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Improving Undergraduate Students' Argumentation Skills Through Problem-Based E-Module with Socio-Scientific Issues Topics

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ABSTRACT
E-module is considered as an effective learning media to create an interactive learning environment. In spite of that it is rare to find the research that examines the development of e-module based on Problem-Based Learning model that integrates Socio-Scientific Issues on argumentation skills to students. This research aims to develop students' argumentation skills through problem-based e-module with socio-scientific issues topics. The researcher used pre-experimental method with one-group-pretest-posttest design. The e-module was implemented to 36 students of Biology Education, State University of Malang, for the 2nd-year from November to December 2022. The research sample was selected by non-random sampling. The research samples were selected by non-random sampling. The research data were collected by opened-ended questions to assess the students' argumentation skills and categorized based on the argumentation skills rubric. The data were analyzed based on the increase of pre-test and post-test scores by using Normalized Gain (N-Gain). The result of the N-Gain calculation showed a score of 0.46 which means the students' argumentation skills developed in the moderate category after the implementation of using problem-based e-module with socio-scientific issues topics. The problem-based e-module with socio-scientific issues topics can train students to identify the problems, analyze data and evidence to give problem-solving solutions packaged of complex argumentation.

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1. INTRODUCTION

Globalization has an impact on various aspects of human life. Globalization has resulted in tighter competition in the world of work, to the point that environmental degradation cannot be separated from the role of education as an institution that can support individual quality improvement. Education in the era of globalization requires individuals to master various skills, one of the skills needed is scientific argumentation (Anita *et al.*, 2019). Argumentation skills are a person's verbal, social and rational activities to convince criticism about certain conditions based on strong evidence and data (Roviati & Widodo, 2019).

Empowerment of argumentation skills is very important because it can help students be more active in the learning process through discussion activities to produce evidence and data based problem-solving solutions (Supena *et a*l., 2021). However, the development of argumentation skills in Indonesia is still not optimal. Several studies have explored students' argumentation skills (Noviyanti *et al.*, 2019; Setiawati & Nurlaelah, 2017) reporting that students' argumentation skills are still relatively low, ranging from level 1-2 based on *Toulmin's Argumentation Pattern* (TAP) rubric (Erduran *et al*., 2004). It is supported by the result of preliminary studies in written argumentation skills test. The results of the written test showed that the students' argumentation ability at level one was 19%, level two was 79%, and level 3 was 3%. Based on those results, the most students belong to level 2, here the students are only able to present the argumentation that consists of 1 claim or counter claim with data or backing but not contains rebuttals. It can be caused by learning environment that has not accommodated yet the improvement of the students' argumentation skills (Noviyanti *et al*., 2019).

The students' argumentation skills improvement does not appear naturally. The development of argumentation skills can be integrated into learning activities. One way to empower argumentation skills is by creating interactive and meaningful innovative learning (Setiawati & Nurlaelah, 2017), namely e-modules. The

use of e-modules in learning can make the learning process more interesting because it can be done anytime and anywhere. To empower argumentation skills, e-module development must consider the history, theory and argumentative perspectives in learning (Archila, 2014). One way to empower argumentation skills in e-module is to integrate *Social-Scientific Issues* (SSI) as learning topics (Purwati *et al*., 2019).

Integrating SSI as a learning topic in e-modules can improve students' activity in conversations, discussions, and debates (Zeidler & Nicholas, 2009). SSI is characterized by two important elements, namely the correlation between science content and social interest which are complex, opened and controversial (Topçu *et al*., 2018). SSI topics related to everyday life can train students to convey their opinions (*claims*) by analyzing pros and cons, assessing the risks and benefits that require scientific and moral considerations, reviews from various perspectives and can produce more than one possible solution (Nida *et al*., 2020), so that in the end it can help students construct quality arguments.

The development of e-modules with SSI topics must be moderated by relevant learning models in accordance with the desired objectives of developing skills. The empowerment of students' argumentation skills can be moderated by the *Problem-Based Learning* (PBL) learning model (Purwati *et al*., 2019). The integration of the PBL learning model syntax in e-module can accommodate the students to identify and present the problems, think of some strategies to learn about a new topic and find the problem solutions, act on the selected solutions and evaluate the learning process outside the classroom so that can create meaningful learning process (EL-Shaer & Gaber, 2014).

