

The Study of Chemical Literacy Related to Chemical Ethics Based on Local Phenomena Day-to-day: A Case of Used Cooking Oil

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Abstract: Literation level, one of them is scientific literation, is possible to be the measurement of a national improvement in education. Scientific literation could be specified by chemistry literation which has four aspects; one of them is the affective domain. In this study, the research focuses on the affective domain consisting of five phases; phase of receiving, phase of responding, phase of valuing, phase of organizing, and phase of characterizing by value set. The study aims to describe the students' chemistry attitude skills related to hydrocarbon materials by integrating local case of everyday life. The local case taken is the cooking oil used in the "penyetan" stall. The research is descriptive qualitative research. The participants of this research are whole students of grade eleventh in a senior high school in Magelang who had been taught hydrocarbon materials. The sample of this research is 70 students of grade eleventh. Questionary is used in the research as a data collection method. The instrument used is a form of a questionnaire, which was a close-ended questionnaire with four possible answers; strongly disagree, disagree, agree, and strongly agree. The result shows the skill of chemistry attitude of hydrocarbon material is 69.12857%. It means that the student's skill chemistry attitude is in a category of fair.

Keywords: Chemical Ethics; Chemical Literacy; Cooking Oil

Introduction

One of the national improvements is the student's literacy level, and one of them is science literacy. Science literacy can be defined as the ability to be employed with scientific issues (OECD, 2015). Science literacy then becomes a focus for students to participate in discussions related to science, technology, people, and environmental problem scientifically (Yore et al., 2007). Other opinions state that science literacy is defined as something that should be known by students so they can have an effective life in their surroundings (Garner-O'Neale et al., 2013). Nowadays, chemical literacy is something important to discuss. It makes the student recognize the advantage of literacy. It can be the main purpose for teachers, experts, and curriculum policymakers (Hewi & Shaleh, 2020).

One of the ways to measure the level of literacy is to use the Program for International Student Assessment (PISA). However, the newest result of the Program of International Student Assessment (PISA) conducted by the Organization for Economic Co-Operation and Development (OECD) in the literacy and science field showed unsatisfying results for Indonesia. The position of Indonesia in 2009, 2012, 2015, and 2018 was 402, 396, 397, and 371 in order. That score is categorized as below the average which is 500. That result showed, as well as in the science field, in 2009, 2012, 2015, and 2018 order was 383, 382, 386, and 396 (Tahmidaten & Krismanto, 2020; Asikin & Yulita, 2019). Based in these result, students in Indonesia have relatively low scientific and chemical literacy abilities (Haetami et al., 2023; Warlinda et al., 2022).

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Some factors causing the low score of students' literacy ability in Indonesia are improper activities, lower-order thinking skill exercises and evaluation, and the lack of library services in the school (Tahmidaten & Krismanto, 2020; Sadhu & Laksono, 2018). Therefore, the ongoing teaching and learning activity should be modified. The modification aims to build the students' scientific literacy model deeply and in a multidimensional way (Cigdemoglu & Geban, 2015).

One of the parts of literacy is scientific literacy. Scientific literacy is the skill to identify problems, employ scientific knowledge, explain scientific phenomena, draw conclusions based on evidence, understand scientific characteristics, acknowledge how science and technology create a natural environment, intellect, and culture, also the skill to involve and pay attention to the issues related to the science (OECD, 2015; OECD 2016). The sequences of scientific competency needed in scientific literacy show the combination of social and cognitive ability throughout the entire knowledge (Crujeiras-Pérez & Brocos, 2021). Scientific literacy shows the theme sequences which include multi-course (Wei & Chen, 2017).

Scientific literacy can be specified as chemical literacy which includes chemistry knowledge and skill necessary for chemistry-based understanding (Mulyopratikno & Wiyarsi, 2023). Scientific literacy, including chemical literacy, really needs to be taught to students so they can live in the midst of a modern 21st century society (Primadianningsih et al., 2023). Chemical literacy consists of three components which are basic chemistry key concepts such as elements, symbols, processes, and models, academic and industrial professional chemistry concepts, and social context (Kohen et al., 2020). Chemical literacy consists of four aspects which are chemistry as knowledge, chemistry as a context, High-Order Learning Skills (HOLS), and affective aspect (Shwartz et al., 2006).

