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The Effect of the Ethnochemistry Approach on Students' Problem-Solving Ability and Chemistry Learning Experiences Based on Gender

Dwi Wahyudiati [1*]

[1]Universitas Islam Negeri Mataram, Mataram, Indonesia

Abstract

This study aims to determine differences in the ethnochemistry implementation (Sasak local wisdom) effect on students' problem-solving ability (PSA) and chemistry learning experiences (CLE) based on gender. This study was a quasi - experimental research with a post-test-only control group design. The sample involved 44 chemistry students, 22 were in the experimental class (7 males and 15 females), and 22 were in the control class (8 males and 14 females) with variations in the cultural background of the samples, namely the Sasak, Samawa, and Mbojo ethnic groups. The measured problem-solving ability covered 4 indicators; understanding the problem, planning problem-solving, carrying out problem-solving activities, and feedback. The chemistry learning experience instrument used consisted of 4 indicators of learning experience: *Lecture, Tutorial and tutor, Practical, and Demonstrator*. The collected data were analyzed by MANOVA test. Based on the results of data analysis and research findings, several conclusions were obtained. First, there were significant differences in chemistry students' problem-solving ability (PSA) and chemistry learning experiences (CLE) based on gender through an ethnochemistry approach. Second, female students' problem-solving ability were higher than male students in experimental and control classes. Third, problem-solving ability were the highest, with the indicator of carrying out problem-solving activities for female students. Female students also owned the highest chemistry learning experience scores on the practical learning experiences indicator.

Keywords: ethnochemistry; problem-solving ability; chemistry learning experience; gender.

Introduction

The demand for chemistry students' quality in the 21st-century prioritizes the realization of skills that focus on developing soft skills to compete in globalization's job market. The expected skills are problem-solving ability, critical & creative thinking, self eficacy, and collaboration ability (Ramdani et al., 2021; Wahyudiati, 2022a, 2022b). Yet, previous research indicated that the increase of chemistry students' problem-solving ability tends to be neglected and is focused more on achieving cognitive learning outcomes to improve 21st-century skills, especially poor problem-solving ability (Dalgety et al., 2003; Rahmawati, 2018; Wahyudiati, 2023a, 2023b).

Developing chemistry students' problem-solving skills is encouraged to develop a career and be responsive in overcoming life's problems. This condition is relevant to various studies which showed that problem-solving skills greatly determine the success of an individual's life, both in increasing academic achievement and in pursuing a career in the community (Ismail & Jarrah, 2019; Mergendoller et al., 2006; Sanabria et al., 2017; Wahyudiati et al., 2021; Wahyudiati & Qurniati, 2022). Thus, it is necessary to start changing learning practices that focus more on developing 21st-century skills, especially problem-solving ability (PSA) and chemistry learning experiences (CLA). Chemistry learning experience (CLA) is a learning activity that must be carried out by students in order to master competency standards, basic skills, and learning materials by involving interactions between teachers and students in chemistry learning which consists of 4 indicators, namely lecture learning experience, tutorial learning experience and tutor, practical learning experience, and demonstrator learning experience.

PSA are the capability to identify, and formulate problem-solving, including identifying problems, compiling and testing hypotheses, and concluding the best solutions to problems (Wahyudiati, 2021; Irwanto et al., 2023; Wahyudiati

Corresponding Author e-mail: dwiwahyudiati@uinmataram.ac.id

https://orcid.org/0000-0003-2655-1807

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2023a). In practice, students' problem-solving ability greatly stimulate their knowledge to solve problems appropriately and could train them to learn independently to improve their learning outcomes (Dalgety et al., 2003; Wahyudiati, 20223b). In addition, PSA are defined as tendencies to act and respond to everyday problems closely related to mental processes that reflect one's intellectual processes. Moreover, chemistry students' problem-solving skills are shaped by the learning experience. Their learning experience could provide authentic experiences and apply to real experiences known as ethnochemistry approaches (integration of chemical concepts with local culture). An CLA is essential to construct students' critical thinking and problem-solving ability (Dewi & Kamaludin, 2022; Mundilarto & Ismoyo, 2017; Sumardi et al., 2020; Sumardi & Wahyudiati, 2021; Wahyudiati, 2022a; Abramova & Greer, 2013; Abungu et al., 2014; Fadli, 2019).

