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Problem-Based Learning versus STAD Leaning Model for Improving Students' Argumentation Skills in Thermochemistry

Frida Kristining Tyas[1], I Wayan Dasna[1,*], Anugerah Ricky Wijaya[1], & Istri Setyowati[2]

[1]Department of Chemical Education, Malang State University, Indonesia

[2]SMA Laboratorium Malang, Indonesia

Abstract: This study investigates whether the use of the Problem-Based Learning (PBL) model and Cooperative learning STAD can improve argumentation skills in the thermochemistry chapter. The research sample is 72 grade 11 high school students. The research design was quasi-experimental with a pretest-posttest control group design. The results of the study: (1) there was no difference in initial ability between the PBL and CL STAD classes with a significance value of > 0.00; (2) there are differences in argumentation skills between PBL and CL STAD classes with a significance value <0.00; (3) the PBL model N-Gain test was 60.50% in the "quite effective" category and CL STAD was 41.97% in the "less effective" category. Therefore, the PBL model is more effective in improving students' argumentation skills.

Keywords: problem based learning, STAD learning model, argumentation skills, thermochemistry.

Abstrak: *Penelitian ini menyelidiki apakah penggunaan model Problem-Based Learning dan pembelajaran kooperatif tipe STAD dapat meningkatkan keterampilan argumentasi pada topik termokimia. Sampel penelitian yaitu 72 siswa kelas 11 SMA. Rancangan penelitian adalah quasi experimental dengan jenis penelitian pretes-posttest control group design. Hasil penelitian: (1) tidak ada perbedaan kemampuan awal antara kelas PBL dan CL STAD dengan nilai signifikansi > 0,00; (2) terdapat perbedaan keterampilan argumentasi antara kelas PBL dan CL STAD dengan nilai signifikansi < 0,00; (3) uji N-Gain model PBL sebesar 60,50% dengan kategori "cukup efektif" dan CL STAD sebesar 41,97% dengan kategori "kurang efektif". Oleh karena itu, model PBL lebih efektif dalam meningkatkan dalam keterampilan argumentasi siswa.*

Kata kunci: *pembelajaran berbasis masalah, model pembelajaran STAD, keterampilan argumentasi, termokimia.*

▪ INTRODUCTION

Science is a form of publication of new knowledge by scientists which involves criticism and argument. Science learning no longer gives birth to scientific concepts only, but also learns how to involve argumentation skills in it (Kuhn, 2010). Argumentation is an important aspect of science education that promotes learning science content and provides a strong foundation for understanding a concept of learning material completely and correctly. Argumentation includes the process of strengthening claims through critical thinking using lots of relevant and specific justifications to support claims with accurate conceptual evidence and logical reasoning (Hasnunidah 2020).

Indonesia has argumentation skills at level 1 which are included in the low category (Jumadi, 2021). Level 1 in the argumentation skills indicator states that students are only able to make simple claims and are unable to provide appropriate

I Wayan Dasna
*Email: idasna@um.ac.id

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concepts to support these claims (Ain et al., 2018). Weak arguments are shown by unscientific, inaccurate, and non-specific considerations (Lazarou & Sutherland, 2017). The ability to convey information, experiences, concepts, principles, or generalizations into discourse is determined by a person's ability with language and his ability to argue (Alqahtani, 2016). The use of scientific argumentation activities can strengthen conceptual understanding, enabling students to obtain new ideas that can broaden knowledge and eliminate misunderstandings (Kuhn, 2015). Argumentation skills also teach the mindset needed by students in the 21st century, where students are expected to be able to make claims that are supported by data and scientific concepts as backups (McNeill & Krajcik, 2008).

One of the learning models that supports students' activeness in arguing is the Problem-Based Learning (PBL) model. PBL is an active learning approach where problems serve as a driving force for learning. Another advantage of the PBL model is that it generates ideas and encourages students to argue about the particular problem being discussed. During the learning process with the PBL method, students define and analyze problems, identify and seek necessary information, share the results of their investigations and work together to actively formulate, and evaluate possible solutions (Barrows & Tamblyn, 1980). The selection of the PBL learning model is also supported by the 2013 Chemistry Curriculum learning which applies when research is carried out, which places more emphasis on a scientific process/work skills approach which includes finding problems, gathering facts related to problems, making assumptions, making observations/experiments, making inferences. predict, collect, and process observational/measurement data, as well as conclude and communicate. So that a problem-based learning model can be used to fulfill the syllabus achievement of the 2013 curriculum (Ministry of Education and Culture, 2017).