Further discussion of the affective aspect, Krathwohl et al. (1964), stated that the affective aspect is an aspect including feeling, value, appreciation, enthusiasm, motivation, and attitude. The students' competencies reflecting good affection can be seen in the mature attitude based on the age and the improvement of the students and the daily attitude in the process of learning both inside and outside the class. The effective skill of the students can be seen from the tendency, change, and development based on the affective domain.

Receiving

This is the phase when the students have the willingness of receiving or attending a stimulus given in the form of problems, situations, phenomena, and others.

Responding

This is the phase when the student responds to a stimulus given in the form of problems, situations, phenomena, and others.

Valuing

This is the phase when the students show that they are ready to receive and value the values given to them.

Organizing

This is the phase when the students claim the values given to them as an internal part of them and claim those values as a priority in themselves.

Characterization by Value Set

This is the phase when the students claim those values as their attitude control in their daily life so it becomes the lifestyle. The advantage of an affective attitude can be related to chemical ethics both directly and indirectly felt by the students in the form of chemical literacy understanding. It can be an example for them to take the decision, think critically and creatively, and also help them solve daily problems or natural phenomena based on their knowledge, and ability to appreciate the nature using science and technology they mastered (Sevian et al., 2018; Wiyarsi et al., 2020; Nisa et al., 2015).

Therefore, the chemistry concept learned by the students in school should be implemented in daily life through chemical literacy skills. For instance, the concept of hydrocarbon can be implemented to determine the number of octane in fuel (Wiyarsi et al., 2020). The concept of the acid base can be implemented in the phenomenon of acid rain, hypoxia, soil acidity, and the production of ammonia (Anggrah & Antuni, 2019; Cigdemoglu et al., 2017). In the concept of chemical equilibrium, it can be implemented in the phenomenon of tooth enamel, air pollution in the atmosphere, sea acidity, and the greenhouse effect (Sadhu et al., 2019; Fadly et al., 2022; Sadhu & Laksono, 2018). In the concept of reaction rate, it can be implemented in the phenomenon of coral reefs, the explosion of the volcano, tropic rain, and the usage of alcohol in medic (Sari & Wiyarsi, 2020; Setyorini et al., 2021). There are still a lot of phenomena around the students' environment that can be a theme of chemical literacy which has never been brought before as research. For example, the theme of "the usage of cooked oil" is found in many areas in Indonesia.

Method

Type of Research

This research is descriptive research with a qualitative approach.

Subject of Research

The subjects of the research are based on the description of the data (Arikunto, 2015). The subject of quantitative research should be in representative way so that the chosen individual could represent the whole population (Creswell, 2012). A population is a group of individual who has the same characteristic. The samples of this research are the 70 students of grade 11th.

Procedure of Research

Descriptive research aims to give the image of a characteristic of a population based on the data collected from the samples (Lochmiller & Lester, 2017). In this research, the data were collected from the result of questionnaires given to the students of grade 11th who had the chemical equilibrium materials. The data then were analyzed quantitatively using descriptive statistics by counting the average of the result. It was made in form of a percentage (%) and then described in the form of a table and graphic to help the decision-making.

Data Collection Technique and Instruments

The data collecting technique in this research was using questionnaires. A questionnaire is a written statement used to get information from the participants which means an individual report or other information they know (Arikunto, 2006). The questionnaires were given to 70 students of grade 11th who had hydrocarbon materials.

The instruments used were divided into two instruments which are the research instrument and the data collecting instrument. The research instrument used was the chemical literacy discourse sheet with the topic of the usage of cooked oil in a *penyetan* restaurant. While the data collecting research used students' questionnaires. The students' questionnaires contained the students' understanding of chemical ethics related to hydrocarbon materials.

The questionnaires used measured five chemical ethics which were receiving, responding, valuing, organizing, and characterization by value set. Receiving, responding, and organizing consist of five questions. Valuing consists of three questions. Characterizing by value set consists of seven questions. The total question is twenty-five questions. The scales used in the questionnaire were the Likert scale with four alternative options. The scales were arranged in the form of a question and followed by the response in which the level was shown. The response options are SD (Strongly Disagree), D (Disagree), A (Agree), and SA (Strongly Agree). The scoring of the Likert scale option is based on the character of the question. Strongly Agree has 4 points, Agree has 3 points, Disagree has 2 points, and Strongly Disagree has 1 point. There was no negative question so the reversal of the score is not necessary.

