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From Experiment to Innovation: The Effect of Experiential Learning on Elementary School Children's Science and Critical Thinking Skills

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Abstract: *The implementation of learning with conventional models does not provide direct experience which results in minimal opportunities for students to explore, reflect, and present scientific findings, especially in elementary schools. This study aims to analyze the effect of the implementation of the Experiential Learning model on science process skills in communicating, critical thinking skills, and its comparison with the Problem Based Learning model in grade IV elementary school students. The type of quasi-experimental research with a nonequivalent control group design, with a sample of grade IV elementary school students taken by purposive sampling. The instruments, in the form of essay tests, were declared valid and reliable with a Sig. (2-tailed) value of 0.000 and Cronbach's Alpha of 0.661 for science process skills and 0.728 for critical thinking skills. Data were analyzed using independent sample t-test and MANOVA with a significance level of 0.05. The results showed that the Experiential Learning model had a significant effect on both science process skills in communication and critical thinking skills, with a significance value of 0.000. MANOVA testing also indicated a significant effect of the model on both variables, with partial eta squared values of 67.5% for science process skills in communication and 30% for critical thinking skills. This indicates that the Experiential Learning model is effective in enhancing both abilities among fourth-grade elementary school students.*

Keywords*: experiential learning model, science process skills communicating, and critical thinking skills*

Pengaruh Penerapan Model Experiential Leraning terhadap Keterampilan Proses Sains Mengomunikasikan dan Kemampuan Berpikir Kritis Siswa kelas 4 SD

Abstrak: Penerapan pembelajaran dengan model konvensional kurang memberi pengalaman langsung yang mengakibatkan minimnya kesempatan siswa untuk menggali, merefleksi, dan menyajikan temuan ilmiah terkhusus di sekolah dasar. Penelitian ini bertujuan untuk menganalisis pengaruh penerapan model *Experiential Learning* terhadap keterampilan proses sains mengomunikasikan, kemampuan berpikir kritis, serta perbandingannya dengan model *Problem Based Learning* pada siswa kelas IV SD. Jenis penelitian quasi eksperimen dengan desain nonequivalent control group, dengan sample penelitian siswa kelas IV SD yang diambil secara purposive sampling. Instrumen berupa soal uraian dinyatakan valid dan reliabel dengan nilai Sig. (2-tailed) 0,000 dan Alpha Cronbach 0,661 untuk keterampilan proses sains serta 0,728 untuk kemampuan berpikir kritis. Analisis data dilakukan menggunakan uji independent sample t-test dan MANOVA dengan taraf signifikansi 0,05. Hasil menunjukkan bahwa model *Experiential Learning* berpengaruh signifikan terhadap keterampilan proses sains mengomunikasikan dan kemampuan berpikir kritis dengan nilai signifikansi 0,000. Uji MANOVA juga menunjukkan pengaruh signifikan model tersebut terhadap kedua variabel, dengan nilai partial eta squared sebesar 67,5% untuk keterampilan proses sains mengomunikasikan dan 30% untuk kemampuan berpikir kritis. Hal ini menunjukkan bahwa model *Experiential Learning* efektif dalam meningkatkan dua kemampuan tersebut pada siswa kelas IV SD.

Kata kunci: *Experiential learning*, keterampilan proses sains, berpikir kritis.

1. Introduction

Currently, critical thinking skills need to be instilled to form students' mindsets that can help adapt to the development of the times. The ability to think critically and creatively, collaborate, and communicate or what is also commonly referred to as 21st century skills that need to be provided to students (Woro Sri Hastuti et al., 2021). These 21st century skills in the world of education are integrated into the learning process and subjects in schools, one of which is Natural Sciences (IPA) or science.

Elementary school science instruction is centred on assisting children in comprehending

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and learning about the events that take place in their environment (Corry, F., 2017). One of the features of scientific education is the existence of scientific Process Skills (SPS). Students that get SPS actively participate in the educational process, develop their problem-solving abilities, adopt scientific habits, are capable of designing experiments, and apply their scientific knowledge (Siti Aisyah, 2024). The following are examples of science process skills: observation, questioning, hypothesis formation, experimentation, measurements, data analysis, conclusion, communication, teamwork, and reflection. A feeling of accountability for learning outcomes and increased student engagement in the learning process can result from instructors, students, and associated parties communicating in an honest, firm, direct, and inspiring manner (Samara RC, et.al; 2023)

Communicating findings from student experiments or projects can improve their ability to convey ideas and results effectively, which is an important part of science skills (Jackson, V., et.al. 2023).

