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The Effect of Problem Based Learning with Laboratory Activities on Students' Problem-Solving Skills

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Abstract: This research is motivated by the low problem-solving skills of students in the kinetic theory of gases and the lack of innovation in the use of models in physics learning. Efforts made by researchers to overcome these problems are by applying a laboratory-based PBL learning model. The purpose of this study was to determine the effect of the laboratory-based PBL learning model on students' problem-solving skills on gas kinetic theory material in class XI IPA SMA Negeri 1 Cilimus. The research method used is a quasi-experimental research design with a pretest-posttest control group design. The results show that after the implementation of the laboratory-based PBL model, it is obtained that is $t_{count} > t_{table}$ so that H_0 is rejected, can be concluded that there is an influence of the laboratory-based PBL learning model on problem-solving skills in gas kinetic theory material in class XI IPA SMA Negeri 1 Cilimus.

Keywords: problem-solving skills, problem based learning, laboratory activities, kinetic gas theory.

Abstrak: *Penelitian ini dilatar belakangi oleh rendahnya keterampilan pemecahan masalah peserta didik dalam materi teori kinetik gas dan kurangnya inovasi penggunaan model dalam pembelajaran Fisika. Upaya yang dilakukan Peneliti untuk mengatasi masalah tersebut adalah dengan menerapkan model pembelajaran Problem Based Learning (PBL) berbasis laboratorium. Tujuan penelitian ini adalah untuk mengetahui pengaruh model PBL berbasis laboratorium terhadap keterampilan pemecahan masalah peserta didik pada materi teori kinetik gas di kelas XI IPA SMA Negeri 1 Cilimus tahun ajaran 2021/2022. Metode Penelitian yang digunakan adalah quasi experiment dengan desain penelitian pretest-posttest control group desain. Hasil penelitian menunjukkan bahwa setelah diterapkannya model PBL berbasis laboratorium diperoleh* $t_{hitung} > t_{tabel}$ *sehingga H_0 ditolak, dapat disimpulkan bahwa ada pengaruh model pembelajaran PBL berbasis laboratorium terhadap keterampilan pemecahan masalah pada materi teori kinetik gas di kelas XI IPA SMA Negeri 1 Cilimus.*

Kata kunci: *keterampilan pemecahan masalah, pembelajaran berbasis masalah, aktivitas laboratorium, teori kinetik gas.*

▪ INTRODUCTION

Physics is a branch of Natural Sciences. Physics is a subject studied by students at the high school or Madrasah Aliah level which is considered difficult and unpleasant by students because it consists of many complicated formulas, and material concepts that are difficult to understand, and learning models. boring and less fun (Ukhtikhumayroh & Rahmatsyah, 2020). Physics discusses a lot of natural phenomena and phenomena that can be observed by humans and applied in life. By learning physics, students can understand various symptoms and problems, reflect, analyze, and be able to solve problems (Nursita et al., 2015). Thus, the problem-solving process is an important part of the learning process, especially in physics.

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Preliminary studies have been carried out by interviewing physics teachers and students, observing physics learning in class, and testing the problem-solving skills of students. Based on the results of interviews with the Physics teacher in the science class at SMA Negeri 1 Cilimus, information was obtained that the physics learning carried out in the classroom was more analytical because the teacher only focused on mathematically deriving physics formulas so that students focused more on memorizing formulas without knowing the exact formulas. both the concept of the physics material. In addition, based on a questionnaire distributed to 100 students, it was found that 56% of students studying physics rarely do practicum and more on learning in class. This is because according to 64% of students that at SMAN 1 Cilimus there is no fixed physics laboratory space, and 72% of students stated that laboratory facilities are not adequate so that teachers and students are more accustomed to doing learning in the classroom.