PBL has the characteristics of student-centered learning because students assume primary responsibility for their learning and the teacher acts as a facilitator or guide (Barrows, 1986). The PBL model is suitable because students can solve structured problems in small groups and present arguments to support solutions (Jumadi, 2021). According to Arends (2008), the syntax for the PBL model has learning stages consisting of 5 stages, starting with the teacher introducing students to a problem and then ending with the presentation and analysis results. The five stages include: (1) student orientation towards problems; (2) Organizing students to study; (3) Guiding individual and group investigations; (4) Developing and presenting works; (5) Analysis and evaluation of the problem-solving process.

Research on the influence of PBL on argumentation skills was conducted by Pritasari (2015) and Jumadi (2020). Pritasari (2015) in his research on increasing argumentation skills through PBL on environmental/climate change and waste recycling stated that the research results showed an increase in the ability of each aspect of argumentation in each cycle. Jumadi (2021) in his research on the impact of PBL using argument mapping and online laboratories for argumentation skills, states that PBL is able to spur students in claim, data, warrant, backing, and rebuttal skills in scientific argumentation skills. PBL has proven to be effective for teaching scientific argumentation skills. In this study, the same thing was done, namely the application of the PBL learning model to argumentation skills by comparing it with other learning models, namely the cooperative learning model. In Pritasari's study (2015) only used

one class so that this study was developed into a quantitative study with experimental procedures and a control class. The control class can further prove the influence of the independent variable on the dependent variable because of the comparison of the results between the two classes used. This research is also conducted offline and adjusts students' abilities needed in the 21st century, namely 4C (critical thinking, creative, collaboration, and communication).

The PBL learning model has one characteristic, namely collaboration. Like cooperative learning, problem-based learning is characterized by students working with one another, most often in pairs or small groups. Working together in groups aims to motivate each other in doing problem-solving tasks and improve communication to carry out investigations together, as well as to develop social skills (Arends, 2008). Therefore, in this research, the cooperative learning model was used as a comparison. The Cooperative Learning learning model has four approaches, such as STAD, Jigsaw, investigative group, and structural approach. Cooperative Learning with the STAD (Student Teams-Achievement Divisions) approach was chosen in this study because it has a syntax that is almost the same as the PBL learning model.

STAD is cooperative learning that is easily applied to science learning (Slavin, 2005) and can improve learning achievement in science learning (Okebukola & Ogunniyi, 1984). STAD is the most widely applied cooperative learning and is the best method for beginners for teachers who are new to using a cooperative approach. Cooperative learning STAD has five main components, namely class presentations, teams, quizzes, individual progress scores, and team recognition (Slavin, 2005). Based on the facts above, this research is expected to be able to determine the effectiveness of the PBL learning model and Cooperative learning STAD on argumentation skills. This can be known by conducting this research.

Research Question

The formulation of the problem in research that the research wants to be answered is as follows: (1) Are there differences in the initial abilities of students between classes that are taught and Problem-Based learning (PBL) with classes that are learned with cooperative learning STAD? (2) What is the difference in argumentation skills between classes that are taught and Problem-Based learning with classes that are learned with cooperative learning STAD in learning thermochemistry for class XI? (3) how is the effectiveness of the Problem-Based learning (PBL) and cooperative learning STAD models on students' argumentation skills?

▪ METHOD

The population in this study were all students of class XI MIPA consisting of XI MIPA 1 - XI MIPA 6 at SMA Lab Malang. The sampling technique used cluster random sampling technique, obtained class XI MIPA 2 as the PBL class and class XI MIPA 3 as the cooperative learning STAD class. Each class consists of 36 students. The sampling technique uses cluster random sampling with the assumption that all students have the same initial ability as one another. The cluster random sampling technique was used because the samples analyzed were in the form of classes or groups, not individuals, so it was hoped that the researchers would give equal rights to each student to have the opportunity to become a sample (Arikunto, 2012).

