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Students' Critical Thinking Skills Through Project-Based Ethnochemistry Learning

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Abstract: Critical thinking skills are still a problem in chemistry learning. One of the causes is teaching strategies do not contextually link chemical concepts into everyday life. This study aimed to determine whether project-based ethno-chemistry learning affected students' critical thinking skills. The research method used a quasi-experimental with a nonequivalent control group design. Purposive sampling was conducted and resulted a sample size of 80 students, consisting of 40 students from class XI IPA 1 (Experimental group) and 40 students from class XI IPA 2 (Control group). The critical thinking test instrument consisting of 19 questions in the topic of colloid material. The results of Mann Whitney test showed a significant difference of critical thinking post-test score between the two groups ($p = 0.000$, $p < 0.05$). Thus, it can be concluded that project-based ethno-chemistry learning had an effect on students' critical thinking skills development. According to the n-gain score (57%), project-based ethno-chemistry learning was considered quite effective to develop students' critical thinking skills. The findings of this study contributed to the selection of various innovative teaching strategies which integrates local wisdom into project-based chemistry learning, so that critical thinking skills can be improved.

Keywords: Colloid material, Critical Thinking Skills, Ethno-chemistry, Project-based Learning

Introduction

Preparing students to face the challenges of the 21st century is one of the main priorities of education in Indonesia. This can be seen from the 2013 curriculum change to an independent curriculum, which emphasizes the achievement of essential skills such as thinking, acting, and living skills (Putriani & Hudaidah, 2021). One of the thinking skills needed to face the 21st century is critical thinking (Alkharusi et al., 2019; Hanipah, 2023; Saleh, 2019).

Critical thinking includes the ability to process and synthesize information to make informed decisions and solve problems effectively (Heard et al., 2020, p. 2). Critical thinking skills are related to Bloom's taxonomy, particularly in the cognitive processes of analysis, evaluation, and creation (Aghaei & Rad, 2018; Susilowati & Sumaji, 2020). Vygotsky stated that social communication plays a fundamental role in the cognitive development process. Social interaction in the Zone of Proximal Development (ZPD) helps develop students' critical thinking skills (Padmanabha C.H., 2018).

In chemistry learning, critical thinking skills play a major role in students' abilities, especially in understanding complex chemistry material (Kawedhar et al., 2020). Several pieces of evidence show that chemistry material is difficult and complex. Priliyanti, et al., (2021) found that students had difficulty learning colloids because they are theoretical, complex, and abstract. Another study conducted by Sariati, et al., (2020) found that students had difficulty understanding buffer solutions.

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Students' difficulties in understanding chemistry concepts are caused by their low critical thinking skills. Many studies have been conducted on low critical thinking skills. Khoirunnisa & Sabekti (2020) found in their study that the critical thinking skills of high school students in Tanjungpinang on the subject of chemical bonds were still low. Setianingsih, et al., (2022) also found that critical thinking skills in chemistry were low. The low critical thinking skills of students are caused by not being accustomed to learning related to critical thinking (Wahyudi et al., 2023); students are not accustomed to critical thinking exercises (Sarip et al., 2022); teacher-centered teaching methods, and a lack of practice in dealing with problems (Rofi'ah & Rokhmaniyah, 2024).

Low critical thinking skills can be addressed through learning innovations that provide students with opportunities to actively participate in learning activities. Contextual learning, which connects the material to real-world situations, can address the above issue (Bustami et al., 2018; López-Fernández et al., 2022; Sarwinda et al., 2020). The use of active learning models such as project-based learning (PjBL) can be a solution. This model provides meaningful experiences because the activities are entirely student-centered, while teachers act only as facilitators (Astri et al., 2022). Through PjBL, students' thinking skills will be trained in dealing with various problems (Nurhidayah et al., 2021). Research results show that there is an increase in critical thinking skills in chemistry lessons through the PjBL model (Desiana et al., 2022; Haleda et al., 2025). This improvement is due to PjBL utilizing a contextual environment to solve problems, thereby obtaining essential concepts from the chemistry material being studied (Sulistiawati et al., 2025).

