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Improving evidence-based argumentation on socioscientific issues through problem-based learning in science students

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A R T I C L E   I N F O

A B S T R A C T

In the scientific education, improving the argumentation skills in socioscientific issues was very important to educate young people as an active society. The aim of this research was to evaluate the implementation impact of problem based learning to the students skils of evidence based argumentation of socioscientific issues.Total of 21 students of Grade XII MIPA of senior high school at surakarta city were used as the sample in the learning process with biotechnology topic. The times taken for the learning activity were 4 week with 4 times of class meeting every week. Pre-test and post-test were applied to 21 students in order to measure of students skills in constructing the argument of socioscientific issues. . The differences between pre-test and post-test scores for each aspects of evidence-based argument, in sequence, are as follows: 61,11 and 92,06 for claims; 30,16 and 84,13 for evidence; and 28,97 and 78,17 for connection claim to evidence. Statistically test for Wilcoxon rank test score for evidence based argument resulted p-value (0,00) which was < 0,05. This means that score of evidence based argument was improved significantly. In the case of qualitative data used, observation during learning process, learning transcipt, result of students works within learning activity as well as interview activity showed that PBL learning had improved the skill of evidence-based argument of science students.

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INTRODUCTION

The era of Society 5.0 was marked by the Internet of things (IoT), bigdata, artificial intelligence, the robotics and blockchain (Alvarez-Cedillo et al., 2019). The direction of Education in Era Society 5.0 is carried out by applying innovative learning models in schools (Tias, 2022). Scientific arguments are needed in the era of Society 5.0 through debate methods that want the audience to believe (Fahy, 2008). Argumentation activities are important for constructing knowledge in science. Argumentation can be used to encourage scientific literacy by understanding, interpreting, and inferring the meaning of texts, speeches, and other representations to construct new interpretations through argumentation. The integration of scientific knowledge into social issues in society is a complex process (Cavagnetto, 2010). Social issues in society can be raised as learning topics. Learning that uses socioscientific issues approach in learning activities by involving students in developing and developing arguments about problems in society (Owens et al., 2017).

Socioscientific issues (SSI) are complex problems that are ill-structured that do not have a definite solution and are issues that involve interaction between scientific knowledge, social and cultural (Cebesoy & Oztekin, 2017; Han-Tosunoglu & Ozer, 2022; Herman et al., 2022). Issues that can be used in SSI are actual issues from biotechnology and environmental application problems such as cloning, climate change, pollution, genetic engineering, genetically modified foods and evolution (Kara, 2012; Sadler & Donnelly, 2006). Learning through SSI causes students to become critical members of society by compiling arguments about the application of science and its implications in social life involving economic, ethical, social, political, tecnological and values considerations (Albe, 2008). SSI supports students to develop argumentation skills which are an important component of scientific literacy by involving students in making decisions, analyzing, synthesizing and evaluating data and information sources to solve multi-perspective problems (Zeidler et al., 2019).

Evidence based argument is a skill of student to make argument with claim supported by evidence (Belland, 2010). Evidence-based Argument component consists of claims; evidence; and the relationship between claims and evidence (Berland & McNeill, 2010). According to McNeill and Martin (2011), a claim is a statement that answers a problem or question, evidence is data that supports a claim, the relationship between claims and evidence is an explanation of why and how the evidence supports the claim (McNeill & Martin, 2011). The argument of students can consist the rebuttal, the students make an alternative claim and provides counterevidence. Evidence-based arguments can be trained, one of which is by using the Problem Based Learning (PBL) learning model (Belland et al., 2011).

PBL processes of learning facilitate students as a problem solver that need deep reasoning of argumentation, metacognition, critical thinking, system thinking and engaging in collaborative learning with peer interaction, also PBL can apply theories of constructivists by Piaget and Vygotsky (Tan, 2003). PBL can be applied in schools by using problems in everyday life, activating student involvement in learning, students can actively make various choices, and invite students to collaborate. PBL has four stage, namely: (1) Meeting the problem; (2) Problem analysis and learning issues; (3) discovery and reporting; (4) Solution presentation and evaluating (Tan, 2003). So, the purpose of this study was used to test whether there were differences in the quality of evidence based argumentation after implementing the PBL learning model.