Research Design and Procedures

This study used an experimental method with a quantitative approach. The research design used in this study was a quasi-experimental design with a pretest-posttest control group research type. Quasi-experimental design is a research design in which the control group and experimental group are not randomly selected (Sugiyono, 2017). The research design used two classes, namely the PBL class and the cooperative learning STAD class. The pretest is given before learning is carried out. The five stages of the PBL model are explained as follows: (1) student orientation towards problems; (2) Organizing students to study; (3) Guiding individual and group investigations; (4) Develop and present work; (5) Analysis and evaluation of the problem solving process. The six stages of Cooperative learning STAD are explained as follows: (1) Delivering goals and motivating students; (2) Presenting/delivering information; (3) Organizing students in study groups; (4) Guiding work and study groups; (5) Evaluation; (6) Giving awards. The posttest is given after the learning is carried out. Research and data collection were carried out at SMA Laboratory UM class XI MIPA 2 and MIPA 3 odd semesters in September - October for the 2022/2023 school year. The research was carried out on the topic of thermochemistry with ten meetings consisting of eight lessons and two tests.

Instruments

The research instruments used consisted of treatment instruments and measurement instruments. The treatment instruments include syllabus, lesson plans, worksheets, and learning media such as power points and chemistry modules. The treatment instrument was tested for validity beforehand on two chemistry lecturers and one chemistry teacher. The measurement instruments include tests of argumentation skills that are tested before and after learning. A test is an information-gathering tool that is more official when compared to other information-gathering tools (Arikunto, 2012). So that in this study using the test as a measurement instrument to determine the level of student argumentation skills. The test questions consist of 15 questions that have been validated by experts and empirical validation. Based on the results of expert validity calculations, a percentage of 94.6% was obtained with a very high category. Based on the results of empirical validity, all questions are considered valid and a reliability result of 0.722 is obtained with a very high category.

Data Analysis

The quality of argumentation can be analyzed using several methods, one of which is Toulmin's Argument Pattern (TAP). TAP is an analytical framework developed by Toulmin. Cetin (2014) developed TAP from Toluin in knowing the quality of argumentation which can be seen in Table 1 below.

Table 1. An analytical framework for argumentation quality, Cetin (2014) modification

Category	Score	Description
Level 1	1	Arguments containing a simple claim
Level 2	2	Arguments that contain claims and warrant
		Arguments that contain claims and backing
		Arguments that contain claims and data

Level 3	3	Arguments that contain claims, data, and warrant
		Arguments that contain claims, data, and backing
		Arguments that contain claims, warrant, and backing
		Arguments that contain data, warrant, and backing
Level 4	4	Arguments that contain claims, data, warrant, and backing

N-gain is used to determine the effectiveness of using the learning model. Hake in Hastiana (2021) states that if N-Gain ≥ 0.7 is classified as high, 0.3 ≤ N-Gain < 0.7 is classified as moderate, and N-Gain < 0.3 is classified as low. The categorization of the interpretation of the effectiveness of N-Gain is also carried out in the form of a percentage (%), namely N-Gain <40% is in the Ineffective category, 40% - 55% Less Effective, 56% - 75% Quite Effective, and N-Gain > 76 % Effective.

▪ RESULT AND DISSCUSSION

Argumentation skills were analyzed based on students' answers to 15 posttest questions given after students studied Thermochemistry through Problem-Based Learning (PBL) and Cooperative learning STAD. The level of argumentation skills uses categories adopted from Cetin's (2014) modifications as shown in Table 1, namely by giving a score of 1 to 4. The argumentation skills test is presented in multiple-choice form where students choose a claim according to the questions presented then choose reasons by three choices are presented where each choice can categorize the level of argumentation skills. Argumentation skills are categorized at level 1 if students choose answers but do not choose reasons or choose reasons but the answers chosen are wrong. Students who answer at level 1 may not be able to make claims related to data, warrants, and backing and may not understand the material concepts described in this phenomenon. This resulted in students not being able to complete the argumentation component so their argumentation skills were at level 1.

