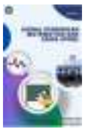

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Enhancing Problem-solving Ability and Written Communication Skills through Ethnochemistry-integrated Problem-based Learning

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Abstract

This study aims: (1) to know the problem-solving ability of the experimental group and the control group; (2) to know the written communication skills of the experimental group and the control group; (3) to know the effective contribution of ethnochemistry-integrated Problem-based Learning (PBL) model to problem-solving ability; (4) to know the effective contribution of ethnochemistry-integrated PBL model to written communication skills. This research used a quasi-experiment model with a posttest-only design. Data were analyzed an independent samples t-test & independent samples effect sizes. The results showed: (1) there is a significant difference in problem-solving ability between the experimental group and the control group; (2) there is a significant difference in written communication skills between the experimental group and the control group; (3) the implementation of ethnochemistry-integrated PBL model gives a strong effect of 1.034 on problem-solving ability; (4) the implementation of ethnochemistry-integrated PBL model gives a strong effect of 1.136 on written communication skills. The implementation of ethnochemistry-integrated PBL can be useful and applied in learning as an innovation with teachers as facilitators and students as the focus of learning in other chemical materials.

Keywords: *Ethnochemistry, Problem-solving ability, Written communication skills, Problem-based learning, Redox and electrochemical reactions.*

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INTRODUCTION

Education has an important role in building the nation's successors, which can be formed through human resource development. Rapidly developing science and technology create challenges in 21st-century education (Azura & Octarya, 2020). Ideally, there are five important skills to be honed and developed in the world of 21st-century education, namely communication skills, critical thinking skills, problem-solving skills, collaborative skills, and creative thinking skills (Malik et al., 2020). Regulation of the Minister of Education and Culture of the Republic of Indonesia (Permendikbud) No. 81A of 2013 states that the implementation of the curriculum aims to ensure that students can creatively, think critically, and communicate which are important for facing the challenges and demands of life in a global society (Fatihah et al., 2022).

However, teacher-centered learning is often dominated by memorization methods without in-depth concepts, so students only receive direct explanations from the teacher passively. If students only receive and record the lesson material explained by the teacher, then their knowledge potential cannot be honed optimally which can have an impact on the lack of student activity in the learning process (Marfuah, 2017). Student-focused learning activities are believed to enhance the learning process through specific designs that help students understand deeper and specific knowledge and practices, as well as develop necessary general skills. Active student engagement in learning can be beneficial, as it can make it easier for students to understand the material (Alawiyah et al., 2015; Damşa & Lange, 2019).

A new framework for designing learning environments has been developed in response to constructivist views of learning over the past two decades. Student-centered learning environments can take various forms, such as collaborative learning, problem-based learning, computer-supported collaborative learning, cooperative learning or active learning (Hoidn & Reusser, 2021; Pratama et al., 2024). Students can be helped in terms of understanding and deepening the learning material by implementing the right learning model, one of which is relevant to apply is Problem-based Learning (PBL). PBL can encourage students to actively participate in the process of solving the problems they face so that it can support students in understanding and deepening the subject matter. The PBL learning model focuses on students who can encourage them to exchange knowledge through discussions in the problem-solving process. Students contribute to each other in finding solutions to the problems they face (Aza et al., 2020). PBL aims to hone students' abilities to solve problems which can make students more challenged and enthusiastic in learning activities (Irsyam, 2020).

Teachers must innovate in learning activities so that students are helped to understand the subject matter. The chemistry studied by students is expected to be able to provide knowledge related to various events and incidents that occur around them. As in the material on redox and electrochemical reactions, Suciwati & Muchlis (2019) stated that this material is one of the materials close to everyday life and has characteristics that require validation to obtain facts and problem-solving processes.

On the other hand, problem-solving skills supported by communication skills can support the learning process of students (Muftihana et al., 2019). Communication skills are needed to convey ideas, support the process of organizing thoughts, and the basis for problem-solving so that they have a positive relationship with problem-solving abilities (Rambe et al., 2022). Developing communication skills, both oral and written, is crucial for optimizing learning design. Several articles have shown that when the learning environment demands enhanced communication skills, it is important to ensure students are fully engaged in interactions with their learning environment. This means that students can develop their communication skills if they are given the space and opportunity to learn and practice these competencies (Khoiriah et al., 2023). Written communication skills were one of the main aspects measured in this study.