Data Analysis Technique

The data analysis technique used was to determine the chemical literacy ability of senior high school students based on the result of the students' questionnaire. The analysis steps done in the research are counting the score collected by the questionnaire calculation, counting the average score of students' chemical literacy ability and deciding the percentage of chemical literacy ability using the category explained in Table 1.

Table 1. Category of chemical literacy ability

Score	Category of Ability
<56	Low
56-75	Fair
76-100	High

Result and Discussion

The students in grade 11th who had been taught the hydrocarbon materials were chosen as the participants of the research. At the early of the research, the researcher asked the approval from all of the teachers in the class who explained the reason for the research. The teachers also guaranteed that all of the data collected (including the identity of the students) are kept in a secret. Before doing the research, the researcher also asked the approval from the students and explain the purpose of the research. In the early of the research, there were 72 participants, however, two students quit so the participants were 70 in total.

The result of the Close-Ended Questionnaire

The developed close-ended question consists of 25 questions divided into five phases. Based on the result, the chemical ethics data in each phase is provided in the Table 2.

Table 2. The result of chemical ethics in each phase

Phase	Percentage (%)
Receiving	65.3571
Responding	75.7857
Valuing	67.2619
Organizing	61.6429
Characterization by value set	73.2143
Average	69.1287

The average of the whole chemical ethics is 69.1287%. This result shows that the students' chemical ethics are in the category of fair. The score data then was analyzed using the descriptive statistics analysis technique. Based on the analysis result, it shows that the student's average ability in each aspect indicator is.

Receiving

The first phase consists of five questions matched with the indicators. The indicators used are to receive and understand that there was a social phenomenon related to chemical ethics in the environment. Those indicators then were explained into five questions summarized in Table 3.

Table 3. Statement of receiving phase

Statements
I believe that there are a lot of <i>penyetan</i> restaurants in my surroundings.
I always see the process of food production in the <i>penyetan</i> restaurant I visited.
I believe that the oil used in the frying process has not turbid-brown color or even black
I believe that the oil used in the frying process has not a bad smell.
I believe that the oil used in the frying process has no froth and precipitation.

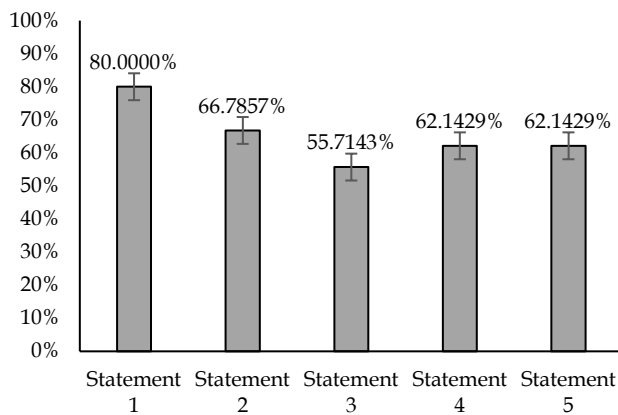


Figure 1. Chemical ethics in each statement of receiving

The result of the student's response is shown in Figure 1. From figure 1, 80% of students believe that there is a lot of *penyetan* restaurant in their surroundings. From the observation, there are only 2 students who disagree with statement 1. This means that the *penyetan* restaurant in Magelang is in the category high and it is a common phenomenon. 66.7857% of the participants is always see the process of food production in *penyetan* restaurants they visited. When they were asked about how they see the process of food production, they answered they only see the frying process because the food was already seasoned before. 55.7143% of the students believe that the oil used in the frying process has not turbid-brown or even black. 62,149% of the students believe that the oil used in the frying process has not been in the bed smell and 62.1429% of others believe that the oil used in the frying process has not froth and precipitation. The total percentage in this phase is 65.3571% and it is in the category of fair.

Responding

The second phase is responding which consists of five questions matched with the indicators. The indicator used is the students can choose the restaurant with certain criteria and can respond to the social phenomenon related to chemical ethics. Those indicators then were explained into five questions summarized in Table 4.