In the classroom, the use of scientific process skills (SPS) is crucial because (I. Wayan, S.; 2020). 1) the rapid development of science requires teachers to train students to seek knowledge in the form of facts and concepts from various sources that are easy in their environment. 2), active interactions carried out by students with their environment will make it easier for them to understand complex and abstract science concepts with concrete examples. 3), the truth of the theory is not absolute and will be refuted if new data is found, what is needed is the instillation of a scientific attitude, 4), concept development needs to be accompanied by the development of attitudes and values in students which can be realized through a process approach involving SPS as a unifier of concept development with attitudes and values.

Communication skills are essential to convey ideas, concepts, and knowledge (Fitri Y, 2023). Students' beliefs about their abilities play an important role in influencing their ability to communicate science (Carroll, et.al; 2024). This activity has a positive impact on students' critical thinking skills. The ability to ask questions is one of the skills in communication skills. Communication process skills need to be taught to students because these skills will train students to think critically and creatively. Critical thinking skills encourage students to evaluate the information obtained as a basis for making more rational and logical decisions. Students' habituation to analyzing and finding solutions to problems can be done in the learning process. Students' experiences in interacting with the surrounding environment are used as provisions for them to study Natural Sciences at school. Science education carried out outdoors, especially in the school environment, enriches student learning by providing direct context regarding natural phenomena. This helps students better understand ecosystems and interactions between organisms (Ayotte, et.al. 2021). Piaget in his theory stated that the basis of learning to think is that knowledge does not come from outside, but is formed by the individual himself in the cognitive structure he has.

Observation results at SD Grogol IV found that there was still a lack of application of experience-based learning in schools, especially in grade IV. Students in grades at SD Grogol IV can be regarded to have a less diverse learning process. One of the approaches that educators employ in the teaching of science is the Problem Based Learning paradigm. Despite the fact that the Problem Based Learning (PBL) concept has been used to education, students' skills in communicating scientific findings and critical thinking are still not optimal, especially in grade IV of SD Negeri Grogol IV, this shows a gap between learning accomplishments and anticipated 21st century skills. Students' development of science process abilities is hampered by this circumstance. Communication abilities are one of the invisible scientific process skills. This less varied learning model results in science process skills, especially communication skills, not developing optimally, as well as the critical thinking process in students at SDN Grogol IV is not visible. During the science learning process, students carry out the learning process limited to what the teacher tells them to do, answer questions from the teacher and collect them to get grades without an in-depth data analysis process.

Implementing the Experiential Learning learning paradigm, in which every learning activity starts with a tangible stage, is one way to solve these issues. In addition, learning using this learning model has several advantages, namely (Richardus Eko, 2022): a) Physical exercise and firsthand experience are emphasised in this approach as essential components of the learning process. b) places a strong emphasis on applying knowledge in real-world situations. c) Students are encouraged to consider and describe their experiences using this approach. d) Students are encouraged to examine their experiences and think critically. Students will be better able to comprehend abstract concepts and develop their

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critical thinking abilities by employing this experiential learning methodology.

It has been demonstrated that using learning models that incorporate firsthand student experience improves student comprehension (Jackson, V., O'Brien, V., & Richards, A; 2023). Students can develop critical thinking skills by reflecting on their experiences through experiential learning. It has been demonstrated that the experiential learning approach in primary schools significantly improves student learning outcomes and helps students meet scientific learning objectives, such as motivation, curiosity, conceptual understanding, and better learning quality. This model emphasizes active student involvement through experience direct, reflection, and application of the concepts learned, which overall create a fun and meaningful learning process, supporting the development of student competencies (Esti, S., et.al; 2023). Both scientific attitudes and science process abilities can be impacted by the experiential learning methodology. Students using the Experiential Learning model outperform those using traditional learning models in terms of their scientific attitudes and science process abilities (Citra, 2021). Choosing the right model in science learning can also help students' thinking processes. Proper communication between teachers and students can increase student involvement in learning (Deehan & Mac, D.; 2024)

Given the demands of the curriculum, which emphasises the application of contextual science and analytical skills, it is imperative that students' scientific communication and critical thinking skills be improved. This is because direct experiments using the Experiential Learning (EL) model must be tested for their effects. Based on the background and results of previous studies, to prove the effect of using the Experiential learning model on science process communication skills and critical thinking skills, researchers will conduct research using the Experiential learning model by comparing two classes, namely the control class and the experimental class on the material of energy changes. This study will compare two Experiential Learning learning models based on the Kolb cycle with PBL and measure the improvement in science process communication skills and critical thinking through pretest-posttest and MANOVA analysis.

