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Vocational High School Students' Chemical Literacy on Context-Based Learning: A Case of Petroleum Topic

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ABSTRACT

The study aims to investigate the effect of context-based learning (CBL) on vocational high school students' chemical literacy of petroleum topics. Through quasi-experimental research with pretest-posttest design, 30 students from the automotive engineering program were assigned as the experimental group, while 31 students from the same school were devoted to the control group. The experimental group was exposed to the CBL whereas the control group was taught with traditional learning. To collect data, a petroleum chemical literacy test (PCLT) with 8 open-ended questions was used. The data were analyzed via Independent t-test and descriptive analysis. The results showed a statistically significant difference between the chemical literacy levels of the experimental and control groups. Even though the students have good chemical literacy in implementing the CBL, they need to improve their abilities to reach the goals of the science/chemistry curriculum. The current study suggests that the CBL should be further used in vocational high school to enhance students' chemistry achievements.

Keywords: Chemical Literacy, Chemistry Learning, Learning Module, Vocational Education.

INTRODUCTION

Chemical literacy not only makes students more critical, and creative, but also helps them solve many daily problems based on their knowledge. Thus, it is a pre-request for developing the 21st century skills. Hence, understanding chemistry concepts, principles, and theories needs to handle complex and rapid changes in daily-life problems (e.g., Gilbert & Treagust, 2009; Ultay & Çalik, 2012; Broman & Parchmann, 2014). Thus, if students have competencies in understanding the framework and the use of chemistry knowledge to solve

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daily life issues, it is called chemical literacy (Shwartz et al., 2006). Chemical literacy, as the main goal of chemistry education, requires students to critically analyze and evaluate their prior knowledge and decision making in daily life issues (e.g., Çiğdemoğlu et al., 2017; Bag & Çalik, 2017). However, students have difficulties at linking chemistry concepts with daily life (e.g., Parchmann et al., 2006; Broman & Parchmann, 2014, Wiyarsi et al, 2020) and decision making about chemistry-related societal issues (e.g., Cigdemoglu & Geban, 2015; Rizal et al., 2017; Yapicioglu & Aycan, 2018). That is, schools should provide any appropriate learning environment to promote students' chemical literacy.

To meet this issue, some researchers have recently implemented contemporary pedagogies, such as discovery learning (Mozeika & Bilbokaite, 2010), ethnoscience based-learning (Sumarni, 2018), and flipped learning (Cigdemoglu, 2020). Chemical literacy asks students to discuss some daily life issues by critically thinking about problem-solving strategies. In another perspective, context-based learning (CBL) approach can be used as a starting point for chemical literacy (e.g., Bulte et al., 2006; Broman et al., 2018). CBL helps students have a better understanding of socio-scientific issues or societal issues. Hence, CBL promotes their chemical literacy and enhances their argumentation levels and environmental literacy (e.g., Mandler et al., 2012; Çiğdemoğlu & Geban, 2015; Cigdemoglu et al., 2017). CBL is a potential pedagogy to enable students to gain chemical literacy in all grades including vocational schools.

A vocational school, as a different part of general high/upper secondary school not only affords students to support their personal development but also trains them at the best level to ensure their future careers. Vocational high school curriculum (e.g., in Indonesia, Turkey, Thailand, and Malaysia) includes a field on industry expertise, and compulsory subject in the first-year of study, e.g., chemistry (Febrianto et al., 2019; Donmez & Azizoglu, 2010; Thummathong &Thathong, 2018; Raub et al., 2018). Moreover, chemistry course is very important for vocational high school students to be better prepared for their future professions, increase their working life achievements and improve the quality required by contemporary technologies (Yagci & Cevik, 2017). Phrased differently, chemistry concepts support students' understanding of vocational subjects to achieve their expertises and make chemistry meaningful.