Table 4. Statement of the responding phase

Statements
I always choose <i>penyetan</i> restaurants before I order the food
I have special criteria to choose the restaurant as a place to eat.
If I see the product of the oil used in the frying process has poor quality, I will choose another restaurant.
In my opinion, producing food with cooked oil is a bad thing.
I often question the truth of information about the dangers behind food fried with cooked-oil

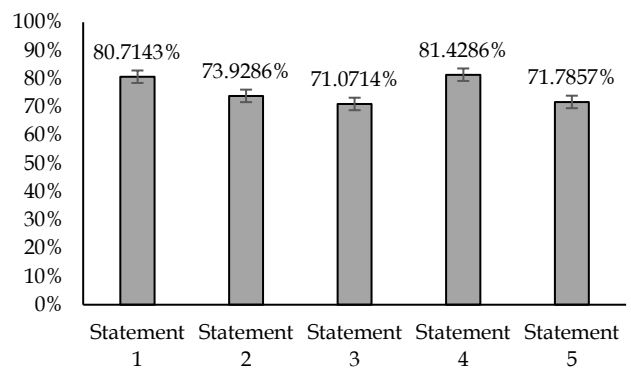


Figure 2. Chemical ethics in each statement of responding

The result of the student's response is shown in Figure 2. From Figure 2, 80.714% of students stated that they always choose *penyetan* restaurants before ordering the food. The result percentage to this statement is in the category of high so the conclusion is that some students choose the place first before ordering the food. Next, 73.9286% of students have special criteria to choose the place to eat. When some students were questioned about the criteria, they answered that the place's hygiene is a criterion that must be met. From the result, there are enough students who can choose and provide responses on the chosen *penyetan* restaurant before ordering food at that place. 71.0714% of students stated that if they see the product of oil used in the frying process as poor quality, they will choose another place. 81.4286% of students stated that food processing using cooked oil is a bad thing. This percentage is in the high category, which means that some students are acknowledging the chemical ethics violation done by the seller who uses the cooked oil. However, there are only 71.7857% of students often wonder about the true information about the dangers behind food fried with cooked oil. The total

percentage from this phase is 75.7857%. This result is still in the category of fair but it is very close to the high category.

Valuing

The indicator in this aspect is the students show an interest in social events related to chemical ethics. The description of this indicator is provided in Table 5.

Table 5. Statement of the valuing phase

Statements
I am interested in reading news related to the negative impact of using cooked oil.
I am interested in reading an article about scientific research related to the negative impact of using cooked oil.
I am interested in discussing the negative impact.

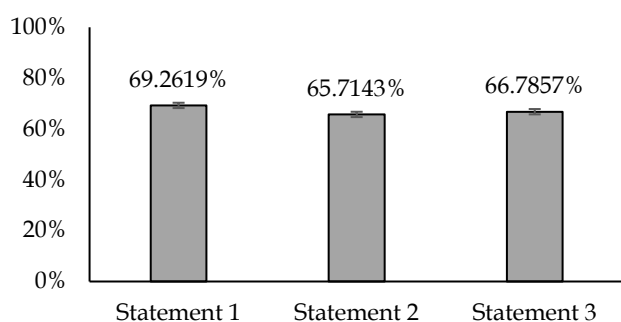


Figure 3. Chemical ethics in each statement of valuing

The result of the student's response is shown in Figure 3. From Figure 3, 69.2619% of students are interested in reading the news related to the dangerous impact of using cooked oil. 65.7143% of students are interested to read the scientific research related to the discussion of the dangerous impact of cooked oil with friends or teachers. The total percentage is 67.2619% and it is in the category of fair. It means that the student's interest in the social phenomena related to chemical ethics is in the category of fair and it needs to be improved.

Organizing

Table 6. Statement of organizing phase

Statements
I am able to decide whether good or not the quality of the oil used in the process of food production based on the understanding I have.
I am able to integrate the understanding of the chemical concept I have about the dangerous impact of using cooked oil.
I believe that the higher the temperature during the frying process the faster the quality decrease.
I am able to mention the dangerous chemical compound coming from the frying process.
I am able to represent the process and chemical reaction when the seller fries the food at a high temperature.

The indicators in this aspect are the students are able to organize the thoughts related to chemical ethics in the chemistry lesson. The description of this indicator is provided in Table 6.

