Integration dilemmas stories in STEAM project of colloid

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Abstract. The study aimed is to develop students’ chemical literacy through dilemmas stories and STEAM project in chemistry learning in colloid topic. The dilemmas stories of environmental pollution were explored to engage students in contextual problems. The STEAM project of smoke absorbance was used as the problem solutions in dilemmas stories. The learning approach consists of several steps such as value reflection, problem solving, project development, project monitoring and evaluation, and transformation. The research employed qualitative approach with data collection of students’ interviews, reflective journals, observations, and chemical literacy tests. Chemical literacy consists of several dimension such as scientific ideas, chemical characteristics, chemistry in context, high-level learning skills, and affective aspects. The results showed that the average chemical literacy ability of students were 85.29% in the good category. The teacher faced the challenges in developing dilemmas stories to be relevant to chemistry concepts and curricula. Students need to shift their paradigms within active learning approach. The results of this study can be concluded that the integration of dilemmas stories in the STEAM project provides opportunity to develop students' chemical literacy.

1. Introduction
Scientific literacy plays important roles in nation developed [1]. Science literacy can be define as the ability to identify scientific issues, explain phenomena scientifically, and use scientific evidence in everyday life [2]. Indonesia faced the challenges of scientist literacy results in international level as shown by the 2018 PISA assessment down when compared with the 2015 PISA results [3-5]. In chemistry learning, the literacy was defined as chemical literacy which according to Shwartz chemical literacy consist of four domains: chemistry knowledge and scientific ideas, chemistry in context, high-level learning skills and affective aspects of students that are still relatively low [6-7]. Chemistry literacy was difficult to develop as students learn through narrow understanding of memory facts in chemistry learning. The chemical literacy can be developed through innovative teaching strategies which are contextual and meaningful for students’ learning experiences. One of the approaches that has been explored in the study is integration of dilemmas stories in Science Technology Engineering Art and Mathematics (STEAM) project. Dilemmas stories is a collection of dilemmas stories which is a collection of stories with characters and plot that contains one or more scenarios that have a dilemma, so students are not only motivated to understand the problems in the story, but also have the ability to solve problems and make decisions [8]. STEAM project is a learning that emphasizes the importance of developing problem solving skills in students by making a project [9]. The previous studies show that the dilemmas stories approach has implications for the reflection of values, collaboration, and increasing environmental awareness and social issues related to chemical learning [10-11]. Meanwhile, the Science
Technology Engineering Art and Mathematic (STEAM) approach emphasizes learning with project-based methods to develop higher-level thinking skills, collaboration, argumentation, and student creativity [12-13]. The study was developed through the dilemmas stories of environmental pollution by the STEAM project of a smoke absorbance as problem solution in the case study in dilemmas stories.

2. Research methods
The research employed qualitative approach with data collection of students’ interviews, reflective journals, observations, and chemical literacy tests. The participants consisted of 34 students of class XI MIPA in one private high school in Jakarta. This research was conducted in the 2019/2020 school year first semester. Students simply memorize topics but they have not been able to apply the knowledge gained in everyday life and are still relatively low in terms of developing chemical literacy abilities. The purpose of this study was to develop the chemical literacy through integration dilemmas stories and STEAM project in colloid topic levels of secondary school students in Jakarta, Indonesia. In the study, the dilemmas stories of environmental pollution were explored to engage students in contextual problems. The STEAM project of smoke absorbance was used as the problem solutions in dilemmas stories while the chemical literacy test consists of five dimensions of scientific ideas, chemical characteristics, chemistry in context, high-level learning skills, and affective aspects. Specifically, the chemical literacy is focused on how students have chemical literacy in chemistry learning.