Meanwhile, chemistry has scientific principles that can be applied in human interactions with the surrounding environment, one form of which is local wisdom. Studies that reveal various aspects of local wisdom in this context are called ethnochemistry. Ethnochemistry investigates human interactions with the surrounding environment and utilizes local wisdom to support an understanding of chemistry (Adesoji et al., 2019). Understanding ethnochemistry in learning activities is one form of developing written communication skills that makes PBL a relevant learning model.

One of the local wisdoms that can be integrated with ethnochemistry is the Jamasan Pusaka Tradition. The Jamasan Pusaka Tradition aims to maintain the existence of cultural heritage or heirlooms as a form of preserving local wisdom. The Jamasan Pusaka Tradition aims for the nation's successors to understand the Jamasan Pusaka Tradition so that they can participate in preserving local wisdom (Ilafi, 2020). The process of caring for heirlooms in the Jamasan Pusaka Tradition can be linked to the redox reaction lesson material.

Figure 1. The jamasan pusaka procession

The use of lime as a natural inhibitor of corrosion on iron aims to clean iron metal from rust. The rate of corrosion can be reduced by the presence of citric acid (Maryati, 2006). The Borobudur Conservation Center can prove that lime is one of the natural inhibitors of corrosion on metal (Swastikawati et al., 2017). The use of citric acid found in lime in chemistry aims to clean the rust that sticks. Metal that has undergone oxidation can be dissolved using citric acid (Pramujo, 2017).

The earthenware vessels used in the jamasan procession are made through a process that has passed the reduction stage and has reached the oxidation stage (Nastiti, 2001). The flowers used in the keris washing process contain polyphenolase enzymes so that a browning reaction occurs in oxidative conditions (Sangadji et al., 2017). Arsenic is used in coating the keris blade in the coloring process to prevent new rust from forming (Priyanto, 2010). The perfumed oil applied to the keris blade after cleaning can inhibit the oxidation reaction due to air humidity on the keris blade (Pramujo, 2017).

Thus, an ethnochemistry-integrated PBL learning model is needed to train students' written communication skills. The Jamasan Pusaka tradition is the focus of study in this study which is expected to build students who understand chemistry and participate in preserving local wisdom. This is essential in education, so research is needed on the effect of the ethnochemistry-integrated PBL model on students' problem-solving abilities and written communication skills.

METHOD

The population in this study was all 12th-grade science students at State Senior High Schools in Semarang City, consisting of 16 schools. Students who can be involved in the study must have the same characteristics, which include students' age between 17 and 19 years, the school having "A" accreditation, using "Kurikulum 2013", and the school having run local wisdom programs.

The probability sampling technique of cluster random sampling type is used for sampling. The determination of the sample in this study was done by analyzing the equality of each class, whether there was a difference or not, based on the Final Semester Assessment (FSA) data covering 5 classes. The FSA score was tested using ANOVA. The results of the analysis showed that there was no difference, so students in several randomized classes had the same ability. The sample in this study was students of class XII MIPA 1 as the experimental group and students of class XII MIPA 2 as the control group. The sample size was 28 students in the experimental group and 34 students in the control group.

The research model used in this study is a quasi-experiment with a posttest-only design. Two research groups were used based on the research hypothesis being investigated. Both groups used the same learning materials, namely redox reactions and electrochemistry. The experimental group was carried out by implementing the ethnochemistry-integrated PBL, while the control group was carried out by implementing the PBL.

Each group in the study received the same number of sessions, namely 5 sessions with a time allocation of 10 × 45 minutes. The time allocation of 5 sessions consisted of 4 sessions for learning and 1 session for the posttest. The difference in problem-solving ability was measured by the posttest, which was administered during the fifth (last) session. The posttest questions consisted of 10 items in the form of descriptions.

The research instruments used are learning instruments and data collection instruments. Learning instruments are in the form of Learning Implementation Plans and Student Worksheets. Data collection instruments are in the form of problem-solving ability tests and written communication skills observation sheets. The essay-type post-test instrument is used to determine how high the students' understanding is after the learning process. The observation sheet instrument is used to measure students' written communication skills at the end of learning.

The test instrument is used to measure the problem-solving ability of students. The indicators of problem-solving ability applied in this study are synthesised results, which can be seen in Table 1. Indicators used in research are identifying and understanding the problem, planning problem-solving, and carrying out the planning. The lattice of students' problem-solving ability test instruments in this study is a description test totalling 10 questions which can be seen in Table 2.