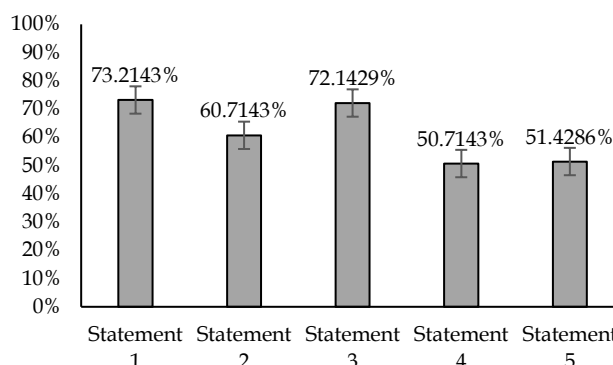


Figure 4. chemical ethics in each statement of organizing

The result of the student's response is shown in Figure 4. From Figure 4, 73.2143% of students are able to decide whether good or not the quality of oil used in the process of producing food is based on the understanding they have. The first aspect of this phase becomes the highest percentage. However, this percentage is still in the category of fair. When some participants are asked related to how they decide the oil quality based on their understanding, they stated it is based on the color, smell, and identifying if is there any froth and precipitation. The researchers assumed that the students only see from the discourse sheet the researchers gave before since there are no variations of answers from the students. 60.7143% of students are able to integrate the understanding of the chemical concept they have about the dangerous impact of using cooked oil. 72.1429% of students believe that the higher the temperature during the frying process the faster the quality decrease. 50.7143% of students are able to mention the dangerous chemical compound coming from the frying process with the high temperature. This percentage in this statement is in the category of low so it can be concluded that there are less of students who relate the chemical concept to the social phenomenon in daily life. This is also supported by the percentage from statement 5 which only got 51.4286%. It means that only 51.4286% of students are able to represent the process and chemical reaction when the seller fries the food at a high temperature. The total percentage from this phase, organizing, is 61.6429% and it is in the fair category. In contrast, this percentage becomes the lowest percentage in the five phases of chemical ethics. This relates to how minimum the students organize their thoughts based on the chemical ethics in the chemistry lesson they learned before.

Characterization by value set

The indicators in this aspect are the students are able to determine the character based on both good and bad value in a social phenomenon with the chemical hydrocarbon concept. The description of this indicator is provided in Table 7.

Table 7. Statements of characterization by value set phase.

Statements
I believe that the seller of <i>penyetan</i> restaurant that uses cooked oil is fraudulent and harms consumers.
I believe that the seller of <i>penyetan</i> restaurant that uses cooked oil violates social ethics and norms.
I believe that the seller of <i>penyetan</i> restaurant that uses cooked oil can be subject to consumer protection articles.
I support the government to keep supervising the seller of <i>penyetan</i> restaurants to forbid the usage of cooked oil in producing their food.
I have a recommendation and other alternatives to process the food instead of frying.
I will persuade my family and friends to reduce consuming the fried-food.
I realize that not consuming the fried-food using cooked oil will bring a positive impact on health.

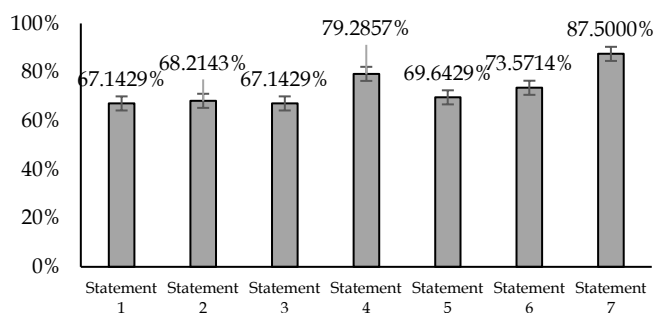


Figure 5. Chemical ethics in each statement of characterization by a value set

The result of the student's response is shown in Figure 5. From figure 5, it is concluded that 67.1429% of students believe that the seller of *penyetan* restaurant that uses cooked oil is fraudulent and harms consumers. Even though it is in the category of fair, however, the percentage result shows that there are only a few students who believe that the seller of *penyetan* restaurant that uses cooked oil is fraudulent and harms consumers. This result is supported by the next statement that only 68.2143% of students believe that the seller of *penyetan* restaurant that uses cooked oil violates social ethics and norms. In the next statement, stating that they believe that the seller of a *penyetan* restaurant that uses cooked oil can be subject to consumer protection articles, got 67.1429%. However, there is a lot of students who support the government to keep supervising the seller of *penyetan* restaurants to forbid