Based on the results of observations of physics learning in the classroom, information was obtained that the teacher used the lecture method in learning physics. In this lecture method, the teacher usually explains the material along with examples of questions, provides practice questions, and also gives assignments to students. The task given to students is also the task of working on physics questions that focus more on mathematics or calculations. Based on these observations, it is known that students tend to practice more on physics questions than understand a physics concept in a contextual and meaningful way. These results are by the questionnaire that was filled out by 100 students 85% stated that physics learning carried out by the teacher used the lecture method. Another problem from what has been described above is that students are less active in participating in physics learning because the teacher does not involve students actively in learning. Therefore, students are not accustomed to solving a problem in Physics. Another problem, according to 64% of students, is that the sources used in learning physics only focus on books without any other sources such as laboratory or practicum activities. Based on the problem-solving skills tests that have been carried out, the researchers also obtained data showing that the students' physics problem-solving skills were still lacking with details of percentage of indicators understanding the problem 54.55%, devising a plan 53.03%, carry out a plan 53.53%, Looking back at the completed solution 31.82%, the average percentage is 48.23% in less category.

Less active students in learning and low physics problem-solving skills can be overcome by one model, namely Laboratory-based Problem Based Learning (PBL). Laboratory-based Problem Based Learning (PBL) is a model that combines Problem-Based Learning (PBL) with laboratory activities. According to Duch in Shoimin (2017) that the problem-based learning model is a model characterized by real problems as a context in which students learn to think critically and proficiently in solving problems and gaining knowledge. Laboratory activities in this research are carried out virtually using Physics Education Technology (PhET) simulations. PhET simulations were made by the University of Colorado which include physics, biology, and chemistry learning simulations that are useful for classroom and individual learning purposes. PhET simulation emphasizes the relationship between real-life phenomena and the underlying science, prioritizes an interactive and constructivist approach, provides feedback, and provides a workplace for creativity (Finkelstein et al., 2006). According to Jauhari et al. (2016), PhET simulation is an intermediary in the form of a virtual-based interactive simulation program, which functions to convey information in physics learning. PhET simulation used in this research is gas properties. The advantage of PhET simulation on gas properties is that it can know the characteristics of ideal gases, ideal gas equations, and ideal gas laws.

Results of previous research conducted by Manik & Sinurya (2019) concluded that the Laboratory-assisted Problem Based Learning model had a significant effect on students' problem-solving abilities on mechanical wave material in class XI IPA SMA Negeri 5 Medan. Sellavia et al. (2018) concluded that the implementation of a Laboratory-based Problem Based Learning (PBL) model could improve students' science process skills on the concept of harmonic vibration. Nurjannah (2017) stated that there was a significant effect of the Problem Based Learning model on students' problem-solving abilities in class XI Fluids at SMA Negeri 1 Tanjung Lubuk. Hastuti et al. (2016) stated that there was a significant effect of the Problem Based Learning model on students' problem-solving abilities in class XI Fluids at SMA Negeri 1 Tanjung Lubuk. Destianingsih et al. (2016) stated that there was a significant effect of the Problem Based Learning model on students' problem-solving abilities in class XI Fluids at SMA Negeri 1 Tanjung Lubuk. Medriati (2013) obtained information that the laboratory-based Problem Based Learning model applied in physics learning can improve student learning outcomes on the concept of light in class VIII.6 SMP Negeri 14 Bengkulu City.

Based on the several studies mentioned above, it can be concluded that the Problem Based Learning (PBL) model in physics learning can be collaborated with laboratory activities, to improve various indicators, one of which is the problem-solving skills of students. The difference between this research and previous research is that laboratory activities are carried out using a PhET Colorado gas properties simulation, the material used is the kinetic theory of gases, and researched on students of class XI IPA SMA Negeri 1 Cilimus for the 2021/2022 academic year. Based on this background, researchers are interested in applying laboratory-based Problem Based Learning (PBL) to the kinetic theory of gases in class XI science by conducting a study entitled "The Effect of Laboratory-based Problem Based Learning (PBL) Learning Models on Students' Problem-Solving Skills on Materials. Kinetic Theory of Gas in Class XI IPA SMA Negeri 1 Cilimus for the Academic Year 2021/2022".

▪ METHOD

Participants

The population of this research is the entire class XI IPA SMA Negeri 1 Cilimus as many as 6 classes with a total of 213 students. The research sample was taken using a cluster random sampling technique of 2 classes, namely class XI IPA 6 as the experimental class and class XI IPA 1 as the control class, with details of each class totaling 36 students.