The study's goals are to: a) examine how the Experiential Learning model affects science process communication skills, b) examine how the Experiential Learning model affects critical thinking skills, c) examine how the Experiential Learning model affects science process communication skills and critical thinking skills, and d) determine the degree to which the Experiential Learning model affects students' critical thinking and science process communication skills, particularly in grade IV Elementary School students.

2. Materials and Methods

This study's design is nonequivalent control group with pretest and posttest, and it is a quasi-experimental study. During the 2024–2025 school year, this study was carried out in SD Negeri Grogol IV in Gunungkidul Regency. Grade IV students made up the research sample, which was further divided into two groups: the experimental group, which was referred to as grade IVA students, and the control group, which was referred to as grade IVB students. Purposive sampling was used for the sample process. There were twenty pupils in the experimental group and nineteen in the control group.

Tests and documentation are used to gather research data for the research instrument, which is a question item. The test used in this study is an essay test. The question indicators in the study used to measure science process skills include: writing observation information, choosing the right communication method so that it is easily understood by others, presenting information using graphs, charts, and tables, and utilizing secondary information sources. Meanwhile, the indicators used to measure critical thinking skills include: providing simple explanations, drawing conclusions, providing further explanations (advanced clarification) and arranging strategies and tactics (strategies and tactics). These indicators are described in the form of descriptive questions given through tests. Before the questions that have been prepared are used in the study, content and empirical validity tests and instrument reliability tests are carried out. Content validity is done by consulting the question items with the validator lecturer while empirical validity is done by distributing questions to grade IV students in cluster 06 Banyubening 1. According to the findings of the instrument validity test, each item of both variables' Sig. (2-tailed) value is less than 0.05, or 0.000, indicating that the question items are deemed valid. All of the questions are deemed trustworthy based on the reliability test findings, which show a Cronbach Alpha value of 0.728 for critical thinking abilities and 0.661 for the science process skills variable. Every question has been deemed credible and valid for use in tests. This exam will be administered as a pretest at the start

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of the learning process and as a posttest at the conclusion. This test evaluates critical thinking and communication abilities related to the scientific process.

Additionally, the MANOVA test and the parametric statistics independent sample t test were used to process the students' pretest and posttest findings. The impact of the independent variable—the learning model—on each dependent variable was examined using the independent sample t test Specifically, critical thinking and communication abilities related to the scientific process. The impact and amount of the independent variable's influence on both dependent variables were examined using the MANOVA test. The partial eta squared value, on the other hand, shows how much the Experiential Learning model affected both dependent variables.

3. Result and Discussion

The impact of using the Experiential Learning model on two variables—critical thinking abilities and science process skills in communication—is examined in this study using the normality test analysis, homogeneity test, independent samples t-test, and MANOVA.

Testing for normality and homogeneity was the first step before employing the independent sample t test and MANOVA to analyse the data. Since there were less than fifty samples, the Shapiro-Wilk test was applied for data normalcy. The data was found to be normally distributed when the Shapiro-Wilk test revealed a significant value (p) > 0.05 for the pretest and posttest scores for both variables in both groups (Priyanto, 2012). The following are the findings of the normalcy test for the pretest and posttest scores:

Table 1. Data of normality test

No	Aspect	Sig. value
1.	Mean Pretest Score of KPS Communicating Control Group	0,356
2.	Mean Posttest Score of KPS Communicating Control Group	0,139
3.	Mean Pretest Score of KPS Communicating Experimen Group	0,799
4.	Mean Posttst Score of KPS Communicating Experimen Group	0,652
5	Mean Pretest Score of Critical Thinking Ability of Control Group	0,976
6.	Mean Posttest Score of Critical Thinking Ability of Control Group	0,308
7.	Mean Pretest Score of Critical Thinking Ability of Experimen Group	0,065
8.	Mean Posttest Score of Critical Thinking Ability of Control Group	0,521
9.	Difference in Science Process Skills scores Communicating control group	0,285
10.	Difference in Science Process Skills scores Communicating Experimen group	0,205
11.	Difference in Critical Thinking Ability scores of the control group	0,311
12.	Difference in Critical Thinking Ability scores of the experimen group	0,629

Next, homogeneity testing is carried out for the data values of both groups. Homogeneity testing with Levene. Levene's test shows a p value > 0.05 in the comparison of the pretest and the difference in scores of the two variables, so that the data is homogeneous. The following are the outcomes of the homogeneity test:

Table 2. Data of homogeneity test

No	Aspect	Sig. value
1.	Pretest Score of Communicating Science Process Skills	0,093
2.	Pretest Score of Critical Thinking Skills	0,219
3.	Difference Score of Communicating Science Process Skills	0,370
4.	Difference Score of Critical Thinking Skills	0.400

The homogeneity test findings indicate that the data is homogenous and can be utilised for hypothesis testing because the Sig. value of the pre-test score and the difference in the values of the two variables for students in the experimental and control classes are both above 0.05.

