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THE INFLUENCE OF ETHNOSCIENCE-BASED LEARNING ON CHEMISTRY TO THE CHEMISTRY'S LITERACY RATE OF THE PROSPECTIVE TEACHERS

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Abstract

A research has been conducted to analyze the influence of ethnoscience-based chemistry learning to prospective teachers' literacy of chemistry. The subjects of the research were 40 students of chemistry education. The instrument of chemistry literacy rate's measurement were essays which are validated by experts' judgement and trials. The result discovered that the implementation of ethnoscience-based learning in chemistry can improve students' literacy in chemistry, specifically in the rate of medium to high on all group of students.

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INTRODUCTION

Chemistry is a subject taught to people as a part of natural science (Rutherford & Ahlgreen, 1990). Learning chemistry is theoretically teaching students to have the ability of identifying chemical problems and making conclusion based on evidences for the sake of recognizing natural changes and the effect of human's interaction to the nature (Gorokhov, 2010). This complex world changes quickly which requires the understanding of chemistry to handle it (Gilbert & Treagust, 2009). Due to the understanding, literacy of chemistry from formal education is highly demanded (Rahayu, 2017). It means that the students should not only know and memorize things related to the concepts of chemistry, but also understand and implement it in their daily life (Holbrook, 2005; Marks & Eilks, 2009)

A new paradigm of chemistry education demands students not only to comprehend conceptual stuffs in verbal way through memorization, formulas, and terms (Liliasari, 2007), but the lecturer must give the students real experiences of chemistry in their daily life (Gallagher, 2007). Besides motivating the students to think about natural phenomenon based on scientific method (*NRC*, 1996), students should also be able to become responsible citizens responding to the chemistry-related events in their surroundings, such as the thinning layer of ozone, global warming, acid rain, green house effect, pollution, etc. (Vilches & Gil-Pe´rez, 2011)

However, the fact shows that chemistry education does not fulfil those demands. Liliasari (2005) states that the daily life of Indonesians do not reflect of what so called being "literate" of chemistry. Many people still show incapability of applying knowledge of chemistry to their life. The research conducted by Ridwan *et al*. (2013); Odja & Payu (2014); Sujana *et al*.(2014); and Sulistiawati (2015) find that most students have difficulty in applying chemistry education in the real world. The finding supports Celik (2014) and Bacanak &Gőkdere (2009) that 56% of prospective chemistry teacher are unable to deliver proper and correct information regarding nominal and functional literacy of chemistry. A huge portion of them have limited understanding on concept in macroscopic level. The future teachers tend to have higher score of memorizations and practical application of formula rather than the conceptual-procedural and multidimensional questions (Celik, 2014).

The researches of Sumarni *et al*.(2017) and Bacanak & Gőkdere (2009) show that many students of chemistry education are incapable of showing the application of chemical concepts as well as relating that to the surrounding phenomena. The problem might be caused by a memory-based learning pattern which has low level of critical thinking challenges and minimum access to applying the memory. This condition shows that students' learning outcome in their senior high or university are not enough to make the literate in chemistry. This literacy reflects the readiness of citizens in encountering global challenges (Archer-Bradshaw, 2015; Holbrook & Rannikmae, 2008).

The findings of the researches above showed that there is a big gap between students' knowledge to the application of it. The students' learning process were mostly filled with facts, empiric data, and formula which only needs to be recalled in their memory instead of applying it to their daily life. Hence, there should be an attempt to improve the literacy level of chemistry education students in chemistry.

Future teaching of chemistry education should be relevant to social issues. The learning approach which suits the proposal is a learning approach which touches the elements of life, finds the solution of it, bases on the local potentials, and makes decision on science-social problems (Holbrook, 2005). The use of chemistry in social life are mostly related on the context of maximizing local wisdom. Local wisdom is a stimulus of motivation for students to construct their knowledge. The integration of cultural competence in different profession will become the determining key for professional service, including in education. Thus, lecturer should be able to utilize local culture to accommodate the demand in the learning process (Nieto & Booth 2010).

The importance of cultural integration in science as an ethnoscience is explained by Nieto & Booth (2010) as in accordance with the social constructivism of Vygotsky (Tobbias & Muffy dalam Mussana, 2012). The concept discusses on the urgency of cultural competence in education. Vygotsky has more emphasis on the sociocultural concept, which is the social and interactional context of students in learning. Vygotsky is also sure that learning process is not only at school, but it can also occur when the students do tasks they never did in school which they can do it well in the society. Therefore, future teacher should obtain the experiences of integrating culture to their learning process.

