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# Students' Chemical Literacy Ability on Hydrocarbon Material: A Case of Toxic Compounds in Fried Food

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**Abstract:** Chemical literacy has become an important issue to be discussed, making students aware of the benefits of literacy, becoming the main goal for educators, scientists, and curriculum policy makers. Chemical literacy is important for students because it equips students to make decisions, makes students more critical, creative, and helps them in solving everyday problems or natural phenomena based on their knowledge. This study aims to describe the chemical literacy abilities of students on hydrocarbon materials with the topic of discourse on the case of toxic compounds in fried foods. This research includes quantitative descriptive research. The population in this study were all students of class 11st at a public high school in Magelang City who had studied hydrocarbons. The number of samples from this study was 100 students taken from three classes. The data collection technique in this research is a questionnaire. The data research instrument used was a student questionnaire sheet which was a closed questionnaire with four choices, namely SD (Strongly Disagree), D (Disagree), A (Agree), and SA (Strongly Agree). The results of the research that has been done can be seen that the chemical literacy ability of students on hydrocarbon materials is 63.1875%. These results indicate that the chemical literacy ability of students on chemical hydrocarbons is fair. The results of the research that has been done can be seen that the chemical literacy ability of students on hydrocarbon materials is 63.1875%. These results indicate that the chemical literacy ability of students on chemical hydrocarbons in fair catagory.

**Keywords:** Chemical Literacy; Fried Foods; Hydrocarbons.

## Introduction

One of the parameters of a country's progress in the field of education is the level of literacy in that country, including scientific literacy. Scientific literacy can be defined as the ability to engage with issues related to science (OECD, 2015; OECD 2016). Scientific literacy then becomes the focus for students to participate in discussing issues related to science, technology, society, and the environment which involve the ability and habit of thinking scientifically (Yore et al., 2007). Another opinion says that scientific literacy defines what students must know about science in order to live life more effectively in their environment (Garner-O'Neale et al., 2013).

However, the PISA results held by the OECD in the fields of reading (literacy) and science showed unsatisfactory results for Indonesia. Indonesia's scores in the field of literacy in 2009, 2012, 2015 and 2018 respectively were 402, 396, 397 and 371. These results are still far below the international average score of 500. In the science sector, Indonesia also obtained unsatisfactory results. Indonesia's scores in science in 2009, 2012, 2015 and 2018 respectively were 383, 382, 386 and 396 (Hewi & Saleh, 2020; Tahmidaten & Krismanto, 2020; Asikin & Yulita, 2019). The PISA results state that student literacy in Indonesia is still in the low category and below the universal average (Haetami et al., 2023; Warlinda et al., 2022).

According to Tahmidaten and Krismanto (2020), there are several factors causing the low literacy skills of students in Indonesia such as public perceptions of developing reading skills which are the responsibility of language subjects, learning activities that are not yet

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appropriate, practice questions and evaluations that are still focused on low-level thinking skills, and the school library services are not maximized. Another reason is the lack of students' attention to issues in the environment (Mellyzar et al., 2022). Therefore, ongoing education must be modified. This modification aims to build a deep and multidimensional model of student scientific literacy (Cigdemoglu & Geban, 2015).

One part of literacy is scientific literacy. Scientific literacy can be interpreted as scientific knowledge and skills to be able to identify questions, acquire new knowledge, explain scientific phenomena, and draw conclusions based on facts, understand the characteristics of science, awareness of how science and technology shape the natural, intellectual and cultural environment, and a willingness to be involved. and care about issues related to science (OECD, 2015). The range of scientific competencies needed in scientific literacy reflects that scientific literacy is a combination of social abilities and cognitive abilities in all sciences, (Crujeiras-Pérez & Brocos, 2021). Therefore, scientific literacy has many benefits for students, especially so that students can relate science concepts to everyday life (Amala et al., 2023; Mujahidin et al., 2023).