Unfortunately, vocational students' interest and attitudes toward chemistry are low (e.g., Adodo & Gbore, 2012; Wiyarsi et al., 2017) because they regard chemistry learning as meaningless (Corrigan & Fensham, 2012; Wiyarsi et al., 2017, Nordby et al, 2017). Hence, they do not pay more attention on chemistry learning that will affect their achievement performances. On the other hand, the use of CBL in chemistry learning promotes students to develop their competencies such as learning motivation (e.g., Ilhan, et al., 2016; King, 2012; Vaino et al., 2012), attitude (e.g., Onen & Ulusoy, 2014; Kutu & Sozbilir, 2010), interest (e.g., Acar & Yaman, 2011), conceptual understanding (e.g., Kocak Altundag, 2018; Demircioglu et al., 2009; Ulusoy & Onen, 2014; İlhan et al., 2015) and chemical literacy. In particular, some studies also implemented CBL in vocational high schools to improve meaningful learning (Kukliansky & Rozenes, 2015), and student's interest in chemistry (Madhuri et al., 2012; Bruijin & Leeman, 2011). Interestingly, even though CBL promotes students' chemical literacy to be a responsible citizenry, none of previous studies has focused CBL on vocational high school students' chemical literacy.

Commonly, CBL embraces environmental and ecological issues, everyday life problems, industrial processes and so on. Further, vocational high school students need to relate several aspects to the nature of vocational subject, learning situation, specification of students' expertises and their learning styles (Faraday et al., 2011). Thus, implementing context-based learning in vocational high school students correlates vocational subject to the students' specific expertises. For example, the petroleum topic in automotive engineering study program may be taught via problems at vehicle burning system as a more familiar vocational subject. In this case, a chemistry teacher should be more creative to arrange his/her lesson since the Indonesian formal curriculum (called Curriculum 2013) is almost the same at general and vocational high schools. In fact, automotive vocational students need more understanding of petroleum-related to vehicle cases. Concepts 'gasoline, diesel fuel, and lubricant' are used to deeply understand the daily cases of vehicles. The irrelevance of this learning content results in vocational high school students' low interest in chemistry learningtoward (Wiyarsi et al., 2017; Madhuri et al., 2012). Students could not understand relevant information on their vocational expertise issues and use scientific evidence in drawing a conclusion for vehicle case-related problems. A teacher could use a vocational case, as the context in chemistry learning, to facilitate their abilities to associate chemistry with their vocational expertises. For instance, CBL can use such contexts as factors causing the blackened and coagulated lubricant oil, recycling lubricant oil, and different qualified gasoline products. Thus, the CBL plays an important role at enhancing vocational high school students' chemical literacy.

Making chemistry content relevant for vocational high school calls for implementing the CBL within vocational context to foster their chemical literacy. The study will initiate extending the foci of the CBL on vocational high schools. Moreover, studying vocational high schools has not become the main priority for chemistry/science educators. The CBL may overcome their problems in linking the petroleum concept with automotive engineering cases. The study may also change their negative perceptions of chemistry subject, e.g., unuseful and unrelated to vocational competence. Hence, vocational high school students may become more interested in chemistry learning and having good chemical literacy. This study proposed to improve chemistry learning in vocational high schools, especially study programs out of chemistry. In addition, researchers may conduct similar researches for other chemistry/science topics. Accordingly, this study aims to investigate the effect of the CBL on vocational high school students' chemical literacy of the petroleum topic. The following research questions guides the current study:

1. Is there any significant difference between experimental and control groups' chemical literacy levels?
2. Is there any improvement in pre- and post-test mean scores of the students' chemical literacy after the implementation of the CBL?
3. How do the students' chemical literacy levels after the implementation of the CBL?

METHODS

a) Research Design

This research employed quasi-experimental research with pre- and post-test design. One group was assigned as an experimental group, whilst the other was devoted to a control group. The experimental group was exposed to the CBL as the teaching intervention, while the control group was taught with the traditional approach. Their chemical literacy levels were measured before and after the teaching intervention.

b) Research Sample

The sample of the study had the same socio-economic backgrounds, aged 16-17 years and was taught by the same teacher. 61 eleventh-grade students were randomly drawn from automotive engineering study programs in a state vocational high school in Yogyakarta regency, Indonesia. The experimental group consisted of 31 students, whereas the control one comprised of 30 students.