The result showed that Javanese culture used various concepts of chemistry through generations. This initial stage of knowledge is useful for students to understand lectures of chemistry. The understanding of content and context of culture in Chemistry will enhance the understanding of students to their culture as well as to their cognitive comprehension of chemistry and their critical thinking skills (Arfianawati *et al.*, 2016).

Based on the facts, considering teachers are important in learning process, there should be an innovation in the learning process of teaching institution. Following the suggestions of Bacanak &Gőkdere (2009), teaching institution should be able to improve the literacy rate of future chemistry teacher. Thus, the writer proposes ethnoscience learning process for chemistry to achieve the objective. This research has a specific objective to analyse the improvement of students' literacy of chemistry through ethnoscience-based chemistry learning.

Practically, the advantages of this research are listed as follows.

1. To become the guidance of consideration in educational policy, especially in developing teaching education.
2. To become a suggestion for lecturer to develop chemistry education that students will have the literacy of chemistry.
3. To motivate other researcher to conduct further researches regarding the development of chemistry based on local wisdom.

METHODS

This research was conducted in a teaching institution in Central Java for the academic year of 2016/2017. The subjects of the research were the students of Chemistry for Foodstuffs. There were 55 students in the class. The data were obtained through essay test which were developed by Sumarni *et al.* (2016). The test coped three aspects of literacy in chemistry, which are contents, contexts, and competences. The test were done after the implementation of ethnoscience-based learning process.

The steps of the learning process modifies the *Chemie im Kontext* (Nentwig, *et.al.*, 2007) based on the following sequences.

1. Contact phase: In the learning process, the lecturer does not only show the application of materials in the daily life, but also discuss it in the future assignment.
2. Curiosity phase: this stage is the time where questions regarding chemistry are answered. The teacher can insert the social issues to the component of decision making to certain problems related to chemistry and involve the students in the problem solving phase (Holbrook*et al.*, 2008).
3. Elaboration phase: there is an exploration, experiment, and chemical concept formation to students. These activities are in details explained as the exploration of local context, the experiment to the proximate element, and the reconstruction to social understanding during fields observation. From these events, it is expected that students will understand the importance of chemistry in their community.
4. Decision making phase: the students made decision under the guidance of the lecturer as their facilitator. During the fields observation, students can find phenomena which are strongly related to chemistry in food. The lecturer supports them to think on "why", "how", etc. During the observation, students are also training themselves to explore their knowledge. The students can come with the knowledge which they previously have and relate their understanding to the concepts in chemistry.
5. Nexus phase : the students make decision based on the materials and apply that to other context.
6. Evaluation phase : there is an evaluation to the learning process to value students' success, including to the apects of content, context, and competence.

The improvement of each literacy aspects are identified using *N-Gain* based on Hake (1998) with the criteria mentioned in Table 1.

The formula is as follows

$$<g> = \frac{\bar{X} < postes > - \bar{X} < pretes >}{100 - \bar{X} < pretes >}$$

Notes: $\bar{X}$ = average

Table 1. Criteria of *N-gain* Achievement

Average Score	Criteria
0.00 – 0.29	Low
0.30 – 0.69	Medium
0.70 – 1.00	High

RESULTS AND DISCUSSION

In the practiced learning approach, the process began with contact phase, where there was a presentation of local cultures in the society which are familiar to the students. The sources of the materials were from the observation, articles, TV news, etc. Then, in the curiosity phase, the students were given knowledge and materials which reinforced their interest. Next, they observed traditional foods (as the final assignment). In the observation, they were asked to implement the basic concept of chemistry and apply it to different contexts. From the application, it is expected that the students did no longer consider chemistry as facts which should be memorized, but as a real phenomenon which should be encountered (Rahayu, 2017). Finally, it is expected that the observation will increase students' attraction to science.

The analysis of *N-gain* to students' literacy of chemistry in terms of content can be seen in Table 2. Table 2 shows that the ethnoscience-based learning is able to improve students' literacy on the content of carbohydrate, fats, and protein for the experiment class. The bottom group achieved the highest literacy, while the top and medium group were in the medium level.

