A culturally responsive teaching approach and ethnochemistry integration of Tegal culture for developing chemistry students’ critical thinking skills in acid-based learning

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Abstract. The aim of this study was to develop students’ critical thinking skills through a Culturally Responsive Teaching (CRT) approach and ethnochemistry of Tegal culture. The teaching approach focused on exploring the culture and local wisdom in Tegal Culture, especially in Acid-Base such as the Nginang, Moci, and Jamasan traditions from chemistry perspectives integrated into CRT. The study employed a teaching model consisting of five phases; self-identification, cultural understanding, collaboration, critical reflections, and transformative construction. The study involved 35 year 11 students from a secondary school in Balapulang Tegal. A qualitative methodology approach was employed using observation, interviews, a critical thinking test, and reflective journals as data collection methods. The results show that the integration of ethnochemistry in a CRT approach engaged students in developing their critical thinking skills by developing a conclusion, making connections, conceptual understanding, and interpretation with the critical thinking skills test which shows 40% of students reached level 3 (Satisfactory). In addition to the students engaging in the cultural identity empowerment, meaningful chemistry learning experiences, and team work, the students were challenged in developing their critical thinking skills.

1. Introduction

Meaningful chemistry learning occurs when content is related to context and everyday phenomena, from a students' perspective [1,2]. Problems occur in chemistry learning when chemical concepts do not align with the context of students' experiences, the curriculum concepts that must be mastered, and the learning of chemistry that tends to memorize [3-5]. A related problem is that chemical learning has rarely been used by the teacher as an opportunity to optimize students' critical thinking skills.

A learning approach that can assist students in linking chemical material with the culture found in the surrounding environment is through a Culturally Responsive Teaching approach that allows teachers to conduct a series of meaningful activities for students that helps them practice thinking critically [6]. This approach is challenged by the differences in cultural background and student characteristics that are reflected in the skills students bring to learning activities [7]. Therefore, the research focused on engaging students in understanding chemistry concepts through meaningful learning experiences by integrating Culturally Responsive Teaching as a teaching approach. This study aimed to develop critical thinking skills through the Culturally Responsive Teaching (CRT)
approach and ethnochemistry of Tegal culture. The teaching approach focused on exploring the culture and local wisdom in Tegal Culture, especially in Acid-Base such as the Nginang, Moci, and Jamasan tradition from chemistry perspectives integrated into CRT.

2. Methods
The study employed a teaching model consisting of five phases; self-identification, cultural understanding, collaboration, critical reflections, and transformative construction. The study involved 35 year 11 students from a secondary school in Balapulang Tegal, Indonesia. A qualitative methodological approach was employed with observation, interviews, critical thinking test, and reflective journals as data collection.

In the first stage of the process, students understand themselves and their backgrounds. This is done via a learning style questionnaire, self-identity, and playing games knowing the characteristics of students. In the second stage of the process students engaged in cultural understanding and construction of knowledge through accessing ethnochemistry articles. In the next steps, students collaborate to discuss the concept and cultural perspective. At the fourth stage, the students presented the results of the project to the class-based ethnochemistry and cultural background of each group. The last stage of the research process involved students changing their values and understanding. In this study, reflective journals were used and critical thinking tests conducted on the values and perspectives of students who experienced changes during the learning process.

3. Result and discussion
The result show that the integration of ethnochemistry in CRT approach engaged students in developing their critical thinking skills. The test showed that 40% students reached level 3 (Satisfactory). In addition students engaged in cultural identity empowerment, meaningful chemistry learning experiences, and working in teams. The students were challenged to develop their critical thinking skills as display in a graph figure 2.
Based on the figure above, it can be seen that most students had enough critical ability to formulate the subject matter and uncover the facts needed. They were able to; determine the concept used, know all information can be used, detect bias, and work on the questions as planned. They were less able to express logical arguments, re-examine answers using other methods, and to draw clear conclusions.