the usage of cooked oil in producing their food (amount 79.2857%). Next, there is only 64.6429% of students have recommendations and other alternatives to process the food instead of frying. Although the percentage result is in the category of fair, there are only a few students who are able to show their alternatives to processing the food instead of frying. 73.514% of students will persuade their family and friends to reduce consuming the fried-food. The good result which it includes in the high category appears in the last statement that 87.5% of students realize that not consuming the fried-food using cooked oil will bring a positive impact on health. The total percentage in this phase is 73.2143% and it is in the category of fair.

If all of the phases are reviewed as a whole, the percentage of students' chemical ethics skills in hydrocarbon materials is 69.12857%. The result of this study shows that the student's skill is in the category of fair. This indicates that the students are not familiar with chemistry learning which uses scientific steps, and also not able to understand the whole materials. This means the learning activities are only forcing the students to understand the materials without relating and applying the social phenomenon in daily life.

The result of the open questionnaire

The open questionnaire used is in the form of a description question. The function of the questionnaire is to support the close-ended questionnaire. There are three questions described in Table 8.

Table 8. Open questionnaire questions

Questions
What do you think about the seller of <i>penyetan</i> restaurant who uses cooked oil to process their foods?
In your opinion, is there any relation between chemical ethics with the case of <i>penyetan</i> restaurant that uses cooked oil to process its foods? Describe your answer!
In your opinion, is <i>penyetan</i> restaurant seller who uses cooked oil to process their foods an unethical person? Give your reason!

Most of the content of the first questions is the students stated that the seller harms the students by ignoring the health aspects. However, some students stated that those cases are not the problem because the seller is also looking for profit. Even one of the students mention that cooked oil is an icon of *penyetan* restaurants because it makes the food more tasteful. This answer took the researchers' attention. The continuing usage of cooked oil at high temperatures will trigger the process of lipid oxidation, the breaking of double bonds in unsaturated fatty acids to produce peroxide groups and cyclic monomers, and saturated fatty acids (Megawati & Muhartono, 2019). The more double bonds in the

chemical structure in the cooked oil the faster the fat oxidation. This causes the food tastier and crispier but contains a lot of negative impacts on it.

In the second question, the students are divided into two groups. The first group is a group that believes that there is a relationship between chemical ethics with the case of *penyetan* restaurant that uses cooked oil to process the foods and the second group is the one that doesn't believe it without knowing the knowledge. The students in the second group stated that frying foods using cooked oil can harm the students yet they can't relate it to chemistry science.

In the third group, a lot of answer variation from the students. Some of them answer that the seller of *penyetan* restaurant who uses cooked oil is an unethical person, some doubted the statements, some others stated that it cannot be determined only by the cooked oil case, and the remains stated that the cooked oil case is not a problem since it is a common problem in Indonesia and it becomes the alternatives way of oil. A variation of students' answers is described in Figure 6, Figure 7, Figure 8, and Figure 9.

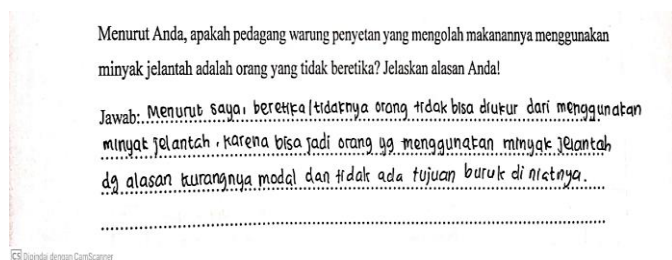


Figure 6. The example of variety answers

Question: In your opinion, is a *penyetan* restaurant seller who uses cooked oil to process their foods an unethical person? Give your reason! Answer: In my opinion, ethical or not someone cannot be measured in the case of cooked oil because they might use cooked oil based on a certain reason such as a lack of capital and there is no bad intention on it.