Parametric statistics, specifically the Independent Sample Test (Sampling Test), are used in hypothesis testing. t) to ascertain how each variable differs, and the MANOVA test to observe how treatment affects both variables at the same time. Using the independent sample t test, the big effect test for critical thinking abilities yielded the following results:

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Table 3. Difference test of pretest posttest scores for science process skills in communicating

Difference test of pretest posttest scores	Sig. value	additional information
Control and experimental groups of science process skills communicating	0,000	Difference

Sig (2-tailed) on equal variance not assumed is 0.000, according to the t-test findings based on the data collected. Or <0.05, M = 43.5, SE = 4.99, t(39) = -8.70, indicating that Ho is rejected according to the previously described criterion. Stated otherwise, the evidence indicates a substantial difference in the variable of conveying Science Process Skills between individuals who utilise the Experiential Learning learning paradigm and those who do not. It is possible to conclude that the application of the Experiential Learning learning model improves student learning outcomes in the communication of Science Process Skills. The following figure shows the disparity in values about explaining science process abilities:

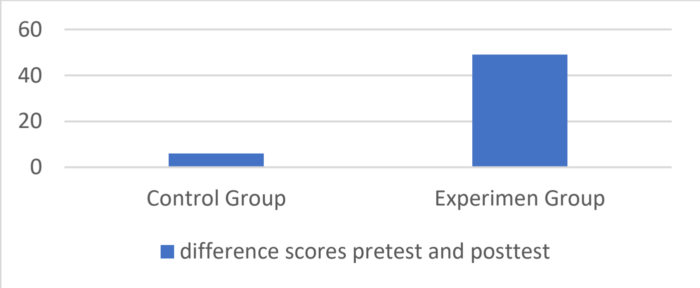

Figure 1. Graph of the difference in scores between pretest and posttest for science process skills in communicating

The results of the large effect test for critical thinking skills using independent sample t test as follows:

Table 4. Difference test of pretest posttest scores of critical thinking skills

Difference test of pretest posttest scores	Sig. Value
Control and experimental groups of critical thinking skills	0,000

Sig (2-tailed) on equal variance not assumed is 0.000, according to the t-test findings based on the data collected. Or <0.05, t(39) = 3.93, M = -13.5, SE = 3.44 In other words, the data indicates that there is a significant difference between those who use the Experiential Learning learning model and those who do not use the Experiential Learning learning model on the critical thinking ability variable. This is demonstrated by the fact that Ho is rejected based on the previously explained criteria. The following graph shows the value difference:

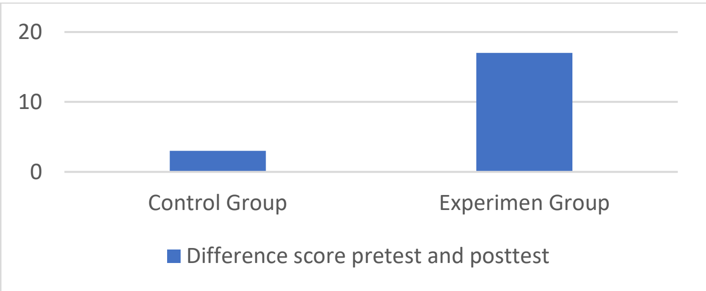

Figure 2. Graph of the difference in scores between pretest and posttest thinking ability

The next test is MANOVA test which used to see the simultaneous effect of both dependent variables. The results of the MANOVA test show the following data:

Table 5. effect of the two dependent variables test

Effect		F	Sig.	Partial Eta Squared
Intercept	Hotelling's Trace	62.907[b]	.000	.778
variabel	Hotelling's Trace	38.509b	.000	.681

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Table 6. effect of each dependent variable test

Source	Dependent Variable	F	Sig.	Partial Eta Squared
variable	KPS Difference	76.792	0.000	0.675
	Critical Thinking Difference	15.867	0.000	0.300

Testing has shown that the experiential learning approach significantly improves critical thinking and science process communication abilities. The adoption of the Experiential Learning model significantly improves students' critical thinking and science process communication abilities, according to the findings of the independent samples t-test and MANOVA statistical tests. The effect's size indicates that communication abilities are more strongly impacted (67.5%) than critical thinking (30.0%).