METHODS
Research Design

The method used in this research is mixed methods research by combining qualitative and quantitative approaches. Quantitative methods are used to measure differences in the dependent variable, namely argumentation skills through pre-test and post-test assessment instruments. Meanwhile, the qualitative method is used to describe descriptively

argumentation skills during learning through observations and interviews. Therefore, the results of research using mixed methods are expected to obtain a more detailed explanation than using only one method (Ary et al., 2010). This study mix methods using a concurrent embedded strategy provide integrated information that can support the discussion of the studies conducted (Creswell, 2009).

Population and Samples

The population used in the study were class XII MIPA students that consist nine class. Biotechnology learning in high school in the 2013 curriculum is given to class XII MIPA students. The sampling technique for this mixed methods study was stratified purposeful sampling technique (Creswell, 2009). Based on analysis of daily tests, observations and interviews with biology teachers, class XI MIPA 1 was chosen as a research subject to implement PBL learning with socioscientific issues.

Instrument

Quantitative data using pre-test and post-test to assess evidence-based argument data statisticaly after the implementation PBL learning. Quantitative data supported by qualitative data using the results of student worksheets, class observations, and learning transcripts during the implementation of the study to asses the argumentation quality os students.

Procedure

Pre-research carried out an analysis of the needs of students and teachers in learning through observing teaching and learning activities, analyzing teaching materials, providing questionnaires of student needs and in-depth interviews with teachers. The needs analysis results show that argumentation skills are low (students just said claim without evidence) and teaching materials do not support students' argumentation skills (students just used one text book).

The stages of the research used PBL learning with socioscientific issues in biotechnology topic. A pre-test is carried out before the implementation of PBL learning. The times taken for the learning activity were 4 week with 4 times of class meeting every week. The First step of PBL learning was meeting the problem. The teacher facilitated student to analysis problem of cloning pet such as a dog. LKPD (Lembar Kerja Peserta Didik) is work sheet that student used to give expression of their evidence-based argument. LKPD contain issue cloning pet from https://www.dailymail.co.uk/news/article-2141574/First-couple-clone-pet-dog-paid-155-000-job-say-new-pup-mannerisms-dead-Labrador.html.
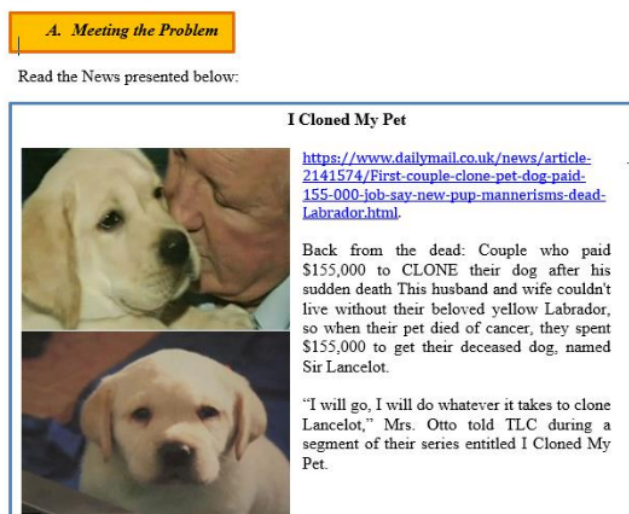

Figure 1. Student's Worksheet about Cloning

The second stage is Problem Analysis and Learning Issues, in this step student made a problem question and hypothesis about cloning pets. The third stage is discovery and reporting, this stage encourages students to collect and compile information that can support the solution of the problems presented. At this stage students actively exchange information obtained to develop solutions in one group. The last stage of the PBL syntax is solution presentation and evaluating. At this stage, each group of students communicates problem statements, hypotheses, and solutions made. At this stage students make presentations to explain and justify the solutions made with other group students. At this stage students compile information on the role of biotechnology in solving each given case

During the lesson, observation and formative tests were carried out to measure students' argumentation skills. Formative tests use of open-ended questions about SSI to analysis quality of the argumentation in students work after learning section, a post-test was carried out to analaysis a difference argumentation skills after treatment PBL learning.