Research Design and Procedures

The research design used in this study is the pre-test-post-test control group design. In this design, there is an experimental group and a control group selected at random (randomly). The experimental group and the control group were given a pre-test and then given treatment and finally given a post-test (Sugiyono, 2019). The research design is shown in Table 1.

Table 1. Pre-test-post-test control group research design

E	R	O_1	X_1	O_2
K	R	O_3	X_2	O_4

This research consists of 3 stages, namely:

1. Planning Stage

This stage includes: preliminary study of existing problems and literature study on laboratory-based Problem Based Learning (PBL), Curriculum review is carried out to find out the syllabus and Learning Implementation Plan (RPP). This curriculum review is intended so that the learning model carried out is in accordance with the objectives to be achieved, making Student Activity Sheets (WORKSHEET) or laboratory-based Problem Based Learning (PBL) practicum instructions and providing tools to be used, making problem solving skill instruments, determine the class that will be used as a place of research, and make a schedule of learning activities.

2. Implementation stage

The implementation stage includes: doing a pretest, carry out laboratory activities with laboratory-based Problem Based Learning, and carry out posttest.

3. Final Stage

In the final stage covers: processing data and comparing the results of data analysis on problem solving skills tests between before and after being given treatment to see and determine whether there is an effect of the laboratory-based Problem Based Learning model on problem solving skills, make conclusions based on the results of data processing carried out. This research was carried out for 8 months, starting from September 2021 to April 2022.

Instruments

The research instrument used in this study was in the form of a test given to students before treatment (pretest) and after being treated (posttest). The test instrument of this research is in the form of an essay with a total of 14 questions on the kinetic theory of gases. Each of these questions includes 4 indicators of problem-solving skills adapted from (Polya, 1985).

Data Analysis

The data analysis technique used is a prerequisite test (normality test uses the Chi-Square formula, homogeneity test uses Fisher's test), and hypothesis testing uses independent sample t-test.

- **RESULT AND DISSCUSSION**

The results of the calculation of the hypothesis test using the t-test with a significance level (α = 0.05) obtained tcount> ttable that is 5.71> 1.67, so Ha is accepted and H0 is rejected. This means that at the 95% confidence level, it can be concluded that there is an effect of the laboratory-based Problem Based Learning (PBL) model on problem-solving skills in gas kinetic theory material in class XI IPA SMA Negeri 1 Cilimus for the 2021/2022 academic year.

This influence is due to the laboratory-based Problem Based Learning (PBL) model involving students directly in solving problems given by the teacher at the beginning of the learning process through virtual laboratory activities using the Colorado PhET simulation, thus spurring students to be more systematic in identifying the problems given and easier to find solutions by conducting virtual laboratory activities. The virtual laboratory activity encourages students to learn actively by finding material concepts contextually and meaningfully, starting from understanding problems, planning strategies, implementing strategies, and evaluating solutions so that in this model the teacher only acts as a facilitator. In addition, students are encouraged to be active in the collaborative learning process to solve problems through discussion so that students' problem-solving skills are better trained. This is in line with research conducted by Manik & Sinurya (2019) that the laboratory-based PBL learning model has a positive effect on improving students' problem-solving skills.

If the post-test average scores are compared, the experimental class uses a laboratory-based Problem Based Learning (PBL) model and the control class uses a laboratory-based direct instruction model. The results of the post-test scores of each student are shown in Figure 1.