Scientific literacy can be further narrowed down to chemical literacy which includes chemical knowledge and skills needed for chemistry-based understanding. 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, namely key concepts in basic chemistry, such as elements, symbols, processes, and models, professional chemistry concepts in academia and industry, and societal context (Kohen et al., 2020). Shwartz, Ben-Zvi, and Hofstein (2006) in their research results stated that chemical literacy consists of four aspects, namely chemistry as knowledge, chemistry in context, High-Order Learning Skills (HOLS), and affective aspects. Students need to get chemical literacy in order to be equipped to make decisions (Sevian et al., 2018), make students more critical (Wiyarsi et al.,2020) and can connect chemical concepts with everyday phenomena (Perkasa & Aznam, 2016).

The research conducted aims to determine the chemical literacy abilities of students in high school education units in the material of hydrocarbons. Hydrocarbons were chosen as the topic of discussion in this study due to the characteristics of the abstract material of hydrocarbons and which were considered difficult by students (Sari & Arianti, 2022). In fact, hydrocarbon is a basic concept that must be mastered by students to understand the next organic chemistry concepts (Tuckey & Selvaratnam, 1991). This is exacerbated by the fact that most students feel that chemistry lessons not important for future lives unless they end up working in a profession related to chemistry (Gilbert, 2006). Whereas if explored more deeply, many phenomena or events in everyday life can be developed from the concept of hydrocarbon. Examples of phenomena or events in everyday life that involve the concept of hydrocarbon include fractionation, gasoline, diesel, lubricants, burning of hydrocarbons, local food, biogas, fermented beverages (Febrianto et al., 2019; Wiyarsi et al., 2020; Nirmalasari et al., 2022; Mulyopratikno & Wiyarsi, 2023).

The theme of the chemical literacy discourse taken is toxic compounds in fried foods. This theme is based on the habits of the Indonesian people who like to eat fried foods (Hanifa et al., 2020). The chemical literacy discourse that was developed was based on the development of chemical literacy discourse and was adapted from a product that had been developed by one of the previous researchers (Pratama & Sari, 2022).

## Method

This research is included in the descriptive research with a quantitative approach. This research was conducted in October–November 2022 and took place at a public high school in Magelang City by taking three sample classes. In order to get a data source that can be obtained information in a study, a research subject is needed (Arikunto, 2010). In quantitative research, the subjects used must be representative, so they can represent the population as a whole (Creswell, 2012). This is because the notion of a population is a group of individuals who have the same characteristics. The samples taken in this study amounted to 100 class 11st students who had studied hydrocarbon material in class.

*Research procedure*

The purpose of descriptive research is to describe the characteristics of the population based on data collected from the sample (Lochmiller & Lester, 2017). The first step is to conduct a literature study by reading various research journal articles on chemical and hydrocarbon literacy. Next is to create research instruments based on 4 aspects of chemical literacy, namely Chemistry as Knowledge, Chemistry as Context, HOLS, and affective aspects. The instrument was then validated by 2 expert judgements. After all statement items are valid, the instrument is tested on 11st grade students who have studied hydrocarbon material. The data obtained was then analyzed using descriptive statistics by calculating the percentage of each statement item. The results of the research are then presented in graphical form and conclusions can be written. The research procedure is briefly illustrated by Figure 1.

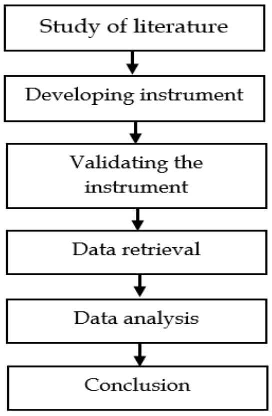


**Figure 1.** Research procedure

*Data Collection Technique and Instruments*

Data collection techniques in this study using a questionnaire. The instruments used in this study were divided into two, namely research instruments and data collection instruments. The research instrument used was a chemical literacy discourse sheet with the topic of toxic compounds in fried foods, while the data collection instrument used was a student questionnaire. The student questionnaire used contained students' understanding of chemical literacy in hydrocarbon material.

The questionnaire used in this study serves to measure four aspects of chemical literacy, namely chemistry as knowledge, chemistry in context, High-Order Learning Skills (HOLS) and affective aspects. Each aspect is translated into 5 statements so that the total questionnaire contains 20 statements that must be answered by students. The scale in the questionnaire used is a Likert scale with four alternative answers. This scale is arranged in the form of a statement and is followed by a choice of responses that indicate the level. The response options in the questionnaire were SA (strongly agree), A (agree), D (disagree), and SD (strongly disagree). The scoring of the Likert scale answer choices depends on the nature of the statement. Strongly agree is worth 4, agree is worth 3, disagree is worth 2, and strongly disagree is worth 1.