c) The Context of Study

The formal education system in Indonesia comprises four categories: elementary school (6 years), secondary school (3 years), high school (3 years) and university (3–4 years) (e.g., Wiyarsi & Çalik, 2019). There are two types of high schools, namely general and vocational high schools. General high school focuses on extending students' understanding of basic natural science, social science, and language science to prepare them for entering higher education/university. Meanwhile, vocational high school equips students with having specific expertise and ready to enter the workpower. The vocational school spectrum in Indonesia has nine expertise groups. Chemistry, as a basis of the vocational subject, is taught at six expertise fields: Technology and Engineering (with automotive engineering as one of its expertise program), Mining, Marine, Agribusiness and Agrotechnology, Health, and Information and Communication Technology (Ministry of National Education and Culture, 2018). Chemistry is only instructed at 10th grade (first-year) for 2 hours a week. The scope of the chemistry taught in these fields is not much different. However, a teacher has the authority to divide chemistry concepts into hours so that (s)he is able to emphasize certain chemistry concepts by considering students' expertises (Wiyarsi, 2017; Febiana et al., 2019; Febrianto et al., 2019).

d) Treatment

The module called Vocational Context-Based Petroleum (VCBPM) and students' worksheets were implemented within the CBL. The VCBPM was prepared by integrating the automotive problems into petroleum concepts (e.g., fractionation, gasoline, diesel fuel, hydrocarbon combustion, and lubricant) that are appropriate for students' specific expertises. A group of expert (three chemistry educators and two chemistry teachers) looked over and ensured the content of the VCBPM. The experimental class used the student worksheets (prepared for the VCBPM) to guide the implementaion of the CBL. The context of the study covered 'The Fires of Oil Refinery' for the 'fractionation' concept, "Black and Viscous Lubricating Oil" for the 'lubricant' concept, "Which is the best gasoline?" for the 'gasoline' concept, "What is biodiesel?" for the 'diesel fuel' concepts and "Vehicle fumes" for the 'hydrocarbon combustion' concept.

A total of the teaching interventions in the experimental and control groups lasted sixth sessions. In the first and last sessions, the students completed pre- and post-test of the petroleum topic. The same teacher (Bachelor in chemistry education and 15 year-teaching experience in vocational school) taught the same topic to both of the groups. The implementation of the CBL covered a five-lesson sequence (i.e., contacting, planning, developing, extending, and evaluating) proposed by Parchmaan et al. (2015). The students worked in their small groups of 3-4 (see Table 1 and Figure 1 for sample lesson plan and student worksheet respectively). The control group was instructed by traditional approach, e.g., chalk and talk.

e) Data Collection Tools

To collect data, the Petroleum- Chemical Literacy Test (PCLT) with 8 open-ended questions (with 23 sub-items) was exploited. The PCLT contained three domains of chemical literacy, namely petroleum content knowledge (PeCK), chemistry in context and higher order learning skills (HOLS) proposed by Shwartz et al. (2006). This study defined the chemistry in context as knowledge of Petroleum in explaining situation or case in automotive engineering. To confirm content validity, a group of experts (three university chemistry educators and two vocational high school chemistry teachers) examined the PCLT. The PCLT was revised based on the feedbacks of the experts. The Cronbach alpha value was found to be 0.71, which indicates that the instrument was reliable for the data collection. Table 2 shows the characteristics of the PCLT. The PCLT was administered as a pretest a week before the intervention, and the same test was immediately re-administered as a post-test after the intervention.