The 5 criteria for measuring critical thinking skills SCIT1020 are as follows:

3.1. Identification of questions
In the learning process, culture issues were discussed by using ethnochemistry articles, thereby encouraging students to increase their curiosity regarding the issues under study. The results indicated that students were able to clearly and consistently identify and formulate the important principles of the topics. This can be seen from a participant’s response regarding the learning process:

"Acetic acid has a weak electrical conductivity, the molecules of vinegar release only a few H + ions, so the lights dim and bubble the air produced is very little, from the results I identified from the table it can be concluded that the higher the price of Ka, the stronger the acid. The acid sequence from the strongest to the weakest is fluoride acid, nitric acid, formic acid, and acetic acid" (Students Interview 14, January 31, 2018, XI MIPA 3, 12.00-13.00).

"Most students can identify the theories of Acid-base, distinguish strong acids and weak acid well" (Observer Note 2, January 22, 2018, XI M Science 3, 10.15-12.00).

Students felt motivated to ask questions when issues from ethnochemistry articles were discussed. The questions raised by students were useful in clarifying their understanding of the issues. Results showed that the average student could identify questions without confusing the topics.

Teacher : How can you identify the strong-weak acid?
Student 10 : I know which one is strong, the other is weak depend on how price Ka, electrical conductivity, also how it ionize. Strong acid such as chloride and sulphate acid, weak acid such as acetid acid. I want to ask why the arrow of weak acid is two while if the arrow of strong acis is one, I am still confused.
Student 27 : It is relating with the strength of ionization. Isn’t it miss?
Teacher : Yes. The arrow is the sign of how its separates into ions. You must learn more it in book or any sources. Tomorrow we will discuss more about it.

The questions raised by the students were important because the other participants could add information from the questions and from the answers given. On the critical thinking skills tests,
identifying problems in subject questions could be said to score high. Based on the results of the study, it can be seen that students mastered 80.57% of the skill of identifying problems in the question.

3.2. Conceptual understanding
In CRT learning, students integrate an understanding of the concepts of acid-base with culture applications to everyday life such as Jamasan Tradition, Nginang, and Moci. The results of the study show that the average conceptual understanding of students was more developed, meaning that students could provide ambiguous responses and the content used had improved. The following is one sample from a student’s critical thinking test:

"It turns out that the function of tohor chalk for ngingang as Tegal tradition in order to keep our teeth in accordance with the concept of acid-base, Ca(OH)2 can release ions hydroxides according to the theory of acid-base according to Arrhenius in everyday life" (Student Interview 8, January 22, 2018, XI MIPA 3, 12.00-13.00).

"I have to describe the essay problem so I have to master the concept of the question" (Student Reflective Journal 6, 31 January 2018, XI Mathematics 3, 7:00-8:30).

From the test results above, it can be seen that students can respond to the problems using an appropriate and adequate understanding of the content. The student’s statement is in accordance with the concept acid-base of Arrhenius. This aligns with the culture issues learning objectives proposed by [8]. By introducing something they know into the learning process students find it easier to construct their knowledge. The practice forms a pedagogical bridge that connects previous knowledge with new knowledge, known as the unknown, which goes from abstract to reality [9]. On tests of critical thinking skills, understanding the subject concept can be considered strong. Based on the results of the study, it can be seen that students have mastered 73.14% of the conceptual understanding skills aspect.

3.3. Connection of ideas
The research project results show that in the application of CRT learning, students' ability to integrate various ideas such as culture, scientific concepts, health and the concepts of acid-base when discussing ethnochemistry articles began to be observed. The statement below shows students were able to connect several ideas when discussing an issue:

“Student 17 linked ethnochemical articles with the tradition of ngingang carried out by her grandmother when there was a celebration at her house” (Researcher Notes, 10 January 2018).

The statement above shows that participants were able to identify a strong relationship between ideas when discussing cultural issues. Students could also connect an acid-base concept with soil problems as explained in the worksheet sample below:

“if we measuring soil pH by testing it with litmus paper showing the color blue so that the soil conditions showed values of acidity greater than seven or alkaline and when mixed with ZA fertilizer it was already true according to the concept of acid-base because it will neutralize each other” (Student 10, 31 January 2018).