Table 1. Synthesis of problem-solving ability indicators

Polya (1973)	Bransford & Stein (1993)	Yuriev et al. (2017)	Bayuningsih et al. (2017)
Understanding the problem	Identify problems and opportunities	Defining the problem	Understanding the problem
Making a plan	Defining objectives	Analysing the problem	Developing a plan
Implementing the plan	Exploring possible strategies	Planning	Implementing the plan
Looking back	Anticipate outcomes and act	Implementing planned steps	Reflecting
	Look back and learn	Evaluating	

Table 2. Test grid for students' problem-solving ability

Stages of Problem-Solving Ability Indicator	Question Indicator	Number of Items
1. Identify and understand the problem 2. Planning problem-solving 3. Carry out the planning	Students can equalize the redox reaction equation using the bilox change method in molecular reactions correctly.	1
	Students can equalize the redox reaction equation using the bilox change method in ion reactions correctly.	1
	Students can equalize the redox reaction equation using the half-reaction method correctly.	1
	Students can identify the arrangement of voltaic cells and the working principle of voltaic cells correctly	1
	Students can calculate cell potential based on standard potential data correctly.	1
	Students can identify the exact arrangement of the voltaic cell series.	1
	Students can analyze voltaic cells in daily life correctly.	1
	Students can analyze the factors that can cause the corrosion process appropriately.	1
	Students can explain the ways to prevent corrosion appropriately.	2
Amount		10

The observation sheet used in this study was to measure students' written communication skills. The communication skills measured refer to the synthesis of concepts or indicators of communication skills put forward by experts, presented in Table 3. Indicators used in research are appropriateness of context, originality, evidence and references, language, and format and systematic writing. The lattice of the observation sheet for written communication skills is presented in Table 4

Table 3. Synthesis of indicators of written communication skills

Rhodes & Finley (2013)	Wankat & Oreovicz (2015)	Mardhatillah et al. (2023)	Wildan et al. (2019)
Appropriateness of context and purpose of writing	Organization	Writing down information	Abstract
Content development	Content	Explaining and representing ideas through illustrations	Source of information
Genre and theme	Abstract or summary	Analyse and provide solutions	Organization
Writing materials and supporting evidence	Format and aesthetics	Closing explanation	Relevance
Writing structure and mechanism	Data presentation and visuals Spelling and grammar Style Citations and references		Content Presentation

.

Table 4. The lattice of observation sheet for students' written communication skills

Indicators	Aspects observed
Appropriateness of context	The content is by the predetermined context.
Originality	Own ideas and no plagiarism.
Evidence and References	Problem-solving is supported by strong theory. References used are more than 5. The references used are published in the last 5 years.

Indicators	Aspects observed
Language	Sentences used are based on EYD rules and are effective.
Format and systematic writing	The writing format is by the provisions, stated systematically, completely, and clearly.

Theoretical validity testing by a judgment expert and empirical validity testing were used in this study with the help of the SPSS program. An empirical validity test was conducted in one school in Semarang City for students who have received redox reaction and electrochemistry materials. The school has the same characteristics as the school used in the study. The posttest question of students' problem-solving ability was tested using Pearson product-moment at the 5% significance level with the help of the SPSS program.

The results of empirical validation of posttest questions of problem-solving ability show that there are 10 questions out of 20 questions have a Sig value. <0.05 which is declared valid. The validation results are shown in Table 5.

Table 5. Empirical validity test results

Item	Significance Value	Description	Item	Significance Value	Description
1	0.124	Invalid	11	0.000	Valid
2	0.000	Valid	12	0.291	Invalid
3	0.066	Invalid	13	0.090	Invalid
4	0.000	Valid	14	0.000	Valid
5	0.000	Valid	15	0.149	Invalid
6	0.296	Invalid	16	0.109	Invalid
7	0.000	Valid	17	0.000	Valid
8	0.158	Invalid	18	0.126	Invalid
9	0.334	Invalid	19	0.000	Valid
10	0.000	Valid	20	0.000	Valid

The valid problem-solving ability posttest questions were tested for reliability using Cronbach's alpha at the 5% significance level using the SPSS program. The classification of the reliability coefficient is > 0.90 with very high criteria, 0.80 – 0.90 with high criteria, 0.70 – 0.79 with fair criteria, 0.60 – 0.69 with low criteria, < 0.60 with very low criteria (Cohen et al., 2018). The reliability test results were obtained at 0.842 which has high criteria.