Table 2. N-gain of content

Materials	Group of Achievement	Average Pretest Score	Average Posttest Score	*N-gain*	Categories
Carbohydrate	Top	22.83	76.17	0.69	Medium
	Middle	28.18	71.98	0.61	Medium
	Bottom	28.20	80.80	0.73	High
Fats	Top	23.83	75.33	0.68	Medium
	Middle	29.84	74.20	0.63	Medium
	Bottom	23.00	78.00	0.71	High
Protein	Top	27.33	78.83	0.71	High
	Middle	27.75	75.59	0.66	Medium
	Bottom	28.40	80.20	0.72	High

From Table 2, it is seen that the mastery of the aspect from the bottom groups were high, while the top and middle group were medium. The improvement of students' content literacy were caused by the change of materials which were memory-based to application-based. This result supports Cigdemoglu (2015) that the learning of context on chemistry improves students understanding on thermochemistry and thermodynamics.

Based on the findings of this research, the students had improvement in mastering the contents of the lectures. They had a chance on applying the knowledge that they had to solve the problem in their surroundings (S Sudarmin, 2014). Laboratory activity helped the students to use all the skills that they had in the class to the real life. The practicum of planning and using the materials in students' daily life can be obtained from the experiment. Besides, the students were able to critically comment their friends as well as being active on asking and showing their opinion to certain concept of chemistry which they have known before. Students can freely opine their ideas to certain problems together.

Literacy of chemistry is a gate to the advancement of science and technology where rational information and decision are highly required (Oludipe & Awokoy, 2010). The statement is in line on integrating culture in learning chemistry to support students in taking ethical decision and help them in determining the relation between science, technology, and society since the integration of culture in chemistry education should make people literate in chemistry.

In the phase of elaboration and decision making, the development of local potentials of carbohydrate, fats, and protein through simple technological application was done starting from designing and making edible film and coating from tubers to preserve tofu and fruits. The context of the chemistry in the case copes the situation of correlation between chemistry to students' daily life for the enhancement of understanding. In Table 3, the N-gain achievement of students in terms of context is presented. The average N-gain score for the aspect is relatively high, except in the utilization of fats and protein which both of them are in the medium level.

Table 3. N-gain of context

Context	Average Pretest Score	Average Posttest Score	*N-gain*	Categories
1	3.67	8.67	0.79	High
2	4.00	8.78	0.80	High
3	3.83	8.33	0.73	High
4	4.33	8.67	0.77	High
5	4.10	7.88	0.64	Medium
6	3.97	7.76	0.63	Medium

Notes : 1) the context of traditional technology of food based on carbohydrate, 2) the context of traditional technology of food based on fats, 3) the context of traditional technology of food based on protein, 4) the advantages of food based on carbohydrate, 5) the advantages of food based on lemak, 6) the advantages of food based on protein.

Based on the context of literacy of chemistry, the context has the aim to teach students the chemistry from the observation of the real world and relate it to the representation of molecules and symbol about the chemical phenomena (Eskrootchi & Oskrochi, 2010; Parchmann *et al*., 2015). The context-based learning of chemistry eases students in learning chemistry (Anga & Reyk, 2013). In context-based learning, the content attaches to the natural context as well as shows the scientific method which can be applied by creating products. The context is adapted to the socio-science issues, because the context should be explicitly relate science and technology to the social sciences (Rahayu, 2017; Pilot & Bulte, 2006).

In this research, the nexus phase is the time when students make edible film as the alternative of fruit preservation. The edible film is used to preserve food and develop students' mindset in building concepts based on experience and solving problems with chemical concepts (Marks & Eilks, 2009). In terms of decision making, students get the composition to make edible film with tensile strength and good biodegradability. The success of making such technology shows the understanding of students in applying scientific concept in the real life as well as showing it in the laboratory.

Based on the data in Table 3, generally, all aspects of context in science application increased significantly. It is proven from the increasing N-Gain (%) from each context. The N-Gain (%) in the context 1 "Carbohydrate food technology" is 79% which is categorized as high, the second context was 80%, the Third context was 73%, and the fourth context was 77%.

The high increase for the N-gain of context 1-4 was caused by the concept of carbon which is close to teacher's life since traditional food like tubers, cassava, coconut oil, and salted egg are people's favourite. The medium increase happened to context 5 "the advantage of fats-based traditional food" as in 64% and context 6 in 62%. These context are lower than context 1-4, because they are conceptual which make students difficult to apply.