The chemistry students' problem-solving skills and learning experience are not only influenced by the selection of learning approaches, methods and strategies applied by lecturers but also by gender (Su, 2020; Wahyudiati et al., 2019, 2020). Man and woman students have different characteristics and capabilities in expanding skills that impact their academic achievement. These conditions confirmed findings that gender influences PSA and constructivist-based chemistry learning experiences (Rahmawati, 2018; Wahyudiati, 2021). Moreover, a study that measures students' PSA and CLE based on gender needs to be conducted as a benchmark for the processes and learning outcomes' quality. Thus, this study aimed to describe and map the factual conditions of PSA and CLE based on gender to contribute to chemistry learning and to develop students' 21st-century skills.

Research Purposes

The objectives of this research are:

1. To find differences between the effect of implementing the ethnochemistry approach on students' PSA and CLE based learning experiences between male and female students.
2. To find differences in the influence of implementing the ethnochemistry approach on students' PSA between male and female students.
3. To find differences in the influence of implementing the ethnochemistry approach on students' chemistry learning experiences based on gender.
4. To determine which indicators of students' problem-solving ability are most influenced by ethnochemistry approach application based on gender.
5. To determine which indicators of students' chemistry learning experiences are most influenced by ethnochemistry application based on gender.

Research question

Research questions consist of:

1. Are there differences in the effect of applying the ethnochemistry approach to students' PSA and CLE between male and female students?
2. Are there differences in the influence of applying the ethnochemistry approach on students' PSA between male and female students?
3. Are there differences in the influence of applying the ethnochemistry approach on students' chemistry learning experiences between male and female students?
4. Which indicators of problem-solving ability are most influenced by the ethnochemistry approach based on gender?
5. Which indicators of chemistry learning experiences are most influenced by the ethnochemistry approach based on gender?

Research Hypothesis

H_0: there is no difference in the effect of applying the ethnochemistry approach to the students' PSA and CLA based on gender.

H_a: there are differences in the effect of applying the ethnochemistry approach to the students' PSA and CLA based on gender.

Review of Literature

Ethnochemistry is a variety of chemically related cultural and societal practices that describes the chemistry practices of identifiable cultural groups and is reflected in the study of chemical ideas found in any culture (Singh & Chibuye, 2016). Ethno refers to group members in a cultural environment identified by certain cultural traditions, codes, symbols, myths, and ways to consider and conclude (Rosa & Orey, 2011). Various studies using cultural products in learning have shown positive results, such as increasing students' abilities to understand chemistry concepts and training critical thinking skills (Sutrisno et al., 2020). Various studies also revealed the advantages of using an ethnochemistry approach to learning. For instance, the learning activities by integrating local wisdom and cultural products with chemical concepts have to increasing critical and problem-solving ability and developing students' scientific attitudes. These increase their academic achievement and positive responses to human rights (Marasinghe, 2016; Rahmawati et al., 2017a; Singh & Chibuye, 2016; Wahyudiati & Qurniati, 2022).

The application of ethnochemistry in learning is also inseparable from the influence of globalization because education has a close relationship with it. Globalization is the expansion from one region/country to another region/country and/or the process of entering a country into world relations. In general, the influence of globalization on every nation will have both positive and negative impacts. The good side of globalization is every country can progress and develop, and the citizens will also be good citizens. Meanwhile, one negative side is that it erodes a nation's local wisdom, values or character (Wahyudiati, 2022b). In education, the influence of globalization also has a positive and negative influence. Through technological advances, where information can be easily accessed anywhere, every country should accept various foreign cultures. Those cultures are not relevant to their identities and result in acculturation. This situation needs action to reduce its bad influence by managing the education system (Rahmawati et al., 2017a). It can be done by creating a more comprehensive and flexible education system to generate graduates who can function effectively in a global society. Specifically, it can be executed by upgrading education with a global perspective through a holistic view which has led to two reforms in education: emphasize students to think globally and act locally to create harmony between education and culture (Mauluah & Marsigit, 2019; Rahmawati et al., 2017b; Rosa & Orey, 2011). The harmony between education and culture must be based on educational theories and, in practice, originating from a local view of life reflected in local wisdom. It means the position of culture in the era of globalization can be utilized as a vehicle for learning. For instance, integrating culture as a source of learning media, natural laboratories, or integrated as a basis for developing approaches, models or learning strategies, which in chemistry learning is known as the Ethnochemistry approach (Ador, 2017; Rahmawati, 2018; Rahmawati et al., 2017b; Sutrisno et al., 2020). This ethnochemistry-based learning is one of the applications of the Culturally Responsive Teaching approach, which combines chemistry with culture in practice.