The dilemma story on the topic of colloids is relevant to the daily lives problems of environmental air pollution. Then, from the existing problems, students were challenges to make a simple smoke absorbance project. The STEAM project mapping in the process of making a simple smoke absorbance sacrifice device is as follows.

| Science | Technology | Engineering | Art | Mathematics |
|---------|------------|-------------|-----|-------------|
| Colloid concept | Technology for making simple smoke absorbance devices | Designing how smoke absorbance works | Decorate the smoke absorbance tool according to students’ creativity | Calculate the working time in making smoke absorbance devices |

The integration of the dilemmas stories and STEAM project approaches is carried out through five stages of value reflection, problem solving, project development, project monitoring and evaluation, and transformation [14]. The general description of the steps is as follows:

**Table 1. Integration of the STEAM in smoke absorbance project.**

| Value Reflection | Students through reflection on grades in the dilemma story |
|------------------|----------------------------------------------------------|
| Project Monitoring and Evaluation | Teachers and students jointly carry out monitoring and evaluation of the resulting project results and the project development process |
| Problem Solving | Students are stimulated to be able to focus on problems and provide solutions through the STEAM project |
| Project Development | Students design STEAM projects through the process of preparing schedules and design tools |
| Transformation | Teachers and students carry out evaluations of the learning process carried out and reflection on changes in values, attitudes and knowledge during the learning process |

**Figure 1.** The dilemmas stories in STEAM project approach [14].
The data collection was conducted throughout the research process. Then data analysis was explored through initial coding of chemical literacy criteria.

3. Results and discussion

3.1. The dilemmas stories in STEAM project

Learning activities through the integration of the dilemmas stories in STEAM project encouraged students to be active participant during the learning process. The study focuses on developing students' chemical literacy skills in relation to apply the chemical concepts for solving the problems in daily lives. The integration of the dilemmas stories and STEAM project approach is carried out using the dilemma story of environmental pollution given at the value reflection and problem solving stages. Then, students created the STEAM projects as a solution to the problems in the story dilemma. The explanation of each of the steps is stated below.

3.1.1. Value reflection. Value reflection is a stage where students reflect values in learning through dilemmas stories. Reflection is about students becoming aware of their own thinking processes, and being able to make those transparent to others [15]. The learning process at the value reflection stage, begins with the teacher delivered a colloidal topic. The teacher explored students' knowledge about the application of colloids in everyday life by stimulating students' thinking a dilemma story of Environmental Pollution. At the end of each story, there is a dilemma that must be discussed and each group is given the opportunity to express their opinions. The findings from the observation sheet show that students have reflected on the values that exist in the dilemma story.

"Students can relate phenomena in the story of dilemmas to everyday life and understand that smoke pollution as a type of colloid. Students also understand the impact of smoke pollution which is directly discharged into the environment to be very dangerous and can cause global warming."

(observation sheet, 10 February 2020)

The results of the observations above are in accordance with the contextual-based learning objectives that connect learning with students' experiences in daily lives and build new knowledge based on student analysis and synthesis during the learning process [16]. The application of dilemmas stories as contextual learning can stimulate students to reflect critically on values and understanding concepts to problems that students have to solve in a dilemma story [11].

3.1.2. Problem solving. Problem solving experience has stimulated students to use the knowledge and skills to solve a problem in a particular situation. In solving problems, students must synthesize what they have learned and apply it to new and different situations [17]. The learning process at the problem-solving stage is that the teacher provides the stimulation of problem solving in the dilemma. Then, the teacher and students engage in a discussion to find solutions to solve the environmental pollution dilemma. Each group provided their opinions and discuss opinions from other groups so that a conclusion came up to make a STEAM-based project that is a simple smoke absorbance. Based on the findings from the observation sheet, the result shows that the learning process of problem solving has engaged students to find the problem solution.

"Students are able to play an active role in discussions and are able to develop conclusion of making a simple smoke absorbance."

(observation sheet, 10 February 2020)

The observations above show that the integration of the dilemmas stories and STEAM project approaches is able to develop students' problem-solving abilities. This is relevant with research conducted by Taylor which shows that dilemmas stories increase student involvement by giving students the opportunity to solve problems and make decisions through discussion [10].
3.1.3. **Project development.** Project development is a stage where students designed STEAM projects as a solution to case study in dilemmas story. In this study, the project that students created absorbent to filter smoke pollution to produce clean air. Activities undertaken by students at the project development stage include tool design, tool making, tool testing, and presentation of STEAM project results. Based on the findings from the observation sheet and students’ interviews, the result shows that the project development stage can run well.

"Students have been able to determine the equipment and materials, design drawings of tools, and how the tools work in making collaborative STEAM projects."

