

The use of socio-critical and problem-oriented approach integrated with green chemistry to develop participant's 21st century skills in hydrocarbon and petroleum learning

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Abstract. The aim of this research was the use of Socio-critical and Problem-oriented approach integrated with green chemistry to develop participant's 21st century skills in hydrocarbon and petroleum learning. This approach connects concepts to social issues in participants' lives. This research was conducted in grade X from 78 high schools in Jakarta, Indonesia. Qualitative research was employed using the data collection techniques of observation, interview, reflective journal, and a 21st century skills questionnaire developed by Triling and Fadel, (2009). The results show that a socio-critical and problem-oriented approach helped developed several 21st century skills in participants. The most dominant skills appear to be in communication and collaboration, information literacy, ICT literacy, and social and culture interaction. Finally, a socio-critical and problem-oriented approach, integrated with green chemistry, could motivate participants to become more actively involved in solving environmental problems.

Keywords: *socio-critical and problem-oriented, 21st century skills, chemistry learning, hydrocarbon and crude oil*

1. Introduction

Science education now requires participants to have the ability to connect the technology, and social aspects of science by paying attention to local issues, public policies, and global problems [1]. In addition, science participants are expected to have the skills necessary to be successful in the 21st century. This skills refer to learning and innovating skills, skills using technology and information, and survival skills using life skills [2]. In reality, chemistry teaching in schools does not provide an optimal environment for developing participants' 21st century skills. More often than not, chemistry continues to be taught using approaches based on material content [3] and participants feel that the approaches favour a certain kind of learner which impacts on their motivation and interest in learning chemistry. Participants feel their motivation and interest in learning chemistry is reduced [4]. These problems reduce the efficacy of chemistry education for answering the environmental problems identified in the Indonesian Science curriculum 2013. Traditional methods of chemistry education are less effective in developing participants' high order thinking and cognitive skills [3].



In many schools, as witnessed during observations, chemistry teachers use limited learning approaches, mainly based on traditional delivery styles. Participants report difficulty in understanding the course content resulting in misconceptions in participants' thinking frameworks. Teachers can play an important role in helping chemistry participants to build their own knowledge rather than transferring their own knowledge to the student. Difficulties in learning chemistry occur when participants are unable to change microscopic matters into macroscopic matters so learning is felt to be meaningless. One of the more complex chemical materials that participants find difficult to understand is hydrocarbons and petroleum. Participants have difficulty visualizing the three-dimensional structure of compounds in this material; both alkanes, alkenes, and alkynes. Because they have difficulty writing about reactions on hydrocarbons, and they lack contextual learning about petroleum material, learning is less attractive to them [1].

One way to connect the knowledge gained at school with real-world problems occurring in the surrounding environment, and to improve high-order cognitive thinking skills (High Order Ordering Cognitive Skills) is to relate learning chemistry directly to social issues [2]. Socio-critical and problem-oriented learning approaches can help increase participants' interest in chemistry and chemistry learning [5], as well as generate broader insights in addressing environmental issues. Problems of environmental pollution due to the use of fuel, incomplete combustion, the amount of environmental pollution, the emergence of the greenhouse effect, and the search for renewable energy substitutes for these fuels that are environmentally friendly are all issues that can be addressed using a socio-critical, problem-oriented approach [6]. These environmental problems can also be related to the 12 principles of green chemistry, one of which is protecting the environment from pollution and preventing the emergence of hazardous chemical wastes [7]. This study uses a socio-critical, problem-oriented, approach, integrated with green chemistry, to solve problems related to learning chemistry. The aim of this research was to develop participants' 21st century skills in hydrocarbon and petroleum learning through a socio-critical and problem-oriented learning approach that is integrated with green chemistry.

2. Research method

The aim of this study was to develop participants' 21st century skills in hydrocarbon and petroleum learning through a socio-critical and problem-oriented learning approach that is integrated with green chemistry. The research uses a qualitative methodology with research participants from Grade X with a total of 31 students at 78 high schools in Jakarta, Indonesia during the 2016/2017 academic year. Observation, interview, reflective journal, and a 21st century skills questionnaire, developed by Trilling and Fadel [8], were used to collect data. the indicators observed were creativity and innovation, think critically and solve problems, communication and collaboration, information literacy, media literacy, ICT literacy, flexibility and adaptability, initiative and self-regulation, social and cultural interaction, productivity and accountability, leadership and responsibility. Data reduction, data presentation, and drawing conclusions were used to analyze the data. The validity of the data was established through prolonged engagement, persistent observation, and member checking. The A socio-critical and problem-oriented learning process is represented in Figure 1.