Several previous studies related to the implementation of Ethnochemistry in learning include; (1) Singh & Chibuye (2016), he stated that ethnochemistry practices in teaching chemistry have a positive effect on increasing high school students' attitudes towards chemistry; (2) Rahmawati et al. (2017b) conducted research on the integration of ethnochemistry in culturally responsive teaching in chemistry classrooms conducting research on implementing ethnochemistry in culturally responsive teaching in chemistry classes and has assisted students in developing critical self-reflection on their own cultural background; (3) Ador (2017) impelementing ethnochemistry into the curriculum could provide students with more significant learning about the preservation and appreciation of the quality of students' cultural heritage; (4) Abramova and Greer (2013) said that the development of ethnochemistry can be seen as a two-step process: the use of original knowledge as a starting point for chemistry, and the second is by further testing to produce patents from the research results; (5) Marasinghe (2016) concluded that learners deciding to study Chemistry at Grade 12 had a significant increase because it was influenced by ancestral traditions in the use of natural ingredients in medicines which are part of their ancestral traditions; (6) Abonyi et al. (2014) conducted research linking appropriate backgrounds, reasons and procedures for integrating indigenous knowledge systems into formal Science classroom processes and in the form of learning modules; and (7) Sutrsino et al. (2020) has applied an ethnochemistry approach to prospective chemistry teachers, namely in Basic Chemistry courses, where the results showed the ethnochemistry approach greatly influences the ability to analyze, solve problems, develop critical and logical thinking skills and also improves the ability of soft skills and hard skills. These studies prove that applying an ethnochemistry approach can be one of the best solutions for improving student learning outcomes, soft skills, and students' HOT skills to achieve maximum chemistry learning goals in elementary, secondary and higher education levels.

Method

Research Design

This quasi-experimental study employed a post-test-only control group design. In this design, the experimental and control groups were compared by giving a post-test (Stevens & Pituch, 2011). This study consisted of one dependent variable (i.e., the ethnochemistry approach) and two dependent variables (i.e., PSA and CLE). This study was conducted for 2 months (October to November 2022). At the end of the treatment, a post-test was given to the experimental and control groups to determine the significant effect on the two dependent variables measured (i.e., PSA and CLE) and see Table 1.

Participants

This study involved 44 chemistry students as the sample, 22 students in the experimental class (7 males and 15 females)

Table 1: Post-test only control group design

Group	*Treatment*	*Post-test*
Experiment	R	X1, Y1
Control	O	X1, Y1

Note: X1 = Problem-Solving Ability
Y1 = Chemistry learning experience
R = Ethnochemisry-based learning approach
O = Conventional learning approach

Table 2. Participants Characteristics

Participants		*Experimental Class n = 22*		*Control class n = 22*	
Quantity		*%*	*Quantity*	*%*	
Gender	Female	15	68%	14	64%
	Male	7	32%	8	36%

and 22 in the control class (8 males and 14 females), as shown in Table 2. The samples voluntarily participated or were actively involved and could withdraw at any time. In addition, participants were given no incentives to avoid non-objective data.