Data Analysis Technique

Data analysis was carried out using statistical methods with the SPSS test. The data obtained from the students' argumentation skills were not normally distributed on the post-test results so they were selected using the non-parametric Wilcoxon Signed Rank Test (Lee et al., 2016). The hypothesis in this study is:

H0 = There is no difference in students' argumentation skills after implementing the PBL model
H1 = There are differences in students' argumentation skills after implementing the PBL model

Based on the hypothesis test, if the P-value is less than 0.05, the null hypothesis is rejected, which means that there are differences in students' argumentation skills after applying the PBL model. While descriptive data analysis is used to describe descriptively the quality of student argumentation structures made by students during learning

RESULTS AND DISCUSSION

Learning process of biotechnology used PBL. Before and after the learning process, tests were carried out, namely Pre-test and post-test. The result showed in Figure 1.
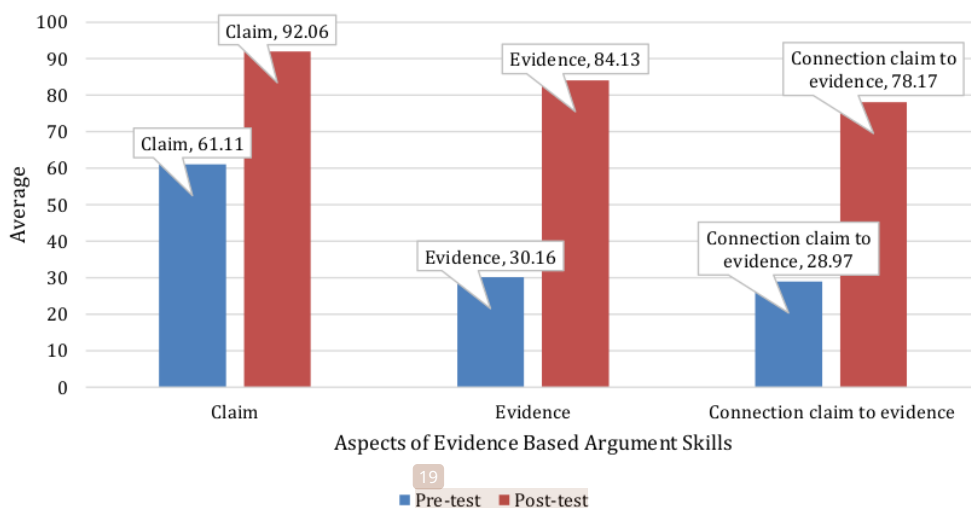
Figure 2. Pre-test ad Post-test Evidence Based Argumentation Skill

The result of pretest and posttest showed that aspect claim, evidence and connection claim to evidence were increased significantly. The claim aspect has an increase in value of 30.95, which means that students have been able to make statements that are appropriate to the problem and statements are correct and complete. Claims are an important aspect because of claim is a decision made to answer socioscientific issues that are uncertainly and ill-structured (Foong & Daniel, 2010).

The evidence aspect has an increase in value of 53.97, this significant increase is due to the pretest students only making arguments without being supported by data or information used as evidence. Relevant evidence is directly connected to the claim and supports the claim (Macagno, 2016). Evidence is a data that supports claims, evidence obtained by students comes from direct investigations, research that has been conducted, or books that provide data (McNeill & Martin, 2011). Interpretation of data from scientific information or scientific investigations carried out by students varies, so students build their own arguments according to their thoughts and perspectives.