Table 1. *An outline of the third lesson about gasoline*

Experimental group	Control group
First-contacting phase Students analyzed the context 'which is the best gasoline?' through reading the narration on the worksheet (see Figure 1).	The teacher began the lesson by giving information about the gasoline topic.
Second-planning phase The students discussed the problems related to the different qualities of gasoline's product and their effects on the burning system, an increase in their qualities, and performance of any mixture gasoline (e.g. with RON 88 & 92). Then, they arranged research questions that would be solved. Afterwards, they planned their own strategies to answer their questions.	Teacher presented the lesson by slide and attracted the students' attention.
Third-developing phase The students deployed the CBPM as the main source. Then, they discussed the foregoing questions/problems to find proper responses. One of the group presentedtheir results for class discussion. The teacher gave feedbacks.	The teacher gave a chance for students to clarify any unclear points.
Fourth-extending phase They extended their knowledge to solve another context-related problem (e.g., alternative fuel). For instance, How can bioethanol replace with the gasoline function? How do they affect the burning system and engines?'. One of the group presented their results for class discussion. The teacher gave feedbacks.	The students completed the exercises on basic concept of gasoline and its application(s). Hence, they differentiated the quality of gasoline's products from each other.
Fifth-evaluating phase The students individually completed the exercises to understand the gasoline concept and its application(s) deeply.	Several students wrote their answers on board. The teacher gave feedbacks.

Please read the text carefully!

The Ministry of Environment and Forestry's policy encouraged Pertamina to reduce Premium production and increase gasoline production with an octane number of more than 90, namely Pertalite and Pertamax. This causes Premium to be scarce on the market today. On the other hand, some people refused to the policy because gasoline prices were getting more expensive. To overcome this problem, some people took the initiative to mix Premium and Pertalite, Pertamax. They don't care about their effect because what's important is getting cheap fuel. They do not understand the importance of gasoline with high octane numbers for environmental quality.

Based on the narration, arrange questions related to chemistry of petroleum!

1. ....
2. ....
3. ....
4. ....

Now, you arrange the strategy to solve the problems!

....
....
....
....

Then, do your strategy and answer all of your questions in other sheet!

For extending your understanding, please solve this problems!

The increasing number of vehicles inevitably impacts the decline of the environment quality such as the air become dirty and hot. Consequently, instead of the efforts to improve environmental quality, the government encourages efforts to use fossil fuels effectively and efficiently and develop alternative energy sources that are considered feasible in terms of technical, economic and environmental aspects. Bioethanol that make from cassava is popular now. How bioethanol can be used as fuel and replace the gasoline function? Is it more effective than gasoline? How about the vehicle burning system and engines?

Figure 1. A Sample Student Worksheet

Table 2. *The Characteristic of the PCLT*

Higher order learning skills (HOLS)	Petroleum content knowledge (PeCK)					Number of item
	Fractionation	Gasoline	Diesel fuel	Lubricant	Hydrocarbons Combustion	
Investigating relevant information	1a	2a, 3a	4a	6a	7a, 8a	7
Explaining phenomena	1b, 1c	2b	4b, 4c	5a, 6b	7b, 8c	9
Using scientific evidence	1d	2c, 3b	-	5b, 6c	7c, 8b	7
Total	4	5	3	5	6	23

f) Data Analysis

The PCLT was calculated with 46 points as a maximal score and zero as a minimum score. Independent samples t-test was used to analyze the experimental and control groups' mean scores of chemical literacy. An improvement in chemical literacy was descriptively analyzed by normalized n-gain formula suggested by proposed by Hake (1998). It consisted of three categories i.e. high (n-gain > 0.70); medium (0.70 > n-gain ≥ 0.30); and low (n-gain < 0.30). To explain the students' chemical literacy level after the teaching intervention, the authors used an ideal rating category by calculating ideal mean (Mi) and standard deviation (SDi) (Gronlund & Linn, 1999) for each aspect of HOLS and PeCK. The category covered *very good* (score > Mi+1.5SDi); *good* (Mi+0.5DSi < score ≤ Mi+1.5SDi); *sufficient* (Mi-1.5DSi < score ≤ Mi+0.5SDi); *poor* (Mi-1.5DSi < score ≤ Mi-0.5SDi) and *bad* (<Mi-0.5SDi).

RESULTS and DISCUSSION

After the intervention, the experimental group gained higher post-test scores of chemical literacy (M=31.8) than the control group (M=25.9). The results of Independent samples t-test showed the value of t(59) = 12.296 at p=0.000, which means a significant difference between the experimental and control groups' chemical literacy.