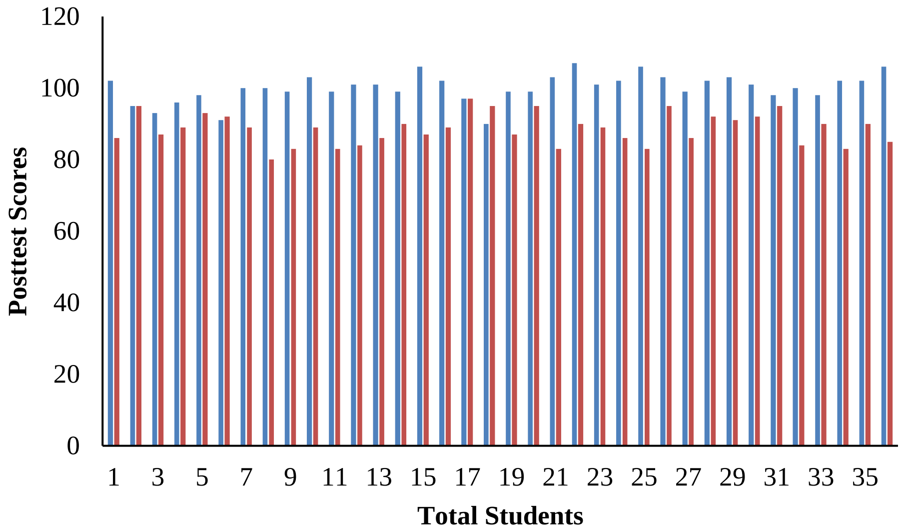


Figure 1. Post-test scores of each student in experiment (blue) and control (red) class

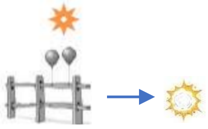
Figure 1 shows that there are differences in the post-test scores for the experimental class and the control class. The maximum score in this study was 112, the post-test average score for the problem-solving skill test tested in the experimental class using the laboratory-based Problem Based Learning (PBL) model was 100.08 while in the control class the average score was 88.61. These results indicate that the average post-test score in the experimental class is greater than the average score of the control class.

The learning model used in the experimental class and the control class can improve students' problem-solving skills, but problem-solving skills in the experimental class using a laboratory-based Problem Based Learning (PBL) model are superior to using a laboratory-based direct instruction model. The difference in post-test results is because the learning process in the experimental class uses student-centered learning, while in the control class the learning process is not student-centered. In the opinion of Kusumaningtias et al. (2013) that learning with the direct instruction model is not yet centered on students (student centered). In this model, the teacher is considered a reliable source of information so students tend to be lazy to find information on their own. Another reason is that the laboratory-based Problem Based Learning (PBL) model is superior because there are real problems given by the teacher regarding the kinetic theory of gases visualized through pictures. In the opinion of Lidinillah (2013) that the advantages of the laboratory-based PBL model are problem-focused learning that encourages students to have problem-solving skills in real situations. According to Schmidt et al. (2011) problems become the focus of students' attention in using prior knowledge. From these problems, students are allowed to observe and predict answers to problems, then find solutions by conducting laboratory activities and collaborative discussions. The existence of these laboratory activities and discussions, makes students integrate their knowledge and skills in real to solve the problems given by the teacher at the beginning of learning. Research conducted by Nurjannah (2017) that the Problem Based Learning model in collaboration with laboratory activities allows students to analyze and solve problems so that they can improve their problem-solving skills. In addition, the learning process in the experimental class also uses WORKSHEET-based Problem Based Learning (PBL) at each meeting, to assist in training students' problem-solving skills. Research conducted by Diana & Makiyah (2021) that Problem Based Learning (PBL)-based worksheets are effective in improving students' problem-solving skills in Physics material.

Problem-solving skills in the control class whose learning process uses a laboratory-based direct instruction model have a lower score than in the experimental class whose learning process uses a laboratory-based Problem Based Learning (PBL) model. This is because learning in the control class is more teacher-centered and fully controlled by the teacher so that students only receive material and instructions without any effort to find and find a concept for themselves. As a result, although in the control class there are virtual laboratory activities carried out by students, the problem-solving skills have not been trained properly. By research conducted by Irawan et al. (2017) that the problem-solving skills of students with a laboratory-based direct instruction model are lower than students who in the learning process use a laboratory-based Problem Based Learning (PBL) model. The following is an explanation of the syntax of the model in the experimental class and control class in Table 2.