Learning activities begin with an introduction to social issues and the learning materials related to hydrocarbons and petroleum, and practicum identification of carbon compounds to analyze the impact



Figure 1. Learning process socio critical and problem oriented.

of carbon compounds on the environment. At this stage, participants are also asked to look for one of the compounds from alkanes, alkenes or alkenes then present it using the cooperative learning namely Two Stay Two Stray (TSTS) strategy. The teacher then divides participants into groups and provides them with a theme to study. Participants are provided with articles related to their issue, and time to discuss them. The second stage of the learning process is a pros and cons debate to identify a solution to the environmental issue. The participants then find solutions to the issues, offering an alternative suggestion as well. Participants then use a project approach to create a presentation of their solutions to be viewed by the whole class.

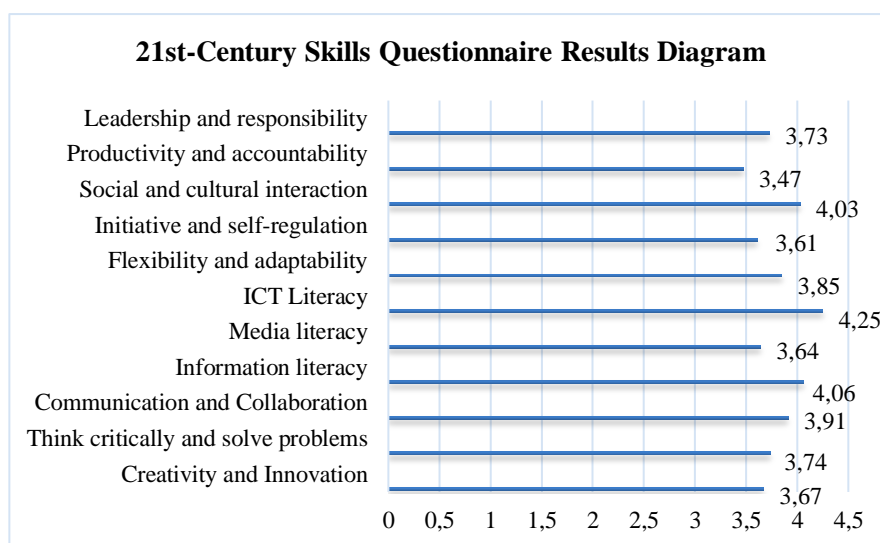


Figure 2. Diagram of results the 21st century skills questionnaire.

3. Results and Discussion

Socio-critical and problem-oriented learning processes require participants to actively interact in their learning and to connect concepts to everyday life. The development of 21st century skills can be observed during the learning process. This study used a 21st century skills questionnaire, the results of which are shown in Figure 2.

Based on the graph above, four skills are more significant compared to the others, namely, communication and collaboration skills, information literacy, ICT literacy, and social and cultural interaction. Other significant skills that can be observed are creativity and innovation, critical thinking and problem solving, flexibility and adaptability, and leadership and responsibility. Media literacy skills, initiative, and self-regulation, as well as productivity and accountability, appear less significant. The 21st century skills emerge after the learning process is applied with a socio-critical and problem-oriented approach, as discussed below.

3.1. Flexibility and adaptability skills

These skills can be observed during the socio-critical and problem-oriented learning process, especially when working in groups. The 21st century skills questionnaire shows that these skills are quite significant on a 3.85 scale. Some participants, out of the 36 participants in this class, developed these skills during the learning process as evidenced by the observations undertaken while the

participants were working in groups, presenting social issues and during debates. The following is a sample of an observation sheet that identifies examples of these skills being demonstrated:

"In learning with today's debate method, participants 15 have flexible and adaptive skills, this is proven by being able to receive input and suggestions from group friends and he is able to work well with his group"
(Observation Sheet, 7 February 2017)



Figure 3. Students flexibility in group work.

The data shows that the implications of learning, participants require to work together in groups and it appears that some participants who have been observed and interviewed have a flexible and adaptive nature to their group peers and can work well together.

This can be seen from participants who are very flexible in accepting their diverse group of friends. Figure 3 show when practicum, they can adapt and work together in making the molecular structure of hydrocarbon compounds. The socio critical and problem-oriented learning, students discuss issues openly in different point of view such as social, moral and scientific concepts, these problems can be in line or conflict with student beliefs [9].

3.2. Initiative and self-organizing skills

Participants demonstrating this skill were able to manage goals and time, work independently and can self-organizing in the learning process. The results of the 21st century skills questionnaire show a less significant number of 3.61, but some participants show have this skill. These participants were observed initiating and regulating their learning process. The reflective journal below is related to what participants do when learning takes place:

"Today's learning is very effective because we prepare material to be presented from various sources independently, and we coordinate ourselves to help the group do the practical work"
(Reflective student journal, February 24, 2017)

The journal entry indicates that during the learning process some participants can be seen taking the initiative to prepare material to be presented during the poster presentation using a cooperative method and coordinate to help the group during the practicum.