The data analysis used is an independent samples t-test & independent samples effect sizes. Independent samples t-test is used to test whether or not there is a significant difference in the ethnochemistry-integrated PBL model on students' problem-solving abilities and written communication skills separately. MANOVA test cannot be performed because the Pearson correlation value is not moderate.

The T-test prerequisite test was conducted first before hypothesis testing. The results of the prerequisite test are as follows (Cohen et al., 2018).

1. Interval or ratio data
2. Random sampling
3. Normally distributed data

The results of the normality test in Table 7 show that the significance value is >0.05. Data is normally distributed if the significance value is >0.05.

Table 7. Shapiro-Wilk normality test results

Variable	Group	Sig.
Problem-Solving Ability	Experiment	0.075
	Control	0.097
Written Communication Skills	Experiment	0.273
	Control	0.091

4. Homogeneous data

Data is homogeneous if the significance value is >0.05. The results of the homogeneity test obtained a value of 0.864 for the problem-solving ability variable and 0.760 for the written communication skills variable, where the significance value obtained was >0.05.

The t-test prerequisite tests have all been met so that the next test can be carried out, namely independent samples t-test & independent samples effect sizes.

RESULT AND DISCUSSION

This research was conducted at SMA Negeri 8 Semarang with an experimental group in class XII MIPA 1 and a control group in class XII MIPA 2. The experimental group used the ethnochemistry-integrated PBL and the control group used the non-ethnochemistry integrated PBL. The purpose of this study was to determine whether or not there was a difference in the implementation of the ethnochemistry-integrated PBL with the non-ethnochemistry-integrated PBL on students' problem-solving abilities and written communication skills in the material of redox and electrochemical reactions.

The implementation of the PBL requires proof to obtain a fact through the problem-solving process. The application of the ethnochemistry-integrated PBL is able to challenge students to solve problems while conveying their solutions to gain new understanding in the learning process. Ramandanti & Supardi (2020) said that the PBL integrated with local wisdom makes students more active because learning is centered on students which allows students to gain deeper knowledge.

The application of integrated local wisdom learning can help students master the learning objectives that have been set (Syazali & Umar, 2022). Learning objectives can be achieved determined by several factors, one of which is the use of an appropriate learning model (Hidayatussani et al., 2020). Integrated local wisdom learning plays a role in building an understanding of the environment and society as well as the concept of chemistry.

The implementation of the ethnochemistry-integrated PBL is based on the relationship between cultural values and scientific knowledge. The tradition of jamasan heirlooms provides knowledge to students regarding the concept of redox reactions, both community and scientific knowledge. The redox reaction process in the metal of heirlooms by oxygen causes rust. The use of lime in the mutih procession of the jamasan heirloom tradition is one way to clean rust. Then the perfume oil is smeared on the blade of the heirloom object to inhibit oxidation reactions due to air humidity.

The ethnochemistry-integrated PBL was chosen to improve students' problem-solving abilities while understanding local wisdom related to chemical material, especially in redox and electrochemical reaction materials. The ethnochemistry-integrated PBL learning model was applied to the experimental group, while the PBL learning model was applied to the control group as a comparison. Each group was carried out 5 times, ending with a posttest.

Learning activities in the experimental and control groups used student worksheets based on the learning model applied to each group. Students were given learning objectives and steps and presented with problems which were the initial steps in learning. The problems presented are relevant challenges in life-related to chemical knowledge about redox and electrochemical reactions. Students can actively participate and be directly involved in the problem-solving process during the learning process.

Students discuss using student worksheets to solve problems and find solutions in groups. There are several stimuli and questions in the student worksheets that contain ethnochemical material. The author assigns group representatives to convey solutions to the problems, which are then evaluated together. The posttest is conducted at the last meeting after students are given treatment.

Students are indirectly asked to be active during the learning process, starting from identifying and understanding problems, planning problem-solving to implementing planning. Problem-solving skills are very much needed by students in strengthening learning materials and facing problems in everyday life. Learning activities that involve the active role of students can produce deeper learning so written communication skills are also important in strengthening the concept of material that has been obtained during the learning process.

Effectiveness of Problem-Solving Ability

The difference in problem-solving abilities was measured through a posttest conducted at the fifth (last) meeting. The posttest questions consisted of 10 items in the form of descriptions. The posttest questions went through a theoretical validation stage by asking for consideration from 2 expert judges. Empirical validation was carried out by testing 72 students of SMA Negeri 16 Semarang. The results of the empirical validation stated that 10 posttest questions were valid and suitable for use in research.