The high and significant improvement of the scientific context occurred due to students' familiarity and curiosity on chemistry in traditional foods (Cigdemoglu, 2015), thereby, after following the ethnoscience-based learning process, the students were enthusiastic to find, discover, and dig information regarding its application. This finding is relevant to Ramsden in (Jong, 2006) which shows that contextual learning process attract the interest of the students to learn chemistry and relate it to applicative context. This way of learning is applicable and hard for students to forget. The result of students' N-Gain in terms of competence can be seen in Table 4.

Table 4 shows that highest N-gain value can be explained as middle group > top group > bottom group. Form the result of the research in Table 4, the increasing literacy of chemistry on competence is caused by the different situation of learning. The increasing learning outcome shows that the ethnoscience learning on chemistry made students actively participate in the learning process. It supports them to have better literacy in chemistry. The result is the same with the learning theory of Vygotsky that learning can happen in social interaction whether with lecturer or friends. The curiosity of the students are improved due to their chances of understanding and applying science in their daily life exists (Rahayu, 2017). Students become aware that chemistry is close to their daily life. Based on the high competence of scientific phenomena, the evaluation and analysis of data, the improvement came from the ethnoscience learning process. With practicum, students are able to identify problems, investigate problems scientifically, and make conclusion to have better competence. High achievement also happens to the competence of showing arguments. The competence forces students to use scientific data and take conclusion.

Table 4. N-gain of competences

Group of Achievement	Indicators	Average Pretest Score	Average Posttest Score	*N-gain*	Categories
Top	1	3.60	6.59	0.48	Medium
	2	3.60	6.60	0.47	Medium
	3	3.60	7.94	0.68	Medium
	4	2.80	8.72	0.82	High
	5	3.20	8.00	0.71	High
Middle	1	3.67	8.67	0.79	High
	2	4.00	8.78	0.80	High
	3	3.83	8.33	0.73	High
	4	4.33	8.67	0.77	High
	5	5.10	7.88	0.57	Medium
Low	1	2.80	8.50	0.79	High
	2	3.36	8.76	0.81	High
	3	3.47	8.08	0.71	High
	4	2.77	8.00	0.72	High
	5	2.43	8.22	0.76	High

Notes : 1) explain scientific phenomena, 2) designing experiment, 3) analysing and evaluating data, 4) showing argument, and 5) concluding

From the data, the bottom group has higher increase compared to middle and top group. It showed that the learning process was meaningful for the bottom group. The students' achievement shows that the integration of ethnoscience needs collaborative activity which make students in the lower group understand it easier. The tendency of top group is that they have higher individualism which makes them uncooperative. The result is the same with Iyer & Kamalanabhan (2006) who show that smart group usually individualistics who want to show off. Meanwhile, the bottom group consists of communicative and creative people who are able to share outstanding questions and use cooperative way in solving problems.

The evaluation phase showed that the increasing rate of students' literacy in chemistry happened during the whole learning process. From the interview with some students, it is found that they were more motivated to learn chemistry as it is more familiar to them. The finding showed that ethnoscience learning process is really helpful in increasing students' literacy. Students can learn chemistry not only from the book, but also from their finding in their community. The reconstruction of social knowledge to become a scientific knowledge forces the students to actively learn different theory and ocnept in the book. This activity is proven helpful for the students in developing their critical thinking, problem solving, and intellectual skills. This finding is in accordance with Holbrook (2005) that culture and local wisdom are the closest things to students which are making them easy to learn new things.

The increasing literacy of chemistry for students can be viewed from the lecturing process where they come to the class in prepared way that they have got all the materials from different sources. Students are more comfortable in asking opinion and showing ideas for an alternative to solve problems (Tawfik *et al.*, 2014).

CONCLUSION

Based on this research, it can be concluded that ethnoscience learning in chemistry can improve students' literacy in chemistry whether in terms of contents, contexts, and competences. This improvement of literacy shows that students: first, becomes more active and motivated in learning; second, are able to solve problem; third, integrate their understanding simultaneously and apply it to relevant context; fourth, students are able to find new things; and fifth, train the students to be more critical in scientific learning. However, lecturers have to identify many things in the local context which are relevant to the concept of chemistry, not only on the content, but also in the context and competence for students' behaviour in chemistry.

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