Argumentation skills are categorized at level 2 if the answers consist of claim and data components. Argumentation skills are categorized at level 2 if the student chooses the answer to the claim correctly and chooses a reason that includes a data component. The data attached is the facts contained in the phenomenon. Students who answer at level 2 may not be able to make reasons to justify the relationship between data and claims (Tippet, 2009). Argumentation skills are categorized at level 3 if the answers consist of claims, data, and warrant components. An example of level 3 argumentation skills can be seen in Figure 1.

The use of LPG gas (C4H10), which is part of the meaning of natural gas, is often used intensively. LPG gas used on gas stoves mainly uses the reaction between butane and air. Non-subsidized LPG gas cylinders used in households generally contain 12 kg. LPG contains the compound butane (C4H10) which has a heat of combustion of 2600 Kj/mol. If a family normally requires 20,000 kJ/ day to cook with LPG, then the cylinder must be refilled after .... days (Ar C = 12 g/mol, Ar H = 1 g/mol, 1Kg = 1000 grams)

Answer

A. 30 days
B. 27 days **(claim)**
C. 24 days
D. 18 days

Alasan:

I	Combustion of 1 mole of butane produces 2600 Kj/mol of heat. The total energy in the LPG gas cylinder is calculated by multiplying the enthalpy of combustion and the total moles of butane in the LPG gas cylinder. From the results of the total energy calculation, it can be seen that the energy will last up to how many days of use divided by the number of uses per day. **(data, warrant)**
II	1 mole of butane produces heat energy of 2600 Kj/mol. The total energy of butane in the LPG cylinder is calculated by multiplying □H and the total moles of butane in the 12 Kg LPG cylinder. The greater the concentration of butane, the greater the energy it will produce. The total energy is then divided by the number of uses per day so that the gas cylinder will last for how many days. **(data, warrant, backing)**
III	The enthalpy change for 1 mole of burning butane is 2600 Kj/mol. The total energy in the LPG gas cylinder is calculated by multiplying the enthalpy of combustion by the moles of butane in the cylinder. **(data)**

Figure 1. Level 3 argumentation skills

Argumentation skills are categorized at level 3 if students choose answers to claims correctly and choose reasons that contain data and warrants as shown in Figure 1. Students who answer at level 3 can make reasons to justify the relationship between data and claims. Students are also able to understand the principles that apply as reasons to justify the relationship between data and claims. Argumentation skills are categorized at level 4 if the answers consist of claims, data, warrants, and backing components. Argumentation skills are categorized at level 4 if the student chooses the correct claim answer and chooses reasons that contain data, warrants, and backing. Students who answered at level 4 were able to make reasons to justify the relationship between data and claims. Students are also able to understand the principles that apply as reasons to justify the relationship between data and claims. Students are also able to include additional information, facts, or theories that support reasons or can justify warrants (Tippet, 2009).

The initial ability of students in this study can be seen from the results of the average pre-test scores listed in Table 4 below.

Table 4. Initial ability analysis data

Class	N	Min	Max	Mean	Std. Deviation
Pretest PBL	36	36.7	68.3	51.89	7.77
Pretest CT STAD	36	40.0	65.0	51.53	7.43

The average results of the pre-test argumentation skills of the Problem-Based Learning (PBL) and Cooperative Learning STAD classes were 51.89 and 51.53. The average value of the pre-test stated that the student's initial abilities were not much different. Students' initial abilities can also be seen from the results of the Mann-Whitney test in Table 5 below.

Table 5. Argumentation skills early test

	α	Sig.	Conclusion
Argumentation skills	0.05	0.804	There is no difference between the pretest scores for Problem-Based Learning (PBL) and Cooperative Learning STAD classes

Table 5 shows the results of the initial ability of argumentation skills with a significance result above 0.05 indicating that students' initial abilities of argumentation skills are the same. The absence of differences in students' initial abilities stated that the Problem-Based Learning (PBL) and Cooperative Learning STAD classes used in the study had equivalent initial abilities so that the results of argumentation skills and students' chemical literacy abilities could be recognized as influences from the learning model applied. It is necessary to know the initial abilities of students from the Problem-Based Learning (PBL) and Cooperative learning STAD classes to avoid other influences other than the treatment or learning model applied. The initial abilities of the students from the Problem-Based Learning (PBL) and Cooperative learning STAD classes showed that they had the same knowledge before being given treatment. Both classes are considered to have the same readiness in receiving treatment in research. This is also shown based on the results of the pretest, where the level of argumentation skills at each level is almost the same. The level of argumentation skills from the pretest results can be seen in Figure 2 below.