Table 2. The syntax of the model in the experimental class and control class

Experiment Class			**Control Class**		
Syntax	**Teacher Activities**	**Student Activities**	**Syntax**	**Teacher Activities**	**Student Activities**
Student orientation on the problem	- The teacher displays a picture of the problem on the projector screen then asks	- Students observe the picture of the problem	**Orientation**	- The teacher conveys the subject matter to be studied, namely the laws of ideal	- Students listen to what the

Experiment Class			**Control Class**		
Syntax	**Teacher Activities**	**Student Activities**	**Syntax**	**Teacher Activities**	**Student Activities**
	students to observe the picture of the problem.  - The teacher gives questions to students. "Why do you think the balloon exploded when it was in the sun?" "What affects the bursting of the balloon if it is associated with the concept of Physics?" - The teacher asks students to make guesses or predictions about the questions given.	displayed by the teacher. - Students make guesses or predictions about questions from the problem pictures given by the teacher.		gases, kinetic energy and energy in ideal gases, and the effective velocity of ideal gases - The teacher reviews the previous lesson - The teacher conveys the purpose of the lesson	teacher says
Organizing students to learn	- The teacher divides students into 4 groups according to the number of students present. - The teacher focuses students on the problem and distributes WORKSHEET.	- Students gather with their group friends. - Students receive WORK SHEET.	**Presentation**	- The teacher conveys material on ideal gas laws, kinetic energy and energy in an ideal gas, as well as the effective velocity of an ideal gas	- Students listen to what the teacher says
Guiding individ	- Guru membimbing setiap	- Students conduct experim	**Guided and struct**	- The teacher divides students into	- Peserta Learn

Experiment Class			Control Class		
Syntax	**Teacher Activities**	**Student Activities**	**Syntax**	**Teacher Activities**	**Student Activities**
ual and group investigations	kelompok melakukan percobaan dalam PhET *simulation* mengenai hukum-hukum gas ideal. - Guru meminta diskusi terkait pertanyaan-pertanyaan yang ada dalam WORKSHEET. - Guru meminta peserta didik untuk mencatat apa yang diperoleh saat diskusi di WORKSHEET yang sudah dibagikan.	ents in PhET simulation regarding ideal gas laws. - Students conduct discussions related to the questions in the WORKSHEET. - Students record what they get during the discussion in the WORKSHEET that has been given.	**ured exercise**	several groups then distributes WORKSHEET - The teacher guides the group to carry out a PhET simulation of ideal gas laws according to the worksheet given	ers gather with their groups and then do a PhET simulation according to the WORKSHEET
Develop and present discussion results	- The teacher gives an opportunity for each group representative to present the results of the discussions that have been carried out regarding the ideal gas laws.	- Each group representative explains the results of the discussions that have been carried out regarding the	**Self-training**	- The teacher asks the students to do the experiment again at home	- Students respond to what is conveyed

Experiment Class			**Control Class**		
Syntax	**Teacher Activities**	**Student Activities**	**Syntax**	**Teacher Activities**	**Student Activities**
		ideal gas laws			
Analyze and evaluate the problem-solving process	- The teacher and students conclude the results of the group discussions that have been carried out. - The teacher provides reinforcement related to ideal gas laws.	- Students together with the teacher conclude the results of the group discussions that have been carried out. - Students respond to what the teacher says.			

The results of the post-test data for the experimental class and the control class can be explained in more detail by calculating the average percentage of post-test scores per indicator. The percentage was obtained from the results of the post-test which consisted of 14 essay questions with each question covering 4 indicators of problem-solving skills. These results can be presented in Table 3.

Table 3. Comparison of the average percentage of post-test scores per indicator in the experiment and control class

No.	**Indicator**	**Experiment Class**		**Control Class**	
		Percentage (%)	**Category**	**Percentage (%)**	**Category**
1	Understand the problem	95,54	Very good	91,87	Very good
2	Devising a plan	92,24	Very good	89,98	Very Good
3	Carry out a plan	89,48	Very good	82,34	Good
4	Looking back at the completed solution	70,73	Good	54,66	Not enough
	Average	**87,75**	**Very good**	**79,71**	**Good**

Table 3 shows that in the experimental class using the Laboratory-based Problem Based Learning (PBL) model, problem-solving skills are improved in the "very good" category in three indicators, namely understanding problems 95.54%, planning strategies 92.24%, implementing strategies 89, 48%, and the "good" category in one indicator, which is evaluating the solution 70.73%. Meanwhile, the control class, which uses a laboratory-based direct instruction model, improves problem-solving skills with the "very good" category in two indicators, namely understanding the problem at 91.87%, planning strategy at 89.98%, category "good" in one indicator, namely implementing the strategy. .34%, and the "less" category in one indicator, namely evaluating a solution of 54.66%. In addition, Table 4 also shows that in the experimental and control classes, the indicators of understanding the problem and planning strategies are already in the "very good" category, but the difference between the control class and the experimental class is in the indicators of implementing strategies and evaluating solutions. In the experimental class, the indicators for planning strategies are categorized as "very good" and evaluating solutions in the "good" category, while in the control class the indicators implement strategies in the "good" category and evaluate solutions in the "less" category.