Based on the results of the posttest that has been carried out, there is a difference in the average problem-solving ability between the experimental group students and the control group. The experimental group students have a mean posttest score of 86.64, while the control group has a mean posttest score of 81.24, which can be seen in Figure 2. The control group range is higher than the experimental group, so the control group has a higher variance. The control group varied more than the experimental group. The experimental group has a standard deviation of 5.19, while the control group is 5.26. The distribution of individual problem-solving ability scores in each group can be seen in Figures 3 and 4.

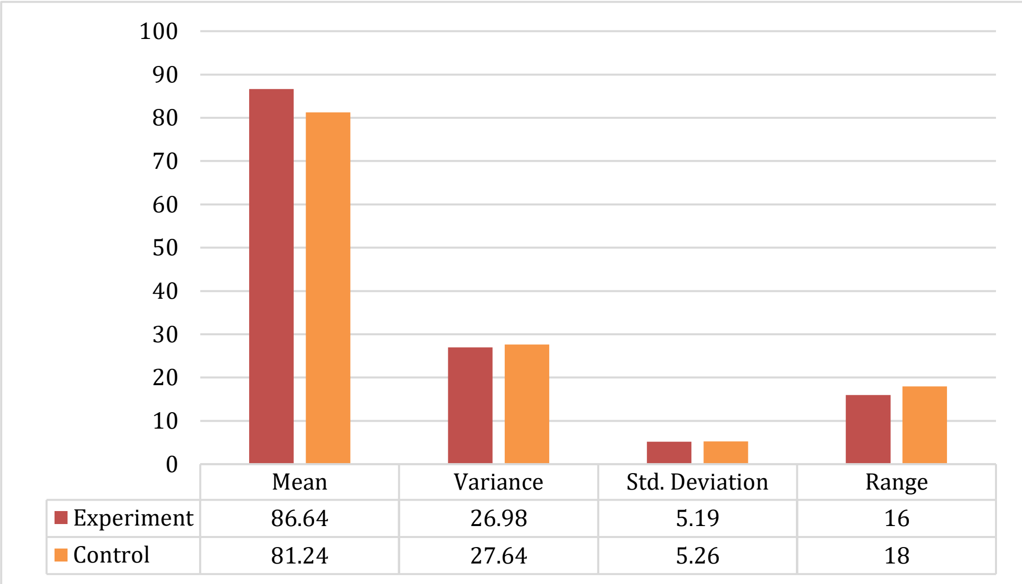

Figure 2. Problem-solving ability

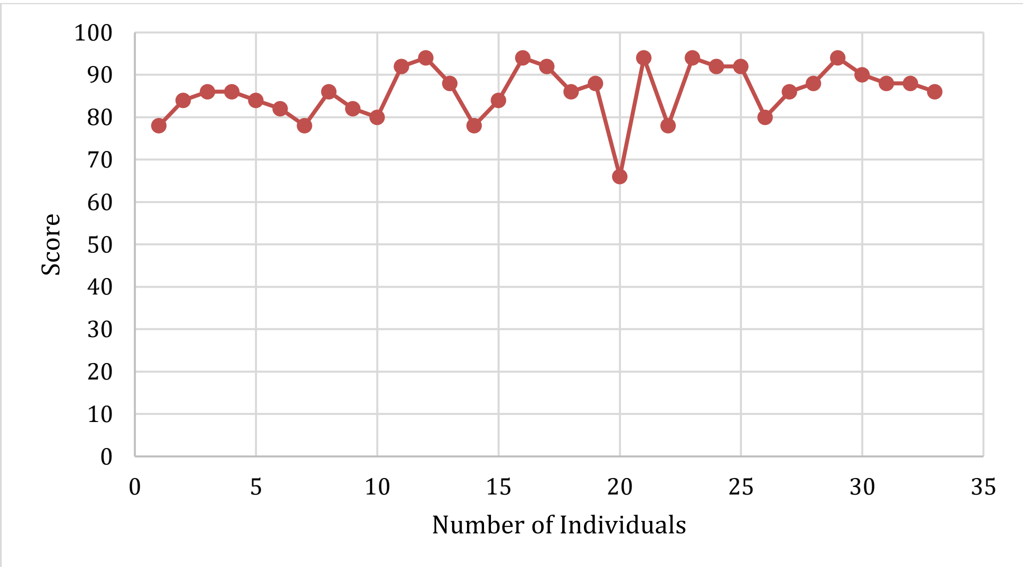

Figure 3. Distribution of problem-solving ability scores in the experimental group