Learning in each group during the study was carried out in 6 meetings with a duration of 70 minutes for each meeting. The assessment of variables, both the variables of science process skills communicating and critical thinking skills were taken from the results of the Pretest and posttest of both variables in the form of essay questions in both groups. Hypothesis testing was then conducted using the Pretest and Posttest data. A precondition test comprising a normality test and data homogeneity was conducted prior to the hypothesis testing, and all test results satisfied the necessary prerequisite tests. To determine if there was a significant difference between the pretest and posttest scores in both groups, as well as to determine the current effect size, hypothesis testing was done using an independent sample t test. In this study, the difference between the pretest and posttest scores in both groups was examined using the paired t test. The magnitude of the effect of the experiential learning model on the skills of the competitive process of communicating and critical thinking skills was tested using the MANNOVA test.

Students' success in responding to posttest questions demonstrates their mastery of the science process skill indicators in this study, which include writing down observational information, selecting appropriate communication tools for others to understand, conveying information using graphs, charts, and tables, and using secondary information sources. In the pretest questions, both the control group and the experimental group did not show answers that were in accordance with the indicators of using graphs, charts and tables to convey information and using secondary information sources. Most students did not understand how to make tables or graphs to change and present experimental results. After the learning process with the experiential learning model in the experimental group and PBL in the control group was completed, a posttest was conducted. In the experimental group, but not in the control group, the experimental group's responses on the students' posttest answer sheets for these markers grew quickly. This occurred because the experimental group's learning process was used to converting data into information in order to present experimental outcomes. In line with the achievement of this indicator, other indicators also developed, namely expressing observational information in writing. The success in expressing observational information supports the success of achieving the indicators of using graphs, charts and tables to convey information and using secondary information sources because in writing the observation results are accompanied by graphs or tables.

Indicators of critical thinking abilities are also growing nicely, in addition to the signs of science process communication capabilities. Students in the experimental group and some students in the control group's posttest scores clearly demonstrate this. Students are asked to solve problems with the tossing of a ball in the posttest questions. They have demonstrated that they can correctly answer these questions and relate them to the energy in the human body. This helps one measure of critical thinking abilities, which is the ability to organise ideas and tactics and give straightforward explanations. Students in the control group documented observations and activities to draw conclusions from the observations during the learning process. The indication of forming conclusions and offering further explanations (advanced clarification) is supported by this activity. This result is also seen in the increase in students' scores on the critical thinking ability indicator items.

The results of the test of the big effect of the experiential learning model's application on each variable revealed a Sig. <0.05, meaning that each variable was significantly impacted by the

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application of the experiential learning model. Consistent with the test results, the MANOVA test yielded comparable findings. The use of the experiential learning model also had a significant influence on both variables at the same time, as indicated by the multivariate test's significance value of less than 0.05. The use of the experiential learning model had a more substantial influence on learning in the experimental group than on learning in the control group using the PBL model, according to the data from the research of two class groups. The science process abilities of communication were more affected by the experiential learning model (67.5%) than the critical thinking skills (30%).

According to the results of the MANOVA test, the application of the experiential learning model had an impact on both dependent variables. Additionally, each dependent variable—that is, students' communication and critical thinking skills related to the science process—saw a significant increase. The variable of communication science process abilities increased significantly. Treatment had a greater impact on communication skills related to the science process (6.75%) than on critical thinking (only 30%).

Learning that fully involves students in learning activities has an impact on improving the process of science communication in students (Fikrotul Azizah, 2023). Active experimental activities invite students to experiment, discuss and communicate in groups.

Learning process in the experimental group that implemented the experiential learning model experienced an increase in students' critical thinking skills compared to the control group that implemented the learning process with the PBL model. During the learning process, differences were seen in the activities of exploring students' experiences related to energy in everyday life. In the experimental group, all children were invited to remember any events they had experienced related to energy utilization. The events experienced by the students were then developed and linked to the material on energy and its changes, in other words, the material they learned at school was something they had actually experienced. Unlike in the control group, the activity began with an introduction to the material from the teacher and then the students in the group got a case or problem which they then discussed together with the help of them. The disparities in each group's pupils' critical thinking abilities are also influenced by this variation in the educational process. Students' critical thinking abilities are positively impacted by active experimental activities in the experiential learning approach (Tri Susanti, Fifi M, & Diandra Oryza; 2022).