*Data analysis technique*

The data analysis technique used to determine students' chemical literacy abilities is based on the results of students' questionnaire answers. The data analysis stage carried out in this study was to calculate the scores obtained, determine the average score of chemical literacy skills, and end by determining the percentage of chemical literacy abilities, using the ideal category assessment described in Table 1.

**Table 1**. Category of chemical literacy ability

| Score Range | Category of Ability |
|---|---|
| $\bar{X} > 85\%$ | Excellent (E) |
| $70\% < \bar{X} \leq 85\%$ | High (H) |
| $55\% < \bar{X} \leq 70\%$ | Fair (F) |
| $40\% < \bar{X} \leq 55\%$ | Low (L) |
| $\bar{X} \leq 40\%$ | Very Low (VL) |

## Result and Discussion

11th grade students at one of the State Senior High Schools in Magelang City who had studied hydrocarbon material were selected to be participants. At the beginning of the study, the researcher asked for research approval from the supervising teacher in the class who explained the reasons for the research and guaranteed that any data collected (including student identity) was kept confidential. Before conducting the research, the researcher also asked for research approval and explained the research objectives to the students. Based on the research results, the results of chemical literacy for each aspect are presented in Table 2.

**Table 2.** Results of chemical literacy for each aspect

| Aspect | Percentage (%) |
|---|---|
| Chemistry as knowledge (CK) | 66.75 |
| Chemistry in context (CC) | 56.55 |
| HOLS | 56.90 |
| Affective Aspect (AA) | 72.55 |
| Average | 63.1875 |

The average result of chemical literacy ability as a whole has a percentage of 63.1875%. This result shows that the chemical literacy ability of high school students is still in the fair category. Furthermore, the score data was analyzed using descriptive statistical analysis techniques. Based on the results of the analysis, it is known that the average ability of students in each indicator for each aspect is as follows.

*Chemistry As Knowledge (CK)*

The first aspect consists of five statement items adjusted to indicators. The description of the statement items is summarized in Table 3. The results of the responses from students are described in Figure 2.

From figure 2, 65.75% of students are interested in an event process that has something to do with the concept of hydrocarbons. Statement 1 is included in the fair category, however, when viewed from a percentage, there are still quite a number of students who are not interested in an event process that is related to the concept of hydrocarbons. This is reinforced by the results of the percentage of statement 2. Only 63% of students can understand an event process related to hydrocarbon material. Statement number 2 is also included in the fair category. Furthermore, only 53% of students could explain the relationship between an event process and the concept of hydrocarbons. Statement 3 is included in the low category.

**Table 3**. Statement of CK Aspect

| Statement |
|---|
| I am interested in a process of occurrence that has something to do with the concept of hydrocarbons |
| I can understand a process of events related to hydrocarbon matter |
| I can explain the relationship of an incident process with the concept of hydrocarbons |
| I believe that a process of occurrence can occur because of the role of the concept of hydrocarbons |
| I believe that a hydrocarbon reaction plays an important role in a process that occurs |