Problem-based e-module with the SSI topic is a learning media design that contains the syntax of the PBL learning model with the SSI topic as a learning stimulus. The learning process is designed in the form of an investigation of the SSI topic which is integrated in the e-module so that students are motivated to identify problems and analyze data to develop evidence-based explanations. Although the e-module is widely adopted, the research that evaluates its impact on argumentation skills is still rare. The research conducted by (Purwati *et al*., 2019) revealed the effectiveness of problem-based modules with SSI topics in reducing the gap in argumentation skills of high school students with different academic abilities. Therefore, efforts are needed to improve and develop students' argumentation skills with innovation and different levels. This study aims to evaluate the improvement of students' argumentation skills through learning using problem-based e-modules with SSI topics.

2. RESEARCH METHOD

This research used a one-group-pretest-posttest design to measure students' argumentation skills after carrying out learning using the problem-based e-module with the SSI topic. This research consists 36 2nd-year Biology Education students from State University of Malang who were taking an Ecology class. The research sample was selected by non-random sampling technique. The study was conducted in November-December 2022. Table 1 shows the one-group-pretest-posttest design.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Ecology Class	O_1	X	O_2

Description:
O1 : Pretest (before learning)
X1 : Learning with PBL E-module with SSI Topics
O2 : Posttest (after learning)

The development of e-module in this research uses development model of Lee & Owens (2004) that consists of 4 stages, namely: 1) *assessment/analysis*, 2) *design*, 3) *development and implementation*, and 4) *evaluation*. The appropriateness of e-module is assessed in the form of validation number instrument from material expert and media expert, and practicality number of (BSNP, 2014). The e-module validation was carried out by 3 experts, namely material expert, media expert and biology educational practitioner.

The learning material used in this research is nvironmental problem solving with the topic of air pollution, water and land. The research instrument used to measure students' argumentation skills is open essay questions based on indicators of *Toulmin's Argumentation Pattern* (TAP) argumentation skills (Erduran *et al*., 2004), including: *claim, ground, warrant, backing*, and *rebuttal*. The tests used have been validated by some experts and declared valid and reliable. The students' answers were analyzed with the appropriateness of argumentation level criteria from (Erduran *et al*., 2004) shown in Table 2.

Table 2. Argumentation Skills Assessment Rubric

Level	Criteria
5	Argumentation displays an extended argument with more than one rebuttal
4	Argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counter-claims
3	Argumentation has arguments with a series of claims or counter-claims with either data, warrants, or backings with the occasional weak rebuttal
2	Argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings but do not contain any rebuttals
1	Argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim

The data obtained was analyzed by calculating the number of scores before and after learning uses normalized gain formula developed by Hake (1999). The results of calculating the N-gain scores are then interpreted based on the category in Table 3.

Table 3. Interpretation of Normalized Gain Value (N-Gain)

Range	Interpretation
$\langle g \rangle \geq 0,7$	High Effectiveness
$0,3 \leq (\langle g \rangle) < 0,7$	Moderate Effectiveness
$(\langle g \rangle) < 0,3$	Low Effectiveness

3. RESULT AND DISCUSSION

First Stage: Analysis/Assessment

The results of the analysis show that the argumentation skills of Biology Department students are still classified at a low level as shown in Table. Most of the students have argumentation skills at level 2. Figure 1 shows students' argumentation skills level.

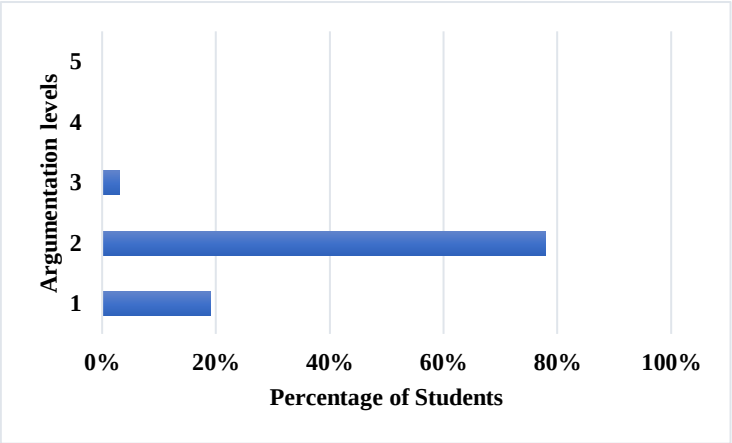

Figure 1. Students' Argumentation Skills Level

Figure 1 shows that 19%, 78%, and 3% of the student belong to level 1, level 2, and level 3 in stating their argumentations. The majority of students have argumentation skills at level 2, it means that students are only able to present their arguments consist of one *claim* or *counter claim* with the *data* or *backing* but it doesn't consist of *rebuttal*. It shows that most of the students have not been able to construct arguments properly. So, it is needed a significant effort to help them in developing their argumentation skills. Argumentation skills are important to be empowered because they can help students build new knowledge and train their reasoning abilities. The empowerment of argumentation skills can help students more selective in arranging knowledge, evidence, and data that are obtained and construct them in the statement to get environment problem solutions (Supena *et al*., 2021). Besides, the results of the assessment showed that in the learning process there were no media teaching materials capable of practicing argumentation skills. So, it is necessary to develop teaching materials that can support students' argumentation skills.