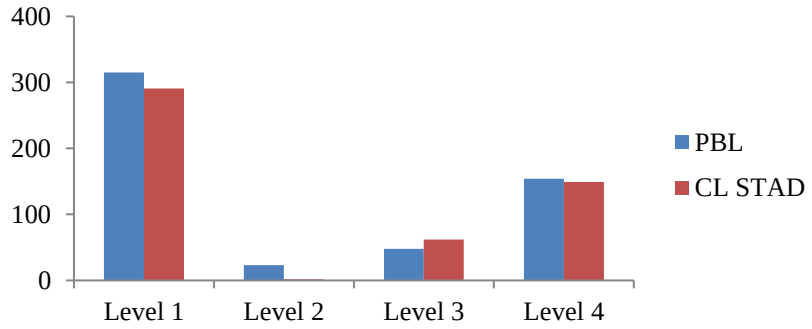

Figure 2. Level of students' argumentation skills based on prettest results

The results of the posttest analysis of argumentation skills in the Problem-Based Learning (PBL) and Cooperative Learning STAD classes can be seen in Table 6.

Table 6. Data analysis posttest argumentation skills

Class	N	Min	Max	Mean	Std. Deviation
Posttest PBL	36	61.7	95.0	81.02	8.36
Posttest CT STAD	36	50.0	80.0	72.88	5.88

Table 6. states that the average value of the argumentation skills of the Problem-Based Learning (PBL) class is 81.02 and the average value of the argumentation skills of the Cooperative learning STAD class is 72.88. The differences in argumentation skills are also shown through the distribution of argumentation skill levels in Figure 3 below.

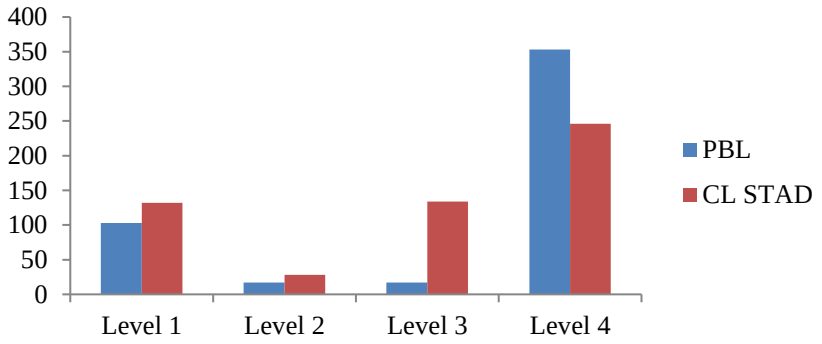

Figure 3. Level of students' argumentation skills based on posttest results

Figure 3 shows the Problem-Based Learning (PBL) class occupies a higher level 4 line so that it can be concluded that the Problem-Based Learning (PBL) class has better argumentation skills than the Cooperative learning STAD class. With problem-based learning, students' argumentation abilities increase because this model helps the thinking process and motivates students to be more courageous in conveying their arguments. Students also have to connect learning concepts with the problems given (Anggraini, 2013).

A hypothesis test using IBM SPSS Statistics 22 for Windows was carried out to prove whether it is true that the Problem-Based Learning (PBL) class has better argumentation skills than the Cooperative Learning STAD class. The statistical test results can be seen in Table 7 below.

Table 7. Posttest difference test of argumentation skills

Ability	α	Sig.	Criteria	Conclusion
Argumentation skills	0.05	0.000	α >Sig.	There is a difference between the posttest scores of the PBL class and the CL STAD class

The statistical test results in Table 7 show that a significance value of 0.00 <0.05 is obtained. This suggests that there are differences between the posttest argumentation skills between the two classes. The test results are also strengthened by testing the effect of independent variables on argumentation skills and testing effectiveness through the N-Gain Score. The test of the effect of the independent variables on the argumentation skills of the Problem-Based Learning (PBL) class and the Cooperative Learning STAD class is shown in Table 8.