The reason for implementing the strategy in the experimental class is that it is very good because it is facilitated by two laboratory-based Problem Based Learning (PBL) syntaxes. The first syntax is to guide group investigation. In this syntax, students are guided by teachers to carry out virtual PhET Colorado laboratory activities related to problems given at the beginning of learning. The second syntax is to develop and present the results of the discussion. In this syntax, students discuss with their group friends the questions in the PBL-based WORKSHEET after which group representatives present the results of their discussion. Indicators of implementing strategies in the control class are still in the good category because although they are facilitated by PhET Colorado virtual laboratory activities in a structured and guided practice syntax, students are still not optimal in implementing strategies because the laboratory activities carried out are not supported by other activities that can improve problem-solving skills. such as giving stimulus questions at the beginning of learning, discussions, and discussion presentations.

The cause of indicators evaluating solutions in the experimental class is categorized as good because it is facilitated by the syntax of analyzing and evaluating the problem-solving process. However, the good category is still at the lower limit and is not categorized as very good, because students are still not optimal in evaluating the results of laboratory activities that have been carried out and are still not optimal in linking the solution of the problem with the concept of the gas kinetic theory of matter. So that students are still not optimal in making conclusions from laboratory activities that have been carried out. When viewed from the aspect of problem-solving, the indicator evaluates solutions that are considered difficult by students, one of which is in question number 1. In question number 1, students can plan strategies by writing the right equation, then calculating with mathematical equations to answer the question correctly. However, evaluating the solution is not optimal, because some students only write down their mathematical answers, and most of them have not been able to relate mathematical solutions to material concepts, as a result, students still have difficulty making conclusions in answering questions. Based on this, it is evident that the indicators for evaluating solutions are still not categorized as very good. Alternatives that can be done so that indicators evaluate solutions can be categorized as very good, namely the need for an evaluation from the teacher in the form of a more detailed explanation of the material that has been practiced by students. The evaluation indicators in the control class are still in the poor category because they are not facilitated by the syntax for evaluating laboratory activities, as a result, students are unable to evaluate the laboratory activities that have been carried out.

The experimental class was carried out in 2 meetings using a laboratory-based Problem Based Learning model. A more detailed explanation o f the relationship between the syntax of the laboratory-based PBL model and the indicators of problem-solving skills is as follows:

a. The syntax of student orientation on problems facilitates indicators of problem-solving skills, namely understanding the problem. The syntax encourages students to be active in understanding the concept of material because it begins with providing problems that must be solved by students through laboratory activities so that they can train students' problem-solving skills.
b. Syntax indicators organize students to learn to facilitate indicators of problem-solving skills, namely planning strategies. Planning a strategy carried out by the teacher, namely dividing students into four heterogeneous groups and distributing PBL-based worksheets as a guide in conducting virtual laboratory activities related to the problems of ideal gas laws given. at the beginning of learning. Planning strategies are carried out by students in the syntax of organizing students to learn, namely making predictions of answers related to some of the questions above with group friends who have been divided by the teacher.
c. The syntax guiding group investigation facilitates indicators of problem-solving skills, i.e. executing strategies. Students carry out virtual laboratory activities for the PhET Colorado gas properties section, namely Boyle's law, Charles' law, and Gay-Lussac's law with their groups with guidance from the teacher.