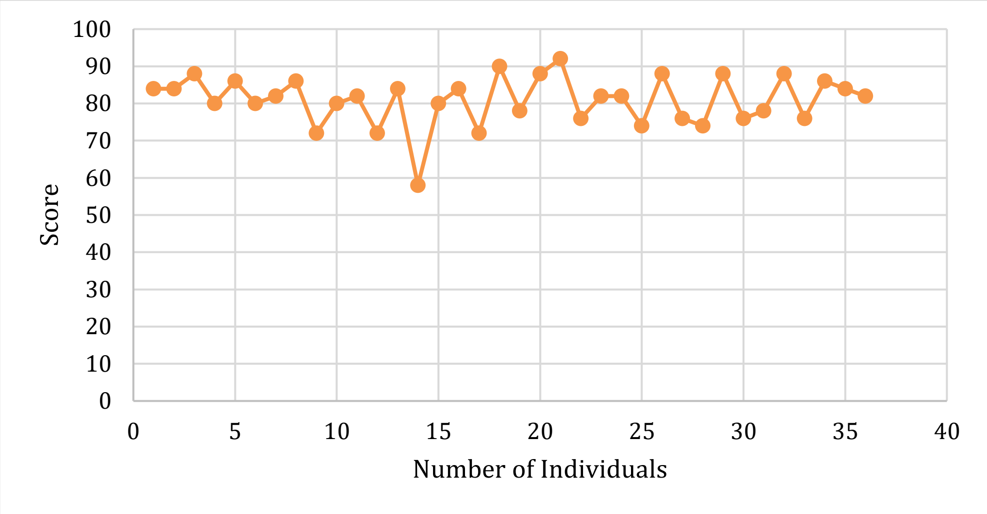

Figure 4. Distribution of problem-solving ability scores in the control group

The results of the independent samples t-test showed that the Sig. (2-tailed) value for the problem-solving ability variable was 0.000, which means the Sig. (2-tailed) value <0.05, so it can be concluded that there is a significant difference in the problem-solving abilities of students who take part in learning with the ethnochemistry-integrated PBL and the non-ethnochemistry-integrated PBL on the redox and electrochemical reaction material. The large contribution of the implementation of the ethnochemistry-integrated PBL to problem-solving abilities can be seen from the results of the independent samples effect sizes with a strong category which is shown in Table 9, which means that the implementation of the ethnochemistry-integrated PBL on the redox and electrochemical reaction material has a strong effect on students' problem-solving abilities.

Table 9. Independent samples effect sizes on problem-solving ability

Statistic	Point Estimate	Category
Cohen's d	1.034	Strong
Hedges' correction	1.021	Strong
Glass's delta	1.029	Strong

The implementation of the ethnochemistry-integrated PBL learning model to students affects their problem-solving abilities. The application of the ethnochemistry-integrated PBL learning model requires students to be able to integrate their understanding of the concepts of redox and electrochemical reactions with local wisdom so that students can build learning concepts by developing problem-solving abilities independently. Students' problem-solving abilities are trained through the PBL model during the learning process (Sabora et al., 2022; Suciwati & Muchlis, 2019).

Problem-solving skills require a more complex thinking process by applying the knowledge that has been acquired to new situations. Therefore, problem-solving skills are very important in learning and everyday life. Problem-solving skills can be built through written communication skills. The stages of problem-solving skills and communication skills are interrelated.

Students sometimes fail to solve problems because they cannot understand the problem. The main thing in problem-solving is interest in facing challenges and the willingness to solve problems. Understanding the problem plays a very important role in planning problem-solving. OECD (2013) states that a problem can be understood by understanding the terms used or language in the problem, formulating what is known and asked, whether the information obtained is sufficient, and what terms or conditions must be met. Then understanding the problem and planning to solve the problem can facilitate the implementation of the plan that will be carried out by students.