Problem solving in PjBL can be done in various ways, one of which is through a cultural approach. Cultural products are related to scientific concepts, including chemistry, which is known as ethnoscience or ethnochemistry. For example, the *Sasak Begibung* culture is related to the concept of electron valence (Umam & Wahyudiati, 2023). Linking learning to local culture makes it easier for students to contextualize abstract concepts (Wahyudi et al., 2023). A cultural approach to learning provides students with the opportunity to engage in analytical activities (Prayogi et al., 2023) and improves critical thinking skills (Hidaayatullaah et al., 2021).

Betawi culture can be used as a contextual approach in chemistry learning. The uniqueness of *Betawi* culture, such as traditional cuisine, musical instruments, dances, and handicrafts, can be linked to chemical concepts through project activities. However, there has been no research linking *Betawi* culture to the improvement of students' critical thinking skills in chemistry lessons. In fact, many chemical concepts can be explored by utilizing the uniqueness of *Betawi* culture. According to Fikri, et al., (2019), concepts such as colloids, acids and bases, polymers, chemical bonds, macromolecules, hydrocarbons, and colligative properties of solutions are related to *Betawi* culture, such as *gabus pucung, kerak telor, asinan,* and *roti buaya*. This research is useful in exploring *Betawi* culture, which can be used as a source of chemistry learning. Thus, this research is expected to not only increase chemistry knowledge but also critical thinking skills and attitudes to preserve *Betawi* cultural heritage. There is an agreed term of the beneficial aspect of ethnochemistry in preserving cultural sustainability in youth (Chibuye & Singh, 2024). Ethnochemistry also resonates with the idea of inclusive education oriented towards technology innovation through learning about students' surrounding environment, its natural resources and challenges, and how to manage and utilize them productively and sustainably (Jannah et al., 2022)

Method

Time and Place of the Research

This study was conducted in second term of the academic year 2022-2023. The research took place in the area of Ciputat, Tangerang Selatan, Banten, Indonesia. The school involved in this study was Muhammadiyah 8 Senior High School.

Research Design

A quasi-experiment with a nonequivalent control group design was used as the method in this study (Gall et al., 2014, p. 251).

Table 1. Design of pretest posttest non equivalent control group research

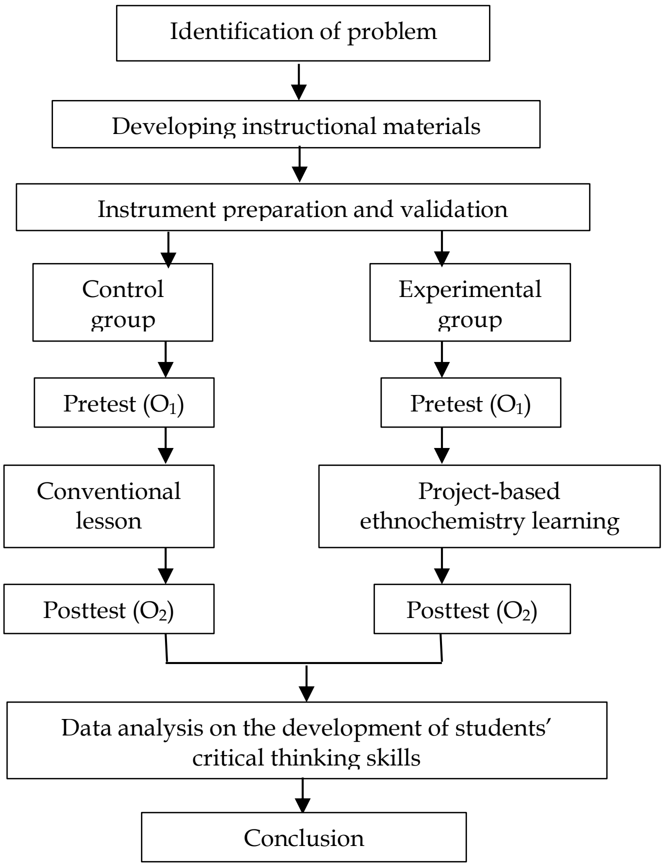
O_1	X	O_2
O_1	-	O_2

O_1 : Pretest
O_2 : Posttest
X : Project-Based Ethno-Chemistry Learning in Experimental Group