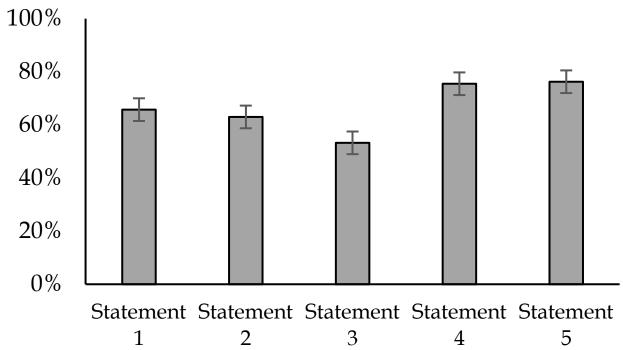


**Figure 2.** Chemical literacy in each statement of CK aspect

The results are quite good shown by the results of statement 4 which is equal to 75, 50% of students believe that an event process can occur because of the role of the concept of hydrocarbons. This statement item is included in the high category. The last item from this aspect gets a percentage of 76.25% and is included in the high category. The total percentage in the aspect of chemistry as knowledge is 66.75%. This percentage is included in the fair category. This is because many students believe enough in the concepts and reactions of hydrocarbons to play a role in an event process, but not many students can explain and understand the role of these hydrocarbons, so that the level of interest of students in events related to hydrocarbon material is not optimal. The last item from this aspect gets a percentage of 76.25% and is included in the high category. The total percentage in the aspect of chemistry as knowledge is 66.75%. This percentage is included in the fair category. This is because many students believe enough in the concepts and reactions of hydrocarbons to play a role in an event process, but not many students can explain and understand the role of these hydrocarbons, so that the level of interest of students in events related to hydrocarbon material is not optimal. The last item from this aspect gets a percentage of 76.25% and is included in the high category.

The total percentage in the aspect of chemistry as knowledge is 66.75%. This percentage is included in the fair category. This is because many students believe enough in the concepts and reactions of hydrocarbons to play a role in an event process, but not many students can explain and understand the role of these hydrocarbons, so that the level of interest of students in events related to hydrocarbon material is not optimal.

*Chemistry in Context (CC)*

The second aspect is chemistry in context which consists of five statements adapted to indicators. The description of the statement items is summarized in Table 4. The results of student responses are described in Figure 3.

**Table 4**. Statement of CC Aspect

| Statement |
|---|
| I can determine what chemical reactions occur in the process of frying at high temperatures |
| I can write down and explain again the chemical reactions that occur in the high temperature frying process |
| I can name all the chemical compounds involved in the high temperature frying process |
| I can explain the reason for the loss of $H_2O$ molecules in the high temperature frying process |
| I can attribute the physical properties of the harmful compounds formed by the high temperature frying process to human health |

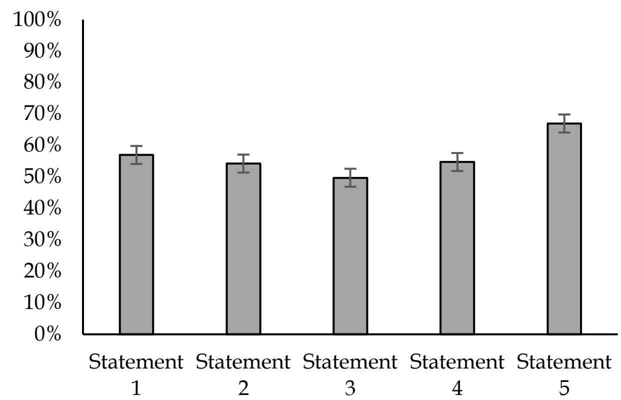


**Figure 3.** Chemical Literacy in Each Statement of CC Aspect

From figure 3, 57% of students can determine what chemical reactions occur in the high temperature frying process. This percentage is included in the fair category. 54.25% of students were able to write down and re-explain the chemical reactions that occur in the high temperature frying process. These results are included in the low category. This shows that only a few students can rewrite and explain the reaction for the formation of acrolein caused by heating cooking oil at high temperatures. Then only 49.75% of students could name all the chemical compounds involved in the high temperature frying process. These results are of course included in the low category. 54.75% of students could explain the reasons for the loss of $H_2O$ molecules in the high temperature frying process. The highest percentage in this aspect is in statement 5 with the result that 67% of students can relate the physical properties of hazardous compounds formed due to the high temperature frying process to human health. This result is included in the fair category. The total percentage for this aspect is 56.55% and is included in the fair category. However, this result is very close to the lower limit of the fair category, which is 55%.

Students' lack of maximum understanding of chemistry in context can occur because students only learn chemistry by rote method, so that students have not been able to integrate the chemistry concepts they have acquired at school with everyday phenomena or events. The total percentage for this aspect is 56.55% and is included in the fair category. However, this result is very close to the lower limit of the fair category, which is 55%. Students' lack of maximum understanding of chemistry in context can occur because students only learn chemistry by rote method, so that students have not been able to integrate the chemistry concepts they have acquired at school with everyday phenomena or events. The total percentage for this aspect is 56.55% and is included in the fair category. However, this result is very close to the lower limit of the fair category, which is 55%. Students' lack of maximum understanding of chemistry in context can occur because students only learn chemistry by rote method, so that students have not been able to integrate the chemistry concepts they have acquired at school with everyday phenomena or events.