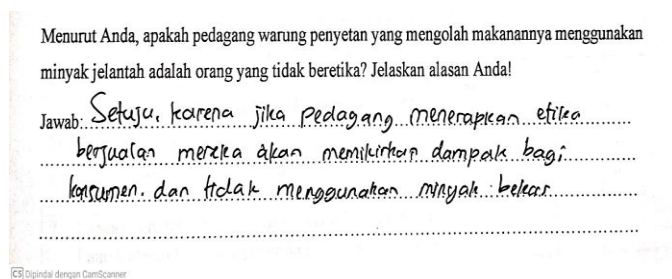


Figure 7. The example of variety answers

Question: In your opinion, is *penyetan* restaurant seller who uses cooked oil to process their foods an unethical person? Give your reason! Answer: I agree. In

case the seller applies the selling ethics, they will think about the consumers' impact and will not use cooked oil.

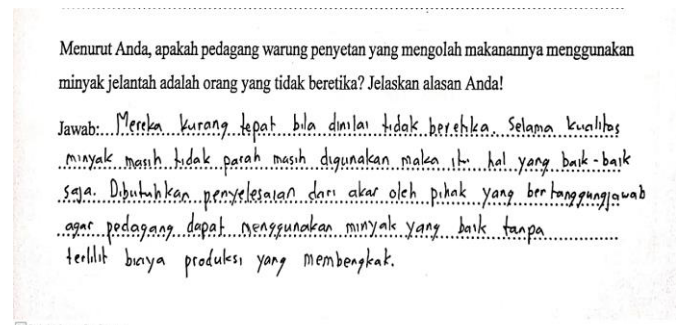


Figure 8. The example of variety answers

Question: In your opinion, is *penyetan* restaurant seller who uses cooked oil to process their foods an unethical person? Give your reason! Answer: It is not right to call them an unethical person. As long as the quality of the oil product is not severe and still useable it is not a matter. The problems need to be solved by the highest party so the seller can use good quality oil without rising the production cost.

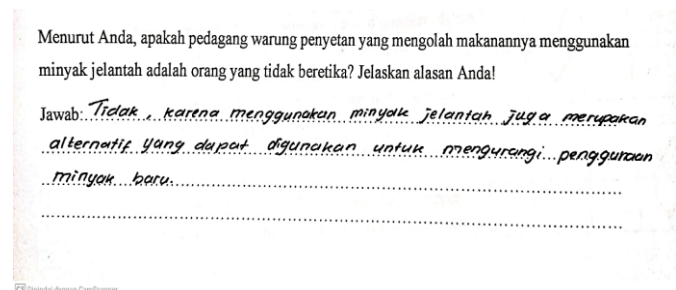


Figure 9. The example of variety answers

Question: In your opinion, is *penyetan* restaurant seller who uses cooked oil to process their foods an unethical person? Give your reason! Answer: No, because using cooked oil is also an alternative way that can be used to reduce the fresh oil.

From the description of the answer variation, it can be concluded that not all of the students understand the social phenomenon of *penyetan* restaurant that uses cooked oil is one of the cases related to chemical ethics. This result is also supporting the previous quantitative results explained by the chemical ethics percentage.

Therefore, in order to achieve chemical ethics related to chemical literacy, the students need to start the learning activities by observing or relating the materials to the phenomenon which happened in the environment. Through those activities, the students will be stimulated to build their knowledge and find the facts that the materials they have learned in school are related to the phenomenon which happens in the environment. The learning activity needs to exercise their scientific

skills so that the students get used to do the things related to the activities such as explaining the phenomena scientifically, using chemical understanding to solve problems, and analyzing the benefit of chemical application. In evaluation activities, which are done at the end of learning, the students need to be introduced to such improving chemical literacy-oriented tests.

Conclusion

The students of grade 11th's skill of chemical ethics related to the hydrocarbon materials in one of the senior high schools in Magelang is in the category of fair with a percentage of 69.12857%. This result shows that the student's skill is in the category of fair. It indicates the students are not get used to the learning activities which used scientific steps, are not able to understand the materials of chemistry as a whole, and are not able to relate the social phenomenon with the chemical concept they have learned. Modify learning activities are needed to achieve the chemical ethics skill related to chemical literacy.

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Conflicts of Interest

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