Research Instruments and Data Analysis

The PSA instrument was an observation sheet with 4 indicators: understanding problems, planning problem-solving, carrying out problem-solving activities, and feedback activities. Meanwhile, the CLE instrument used in this study adopted the CAEQ (chemistry attitudes and experiences questionnaire), which consisted of 4 indicators: lecture learning experiences, tutorial and tutor learning experiences, practical learning experiences, and demonstrator learning experiences. The instruments were validated through construct validity, face validity, and empirical testing with a Cronbach's alpha coefficient of $\alpha = .85 > .70$. It resulted that the research instruments met the valid and reliable requirements. The prerequisite tests carried out for learning outcomes are on the topic of changing material that has relevance to local Sasak wisdom, such as changes in chemistry and physics and their implementation in everyday life. The results of problem-solving ability measurement and chemistry learning experiences were analyzed using the Manova test. Before testing the Manova hypothesis, the normality test, homogeneity test, linearity test, and a multicollinearity test were performed (Stevens & Pituch, 2011). The requirement for the significance of the normality and homogenity test is if the p-table value is > 0.05 (which means H_0 is accepted), it can be concluded that data were normally and homogenous distributed. The scatter plot matrix was used to identify a linear relationship between the independent variable and the dependent variable. The multicollinearity test was utilized to see whether the regression model found a correlation between independent variables. After all the conditions were fulfilled, the test was continued with the Manova hypothesis test using statistical analysis of the SPSS 24.0 program.

Research Procedures

The research was conducted on both sample groups on the same material; subject matter and its changes, specifically

Table 3: Research Stages and Procedures

No	*Stages*	*Activity*
1	Research Preparation	Research design Study of literature Constructing PSA research instrument Constructing chemistry learning experience research instrument
2	Research Implementation	PSA Instruments validation Chemistry learning experience Instrument validation Implementing the ethnochemistry approach in the experimental class, and the conventional approach in the control class Post-test
3	Final Stage	Data processing and analysis Discussion of research results Concluding

the sub-topic of physical changes, chemical changes, and the separation of mixtures' components. The materials were taught for 8 meetings in the experimental and control classes. The research procedures are shown in Table 3. Obtaining PSA data was carried out through observation activities involving 3 observers whose job was to observe PSA abilities at the time the research was conducted. As for the CLE data, it was obtained by distributing research questionnaires to predetermined samples.

Results and Discussion

Research data related to chemistry students' problem-solving ability and chemistry learning experiences were analyzed using the Manova test after fulfilling the prerequisite test. The application of ethnochemistry in learning is through integrating the concept of material changes (physical and chemical changes) which are related to local Sasak wisdom. An example is the concept of chemical change found in local Sasak wisdom such as making *poteng* (glutinous tape) and coloring *Sesek cloth* (traditional cloth of the Sasak tribe), as well as *Sasak coffee* milling which is an implementation of the concept of physical change.The prerequisite test showed the data were normally distributed with a p-value > 0.05, that is, 0.15. Likewise, the homogeneity test results revealed the data were homogeneous with a p-value > 0.05, that is, 0.25. The multicollinearity test results obtained VIF = 0.47 (no multicollinearity), and the scatter plot matrix results for the linearity test showed a positive correlation for each pair of research variables. Before testing the hypothesis, a descriptive analysis of chemistry students' PSA and CLE based on gender was performed. A comparison of the results of the descriptive analysis of the chemistry students' problem-solving ability based on gender for each indicator in the experimental and control class is presented in Tables 4 and 5.

Table 4 shows differences in the post-test scores between males (Mean = 75.40) and females (Mean = 85.70), which meant that the PSA ability of female students tended to be higher than that of male students.

Table 5 displays a difference in post-test scores between males (Mean = 75.11) and females (Mean = 75.27), which means that the female students' PSA was higher than the male students in the control class. Tables 4 and 5 portray the students' PSA was found to be highest in female students in the experimental class with an average value of 85.70, and the highest average score for the PSA indicator was obtained by female students in the indicator of carrying out problem-solving activities (Mean = 88.48).