The research population consisted of all students at Muhammadiyah 8 Senior High School, while the research sample consisted of 40 students from class XI IPA 1 in the experimental group and 40 students from class XI IPA 2 in the control group, selected using purposive sampling. Colloids are one of the topics covered in the 10th-grade chemistry curriculum. The variables of this study comprised the project-based ethno-chemistry learning model as independent variable and students' critical thinking skills ability as the dependent variable.. Written test procedure was undertaken to gather data regarding the latter variable. The research instrument used an essay test to measure 10 indicators of critical thinking according to Ennis (1995).

Research Procedure

This study began with a problem identification and the posing of a hypothesis. Following that, the development of instructional materials and the design of assessment instruments were conducted.



Picture 1. Flowchart of the research procedure

In the next phase, a pre-test was administered to both groups to measure the students' initial critical thinking skills. Subsequently, students in the experimental group were taught about colloids using a project-based ethno-chemistry learning model, while the control group was taught using the conventional learning. After the instruction was completed, the students took a post-test. In the final section, data analysis was conducted to test the hypothesis, and conclusions were drawn. The procedure followed the steps described below.

Research Data Analysis

Data analysis deployed Mann-Whitney test technique with a preliminary normality test using SPSS version 25. To see how effective project-based ethno-chemistry learning was in developing critical thinking skills, an n-gain test was conducted, referring to Hake (Sukarelawan et al., 2024, p. 11), with the following criteria: Ineffective (< 40%); Less Effective (40% - 50%); Moderately Effective (56% - 75%); and Effective (> 76%). Research design and method should be clearly defined.

Result and Discussion

The data on students' critical thinking skills obtained from the pre-test and post-test results were then analyzed using descriptive and inferential statistics. The pre-test and post-test results data from the experimental and control classes can be seen in Tables 2 and 3.

Table 2. Mean and Standard Deviation of Pretest Scores

Data	Pretest	
	Experiment	Control
Lowest Score	3.75	13.75
Highest Score	46.25	48.75
Mean	29.84	32.12
Standard Deviation	9.64	9.79

In Table 2, the average pre-test score obtained by the control class was 32.12, and that of the experimental class was 29.84. This shows that the initial abilities of the students were almost the same, although the average score obtained by the control class was higher than that of the experimental class. Similarly, the standard deviation shows that the distribution of pre-test scores for both classes was not much different.

Table 3. Mean and Standard Deviation of Posttest Scores

Data	Posttest	
	Experiment	Control
Lowest score	50.00	37.50
Highest score	87.50	82.50
Mean	70.21	58.71
Standard Deviation	9.67	9.94

In Table 3, the average post-test score of the experimental class was 70.21, which was higher than that of the control class, which was 58.71. This shows that the final ability of the experimental class with project-based ethnochemistry learning was better than that of the control class. Although the average score of the two classes was different, the distribution of the post-test scores of the two classes was not very much different.

The next step is to determine normality and homogeneity as prerequisites for hypothesis testing. The results of the pretest and posttest normality tests for both experimental and control classes are presented in the following table.

Table 4. Normality Test Results

Class	Kolmogorov-Smirnov		Conclusion
	N	Sig.	
Pretest Experiment	40	0.014	Not Normal
Pretest Control	40	0.113	Normal
Posttest Experiment	40	0.200	Normal
Posttest Control	40	0.200	Normal

The normality test results in Table 4 showed that the significance value of the pretest for the experimental class is less than 0.05 (sig. < 0.05) and that of the control class is greater than 0.05 (sig. > 0.05). Meanwhile, the significance values for the post-test, both for the experimental class and the control class, are greater than 0.05 (sig. > 0.05). Thus, it can be concluded that not all data are normally distributed. Next, a hypothesis test was conducted using the Mann-Whitney test, as shown in Table 5.