*High Order Learning Skills (HOLS)*

The next aspect of chemical literacy is HOLS. In this aspect, students are required to have a high level of reasoning power. There are 5 statements in this aspect which are adjusted to the indicators. The description of this indicator is presented in Table 5. The results of student responses are described in Figure 4.

From figure 4, it can be seen that only 48% of students always use chemistry related to concepts and reactions of hydrocarbons in solving problems in life. This percentage is included in the low category. The results showed that not many students used chemistry related to the concepts and reactions of hydrocarbons in solving problems in life. Even though there are many problems in everyday life related to hydrocarbon matter. Furthermore, 57.75% of students could relate the high-temperature frying process to the formation of harmful compounds in fried foods that had a relationship with each other, 56.25% of students could give reasons for the loss of $H_2O$ molecules which could make the resulting fried foods crispier, 64, 25% of students can provide suggestions and alternatives in the frying process so that the harmful chemical compounds produced can be minimized, and 58.25% of students can link understanding of hydrocarbon material with harmful compounds in fried foods that have a relationship with each other. Statements 2 to 5 in this aspect are included in the fair category. The average value of this aspect is 56.9% and is included in the fair category. However, similar to the chemical aspect in context, the percentage obtained is very close to the lower limit of the fair category. The percentage results show that not many students have high-level reasoning abilities. This is because classroom learning has not fully taught students to have HOLS abilities.

**Table 5**. Statement of HOLS Aspect

| Statement |
|---|
| I always use chemistry related to the concepts and reactions of hydrocarbons in solving problems in life |
| I can associate the high temperature frying process with the formation of harmful compounds in fried foods that have a relationship with each other |
| I can give reasons that the loss of $H_2O$ molecules can make the resulting fried food crunchier |
| I can provide suggestions and alternatives in the frying process so that the harmful chemical compounds produced can be minimized |
| I can link the understanding of hydrocarbon matter with harmful compounds in fried foods that have a relationship with each other |

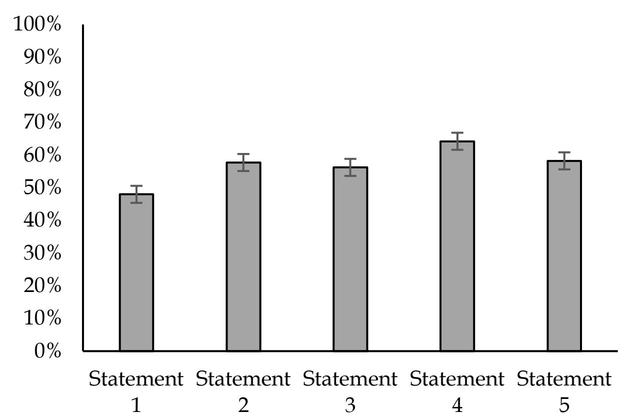


**Figure 4.** Chemical literacy in each statement of HOLS aspect

*Affective Aspect*

The indicators in this aspect support real action as a form of concern for a phenomenon. There are five statements developed from the indicators. The description of the indicators is presented in Table 6. The results of student responses are described in Figure 5.

**Table 6.** Statement of Affective Aspect

| Statement |
|---|
| I like to find and read research articles related to the dangers that lurk behind fried foods |
| I often question the veracity of information about the dangers that lurk behind fried foods |
| I will invite my family and friends to reduce eating fried foods |
| I have recommendations and other alternative ways of processing food besides frying |
| I realized that reducing fried food consumption would have a positive impact on health |