Table 4: Differences in problems solving ability post-test scores in the experimental group based on gender

Sub Indicator	*Group*	*Mean*	*SD*
Understanding problem	Female	84.48	7.84
	Male	77.88	6.29
Planning problem-solving	Female	82.44	5.98
	Male	75.64	5.99
Carrying out problem-solving activities	Female	88.48	8.10
	Male	72.28	6.37
Feedback Activities	Female	87.40	7.72
	Male	75.80	6.35
Overall PSS	Female	85.70	7.54
	Male	75.40	6.30

Table 5: Differences in problem-solving ability post-test scores in the control group based on gender

Sub-Skills	*Group*	*Mean*	*SD*
Understanding problem,	Female	76.12	4.92
	Male	75.64	5.77
Planning problem-solving,	Female	76.48	7.58
	Male	75.28	6.27
Carrying out prob-lem-solving activities	Female	74.96	5.86
	Male	75.72	5.99
Feedback Activities	Female	73.52	7.73
	Male	73.8	6.27
Overall PSS	Female	75.27	7.34
	Male	75.11	6.74

Furthermore, a comparison of the descriptive analysis result of students' chemistry learning experiences in terms of gender for each indicator in the experimental and control classes is presented in Tables 6 and 7.

Table 6 shows differences in post-test scores between female (Mean = 87.70) and male students (Mean = 77.40), which means that the chemistry learning experiences of female students were higher than their male counterparts in the experimental class.

Table 7 illustrates differences in post-test scores between female (Mean = 77.77) and male students (Mean = 77.11), which means that the chemistry learning experiences of female students tend to be higher than males in the control class. In addition, Tables 6 and 7 indicate student chemistry learning experience was highest among female students in

Table 6. Differences in chemistry students' post-test scores of chemistry learning experience based on gender in experimental group

Sub indicator	*Group*	*Mean*	*SD*
Lecture learning experiences	Female	86.48	7.94
	Male	79.88	6.39
Tutorial and tutor learning experiences	Female	84.44	5.99
	Male	77.64	5.98
Practical learning experiences	Female	90.48	8.20
	Male	74.28	6.37
Demonstrator learning experiences	Female	89.40	7.82
	Male	77.80	6.65
Overall	Female	87.70	7.55
	Male	77.40	6.40

Table 7. Differences in chemistry students' post-test scores of chemistry learning experiences based on gender in the control group

Sub indicator	*Group*	*Mean*	*SD*
Lecture learning experiences	Female	79.12	4.92
	Male	77.64	5.77
Tutorial and tutor learning experiences	Female	78.48	7.58
	Male	77.28	6.27
Practical learning experiences	Female	76.96	5.86
	Male	77.72	5.99
Demonstrator learning experiences	Female	76.52	7.73
	Male	75.8	6.27
Overall	Female	77.77	7.34
	Male	77.11	6.74

the experimental class with an average score of 85.70. Female students obtained the highest average score for the chemistry learning experience indicator at the Practical learning experiences indicator (Mean = 90.48).

Furthermore, the Manova hypothesis test was performed to answer the research hypothesis. The test showed differences in chemistry students' PSA and CLE based on gender with a p-value <0.05 (Table 8), meaning that the null hypothesis is rejected and the alternative hypothesis is accepted. These results are relevant to a previous study that gender differences affect students' problem-solving ability (Zhu, 2007).

The Manova test was continued with the Test of Between-Subjects Effects to determine the differences in each factor to the affected variables. The results of the study showed differences in problem-solving ability and chemistry learning experiences of chemistry teacher candidates based on gender because a p-value <0.05 was obtained (Table 9), meaning that the null hypothesis was rejected and Ha was accepted.

Research findings based on the Manova test result illustrated differences in chemistry students' PSA and CLE based on gender. This study's results confirmed differences in problem-solving ability between male and female (Majere et al., 2012; Zhu, 2007). The differences in chemistry students' problem-solving ability and chemistry learning experiences based on gender were because females have higher interest, motivation, and persistence in class and practicum assignments than males (Fadli & Irwanto, 2020; Majere et al. 2012; Wahyudiati et al. 2021). Problem-solving skills are also influenced by the application of approaches, learning models, and the lecturer's teaching and learning strategies applied during the learning process. Through experimental ethnochemistry-based activities, it presents real and concrete experiences to develop the ability to analyze and solve problems that impact student learning outcomes (Gunawan et al. 2020; Sumardi & Wahyudiati, 2022; Sutrisno et al., 2020; Wahyudiati et al., 2022).