The current study shows that fourth-grade students' critical thinking and science process communication skills are greatly improved by the experiential learning approach. The substantial partial eta squared values ($\eta^2 = 0.675$ for communication skills and $\eta^2 = 0.300$ for critical thinking) highlight that learning by direct experience fosters more meaningful engagement with scientific concepts compared to conventional and PBL approaches. These findings reinforce Kolb's (2014) theoretical assertion that authentic, hands-on activities enable learners to construct deeper understanding through reflection and abstraction.

The implications of this research include: a)Curriculum Design**:** Incorporating structured experiential learning cycles can transform abstract science topics into tangible experiences, promoting accurate use of tables, graphs, and secondary sources during data communication. To optimise skill development, educators should create lesson plans that methodically go through abstract conceptualisation, reflective observation, active experimentation, and tangible experience. b) Professional Development for Teachers: Educator training programs must emphasize strategies for effective facilitation of student-led experiments and guided reflections. Equipping teachers with formative assessment tools to monitor students' communication of scientific findings can help identify gaps in understanding in real time. c) School Policy: School administrators should allocate resources and schedule adequate time for laboratory and field-based activities, recognizing that experiential learning demands more classroom flexibility but yields higher order thinking gains.

Limitations in this study include: a) Sample Generalizability: The purposive sample from a single elementary school limits external validity. Results may differ in schools with varying resources, teacher expertise, or student socio-economic backgrounds. b)Duration of Intervention: The six-week intervention may not capture long-term retention or transfer of skills. Without longitudinal follow-up, it remains unclear whether improvements persist beyond the study period. c) Assessment Scope: Reliance on essay-based pre- and post-tests may not fully capture multimodal communication skills (e.g., oral presentations, 3D modeling) or nuanced critical thinking processes.

In order to perfect this research, here are some suggestions that can be carried out by

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future researchers who will conduct similar research, including: a) Future Research: Conduct longitudinal studies with diverse school settings and larger samples to assess the sustainability and scalability of experiential learning effects. Mixed-method designs incorporating observations and interviews could deepen insights into students' metacognitive processes. b)Assessment Enhancement: Develop and validate performance-based assessment rubrics for evaluating oral and digital science communication, as well as collaborative critical thinking tasks, to provide a more comprehensive evaluation of student competencies. c) Integrated Pedagogy: Explore blended instructional models that combine experiential learning with problem-based or inquiry-based approaches to leverage the strengths of each method and address varied learner needs. d). Policy Advocacy: Engage stakeholders—curriculum developers, school boards, and funding agencies—in dialogues about shifting from teacher-centered to learner-centered science education, emphasizing the documented benefits for 21st-century skills development.

Significant effect of the experiential learning model on both variables is certainly inseparable from good learning activities. Full and conscious student involvement is a supporting force in this study. The existence of this positive effect also proves that the theory of learning from experience is a good, true and proven learning process.

4. Conclusion and Suggestions

Theoretically, it can be inferred from the research findings that using the Experiential Learning model regularly enhances students' critical thinking abilities and their capacity to explain the scientific method. These findings address the study question that direct experience-based learning is superior to problem-based learning as a traditional method for developing both abilities. Therefore, in order to promote active student participation, a thorough comprehension of ideas, the development of analytical abilities, and the presentation of scientific arguments, the Experiential Learning model deserves to be the primary approach used in science instruction in elementary schools.

It has been demonstrated that by encouraging students to actively participate in each phase of the scientific process, the Experiential Learning Model improves the structure and significance of their communication of concepts, procedures, and observational findings. By emphasising firsthand experience, students grow not just as information consumers but also as scientific communicators capable of rationally and effectively presenting findings.

Students' critical thinking skills are developed through systematic reflection and experimental learning experiences. Students gain the ability to analyse information, assess supporting evidence, and draw logical conclusions in this setting. This method develops critical thinking abilities that are applicable to scientific instruction in primary schools and long-lasting.

When compared to traditional methods and problem-based learning, the experiential learning model provides a more comprehensive framework for learning. This model addresses the issue of poor science communication and critical thinking abilities by combining practical experiences, introspection, and concept application. It also lays the groundwork for the creation of more efficient and significant teaching methods at the elementary school level.

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