Effectiveness of Written Communication Skills

Students' written communication skills were measured using an observation sheet instrument at the end of learning. The observation sheet has gone through a theoretical validation stage by asking for consideration from 2 expert judges. Based on the results of the observation sheet, there was a difference in the average score of written communication skills between students in the experimental group and the control group. Students in the experimental group had a mean observation score of 54.69, while the control group had a mean observation score of 47.06, as shown in Figure 5. The experimental group range is higher than the control group, so the experimental group has a higher variance. The experimental group varied more than the control group. The experimental group has a standard deviation of 6.721, while the control group is 6.719. Students in the experimental group had deeper written communication skills regarding redox and electrochemical reactions. The distribution of individual written communication skill scores within each group can be seen in Figures 6 & 7.

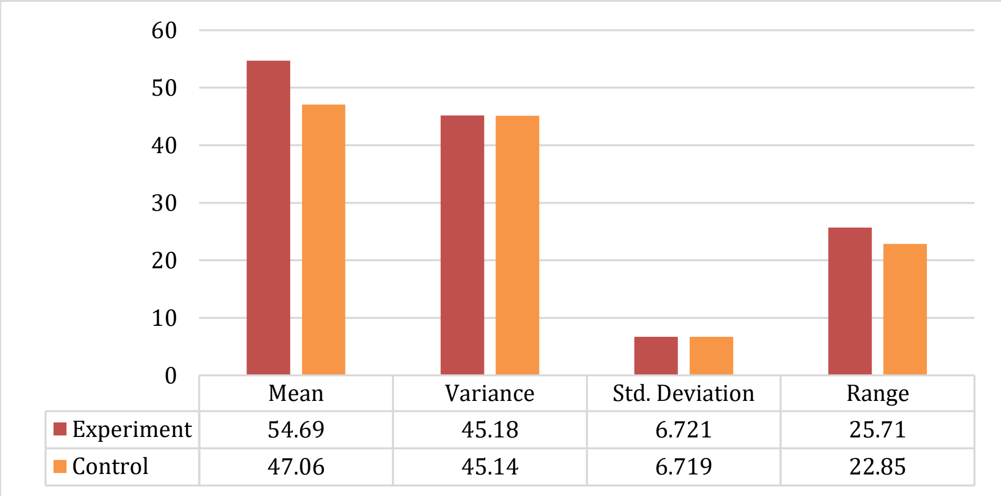

Figure 5. Written communication skills

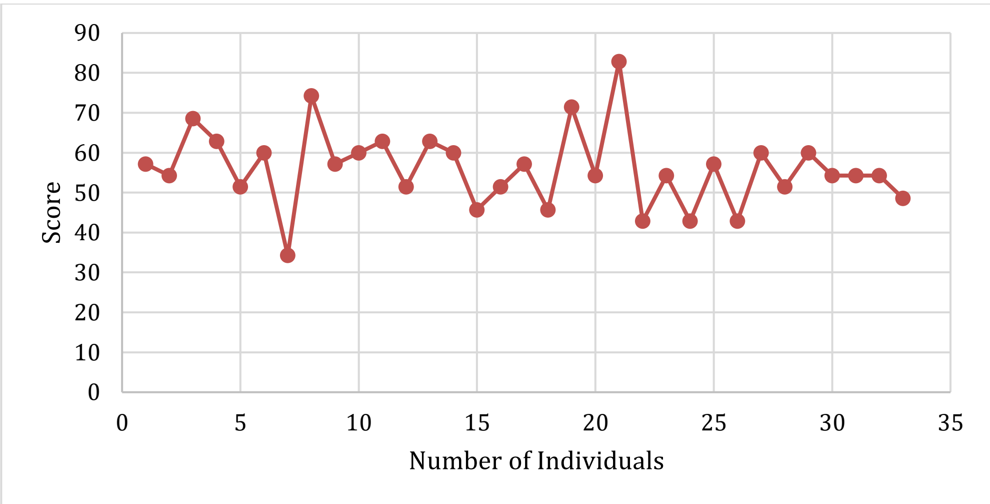

Figure 6. Distribution of written communication skills scores in the experimental group