Table 5. Mann-Whitney Test Results

Data Test	N	Level of Significance (α)	Sig. (2-tailed)
Pretest	40	0.05	0.225
Posttest	40	0.05	0.000

The results of the pretest score hypothesis test using the Mann-Whitney test obtained data with a significant value greater than 0.05 or accepted, that is 0.225. A significant value greater than 0.05 indicated that the average learning outcomes of students do not have a significant difference. This shows that the initial abilities of students before being given treatment are the same or equivalent.

The results of the posttest score hypothesis test obtained a significance value of less than 0.05. So, it can be concluded that H_0 is rejected, meaning that there is a difference in the average score of critical thinking skills between students in the experimental and the control classes. Thus, we can say that project-based ethnochemistry learning posed an effect on critical thinking skills development in the topic of colloid material.

To see how effective project-based ethnochemistry is on critical thinking skills development, an n-gain test was conducted. The results of the n-gain test showed that in the experimental class, the presentation score was 57% with a criterion of sufficiently effective, while in the control class it only reached 38% with a criterion of ineffective.

Based on the results of hypothesis testing and n-gain, it was found that project-based ethnochemistry learning had a significant effect on students' critical thinking skills enhancement. This is in line with previous research results stated that project-based learning activities with integration of local wisdom knowledge has a significant effect on improving critical thinking skills (Mudatsir, et al., 2022) along with innovation skills (Tanjung et al., 2025).

In addition, teaching science using culture-embedded approach could enrich students' learning experience and nurture them to create bridge between home and classroom context within an inclusive learning environment (Ladzon-Bilings, 2021). Gay (2002) emphasizes that culturally responsive teachers bring about "cultural characteristics, experiences, and perspectives of ethnically diverse students" to engage them in fruitful learning. Besides that, in this nuance, academic content and skills are "situated within the lived experiences and frames of reference of students, [so] they are more personally meaningful, potentially increasing learning interest, and are easier and more thoroughly learned". Incorporating indigenous and local culture would give students a deeper emotional attachment within a familiar context, make them feel appreciated and accepted (Goodenow, 1993). Therefore, it would nurture students' academic engagement and the development of thinking (Ryan & Deci, 2000), which also give a positive support towards students' belongingness in school (Ialuna et al., 2024).

In this study, students were initially exposed to real-world issues and later carried out project activities which applied the integration of chemistry concepts and traditional knowledge to produce relevant products as solutions to the problems. Ethnochemistry project-based learning goes in accordance with inclusive education oriented towards technology innovation through learning about students' cultural environment and how to manage and utilize them productively and sustainably in explaining scientific phenomenon and addressing daily life issues (Jannah et al., 2022). Using culture as starting point enables them to gain and/or apply a deeper and a more meaningful cognitive comprehension of the particular chemical concepts (Chibuye & Singh, 2024), including understanding the definition of relevant terminologies.

Moreover, indicators of basic clarification (e.g identifying assumptions) and inferring potentially lays foundational elements for supporting other intellectual thinking development, for instance making decision towards responsible actions as problem solutions (Latfia et al., 2022). Specifically, in this study context, project activities within a cultural approach was proven effective to make students more active in the learning process with critical thinking skills development as endpoint, as also mentioned in relevant literature (Anggraini & Wulandari, 2020).

Subsequently, the learning activity continued to students presented the project design and timeline. The manufacturing process suggested by students involved various chemical concepts, including colloids. Next, students were asked to formulate questions from the material presented by the teacher in the student worksheets.

During the third step, students were involved in designing a project plan by the aid of the worksheet. They organized systematic steps of activities, as well as identifying the tools and materials needed in the project. Each group was assigned to design a different project activity, yet still covered a general project theme, namely making a *Betawi* food products that applied colloidal system concepts. Each group was administered the project specific topic using Spin Wheel apps. Various topics covered were making *Es Putar, Kue Pepe, Selendang Mayang, Kembang Tahu*, and *Roti Gambang*.