3.3. Social and cultural interaction skills

Indicators of social and cultural skills are demonstrated when participants able to interact and work effectively with diverse groups. The ability to interact socially and be able to adapt to various cultures is one of the most important skills that participants must possess. The results of the 21st century skills questionnaire show a very significant number of 4.03 because using a socio-critical, problem-solving approach means that participants must work together with group members from diverse cultures so that social interaction occurs. An example of this interaction is below:

"Very good method sir, helping us in teaching and learning activities especially in interacting with others because we are always required to discuss especially during debates"

(Reflective student journal, March 24, 2017)

From the reflective journal, it can be seen that this approach raises the process of social interaction with others, especially when debating social issues. Participants argued that waste spills caused by petroleum refineries produce organic compounds such as benzene, toluene, ethylbenzene, and xylene that are harmful to the environment. This was observed during the learning process and during the debate where all participants were active in discussing and interacting with each other [10].

3.4. Productivity and accountability skills

Of the 21st century skills that appear in this study, productivity and accountability skills had the lowest value at 3.7. The final stage of this research required participants to create a video to demonstrate their understanding of the social issue they investigated. Participants interviewed people about the issue, developed an explanation of the pros and cons and came up with a solution to the problem and posted the video on social media or a blog. By undertaking the project, the participants became more productive, they produce videos or posters that contain issues so that these issues can be seen and understood by others in interesting ways. This outcome aligned with the aims of socio-critical and problem-oriented learning which was to develop student interest in science and technology and to display an understanding of the relevance of science in society [11].

3.5. Leadership skills and responsibilities

The 21st century skills of leadership and responsibility skills rate at 3.71 on the questionnaire. These skills were observed when participants worked together in groups. Out of the 36 student participants, some participants actively lead discussion, including during the pros and cons debate. This is evidenced by the following student interview data:

"These lessons make me always coordinate the course of discussions and I am also able to make decisions when working in groups"

(Student Interview 13, 24 October 2017)

The data shows that group work enabled participants to develop the 21st century skills of leadership and responsibility. Leadership attributes were observed during group discussions where several participants took the lead. Some participants demonstrated leadership qualities when debating by leading the debate and discussion, as indicated by the interview data. Learning with a discussion conducted in this study can optimize the role of students, fostering teamwork, and building a sense of responsibility [12].

3.6. Critical thinking skills and problem solving

The 21st century skills questionnaire indicated that critical thinking a problem-solving skills rated a score of 3.74. The pros and cons debate show that some participants demonstrate these skills when expressing their opinion regarding social issues related to hydrocarbon and petroleum material, as indicated by the interview excerpt below:

Pro: "We strongly agree with the eradication of petroleum refineries because these refineries produce a lot of organic wastes such as benzene, toluene, ethylbenzene, and xylene. In addition, due to oil production, pollutants such as carbon monoxide (CO), carbon dioxide (CO₂) and sulfur trioxide (SO₃) are increasing."

Cons: "but let us review the negative effects of eradication. During this time, petroleum is an industry that has become one of the biggest revenues for the country, besides that petroleum is one of the needs that are rather difficult to replace with other alternative fuels and sources of employment."

Pro: "Isn't there already a lot of other alternative fuels that are more environmentally friendly such as nuclear power, solar power or maybe biodiesel. Then according to you, if you want to be maintained, how do you reduce that waste?"

Cons: "Based on the sources we read we can use organisms such as bacteria and algae, and plants that can break down these pollutants called bioremediation and phytoremediation."

A socio-critical, problem-solving approach enabled participants to criticize each statement from the opposing group as it stated their pro and cons. They based their critique on what they had learned whilst preparing for the pros and cons debate. Learning chemistry based on socio-critical and problem-oriented can stimulate critical and creative thinking and argumentation [13].

3.7. Communication and collaboration skills

Communication and collaboration skills are the ability of participants to express their opinions clearly and persuasively both orally and in writing. The results of the 21st century questionnaire showed a score of 3.91. The approach required participants to communicate and collaborate both with culturally diverse individuals during the pros and cons debate as reported by this student:

"Today learning with the debate method, very exciting. I was able to share each other's knowledge with our group and even with other groups, besides forming us to be able to work together in teams (Teamwork)"
(Reflective journal, March 24, 2017)

Based on the reflective journals entry above, it can be seen that many methods required participants to work together in groups, resulting in the communication and collaboration skills of some participants showing improvement. The ability to communicate was observed during the debate where participants delivered their arguments, and during the preparation of bulletin presentations. Participants need to collaborate with others to solve difficult problems, then student arguments arise during active debate in front of the class when discussing social scientific issues [14].