The connection claim to evidence has an increase in value 49,2. The relationship between claims and evidence is to explain "why" and "how" evidence supports claims (Belland, 2010). The connection claim to evidence is very important in scientific literacy because to build a logical argument to representations and drawing appropriate scientific conclusions (OECD, 2019).

Furthermore, pretest and post-test were tested by the normality test. The results showed that the post-test results were not normally distributed. Normality test results are presented in table 1.

Table 1.
Normality Test

		P-Value	Result	
			Description	Decision
evidence-based	Pre-test	0,150	P-value> 0,05	normally distributed
arguments score	Post-test	0,016	P-value<0,05	not normally distributed

Post-test were not normally distributed, so the analysis data used nonparametric statistic. The nonparametric statistic used Wilcoxon Signed Rank Test. Wilcoxon Signed Rank Test is presented in Table 2.

Table 2.
Wilcoxon Statitic

Sample	N for Test	Wilcoxon Statistic	P-Value
Postes-pretes	21	231,00	0,000

Statistically test for Wilcoxon rank test score for evidence-based argument resulted p-value (0,00) which was < 0,05. This means that score of evidence-based argument was improved significantly because of PBL learning. Based on the results of statistical tests, it shows that the application of the PBL learning model that provides socioscientific cases can make a positive difference to students' abilities to interpret knowledge about socioscientific problems by building evidence-based arguments.

Argumentation of students are presented as follows:

Student A: The scientist and Mr. Otto did cloning (CLAIM), by taking Lancelot somatic cells and other dog eggs and then taking the nucleus of the egg cells and replacing them with Lancelot somatic cells (EVIDENCE), then putting them into a surrogate mother, so that later

their properties were exactly the same with Lancelot via retrieved somatic cells (LINK CLAIM TO EVIDENCE).
Student B: Cloning Lancelot's dog, I don't think it is necessary (CLAIM), living things must live and eventually die (EVIDENCE), so Mr. Otto can accept the death of his beloved dog (LINK CLAIM TO EVIDENCE). Mr. Otto can look for a new dog while there are still many healthy abandoned dogs but just need to be trained (ALTERNATIVE ARGUMENT).

From the sample responses student show that 1) in aspect claim, student can make assertion that is related to the problem, clear and complete; 2) in aspect evidence, student provide evidence in their claim and the evidence is clear and 3) in the link claim to evidence make the relevant relationship between evidence and claim clearly. Student also give alternative argument to support alternative solutions. This qualitative data supports the quantitative data which shows that the quality of argumentation has also increased as seen from the worksheets done by students during the implementation of PBL with socioscientific issues.

The results of the study are supported by research by Belland (2010) that the stages of PBL learning can have a significant influence on students' argument scores through defining problems, determining required information, seeking information, organizing information, developing claims, and linking claims with evidence. Training Students in evidence-based argumentation need to fix literacy science because of Indonesian Lowest Ranking in PISA. PISA provide an assessment of the competence of interpreting data and evidence on students' scientific literacy tests by analyzing and evaluating scientific data, claims and arguments (OECD, 2013).

PBL learning is proven to be able to practice evidence-based argument skills by presenting problems, discussing them, and answering problems with various points of view. Karl Popper (1992) (in Tan, 2003) said that a school can bring young people learn by stimulated with problem and discuss them, not study for passing exam goals. In the future research, PBL can be applied for various biology learning material, not only biotechnology. Teacher can bring student with daily life problem of student, discuss with them, answer the problem and make the solution in classroom.

CONCLUSION

PBL-based learning can be used as an alternative to help students improve evidence-based argument skills seen from significant statistical results. In all three aspects of evidence-based argument, namely claims, evidence, connection claims to evidence, there has been a significant increase. The quality of students' arguments after implementing PBL supported by LKPD (Student worksheet) can be seen from the students' explanations which consist of claim, evidence, link claim to the evidence and can also include alternative arguments. In future research, it can be studied about argumentation skills on socioscientific issues in other biology learning topics such as climate change, pollution, evolution, and deforestation.

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