Additionally, students also arranged a schedule due date for completing the project. Each group wrote down the timely manner procedure within certain period in the student worksheet. It is important to train students the time management skills according to the specified deadline. This is in line with the research by Dinda & Sukma (2021) which found that the stage of arranging a schedule trained students to be more disciplined and responsible towards the schedule that had been set. In addition, teacher must ensure that the projects could be completed within the allocated time.This kind of activity is also believed to foster students' self- regulated learning (Sukmawati, et.al, 2025) which is also foundational in the development of critical thinking competences (Lidiawati et al., 2022).

In the fourth stage, students carried out project activities in groups and were allowed to complete the tasks at home. Teacher monitored and supervised the projects carried out by each group. In order to make it time and resource efficient, students' progress reports were uploaded in the form of video clips sent to a Google Drive folder in learning management system. This was done so that teachers could identify any obstacles faced by students and gave them supportive feedback and recommendations. Relevant feedback is potentially the most powerful tool when it comes to supporting students' learning processes and critical thinking skills (Yulhendri et al., 2025).

When students and teacher communicated interactively within an asynchronous environment, students learned how to determine the strengths, weaknesses, opportunities as well as threats met during the whole process of the project completion. By doing this, students' focuses on the learning improvement through a reflective evaluation process as important feature of critical thinking augmentation (Sinusi et al., 2024).

The fifth stage involved testing the results by having each group to present their project or product. In the final stage, students evaluated their learning experience by sharing their feelings and experiences during the process of creating the project using chemical knowledge and skills they had learned. Addressing students' emotional feeling during science learning, particularly in studying difficult concepts or tasks, should be also a priority in teacher's attention. Study revealed that psychologically supportive learning environment could foster students' mental health well-being (Dimitropoulou et al., 2025). Furthermore, students' well-being state significantly influence their motivation in science learning which later affect academic achievement (Bazar et al., 2024). The learning activity of making various types of *Betawi* food and drinks carried out by students in the experimental class had a greater impact on critical thinking skills than students in the control class. This can be seen in the presentation of each indicator of critical thinking skills of students in the experimental and control classes.

Based on Table 6, the critical thinking indicator that obtained the lowest percentage in the experimental class was making deductions and considering the results of deductions, while the control class obtained the highest percentage in the indicator of deciding on an action. The highest percentages for the experimental class and the control class were in the indicators of asking and answering questions.

Overall, the average post-test scores of the experimental class were higher than those of the control class on all critical thinking skill indicators. The following describes the achievement of each critical thinking skill indicator.

Focusing the question

Focusing the question related with the students' ability to formulate problems from a given phenomenon (Fernanda et al., 2019). To measure this indicator, students were presented with a discourse on experiments using two types of *Betawi* drinks, namely *Teh/Nyanyi* and *Bir Pletok Susu*. The research findings showed 75% in the experimental class and 65.63% in the control class. This difference in percentage results was due to the different treatments between the experimental and control classes. Based on the text in the worksheet, students in the experimental class were required to formulate several problems that could represent the existing issues. In line with Samin et al., (2023), the project-based learning model includes the sub-indicator of critical thinking skills, which includes the indicator of problem formulation.

Table 6. Percentage (%) of Critical Thinking Skills Indicators at the Posttest

Critical Thinking Skills Indicators	Exsperiment	Control
Focusing the question	75.00	65.63
Analyzing the argument	78.12	61.25
Asking and answering questions of clarification	90.00	88.75
Judging the credibility of a source	60.62	49.37
Deducing and judging deductions	57.81	48.75
Inducing and judging inductions	82.18	63.43
Making and judging value judgments	68.93	66.18
Define terms and judge definitions	68.56	56.31
Identifying assumptions	72.08	62.25
Deciding on actions	64.50	43.31

Analyzing the argumentation

Analyzing the argumentation aims to enable students to think more insightfully and provide solutions to a given problem. To measure this indicator, students were given a passage about *Betawi* crocodile bread, which has pores in its texture. Students were then asked to explain the relationship between this and the dispersed phase and the dispersion medium. The research findings show that the experimental class scored 78.12% and the control class scored 61.25%. The difference in these percentages is due to the different treatments between the two classes. In the experimental class, students carried out a project to make various types of *Betawi* specialties. This activity involved students' critical thinking skills in the form of analyzing arguments by linking the process of making crocodile bread with the concept of colloids.