Second Stage: Design

The results of the preliminary study stage (*analysis/assessment*) are used as a reference to design a learning media (e-module). There are several characteristics analysis results that can be used as design references, namely:

improving argumentation skills, problem-based learning, integrating SSI and using learning media e-module. The design stages produce media specification and learning structure. The media specifications used in this research is in the form of website because it has the advantages can be accessed by using various types of media, for example smart phone, laptop or PC and can be accessed anywhere and anytime. The learning structure is designed in accordance with criteria of the analysis results namely problem-based learning integrated with scientific social problems. This learning is designed to improve the students' reasoning skills and high order thinking skills through their analysis on scientific social issues that require the students to be involved in conversation activities, discussion and debate to produce solutions (Nida *et al*., 2020; Zeidler & Nicholas, 2009). Table 4 shows the learning structure designed in e-module.

Table 4. Learning Structure

PBL Syntax	Activity in E-module	Students Activity
Orient students to the problem (SSI topics)	Students are stimulated with SSI topics related to climate change material	Identifying the problems presented in e-module
Organize students for study	The students are directed to make groups and formulate problem formulations in their group	Form groups and formulate problems
Assist independent and group investigation	The students are directed to gather information from various sources to answer problem formulation that have been made	Gather information from various sources to answer the formulation of the problems
Develop and present artifacts and exhibits	The students are directed to discuss to develop problem solving solutions and present the discussion result in front of the class	Discussion to decide the best solution idea and present the discussion result in front of the class
Analyze and evaluate the	The students are directed to reflect on their learning outcomes	Reflect on learning outcomes and convey the conclusion

Third Stage: Development and Implementation

The results of the previous design stage are used as reference to develop the initial prototype at this stage, those are story boards, interface design and content which is then packaged in the form of a web-based e-module. The initial Prototype of e-module was then reviewed by some expert namely material expert, media expert and educational practitioner to determine its feasibility. Table 5 shows the results of problem-based e-module with SSI topics expert validation.

Table 5. Learning Media Prototype Validation Result

Validator	Percentage (%)	Category
Material	97.7	Very Valid
Media	88.3	Very Valid
Educational Practitioner	87	Very Valid
Mean All Aspects	91	Very Valid

The results of the review and improvement from the experts resulted in the second e-module prototype which was then tested on the students. Limited trials hold to find imperfect parts and can be revised before the implementation. The e-module trials were carried out in 3 stages, those are individual trial, small group trial and field trial. The limited trial shows that problem-based e-modules with SSI topics was practical to use in learning. Table 6 shows the recapitulation of limited trial scores on students.

Table 6. E-Module Limited Trial Result

Types of Trial	Percentage (%)	Category
Individual Trial	81.95	Very Practical
Small Group Trial	82	Very Practical
Field Trial	86.21	Very Practical
Mean	83.4	Very Practical

This stage results in the third prototype product or learning media in the form of problem-based e-module with SSI topics that is feasible to implement. The final prototype will then be implemented in accordance with the learning design that has been designed in table 4. to know how far the development of multimedia can improve integrated skills.

Fourth Stage: Evaluation

The evaluation result measured in this research is the effectiveness to improve students' argumentation skills and their responses to learning that uses problem-based e-modules with SSI topics. The effectiveness of e-module on improving argumentation skills is measured through the results of the students' answers on pretest and posttest questions that are scored according to the rubric from (Erduran *et al*., 2004) as presented in table 7.

Table 7. Dexcriptive Statistics of N-Gain Score

Class	N	x̄ *Pretest*	x̄ *Posttest*	x̄ N-Gain	Criteria
Ecology Class	36	43.06	67.50	0.46	Moderate

The average N-Gain value is 0.46 and can be categorized moderate. So it can be interpreted that the using problem-based e-module with SSI topics has a tendency to improve students' argumentation skills in the moderate effectiveness category. The main purpose of this research is to find out how learning using pbl-ssi e-module can improve students' argumentation skills. The results of analysis show that most of students have increased their argumentations level from level 1 to level 5 after implementing learning using e-module. Figure 2 presents the level of students' argumentation skills level at the beginning and end of learning.