During the implementation of the CBL, the students felt that chemistry learning was fun and important. They were also excited to engage and complete all tasks. The CBL with the VCBPM asked the students to link the 'petroleum' concept with daily life issues of the automotive field. The relationship between science and daily life creates students' positive attitudes toward science (e.g., Cepni et al., 2017; Çalik & Cobern, 2017). In this case, the students had positive attitudes toward chemistry and felt that chemistry was interesting and promoted their specific expertises. Through the VCBPM, the students had the chance to develop higher order learning skills such as critical and analytical thinking skill to solve the problems. Thus, they actively found chemistry concepts and appled them to the real contexts. Hence, the implementation of the CBL promoted their chemical literacy-related skills.

The CBL combines the chemistry content with the daily life issues to make the problem more relevant and foster a higher level of scientific literacy (e.g., Hofstein et al., 2011, Demircioglu et al., 2013; Broman et al., 2018). A better chemical literacy facilitated the students' problem solving skills of the 'petroleum' problems in the automotive field. Given the idea 'students need a higher order learning skill to the decision making and drawing conclusion about any problem-solving,' the VCBPM promoted them to get new ideas for solving a problem. They needed a higher order learning skill to use their prior knowledge (Broman & Parchmann, 2014). The higher order learning skills proposed by Shwart et al. (2006) required them to investigate relevant information on the problems of the petroleum topic and solve those problems. The students could explain the phenomena and draw their conclusions through the use of the scientific evidence. Such a process enabled them to retain their gained knowledge and understand the relevance of petroleum to the 'automotive engineering' context.

N-gain values of pre- and post-PCLT were used to understand any improvement in their chemical literacy levels after the implementation of the CBL. Their chemical literacy levels were based on the aspects of the HOLS and the concept of the PeCK. As seen from Table 3, only the 'explaining phenomena' aspect had a high n-gain value. Otherwise, the CBL, which emphasizes active learning, seems to have improved their abilitiesy of three aspects of the HOLS. The three HOLS were the main competencies that support their expertises and challenge the demands/needs of workpower.

Table 3. *An improvement at the students' chemical literacy of the HOLS' Aspects*

	All aspects (N item = 23)	Investigating relevant information (N item=7)	Explaining phenomena (N item=9)	Using scientific evidence (N item=7)
Mean of pretest	6.16	3.51	0.65	2.00
Mean of posttest	31.8	8.61	13.35	9.80
n-gain	0.64	0.48	0.73	0.65
Category n-gain	Medium	Medium	High	Medium

The implementation of the CBL developed the students' abilities to explain the phenomena in the automotive field better. Exploring the problems raised their abilities to connect interrelated concepts with the context, e.g., analyzing complete and incomplete combustion within several types of gasoline. Students may explain it throughout n-heptane and isooctane composition. Nevertheless, the ability to use evidence has still needed to be improved. The students were expected to address how molecule structural differences affect the reaction and process. Theoretically, this ability is higher than the other two aspects of the abilities and requires to use scientific evidence via the ability of scientific argumentation. The results indicated that the students' argumentation abilities needed to be improved for having a deeper view in solving vehicle problems of the petroleum concept. Given the related literature reporting that pre-existing knowledge, motivation and classroom atmosphere influences scientific argumentation (e.g., Chang & Chiu, 2008; Bag & Çalik, 2017; Demiral & Cepni, 2018; Torres & Cristancho, 2018; Placklé et al., 2018), students should have a better conceptual understanding and motivation that shape argumentation abilities. Classroom atmosphere in active learning, such as the CBL, develops these abilities and enhances students' chemical literacy as well as supporting sustainable CBL with vocational context(s).

As can be seen from Table 4, the students had a good chemical literacy in each aspect. However, there were no students having a *very good* ability in investigating relevant information, despite more 40% of the students only possessed *sufficient* ability. Theirabilities to explain phenomena and use scientific evidence ranged evenly from *very good* to *sufficient* category.

