidikan: Jurnal Fakultas Keguruan Dan Ilmu Pendidikan*, *17*(1), 51–58. https://doi.org/10.36456/bp.vol17.no1.a3161

Prabha, T., & Abdul Aziz, A. (2020). Effectiveness of using poly category mind map for vocabulary development. *Arab World English Journal*, *11*(2), 214–231. https://doi.org/10.24093/awej/vol11no2.15

Rahmawati, T. A., Supardi, Z. A. I., & Hariyono, E. (2022). Pengembangan media pembelajaran interaktif berbasis video dengan model POE (Predict Observe Explain) untuk melatihkan keterampilan proses IPA siswa sekolah dasar. *Jurnal Basicedu*, *6*(1), 1232–1242. https://doi.org/10.31004/basicedu.v6i1.2267

Rohmah, A. N., Sutama, S., Hidayati, Y. M., Fauziati, E., & Rahmawati, L. E. (2022). Planning for cultivation numerical literacy in mathematics learning for minimum competency assessment (AKM) in elementary schools. *Mimbar Sekolah Dasar*, *9*(3), 503–516. https://doi.org/10.53400/mimbar-sd.v9i3.51774

Safira, C. A., Setyawan, A., & Citrawati, T. (2020). Identifikasi permasalahan pembelajaran ipa pada siswa kelas III SDN Buluh 3 Socah. *Jurnal Pendidikan MIPA*, *10*(1), 1–11. https://doi.org/10.37630/jpm.v10i1.277

Sharma, A., & Buxton, C. (2018). The natural world and science education in the United States. In *The Natural World and Science Education in the United States*. https://doi.org/10.1007/978-3-319-76186-2

Sutadji, E., Susilo, H., Wibawa, A. P., Jabari, N. A. M., & Rohmad, S. N. (2021). Authentic assessment implementation in natural and social science. *Education Sciences*, *11*(9). https://doi.org/10.3390/educsci11090534

TAS, Erol, Guler, H. (2022). The Impact of the argumentation- flipped learning model on the achievements and scientific process skills of students Erol Taş Hatice Güler Jülide Sarigöl Filiz Demirci. *Participatory Educational Research (PER)*, *9*(November), 335–357.

Usman, M., I, I. N., Utaya, S., & Kuswandi, D. (2022). The Influence of JIGSAW Learning Model and Discovery Learning on Learning Discipline and Learning Outcomes. *Pegem Egitim ve Ogretim Dergisi*, *12*(2), 166–178. https://doi.org/10.47750/pegegog.12.02.17

Utama, E. G., Lasmawan, I. W., & Suma, K. (2019). Pengaruh model pembelajaran POE (Predict, Observe and Explain) terhadap keterampilan proses sains siswa sd kelas v ditinjau dari keterampilan metakognitif. *JPDI (Jurnal Pendidikan Dasar Indonesia)*, *4*(2), 46. https://doi.org/10.26737/jpdi.v4i2.1364

Wang, W., Song, J., Fan, C., Li, Q., Ma, D., & Yin, W. (2023). Cross-sectional study of factors affecting the receipt of mental health education in older migrants in China. *BMC Public Health*, *23*(1), 1–10. https://doi.org/10.1186/s12889-023-15287-6

Warju, W., Ariyanto, S. R., Soeryanto, S., Hidayatullah, R. S., & Nurtanto, M. (2020). Practical learning innovation: real condition video-based direct instruction model in vocational education. *Journal of Educational Science and Technology (EST)*, *6*(1), 79–91. https://doi.org/10.26858/est.v6i1.12665

Widodo, E., & Hazimah, A. (2022). Development of student worksheet based on learning cycle 7e to improve science skills of 7th grade junior high school students. *AIP Conference Proceedings*, *26*(12), 1–8. https://doi.org/10.1063/5.0117383

Yang, D., Cai, Z., Wang, C., Zhang, C., Chen, P., & Huang, R. (2023). Not all engaged students are alike: patterns of engagement and burnout among elementary students using a person-centered approach. *BMC Psychology*, *11*(1), 1–12. https://doi.org/10.1186/s40359-023-01071-z

Zorluoğlu, S. L., Önder, E. Y., Timur, B., Timur, S., Güvenç, E., Özergun, I., & Özdemir, M. (2022). The Scope of science process skills and the 5e educational model in science education. *Journal of Baltic Science Education*, *21*(6), 1101–1118. https://doi.org/10.33225/jbse/22.21.1101