Analysis of students’ argumentation skills in chemistry class of grade XI through product life-cycle analysis assessment on colloid lesson

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Abstract. This study aimed to investigate the students’ argumentation skills in chemistry classes of Grade XI after completing lesson through Project Based Learning (PBL) and Life-Cycle Analysis (LCA) on Colloid Lesson. The method used in this study was qualitative research. The data of the study were pre-task and post-task stories, students’ essays, and students’ projects. The data were analyzed into the Toulmin aspects. This study focused on the analysis of students’ argumentation skills through life-cycle approach on lessons by combining social and scientific issues and life-cycle analysis. The result of the study shows that the students’ argumentation skills on ecological and socio-economic aspects were developed. Students’ argumentation skills on scientific and moral aspects were indicated lower than on ecological and socio-economic aspects. The data shows that the Life-Cycle Analysis (LCA) in chemistry class was effectively used to develop students’ argumentation skills.

1. Introduction
Based on the data from Education for All Global Monitoring Report published by UNESCO, education in Indonesia is considered lower than other countries in ASEAN. In 2011, Indonesia was at the 69th place out of 127 countries in Education Development Index (EDI). Research product from primary and middle schools have not been improved significantly to promote students’ critical thinking skills. Indonesian children are only able to comprehend 30% of the reading materials and they find difficulties to answer question which require logical reasoning skills. In fact, logical reasoning and critical thinking skills are essential to solve problems on a daily basis.

According to the observation conducted by the researcher in August to Desember 2014, the students’ argumentation skills were indicated low. The students were passively involved in the learning process. The lack of argumentation skills were caused by the learning process which emphasized the importance of learning materials and scores. Juntunen and Aksela stated that one of the predominant factors that inadequacy of opportunities to practice making arguments in the learning sessions [1]. This happened
as a result of the students’ lack of confidence and therefore they did not quite contribute to the discussion. In general, students tended to state something without presenting facts to support or to oppose the arguments. A study by Juntunen and Aksela found that the life-cycle analysis and inquiry-based learning approach could be applied in chemistry class to solve this problem [1]. These approaches were expected to enhance students’ argumentation skills by discussing social and scientific issues related to products used in daily life to strengthen students’ motivation, curiosity, and critical thinking skills.

The study of life-cycle analysis approach in chemistry class on colloid lesson conducted by the researcher is aimed to investigate the students’ argumentation skills. Colloid is one chemistry lessons directly related to real life and current issues which are expected to boost students’ critical thinking skills, to develop their argumentation skills, and to strengthen their motivation to learn chemistry. The problem identification of study is about the how to apply life-cycle analysis assessment in chemistry class, what obstacles to use the approach, and how to improve the students’ argumentation skills by applying the approach. The scope of the study is the students’ argumentation skills analysis by utilizing Toulmin’s Argumentation Pattern (TAP). Four classification aspects evaluated in the research are socio-economic, moral, scientific, and ecological aspects. The study is mainly intended to analyse students’ argumentation skills on colloid lessons through life-cycle analysis.

1.1. Life-Cycle Analysis
Life-Cycle Analysis (LCA) is technique to assess environmental impacts associated with a product [2]. In LCA, the assessment of environmental impact is carried out to measure net-flows of chemical process, materials, and energy of the product manufacture [3]. Life-cycle assessment of a product is implemented to examine resources, emissions, and their possible impacts to environtmental health [4]. In chemistry perspective, LCA is unfied approach: it incorporates green chemistry, sustainable chemistry and engineering, which are included to moral science and moral awareness aspects [4].

Learning through LCA project based is a new approach in education to be presented in chemistry subject [5]. This approach is student-centred, each student is able to choose topics which are suitable to their interests and abilities to comprehend the materials relates to their daily life. This project analysis is based on the investigation correlated with social and scientific issues to encourage students to practice higher order thinking skills in their thinking system [6].

1.2. Argumentation
The study is aimed to evaluate the students’ argumentation skills after they learned LCA products discussed in the lesson [7]. Inch pointed out that argumentation is a statement of a claim supported by data and discovered to persuade people [8]. Involving students in discussion activity by giving them opportunities to tell their arguments is important to students. The students would be put in a situation where they were able to collect, interpret, and evaluate evidence they found [9]. Some studies reported that understanding argumentation and explanation should be emphasized in science education as a part of science practice, as argued by Duschl [10]. Sampson and Clark indicated that students’ argumentation is analyzed through various methods and set of data [11]. The argumentation is analyzed from interview toward students involved in arguments, recordings of constructive arguments, and students opinion responded during the lesson, and essay writing.

Toulmin model was adopted in this study on the grounds that the model describes three arguments’ criteria developed by Inch, they are claim, supporting claim, and persuasion attempt which are suitable for Toulmin Model of Argumentation [12]. Toulmin Model of Argumentation in Freeley used these terms to describe the six parts: Claim (C), Data (D), Warrant (W), Backing (B), Qualifier (Q), and Rebuttal (R). Socio-economic, moral, ecological, and scientific aspects were four of variability argument aspects expected. The four aspects were considered synchronized with regular model of sustainable development which consists of economical, ecological, and socio-cultural aspects. The aspects were shown in the table below.
Table 1. Concept keys of four categories used in data content analysis.

| Category       | Concept Key                                                                 |
|----------------|------------------------------------------------------------------------------|
| Socio-economic | Cost or profit                                                               |
| Moral          | Opinion about value, moral, or future                                        |
| Ecological     | Impact to ecosystem, environment friendly product, and lifestyle             |
| Scientific     | Natural resource, technology, energy, and material                           |

The table above shows argumentation concept keys which are expected from students’ arguments. The concept keys are directions in categories of each aspect will be used in this study. Research intervention phase allows students to take their time to practice and develop argumentation skills about product life-cycle issues.