On tests of critical thinking skills the skill of connecting between subject concepts can be unsatisfactory. Based on the results of the study, it can be seen that students mastered only 58.86% of the skill aspect connecting between concepts.
3.4. Assumptions
The learning process to address culture issues encouraged participants to actively express their opinions or assumptions in accordance with the views of each group. Students collaborated (worked in groups) to discuss the concept and cultural perspective. In addition to collaborating in groups, students also collaborate with teachers. This is evident from the following observation sheet:

"Some of the students answered questions about the estimated aspirin more absorbed in the stomach than in the intestine" (Researcher Note, January 22, 2018).

Participants were challenged to develop their critical questions through curiosity in a case. Group discussions allow individuals to get more a comprehensive solution [10] and provided opportunities for students to communicate [10, 11]. The statement below shows students were able to make right assumptions in discussing the issue:

Teacher : What is your opinion on this issue? (How aspirin works in the body)
Student 35 : Aspirin is absorbed in the stomach and in the small intestine, but is absorbed more in the small intestine
Teacher : Why you assume that?
Student 35 : Because aspirin is acidic it will be more easily absorbed by alkaline solutions so it will be more neutral

In the test of critical thinking skills, the aspect of higher-order thinking skills can be said have an unsatisfactory response. Based on the results of the study, it can be seen that students only controlled 52.57% of the skills aspect.

3.5. Conclusions
During the learning process, participants were observed drawing conclusions based on the results of discussions.

“Always measure the pH of the plantation, so that the land can be planted well and where the land can flourish” (student 10, 31 January 2018).

“Conclusion is that Pak Slamet's land is acidic because the litmus paper turns red, while the soil in the land is said to be base because it changes the color of the litmus to blue” (student 13, 31 January 2018).

The participants’ conclusions are correct based on the data and are consistent with the group’s views on the issues raised. On tests of critical thinking skills the aspects of drawing conclusions can be said to have an unsatisfactory answer. Based on the results of the study, it can be seen that students only controlled 42.86% of the aspects of drawing conclusions.

Learning is associated with developing students who are open-minded and intrigued by their surrounding cultures that make them want to learn more deeply. In addition, learning helps students build chemical concepts holistically [12]. It makes students' thoughts and insights more extensive and related to each other, not only from one aspect but related to each other. In addition, giving story questions integrated with Tegal culture, also enabled students to think more critically. This is supported by observers and researchers' notes as follows:

"Learning activities are able to arouse the curiosity of students because they often discuss cultural issues related to the material being studied. In addition, this can be seen from the increasing number of students who dare to ask questions and are no longer shy during the learning process."
Researchers play an active role in motivating and guiding students in straightening the answers given” (Observer note 1, January 24, 2018).

The Culturally Responsive Teaching integrated ethnochemistry raised issues related to Tegal culture. Ethnochemistry examines culture from a chemical perspective so that students can better understand the application of chemical concepts in everyday life. Students will be more motivated to actively express opinions in discussion about controversial topics through their experiences in chemistry learning [13]. Most students already know the typical culture of Tegal but do not know the chemical concepts contained in it. Students assume that ancient people did not study chemistry, however, the culture was in accordance with chemistry concepts. This discovery makes students more curious and want to know more about their culture. Curiosity can stimulate students’ critical questions [14]. They become increasingly aware of the importance of chemical concepts in everyday life is proven to be applied in their regional culture. Students feel responsible for preserving the culture they have. This causes students to think more critically when they come across a cultural issue.

4. Conclusion
Culturally Responsive Teaching integrated with Tegal ethnochemical culture on acid-base material can accommodate various learner characteristics and helped students better understand the chemical concepts and their application in their cultural traditions. This approach has made students begin to reflect on themselves to develop their cultural identity in understanding themselves and others. Students found a connection between the concept of acid-base chemistry and traditional chemistry through story. In addition, the learning experience encouraged students to be more critical and independent. Learning is associated with developing students who are open-minded and intrigued by culture so as to make changes in their values and perspectives following the learning process. Students are increasingly aware and responsible for their culture, sand they are increasingly active in their learning. The learning process encouraged participants to use their intellectual abilities and, as such they develop critical thinking skills equal to 40% or level 3 (Satisfactory). Achievement of the highest indicators was: identify the question at issue (80.57%) and lowest: inferences (42.86%).

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