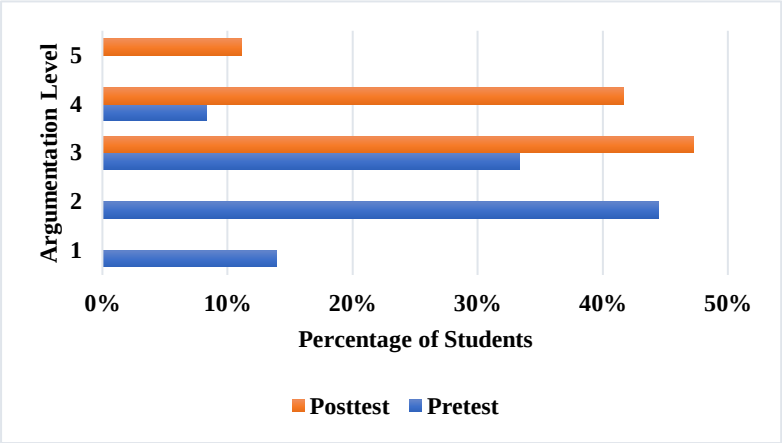

Figure 2. Students' Argumentation Level in Pretest and Post-test

The pretest results show that most of the students belong to level 2 in presenting argumentations. It means that they can submit claims by data, warrants or backing in their argumentative discourse, but they need to improve their skills in providing rebuttals. The low argumentation skills of the students can be affected by their learning environment that does not facilitate the students to express their opinions. This is relevant to this research (Lin & Mintzes, 2010) which states that students' argumentation skills improvement will be limited if not explicitly taught, strategy innovative teaching strategies and materials are important factors to support the students' argumentation skills improvement. However, the pretest results also showed that some of the students were able to reach level 4 in presenting their argumentations, meaning that those students were able to compose good arguments and accompanied by identifiable *rebuttal*.

Based on the result of the posttest, most of the students were able to improve their argumentations quality at levels 3 to 5, where most of the students belonged to level 3. This means that the students have experienced an increase in the preparation of scientific argumentation, but have not been able to compile a claim that is supported by a good rebuttal. It shows that the problem-based e-modules with SSI topics relatively effective in improving the students' argumentation skills, because they are directed to analyze and solve scientific social issues those are classified as ill-structured problem. It is relevant to this research (Dawson & Carson, 2020; Purwati *et al*., 2019) which states that learning that involves social scientific problems are able to improve the students' argumentation skills. The following are the examples of students in 5 different levels of argumentation.

Level 1: "*No, because that regulatory approval causes forest fires and air pollutions*".

Level 2:" *No, because that regulatory approval causes some negative impacts. One of the impacts is air pollution from forest fires that is intended by local community that has purpose to clear agricultural land*".

Level 3:" *In my opinion the government has made the wrong decision because with the publicity of that regulatory the forest fires/land that has purpose to clear agricultural land is justified. So indirectly the government*

justifies the happening of air pollutions that disturb the society activity and cause acute respiratory infections (ARI) to the citizens".

Level 4:" *No, because based on the investigation result it shows that most of the forest fires in Kalimantan is caused by human activities. It can be said that the regulatory approval indirectly allows the society to burn the land to clear the land. Based on the investigation report, in 2019 there was forest fire that is caused by land clearance activity which results ± 94,26 hectares of burnt land, 4.000 citizens got acute respiratory infections, and some public activities had to be stopped due to the haze. Therefore, that regulation approval doesn't prosper with the community but instead harms the community in various aspects*"

Level 5:" *In my point of view the government decision is not correct, because that regulatory indirectly justifies society activity to burn the forest for individual interests. Based on the investigation report, the forest fires almost happen every year in the dry season that is caused by human activity, it shows that there is no relevant regulation yet in that regulatory implementation. The regulation has been made only on how large is the land that might be burned and the conditions that will be fulfilled. But, in that implementation there are some societies that are not follow the rules and burn the forest. The illegal forest fires along 2019 had been reported happened in Kalimantan caused by human activities, That will cause losses in various aspects such as education, health and society economic. So that, that regulation needs to be reviewed so that people's welfare can be optimized*"

This research focuses on the improvement of students' argumentation skills using the problem-based e-modules with SSI topics. The research result showed that the application of problem-based e-modules with SSI topics had a moderate category effect on improving the students' argumentation skills with an N-Gain value of 0.46, which is shown in table 7. In other words, the students who use the problem-based e-modules with SSI topics experience in their argumentation skills. The result of this research is relevant to the research (Dawson & Carson, 2017, 2020) which shows that the topic about environment pollution can improve students' argumentation skills. The problem-based e-modules with SSI topics has a great contribution to empower argumentation skills on ach learning stage. The students triggered to carry out learning activities and construct the knowledge during the learning process.