2. Method
Qualitative research methodology was employed by the researcher. Creswell explained that qualitative research is a method to describe a situation or event objectively based on visible or real facts by providing description comprehensively and complexity through words, report detail views acquired from information sources, and draw general conclusions based on historical facts. The qualitative research was intended to gain comprehensive pictures of participants’ opinion. The research was related to ideas, perception, opinions, or beliefs of participants and the data is not measured by numerical symbols.

2.1. Participants
The participants of this study were 35 students from class XI IPA in SMAN 11 in December 2014 to May 2015.

2.2. Intervention and data intervention techniques
Phases of the research included planning, execution, and finishing phase. At the preparation phase, introduction analysis was done through interviewing chemistry teacher of grade XI to gather information about teacher’s perception about LCA approach and how they used it at school. Characteristic analysis of the materials was applied since the approach would be suitable only for certain lessons. At the finishing phase, compiling assessment instruments for argumentation skills were completed by using TAP model and classifying assessment categories to four aspects (Socio-economic, ecological, moral, and scientific aspects).

At the execution phase, colloid lesson was delivered by the researcher based on the lesson plan. A pre-task was given to the students before the LCA was introduced to them. This was aimed to assess initial students’ argumentation skills. Subsequently, the LCA was introduced to the students. At the intervention phase, a project about life-cycle of a product was assigned to the students according to their interests. Posters were made creatively by students to accomplish the project. After the students’ intervention was completed, the learning evaluation was implemented by giving a post-task. The students were asked to do storytelling and criticize the stories. Post-task of the lesson was essay writing about their project or anything else related to their interests. The outline of this intervention phase can be seen from the table below.

Table 2. Outline of the study.

| Week | Activity   | Time Allotted |
|------|------------|---------------|
| 1    | Task preparation | 15 minutes   |
| 1    | Pre-task     | 20 minutes    |
| 1    | Intervention  | 2-5 hours     |
| 2    | Post-task    | 30 minutes    |
Table 2. Cont.

|   |   |   |
|---|---|---|
| 2 | Debate | 20 minutes |
| 2 | Essay writing | 2-3 hours |

The table above shows students activities during the intervention phase where the task preparation, pre-task, intervention, post-task, debate, and essay writing. The finishing phase of this study was data collection and data analysis of the learning process and its evaluation. The conclusion could be drawn after the coding process by the TAP was completed.

2.3. Data analysis

Triangulasi was employed as the data analysis technique. Documentation and portofolio of the students were categorized to TAP aspects. The steps in students’ oral argumentation analysis were transcription phase, reduction phase, and categorization phase. The transcription phase was started by copying the data from students’ portofolio. The reduction phase was categorization of all students’ arguments to TAP aspects. The number of emerging arguments related to each aspect could be decided afterwards to put them as the backing, qualifiers, or rebuttals.

2.4. Quality standard

Quality standard applied in this study was trustworthiness. Guba and Lincoln stated that trustworthiness was equally valid, reliable, and objective criteria in quantitative research [13]. Guba arranged relevant criteria for qualitative research, they were credibility (equal to internal validity), transferability (equal to reliability), and coformability (equal to objectivity). Credibility administered in this study was member checking, persistent observation, progressive subjectivity, and prolonged engagement.

3. Result and discussion

An intervention group consisted of 35 students analyzed life cycle to paint, milk, hairspray, and detergent. Analysis in the form of poster and presentation of product result were made by the students. The poster included all main phases from life cycle of all products to the recycled products. The students’ work included various information and data, moreover, the students were proud to show and present them.

The students delivered their arguments through the pre-task story, post-task story, and essay which were analyzed later into selected categories. Research findings show that students’ argumentation skills were significantly improved and most of the students were able to express their arguments well. The LCA project was proven to give positive effects in developing students’ argumentation skills. The results of the students’ project are shown in the pictures below.
These project results (figure 1) were presented by students to their classmates and then continued to write an essay about the project they made. After the presentation of the project, discussion and debate were performed to criticize the project results. The arguments were taken to the data analysis to discern students’ argumentation skills. The argumentation analysis of this study is shown in the graphic below.

![Figure 1. Example of the posters students’ project.](image)

According to the figure 2, the students’ argumentation skills were categorized into three basic skills in Toulmin Argumentation Pattern (TAP), they were rebuttal, backing, and qualifier. This can be seen from the graphic above that the post-task or essay to express rebuttal, backing, and qualifier were improved. This was relevant to the study conducted by Juntunen and Aksela in Finlandia that LCA approach was able to be used to improve students’ argumentation skills [11]. Categorization based on TAP was done,
and eventually continued to analyzing students’ argumentation skills based on aspects categorization. The statistics of the categorization aspects could be seen on the graphic below.

![Graph showing argumentation skills](image)

**Figure 3.** The number students’ arguments for each aspect of TAP.

Figure 3 shows that the students’ argumentation skills were improved. It shows that students’ argumentation skill significantly improved was ecological aspect. It reports that most of the students were interested to their environmental condition. This improvement was also implied by the study of

4. Conclusion

The research finding show that life-cycle analysis and project based learning approach in chemistry learning was effectively used to develop students’ argumentation skills. This can be identified from students’ argumentation at pre-task, post-task, and essay. The number of students’ arguments was increased at post-task and essay after the implementation of the life-cycle analysis. The data reveals that life-cycle analysis could be used to encourage students’ in learning, make the materials more easily to be understood, and provide something new for the students. Since the students had stronger eagerness to learn, their understanding ability would be increased. Therefore, the number of the students’ arguments were increased after the life-cycle analysis was introduced.

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