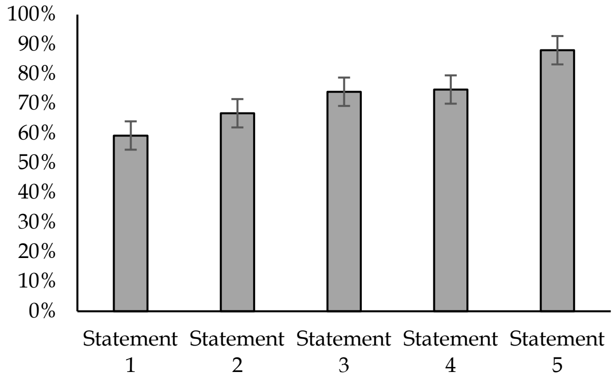


**Figure 5.** Chemical literacy in each statement of affective aspect

From figure 5, 59.25% of students like to find and read research articles related to the dangers that lurk behind fried foods. The results of this percentage belong to the category of fair. However, these results indicate that not many students like to search for and read research articles related to the dangers that lurk behind fried foods. Furthermore, 66.75% of students often question the truth of information about the dangers that lurk behind fried foods. The results of statement 2 are also included in the fair category. Furthermore, 74% of students will invite my family and friends to reduce consuming fried foods. Although this result is relatively quite better than the two previous statements, this result is considered not optimal. There are still many students who do not agree with this statement. Whereas, if they understand the impact of fried food, they should choose the agree or strongly agree option. Furthermore, 74.75% of students have recommendations and other alternative ways of processing food other than frying. This result is also included in the high category. The results in the high category are shown by statement 5, namely 88% of students realize that reducing fried food consumption will have a positive impact on health. The average result for this aspect is 72.55% and is included in the high category. The average result of affective attitude is the highest average score among other aspects of chemical literacy. This is based on awareness of the bad effects of toxic compounds that will reduce the body's health if you consume too much fried food.

The percentage of overall chemical literacy ability in hydrocarbon material is 63.1875% and is included in the fair category. The indications that occur are that students are not quite familiar with learning activities that use scientific steps, have not been able to fully understand chemical material, and have not been able to integrate understanding of chemical concepts with phenomena in everyday life. In order for chemical literacy skills to be honed, it is necessary to modify learning activities in class. Learning can be started by observing phenomena or events in the students' environment in order to build their knowledge and be able to find the fact that there is a relationship between phenomena or events in the environment and the material being studied at school. This is not only true in chemistry learning,

Learning that is carried out in class must be emphasized to train science skills so that students are accustomed to carrying out scientific steps such as being able to explain a phenomenon or event scientifically, integrating chemical concepts they have with phenomena or events in order to solve problems and provide alternative solutions, and provide can provide benefits from real chemistry learning in everyday life. At the evaluation stage, introduce students to questions that are oriented towards increasing chemical literacy skills (Prastiwi et al., 2017). This must be balanced with the provision of training or workshops for chemistry teachers so that they can make chemical literacy questions with HOLS characteristics or can adapt the creation of chemical literacy questions derived from PISA scientific literacy questions, so that the chemical literacy skills of students in Indonesia become better. If examined further, there are many phenomena or events around the students' environment that can be raised as chemical literacy talks. For example, in the matter of hydrocarbons, you can make chemical literacy questions with the theme of LPG gas, toxic compounds in fried foods, paracetamol, light sticks, and other themes. There are many phenomena or events around the students' environment that can be raised as chemical literacy talks. For example, in the matter of hydrocarbons, you can make chemical literacy questions with the theme of LPG gas, toxic compounds in fried foods, paracetamol, light sticks, and other themes. There are many phenomena or events around the students' environment that can be raised as chemical literacy talks. For example, in the matter of hydrocarbons, you can make chemical literacy questions with the theme of LPG gas, toxic compounds in fried foods, paracetamol, light sticks, and other themes.

## Conclusion

The chemical literacy ability of class 11th students on hydrocarbon material at a public high school in Magelang City is in the fair category with a percentage of 63.1875%. Indications from the results of this study are that students are not quite familiar with learning activities that use scientific steps, have not been able to fully understand chemical material, and have not been able to integrate understanding of chemical concepts with phenomena in everyday life, so learning modifications are needed so that they can improve students' chemical literacy skills. Further studies for other researchers can use a wider range of research subjects and use an experimental research design in order to be able to measure the level of students' chemical literacy abilities more accurately.

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**Conflicts of Interest**
The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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