The learning process of PBL directs the students to solve the problems through meaningful and contextual scientific methods, so that the students can learn the knowledge relate to that problem independently by learning in groups and have skills to solve the problems. Group discussion activities in the problem solving process are able to stimulate the students to express their arguments, accompanied by valid information and evidence relate to the problems presented, so that PBL learning model is believed to be able to improve argumentation skills (Purwati *et al*., 2019; Rohayati *et al.*, 2020).

PBL steps trigger the students to find solutions by developing their argumentation skills in group discussions. At the problem orientation stage, the students are faced by scientific-social issues that trigger them to come up with solutive ideas for problems that are *claims.* The use of SSI that are classified as (*ill-structured problem*) can stimulate students to think more deeply and encourage the students to consider a variety of different perspectives when determining problem-solving ideas (Malogianni *et al*., 2021). SSI used as triggers in learning can stimulate students to identify the claims that required scientific and moral justification by using scientific data as evidence (Zeidler & Nicholas, 2009).

At the stage of organizing students to learn, the students are formed into some small groups to discuss with their friends in group. This stage can train students to construct knowledge from SSI topics that are presented through literature study activities or direct observation. The use of SSI in learning can increase the active participations of the students during learning using PBL based e-module (Demiral & Çepni, 2018). The students are motivated to identify socially accepted claims critically, then strengthen them with supporting ideas (*warrant*) or refute them by giving *evidence* (Braund *et al.*, 2013).

Furthermore, at the independent or group investigation stage, the students are directed to apply the knowledge or information that has been collected previously in terms of evaluating and analyzing several choices of problem solving ideas (Fitriani *et al*., 2020). Discussion and analysis activities in this group are able to stimulate the students to collect the evidences (*data*) and reasons (*warrant*) as hypotheses or temporary answers to answer the formulation of the problem earlier (Purwati *et al*., 2019).

The next activity in e-module is developing and presenting work. Developing work through literature studies or direct experiments can help the students to build knowledge and improve negotiations among the group members. The evidence in the form of data and reason (*warrant*) for findings will be used to support (*backing*) claim, so that at the end the learners can determine one of the most likely problem-solving solutions (Novita *et al*., 2022) by analyzing pros and cons, assessing the risks and benefits that require scientific considerations of , moral and ethic (Nida *et al*., 2020).

The next activity is the presentation of the results of the work, in which the students present their works in the form of problem solutions in front of the class. This activity can increase the rebuttal indicator because during the presentation of the results, they have experienced cognitive conflict in group discussion. This is because during the presentation of the results, the students will be faced with various claims in which they are asked to show scientific evidence and alternative reasons to refute the claims submitted by the other groups (Purwati *et al*., 2019).

The last activity in e-module is analyzing and evaluating problem solving process. This activity can train the students' claims indicator through evaluation activity and self-reflection at the end of learning. The evaluations that is submitted by the educators relate to some problem solving ideas that is submitted by the students to add the students' insight relate to decision-making considerations when determining problem solving solutions. At this stage a claim appears in the form of conclusion or decision (Kim *et al.*, 2015). The claim that appears at the final stage is actual claim because it has been supported by correct and logical data, justification (*warrant*), support (*backing*) an reason (*rebuttal*) to solve the problems (Purwati *et al.*, 2019).

All the steps of PBL learning involve the students in meaningful, relevant, and contextual problem-solving process. The development of group learning activities using SSI as requirement that is needed to improve the students' argumentation skills (Purwati *et al*., 2019). The group learning process allows the students to build new knowledge through discussion and evaluation of solutions which can ultimately improve their argumentative quality (Torres & Cristancho, 2018).

4. CONCLUSION

Problem-based e-module with SSI topics can improve the students' argumentation skills in moderate category. The PBL syntax which is integrated in e-module provide the students to build an understanding of factual concepts in constructing claim, discussing to collect some information and evaluating solutions to construct complex arguments. Further research can be carried out by measuring different skills such as problem-solving skills, scientific literacy, environmental literacy, collaboration skills, concepts mastery, and creative thinking skills.

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