Table 8. Test the effect of independent variables on argumentation skills of pbl and cl stad classes

Class	Sig.	Criteria	Conclusion
PBL	0.000	α >Sig.	there is a difference in the pretest-posttest average, so there is an effect of using Problem-Based Learning (PBL) strategies on argumentation skills

CL STAD	0.000	α >Sig.	There is a difference in the pretest-posttest average, so there is no effect of using the Cooperative learning STAD strategy on argumentation skills

The test results of the effect of the independent variables on argumentation skills in the two classes show that the significance value is 0.00 <0.05. This states that there is a difference in the pretest-posttest average, so there is an influence on the use of the learning model used in the Problem-Based Learning (PBL) class and the Cooperative learning STAD class. Testing the effectiveness of the learning model is carried out through the N-Gain Score test shown in Table 9.

Table 9. Test the effectiveness of independent variables on argumentation skills

Class	N-Gain	%	Criteria	Conclusion
PBL	0.61	60.50	0.3-0.7 (Medium) 56-75 (Effective Enough)	The Problem-Based Learning (PBL) learning model is quite effective in improving argumentation skills
CL STAD	0.42	41,97	0.3-0.7 (Medium) 40-55 (Less Effective)	The Cooperative Learning STAD learning model is less effective in improving argumentation skills

The N-Gain test results for the Problem-Based Learning (PBL) class were 0.61 and for the Cooperative Learning STAD class were 0.42 with both scores included in the medium category. The results of the N-Gain test are also represented in percent form to categorize the effectiveness of the applied learning model. The results of the Problem-Based Learning (PBL) class test were 60.50% with sufficiently effective criteria and the Cooperative Learning STAD class was 41.97% with less effective criteria. The test results stated that the Problem-Based Learning (PBL) learning model was more effective in improving argumentation skills compared to the Cooperative Learning STAD learning model. This is in line with Kumala (2017) which states that problem-based learning is very effective in training students' argumentation skills, because students are trained to solve problems given through a discussion process and then are directed to argue or exchange opinions with their group (Kumala, 2017)

Based on the research that has been done, the Problem-Based Learning (PBL) model can be implemented to improve students' argumentation skills because it provides greater results. This is also by Pritasari (2015) in his research which shows an increase in the ability of each aspect of argumentation in each cycle with the PBL model. The problems given in the PBL model give students space to connect the answers they make with supporting reasons through the argumentation process. This is in line with Jumadi (2021) who states that PBL can spur students in claim, data, warrant, backing, and rebuttal skills in scientific argumentation skills. Argumentation activities carried out in groups can be more effective because there is an exchange of ideas between students so strong evidence will form to support claims. Group argumentative activities, such as discussing, asking, evaluating, and criticizing can improve students' argumentation skills (Heng, 2015).

▪ CONCLUSION

Based on the research that has been done, it can be concluded that the results of the study indicate that there is no difference in initial ability between Problem-Based Learning (PBL) and Cooperative Learning STAD classes. differences in argumentation skills were seen after the two classes were given treatment, namely, the argumentation skills of the Problem-Based Learning (PBL) class were higher than those of the Cooperative learning STAD class. The results of the analysis are shown by the difference in the posttest average results where it is 81.02 for the Problem-Based Learning (PBL) class and 72.88 for the Cooperative learning STAD class. The analysis is also supported by SPSS with a significance value of 0.00 which means that there is a difference between the posttest scores for the Problem-Based Learning (PBL) class and the Cooperative learning STAD class. based on the results of these data, it can be seen the effectiveness of the learning model through the N-Gain score. The N-Gain test results for the Problem-Based Learning (PBL) class were 0.61 and for the Cooperative Learning STAD class were 0.42 with both scores included in the medium category. The results of the N-Gain test are also represented in percent form to categorize the effectiveness of the applied learning model. The results of the Problem-Based Learning (PBL) class test were 60.50% with sufficiently effective criteria and the Cooperative Learning STAD class was 41.97% with less effective criteria. Therefore it can be concluded that the Problem-Based Learning (PBL) learning model is more effective in improving argumentation skills compared to the Cooperative Learning STAD learning model. Researchers hope that the results of this study can be a reference for the implementation of Problem-Based Learning (PBL) and Cooperative Learning STAD models in different chemistry lessons to find out how changes in the dependent variable are under study.

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