Table 4. *The students' achievement levels of chemical literacy and the aspects of the HOLS*

	Chemical literacy	HOLS		
		Investigating relevant information	Explaining phenomena	Using scientific evidence
Number of items	23	7	9	7
Maximal Score	46	14	18	14
Posttest Mean Score	31.8	8.61	13.35	9.80
Category	Good	Good	Good	Good
Percentages of each level (%)				
Very good	22.58	0	16.13	6.45
Good	77.42	58.06	77.42	77.42
Sufficient	0	41.94	6.45	16.13

The results of the HOLS pointed that the students had a better ability in explaining phenomena as compared with the other aspects of chemical literacy. The results showed a good basis for enhancing vocational high school students' chemical literacy levels. The good ability in explaining phenomena indicated that they had a better understanding of the concept. Therefore, it impacted their abilities to apply chemistry concepts to their expertise contexts. This intertwines the aim of chemistry learning at a vocational school to the students' understanding of vocational content. The ability to explain the 'petroleum' concept was beneficial for the students' vocational practices. The students understood that petroleum fuels were complex chemical compounds and the type of fuel had to be adjusted in regard to the engine work system. This means that it is not easy to replace a vehicle's fuel without considering the type of engine and vehicle combustion system.

The implementation of the CBL afforded the students to construct their understanding through group collaboration. They examined the module to develop their abilities to explain why a phenomenon happens. The results also showed that they had good ability in using scientific evidence even though it was not as good as the ability to explain phenomena. This ability was higher because it required the students to analyze the cause and effect of a case. The ability to use scientific evidence is closely related to students' abilities to argue and make decision based on the facts. For making a good decision, students need good reasoning. Through the CBL, the students found their own problems and had more chance to gain information from many sources. Hence, they might get good scientific reasoning from the VCPBM. In addition, the students did not easily accept the truth in science by analyzing a case and using scientific evidence. Critical thinking skills act as a cornerstone to develop these abilities and need to be acquired from early ages (e.g., Güler & Akman, 2006; Bag & Çalik, 2017).

On the contrary, only one aspect 'investigating relevant information' fell into sufficient category. The low achievement of this ability may come from the students' unwillingness to read all contextual narratives. They tended to only attend the contexts, which are explicitly related to their vocational expertises. Informal observations also showed that they checked the questions before reading the text and then focused directly on finding answers to the questions. .

The students' chemical literacy of the PeCK incorporated five main concepts of the 'petroleum' lesson (i.e., fractionation, gasoline, diesel fuel, lubricant, and hydrocarbon combustion).As seen from Table 5, the experimental group showed some improvements at all concepts of the PeCK.

Table 5. *The experimental groups' improvements at the Concepts of the PeCK*

	Petroleum Content Knowledge (PeCK)				
	Fractionation (N item=4)	Gasoline (N item=5)	Diesel Fuel (N item=3)	Lubricant (N item=5)	Hydrocarbon Combustion (N item=6)
Mean of pretest	1.87	2.26	0.29	1.74	0.00
Mean of posttest	7.19	6.87	3.45	9.26	4.93
n-gain	0.87	0.59	0.55	0.92	0.42
Category n-gain	High	Medium	Medium	High	Medium

As can be seen from Table 5, the students' achievement levels of chemical literacy were varied for the concepts of the PeCK. That is, the students held *very good* achievement for the 'fractionation and lubricant' concepts, *sufficient* achievement for the 'diesel fuel and hydrocarbon combustion' concepts and *good* achievement for the 'gasoline' concept. This means that their chemical literacy levels are dependent on the concepts under investigation.

As seen from Table 6, the concepts 'fractionation and lubricant' fell into *very good* achievement, while the 'gasoline' concept was labeled under a *good* achievement of chemical literacy. Some students had *very good* chemical literacy in the 'diesel fuel' concept, whilst the 'hydrocarbon combustion' concept among the concepts of the PeCK was the lowest achievement level. There were some students holding *bad* achievement at the 'hydrocarbon combustion' concept.