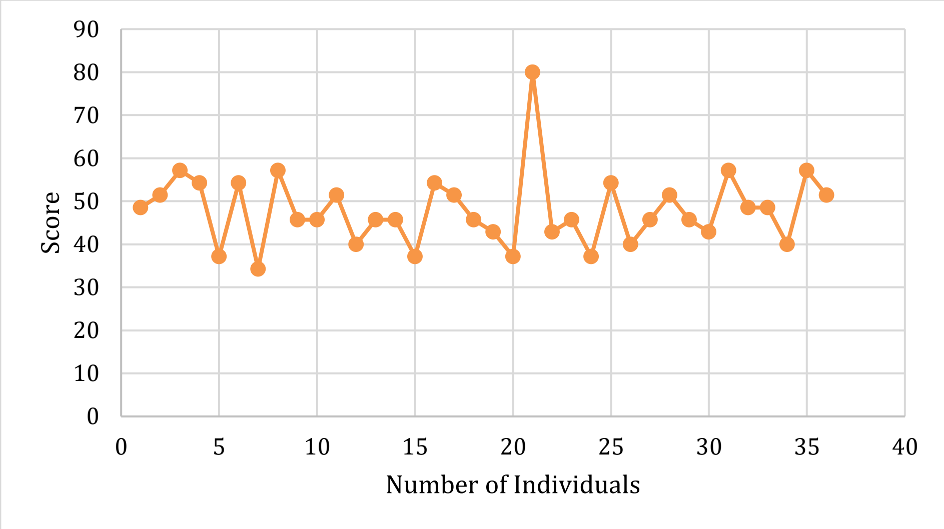

Figure 7. Distribution of written communication skills scores in the control group

The results of the independent samples t-test showed that the Sig. value. (2-tailed) for the written communication skills variable of 0.000, which means the Sig. (2-tailed) value <0.05, so it can be concluded that there is a significant difference in the written communication skills of students who take part in learning with the ethnochemistry-integrated PBL and the non-ethnochemistry-integrated PBL on the redox and electrochemical reaction material. The large contribution of the implementation of the ethnochemistry-integrated PBL to written communication skills can be seen from the results of the independent samples effect sizes with a strong category which is shown in Table 10, which means that the implementation of the ethnochemistry-integrated PBL on the redox and electrochemical reaction material has a strong effect on students' written communication skills.

Table 10. Independent samples effect sizes on written communication skills

Statistic	Point Estimate	Category
Cohen's d	1.136	Strong
Hedges' correction	1.122	Strong
Glass's delta	1.137	Strong

The difference in students' written communication skills between the experimental group and the control group is influenced by the implementation of the ethnochemistry-integrated PBL in the experimental group. The development and presentation activities of the results in the PBL provide students with the opportunity to build new knowledge through active communication both verbally and in writing (Maridi et al., 2019). Students write down the results of their thoughts and analyses communicatively and effectively regarding the problems that have been given. Writing and analyzing activities trigger students' written communication skills.

The process of solving problems requires students' written communication skills. Communication aims to convey the concept of knowledge that has been obtained either orally or in writing (Widiasworo, 2016). Written communication skills in this study are intended to train students in processing and conveying information, expressing ideas, and presenting the results obtained to others through writing.

Written communication skills are measured by observation sheets from the results of giving essay assignments. Among them are indicators of originality assessment. Originality assessment does not provide a strong enough contribution to the final assessment. The originality indicator has its idea aspect and is not plagiarized with the results obtained an average score of 2. This shows that the essay is almost the same as someone else's work and plagiarism is 51-99%.

Rapidly developing technology does not rule out the possibility of having a negative impact on the world of education. The use of Artificial Intelligence (AI) is one example of technological developments that can have a negative impact. AI can be used to create essays so that students are not used to developing their ideas, arguments, and opinions by combining data and facts. In addition, the use of AI that is not in accordance with ethics can lead to increased plagiarism and academic violations (Lukman et al., 2023). Schools and educators need to develop effective strategies in AI use policies for students (Pratiwi & Yunus, 2025).

CONCLUSION

There is a significant difference in the problem-solving ability of students who take part in learning with the ethnochemistry-integrated PBL and the non-ethnochemistry-integrated PBL on the redox and electrochemical reaction material. There is a significant difference in the written communication skills of students who take part in learning with the ethnochemistry-integrated PBL and the non-ethnochemistry-integrated PBL on the redox and electrochemical reaction material. The effective contribution to the problem-solving ability variable is 1.034 with a strong category, which means that the implementation of the ethnochemistry-integrated PBL learning model on the redox and electrochemical reaction material has a strong effect on students' problem-solving abilities. The effective contribution to the written communication skill variable is 1.136 with a strong category, which means that the implementation of the ethnochemistry-integrated PBL on the redox and electrochemical reaction material has a strong effect on students' written communication skills. Further research is expected to develop an integrated PBL of ethnochemistry for different dependent variables and chemical materials so that it can provide diverse information related to the implementation of the integrated PBL of ethnochemistry. Further research is expected to expand the research population so that it can provide broader information.

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