(observation sheet, 11 February 2020)

"The tools and materials our group uses include fans, used paint buckets, aerators, and lime water which serves to absorb smoke pollution so that it can produce clean air"

(students’ interviews, 11 February 2020)

The observations and interviews above show that the integration of the STEAM approach in chemistry learning provides opportunities for students to develop critical thinking skills and student creativity and increase student involvement in learning [11].

3.1.4. **Project monitoring and evaluation.** Project monitoring and evaluation is a stage carried out by the teacher and observer to monitor activities undertaken by students in completing the STEAM project. In monitoring the activities, the teacher looks at the progress of project work conducted by students and predicts the suitability of project completion times to be precise and in accordance with the timeline. Based on the findings from the observation sheet, the result shows that project-based learning has effective in developing student involvement in learning [18]. The following is an example drawing of a smoke absorbance design.

![Figure 2. Smoke absorbance design.](image)

3.1.5. **Transformation.** Transformation is a stage to evaluate the learning process and reflection on the making of values, attitudes, and knowledge of students during the learning process. The stages of transformation in this study consisted of evaluating experiences, projects, and student learning outcomes obtained from chemical literacy tests. Experience evaluation is done by students by expressing students' feelings and experiences while completing the project. The things that are reflected are about the constraints experienced and the solutions made by students while completing the project, as well as the students' feelings when doing learning activities. In addition, the teacher also evaluates the STEAM
project using the project appraisal rubric and tests students' understanding of the concept of colloid topic. Based on the results of student reflection, the result shows that students feel trained to think critically and creatively. This is because students are challenged to create a project that integrates the concepts of chemistry, looking for information related to equipment and materials to work on the project, taking into account the time the project works so students must use the right strategy in collaboration.

"In my opinion, learning using dilemmas stories and STEAM project is something new for me while studying chemistry so that it makes me feel challenged to think critically in solving problems that exist in the story of the dilemma. And the thing that I like the most from this learning, I and the group can be creative to design and decorate the smoke absorption absorber that is made.”

(students’ interviews, 11 February 2020)

The results of the above reflection indicate that the integration of the STEAM project in learning chemistry can develop students' critical and creative thinking skills [11].

3.2. Analysis of development of students' chemical literacy through integration dilemmas stories and STEAM project

The development of students' chemical literacy is the main subject of analysis in this study. The chemistry literacy of students analyzed is the chemical literacy that arises in each colloidal topic learning by applying the integration of the dilemmas stories and STEAM project approaches. To analyze the level of achievement of chemical literacy, students are given a test in the form of chemical literacy questions consisting of five essay questions divided into five aspects of chemical literacy based on the chemical literacy rubric developed by Shwartz namely general scientific ideas, chemical characteristics, chemistry in context, high-level learning skills, and affective aspects [6]. Each aspect has a weight of 20% in determining the level of achievement of chemical literacy which is divided into 5 categories, which are very poor, not good, enough, good, and very good. Based on the overall results obtained, the range of student learning outcomes on the chemical literacy test is as follows:

| No. | Categories     | Range of Scores | Total Students |
|-----|----------------|-----------------|----------------|
| 1.  | Very good      | 81 – 100        | 3              |
| 2.  | Good           | 61 – 80         | 29             |
| 3.  | Enough         | 41 – 60         | 2              |
| 4.  | Poor           | 21 – 40         | 0              |
| 5.  | Very poor      | 0 – 20          | 0              |

Based on the results above, it appears that most students achieve a good level of chemical literacy. This means students have been able to carry out scientific investigations and make generalizations of findings, be able to explain macroscopic phenomena in the form of material structures properly, can use chemical knowledge to explain phenomena in life, be able to ask questions, and understand the impact and application of chemistry in daily life.

4. Conclusion

The students developed chemical literacy by developing chemistry conceptual understanding, however they faced the challenges in high order thinking skills. They understood chemistry concepts of colloid as chemistry characteristics. Meanwhile they were aware of environmental problems of smoke pollution. The results showed that the average chemical literacy ability of students was 85.29% in the good category. The teacher faced the challenges in developing dilemmas stories to be relevant to chemistry concepts and curricula. Students need to shift their paradigms within active learning approach. The results of this study can be concluded that the integration of dilemmas stories in the STEAM project is very possible to develop students' chemical literacy abilities.
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