3.8. Creativity and innovation skills

Creativity and innovation skills on the 21st century questionnaire obtained a score of 3.67, which is considerably lower than other skills areas. However, during the socio-critical and problem-oriented learning process some participants provided creative and innovative solutions:

"CFD is a program that in my opinion is very good for efforts to reduce air pollution caused by motorized vehicles, but there is still little public awareness about it. So we are classmates planning to go to the CFD and will make an invitation to our friends first to join the CFD and not bring a motorized vehicle"
(Student Interview 8, 30 October 2017)

This student wanted to invite his classmates to join the Car-free day program together to reduce air pollution caused by burning hydrocarbon compounds in motor vehicles. Some participants from a different issue groups also offered a number of creative solutions, for example, some of them suggested that the bemo, an iconic vehicle in Indonesia, should not be removed from the road but should have the engine replaced to enable the use of environmentally friendly fuels such as biodiesel; a mono-alkyl ester mixture from fatty acid chains that can eliminate air pollution. Some participants' creativity was also observed when making a wall magazine. In addition to presenting wall magazines, one group also made a small brochure to distribute while visiting other bulletin groups.

3.9. Information literacy and media literacy skills

The results of the 21st century skills questionnaire show a significantly high result for information literacy skills at 4.06 but very low for media literacy at 3.64. Information and media literacy requires participants to frequently discuss and express opinions about information accessed through various sources. This skill was observed in some participants, especially during the pros and cons debate, as indicated by the following interview excerpt:

"During the debate, we not only read the articles given but we also sought from other sources such as the internet to add our insight to environmental issues that are issued in our group"
(Student Interview 8, 31 October 2017)

From this observation, it appears that some participants look for a broad range of information, indicating a level of information literacy. Information and media literacy is considered to be one of the most important skills for the 21st century. Some participants demonstrated this skill by searching deeper for information, not only in articles showing existing solutions to issues such as ways to reduce waste oil spills by phytoremediation; an absorption of heavy metals by plants. Students' knowledge and information increases when students discuss the given social issues, students will find valid information from various sources of information [14].

3.10. ICT literacy skills

The 21st century skills that rated the highest on the 21st century questionnaire were ICT literacy skills, at 4.25. These skills were demonstrated during the project by creating a video of the issues. Observation sheet below shows that the most emergent skill to master, of all the 21st century skills, is ICT literacy skills.

*"Today the whole group presents the project they have been working on. Videos from them are also very good and creative."
(Observation Sheet, 7 April 2017)*

The socio-critical, problem-solving approach enables participants to express their ideas and creativity through information technology where skills emerge as they practise them. This is relevant to the main objectives of a socio-critical and problem-oriented approach is to build readiness for life in a modern society based on science and technology [10].

The socio-critical and problem-oriented approach learning in this study is good enough in developing 21st century skills. Chemical learning that is associated with everyday life will help students develop chemical concepts and can stimulate critical and creative thinking and argumentation [13], [15]. A combination of science concepts and social-scientific problems is an effective way to engage students in active discussion and develop their ability to make decisions and think critically [11], [16]. The 21st century questionnaire shows that 21st century skills emerge in some participants who may have had these skills before and developed them again due to the application of the socio-critical learning approach and problem-oriented integrated green chemistry. The approach should be developed for use in chemistry education in order to create more meaningful chemistry learning. The approach does not develop the skills in all participants, however, a significant number of participants benefited from the approach, as indicated by the questionnaire. Participants in this research who do not develop 21st century skills may be affected by several factors such as a lack of observation or teacher methods that do not enable participants to develop 21st century skills so that in the future socio-critical and problem-oriented approaches can continue to be developed in order to bring more positive implications especially in developing 21st century student skills.

4. Conclusion

The application of a socio-critical and problem-oriented approach integrated with green chemistry related to hydrocarbon and petroleum material had positive implications for some participants. This approach use media, in the form of articles on social issues related to hydrocarbons and petroleum, and a variety of socio-critical and problem-oriented approaches in the learning phase. Participants were enthusiastic about participating in the approach and many positive outcomes were observed during its application. The implication that emerges from this research is 21st century skills. The results of the questionnaire showed that there are 4 most dominant 21st century skills were communication and collaboration skills, information literacy, ICT literacy, and social and cultural interaction. In the future it needs to be developed by more supporting methodes in using socio-critical and problem-oriented approach to developed 21st century participants.

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