Asking and answering questions of clarification

Asking and answering questions is the ability to identify facts from a problem in order to solve it (Fernanda et al., 2019). To measure this indicator, students were presented with a table of types of colloids with dispersed phases and dispersing media. Furthermore, students were required to be able to mention examples of food or drinks in their daily lives that they knew were related to types of colloids. The research findings showed a result of 90% for the experimental class and 88.75% for the control class. The percentage results showed that there was no significant difference between the experimental class and the control class in asking and answering questions. This slight difference in percentage is due to the fact that students are accustomed to knowing facts that are already known in a problem by mentioning examples of colloid types. In addition, this indicator is found in the project testing stage. When presenting their project results, students were required to be active in asking and answering questions. In line with Budayani, et al., (2023), when students presented their work, students from other groups became more active in asking and answering questions.

Judging the credibility of a source

Assessing the credibility of a source is the ability of students to use sources or facts to determine procedures Nahadi et al., (2021). To measure this indicator, students were given a text related to the procedure for making *Betawi*-style *Ongol-ongol*. Next, students were asked to determine how to make colloids using the available sources. The research findings show that the percentage of the experimental class was 60.62%, while that of the control class was 49.37%. These results indicate that students in the experimental class were better than those in the control class at considering whether a source was reliable or not. In the experimental class, students were given the activity of designing a project. This activity required students to consider whether the procedures used were appropriate or not. This is in line with the opinion Zahroh, (2020), that at the stage of designing a project, students look for various reliable sources to carry out the project experiment to be made.

Deducing and judging deductions

Interpreting data is the purpose of indicators to make deductions and consider the results of deductions. To measure this indicator, students were presented with the procedure for making *Kue Lapis*, a typical *Betawi* food. Through this discourse, students were asked to analyze *Kue Lapis* in relation to the colloid system based on the dispersed phase and dispersion medium, as well as to determine the type of colloid. The results of the study showed that the experimental class scored 57.81% and the control class scored 48.75%. The difference in the results of the study shows that students in the experimental class were better than those in the control class at making deductions and considering the results of those deductions. When carrying out the project, students in the experimental class were given the task of presenting the projects made by each group. In addition, there were factors within the students themselves. In line with Mutakinati et al., (2018), who stated that students' lack of critical thinking skills was due to their low logical thinking skills. In line with the research conducted by Sutinah in Zahroh, (2020), it was shown that one of the reasons for students' low logical skills was because they were not yet able to connect prerequisite concepts with the concepts being studied.

Inducing and judging inductions

Making inductions and considering the results of inductions is the ability of students to draw conclusions from problems that have been solved (Fernanda et al., 2019). To measure this indicator, students were presented with a procedure for making layer cake. Students were asked to determine how to make layer cake based on the colloid system. The research findings showed that the percentage of achievement in the experimental class was 82.18%, while in the control class it was 63.43%. These results show that students in the experimental class performed better than those in the control class. In the experimental class, students engaged in activities to draw conclusions from the discourse presented, so that they gained experience in project development. This is in line with the opinion of Zahroh (2020), that students are accustomed to drawing conclusions from the material and events they experience in conducting experiments.

Making and judging value judgments

Making and considering decision values is a conclusion drawn through testing the relationship between several discourses (Ontowijoyo et al., 2022). To measure this indicator, students were asked to predict the function of gelatin in Es Podeng. The research findings show that the percentage of critical thinking in the experimental class was 68.93% and in the control class was 66.18%. These results indicate that the experimental class and the control class had similar results. However, on average, students in the experimental class performed better than those in the control class. In the experimental class, there were activities to monitor activity and consider the project. At this stage, students were required to obtain accurate information, make and consider decision values. In line with the opinion of Aini et al., (2022), which states that in using the Project-based learning model, students must analyze various sources to be able to determine the results of considering a problem.