Table 6. *The experimental group's chemical literacy levels in regard to the concepts of the PeCK*

	PeCK				
	Fractionation	Gasoline	Diesel Fuel	Lubricant	Hydrocarbon combustion
Number of items	4	5	3	5	6
Maximal Score	8	10	6	10	12
Posttest Mean Score	7.19	6.87	3.45	9.26	4.93
Level of chemical literacy	Very good	Good	Sufficient	Verygood	Sufficient
Percentages of each achievement category (%)					
Very good	90.00	0.00	10.00	83.33	0.00
Good	6.67	70.00	33.33	16.67	0.00
Sufficient	0.00	30.00	53.33	0.00	86.67
Poor	6.67	3.33	6.67	3.33	13.33
Bad	0.00	0.00	0.00	0.00	3.33

This study covered the concepts 'fractionation, gasoline, diesel fuel, lubricant, and hydrocarbon combustion' for chemical literacy. The 'fractionation' concept was used to determine the main components in petroleum and the separation principle of petroleum. The 'gasoline' concept was used to describe how the gasoline price is related to octane number and the quality of gasoline. The differences of diesel fuel and the way to improve its quality was described in the 'diesel fuel' concept. Moreover, the 'lubricant' concept was used to explain the effects of the lubricant oil on vehicle (e.g., blackened and coagulated) and recycling. The 'hydrocarbon combustion' concept was used to describe the fuel combustion, which affects the greenhouse and/or global warming. The use of these contexts, which are closely related to the competencies of the automotive engineering expertise, may have led to improve the students' chemical literacy levels.

The previous study states that the context-based learning helps students to get meaningful learning (Jong, 2006). Students are familiar with various types of gasoline and its use as a motor vehicle fuel. Hence, the implementation of the CBL did not give a significant effect on the students' chemical literacy levels. Moreover, the students had only a *sufficient* achievement of chemical literacy for the 'diesel fuel and hydrocarbon combustion' concepts. This may stem from their unfamiliarity with diesel fuel. If students are familiar with the number of octane in daily life, they may consider the cetane number that indicates the quality of diesel fuel. On the other hand, although the 'hydrocarbon combustion' concept is closely related to daily life, the students only had a sufficient level of chemical literacy. This may result from their poor mathematical abilities. Namely, the students seem to have had difficulties in solving the problems related to the 'hydrocarbon combustion' concept.

CONCLUSIONS

One of main goals in chemistry learning is to develop students' chemical literacy. The recent studies have showed that the context-based learning may be an alternative way to improve their chemical literacy. The current study initially extended the CBL into a vocational school for accomplishing chemistry learning. The CBL enabled vocational high school students to link the 'petroleum' concept with cases/problems of the automotive engineering. The present study revealed that the implementation of the CBL-supported VCBPM was good at improving the students' chemical literacy of the 'petroleum' topic as compared to the traditional approach. But, all students did not achieve the expected skills of chemical literacy. A relatively small-size sample and preliminary results may be seen as the limitation of the study.

Overall, the CBL with a vocational context promotes the students' chemical literacy. As an active learning approach, the CBL emphasizes students to construct their own concepts and help them retain their gained knowledge in a long-term mind. The use of a vocational context that is very closely with daily-life problems and future workpower promotes students' interest in chemistry and positive attitudes towards chemistry. Having a good interest and attitude will result in a higher motivation to achieve learning goals (e.g., Hulleman et al., 2008; Boddey & de Berg, 2015). The implementation of the CBL should also be strengthened with more challenging cases/contexts. To improve the effectiveness of the CBL, future studies should use the context of biofuel as a socio-scientific issue (SSI). Becuase the characteristic of biofuel, as a SSI, attracts students' interest in chemistry (e.g., Feierabend & Eilks, 2011;) and gives a chance to students for using their scientific thinking skills (e.g., Karisan et al, 2018; Suephatthima & Faikhamta, 2018). On the other hand, given the idea 'the use of hybrid learning and multimedia promotes students' achievement levels of petroleum learning' (e.g., Fitriyana et al., 2018; Wiyarsi et al., 2019), future studies should enrich the implementation of the CBL with these learning tools. Phrased differently, since prospective and chemistry teachers lack of integrating vocational context into chemistry learning (Febianto, 2019; Wiyarsi et al., 2017, 2019), teacher preparation and professional development programs are supposed to be improved.

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