Table 8. Results of the manova test on chemistry students' problem-solving ability and chemistry learning experiences based on gender

Effect	*Results of the Manova*	*Value*	*F*	*Sig.*
Gender	Pillai's Trace	.003	.490	.000
	Wilks' Lambda	.002	.490	.000
	Hotelling's Trace	.003	.490	.000
	Roy's Largest Root	.002	.490	.000

Table 9. Results of Test of between-subjects effects of chemistry students' problem-solving abilit y and chemistry learning experiences based on gender

Effect	*Dependent Variables*	*F*	*Sig.*
Gender	Problem-solving ability	.002	.000
	Chemistry-based learning experience	.004	.000
	Overall	.003	.000

There are differences in PSA (problem-solving ability) andCLE (chemistry learning experiences) for chemistry teacher candidates based on gender due to differences in characteristics between men and women. Women have better problem-solving ability compared to men. It is because the ability to work a woman's brain is much more effective and efficient. The neurons that regulate brain work could communicate much better with each other than the neurons in the male brain so that women can complete tasks and work more effectively than their male counterparts (Chua & Karpudewan, 2015; Hariyanto et al., 2019; Zhu, 2007). In addition, other research findings also show that female are more thorough in PSA than men. It is supported by the findings that there are differences in character between men and women, and generally, men are better at reasoning. In contrast, women are better at accuracy, thoroughness, and attentiveness in thinking (Fadli & Acim, 2022). In addition, women's scores were higher than men's on several critical thinking scales and higher-level critical thinking skills (Ismail & Jarrah, 2009; Majere et al., 2012; Malik & Ubaidillah, 2021).

Other research also proved differences in chemistry learning experiences (CLE) between male and female students. The current study results validated previous research where female students have a better ethnochemistry learning experience than men (Abonyi et al., 2014). The application of the ethnochemistry approach in learning is the integration of chemical concepts with the student's daily experience, both in the form of ideas, cultural products and community traditions relevant to chemical concepts (Singh & Chibuye, 2016; Sutrisno et al., 2020). Another advantage of the ethnochemistry approach is it could help teachers to increase student involvement in associating chemical concepts with everyday life to create a more significant learning experience (Rahmawati et al., 2017a; Wahyudiati, 2021). Previous studies have also proven that a constructivist-based learning environment makes learning more meaningful and real and influences students' chemistry learning experiences and problem-solving ability (Ador, 2017; Rahmawati et al., 2017b; Singh & Chibuye, 2016; Wahyudiati, 2022a, 2022b).

Conclusion

Based on the results of data analysis and research findings, several conclusions were obtained. First, there were significant differences in chemistry students' problem-solving ability (PSA) and chemistry learning experiences (CLE) based on gender through an ethnochemistry approach. Second, female students' problem-solving ability were higher than male students in experimental and control classes. Third, problem-solving ability were the highest, with the indicator of carrying out problem-solving activities for female students. Female students also owned the highest chemistry learning experience scores on the practical learning experiences indicator. All in all, these findings can be used as a reference in assessing the ability of problem-solving ability and chemistry learning experiences at the tertiary level.

Implications

The current study revealed how educators could improve students' soft skills, communication skills and learning experiences through an ethnochemistry approach. The application of the ethnochemistry approach in learning is the integration of chemical concepts with students' daily experiences in the form of ideas, cultural products and community traditions relevant to chemical concepts or theories. Another advantage of the ethnochemistry approach is helping teachers to increase student involvement in associating chemical concepts with their daily experience. In addition, it could increase students' motivation by describing chemical concepts in cultural traditions that make them more interested in learning chemistry. Therefore, chemistry students could achieve more optimal learning outcomes.

Limitations and Recommendations

The limitations of this study are the research sample was still limited to 44 students with a post-test-only design. Therefore, further research is needed with a larger sample using a complete design, namely one group pre-test post-design, to compare previous and after treatment in the experimental and control classes. In addition, it is crucial to examine the chemistry students' problem-solving ability and chemistry learning experiences based on grade levels at all levels of education.

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