Define terms and judge definitions

Defining terms and considering definitions is the ability to provide descriptions based on facts and to train thinking skills in providing clear and detailed descriptions based on the knowledge possessed by students (Ontowijoyo et al., 2022). To measure this indicator, students were given a discourse in the form of *Betawi* customs, namely *Nabun*. Students were asked to determine the nature of the Tyndall effect based on the Nabun phenomenon. The results showed that the percentage for the experimental class was 68.56%, while that for the control class was 56.31%. These results indicate that the experimental class performed better than the control class. In the experimental class, students engaged in basic questioning activities. In this activity, the teacher asked students to explain the definition of the Tyndall effect. In line with the opinion of Fitrianingsih et al. in Zahroh, (2020), that the experimental class did not feel confused in answering questions, the students had good ability in defining terms and considering definitions.

Identifying assumptions

Identifying assumptions is closely related with skill in valid reasoning and argumentation (Fernanda et al., 2019). To measure this indicator, students were given a passage about a typical *Betawi* dish called *Gabus Pucung*. Students were expected to be able to explain how to make a colloid mixture from the the dish. The research findings showed that the percentage of the experimental class was 72.08%, while that of the control class was 62.25%. These results show that students in the experimental class performed better than those in the control class in identifying assumptions. In the experimental class, students presented their findings, while students in the other group asked questions, raised objections, and expressed their opinions and/or different discussion results. This activity trained students to present arguments about a discussed issue. This activity made students highly curious. This is in line with Munawwaroh et al., (2023) declaring that involving students in finding answers to problems through thinking and discussion processes can improve critical thinking skills. Another opinion, Agustiana (2019), states that giving students the opportunity to ask questions can improve their critical thinking skills, namely identifying assumptions.

Deciding on actions

The research findings showed a result of 64.5% in the experimental class and 43.31% in the control class. These results showed that students in the experimental class performed better than those in the control class in terms of determining an action. Different perspectives towards an issue may result in various interpretation, which can lead to different problem statements and solutions. By working on specific project theme which involves students' analytical and critical thinking competence could help them in determining a suitable solution which will be represented in their actions (Latfia, Kusumastuti, & Hamdiyati, 2022). Ability to take actions in responding to an issue internalized all aspects of critical thinking. Project-based ethno-chemistry learning emphasizes on the development of individual skills as innovators, scientist, researchers and intellectuals. Numerous studies have indicated that incorporating students' cultural backgrounds and life experiences within the curriculum positively impacts their sense of value and intellectual competence (Dee & Penner, 2017; Gay, 2000; Sleeter, 2011).

In the experimental class, students were trained to make decisions based on the problems they faced. This enabled students to determine the most appropriate action to solve a problem by applying the knowledge they had acquired. This is in line with the idea that the application of the project-based learning model, where students are given a problem, enables them to describe, analyze, and evaluate the problem with the right considerations, potentially enable students to opt actions in addressing a problem. While evaluating the results, reflection made by students would also help them to figure out alternative solution if one was not succeeded innovatively.

Conclusion

Based on the results of hypothesis testing using the Mann-Whitney test, a significance value (2-tailed) of 0.000 was obtained ($p < 0.05$), meaning that there is a significant difference in the critical thinking skills of students in the experimental class and the control class. Thus, it can be concluded that project-based ethno-chemistry learning has a significant effect on students' critical thinking skills in colloid material. The n-gain test results show that the effect of project-based ethno-chemistry learning on critical thinking skills is 57%, which is considered quite effective. Students who learned in project-based ethno-chemistry learning environment achieved more progress in their skill of analyzing the argument. The results of this study contribute to the selection of various innovative teaching strategies, such as integrating local culture into chemistry project activities, so that critical thinking skills can be improved.

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The authors declare no conflict of interest.

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