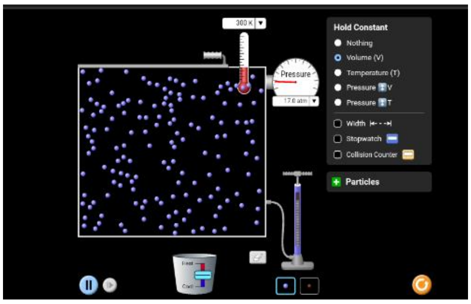


Figure 2. Display of gay-lussac law phet colorado laboratory activities

Figure 2 is an example of a virtual laboratory activity carried out by students through a PhET Colorado simulation in the discussion of Gay-Lussac law. The simulation aims to determine the relationship between pressure and temperature if the volume is kept constant and to prove that the quotient between pressure and temperature in the experimental data of Gay-Lussac's law is close to a constant value. The Gay-Lussac law experiment was carried out by varying the pressure and temperature values so that it was by the Gay-Lussac law equation that P/T = constant.

d. The syntax of developing and presenting discussion results facilitates indicators of problem-solving skills, namely implementing strategies. Figure 2 shows that students write down the data obtained from laboratory activities regarding ideal gas laws in the worksheet, then discuss the results obtained to answer the problem. The results of the discussion are presented by each representative of the group members. Laboratory activities and discussions that have been carried out affect the problem-solving skills of students during the Physics learning process.

Figure 2. Developing and presenting discussion results

e. Syntax indicators analyze and evaluate the problem-solving process facilitating indicators of problem-solving skills, namely evaluating solutions. Figure 10 is an example of an application to the material of ideal gas laws, the teacher analyzes the results of student discussions then the teacher and students make conclusions regarding one of the problems, namely the ideal gas laws.

Figure 3. Analyzing and evaluating the problem-solving process

The conclusion of the problem in Figure 3 is that the balloon explodes when in the sun because the air in the balloon expands due to changes in temperature so that the volume and pressure on the balloon increase as a result after a few hours the balloon explodes, the factors that affect the bursting of the balloon if associated with the concept of physics are temperature, pressure, and volumes. Physical quantities that affect the state of the balloon before and after it explodes are temperature (T), pressure (P), and volume (V).

Based on the discussion above, research using laboratory-based Problem Based Learning is appropriate to use in learning Physics on gas kinetic theory material in class XI IPA SMA Negeri 1 Cilimus. These results are evidenced by the average post-test score and the average percentage of post-test scores per indicator of problem-solving skills using a laboratory-based PBL model which is higher than the average post-test score and the average percentage of post-test scores per indicator of students' problem-solving skills. which uses a laboratory-based direct instruction model. This is in accordance with the opinion of (Alrahlah, 2016) that the laboratory-based PBL model is effective for improving problem solving skills, also supported by research conducted Gunantara et al. (2014) stated that the improvement of problem-solving skills in students was due to the laboratory-based Problem Based Learning (PBL) learning model that allowed students to be independent in thinking analytically about problems.

▪ CONCLUSION

The results of hypothesis testing using the t-test at the significance level (α= 0.05) show that after the implementation of the laboratory-based Problem Based Learning (PBL) model, it is obtained that t_count>t_table so that H0 is rejected. This means that at the 95% confidence level, it can be concluded that there is an influence of the laboratory-based Problem Based Learning model on problem-solving skills in gas kinetic theory material in class XI IPA at one of the public schools in Kuningan regency in the 2021/2022 academic year.

The implications of this research can be seen from the post-test score of the experimental class which is greater than the post-test score of the control class. This can be used as a reference that the laboratory-based PBL model applied in the experimental class can be used as an alternative for teachers to improve students's problem-solving skills, especially in the kinetic theory of gasses. The limitation of the laboratory-based PBL model is that it takes a long time in the process, therefore the teacher must really understand the learning syntax so that the model application time can run effectively and efficiently.

▪ REFERENCES

Alrahlah, A. (2016). How effective the problem-based learning (PBL) in dental education. A critical review. Saudi Dental Journal, 28(4), 155–161.

Destianingsih, E., Pasaribu, A., & Ismet. (2016). Pengaruh Model Problem Based Learning Terhadap Kemampuan Pemecahan Masalah Siswa Pada Pembelajaran Fisika Kelas Xi Di Sma Negeri 1 Tanjung Lubuk. Jurnal Inovasi Dan Pembelajaran Fisika, 3(1), 1–6. https://doi.org/10.36706/jipf.v3i1.3423.

Diana, R., & Makiyah, Y. S. (2021). Efektivitas Lembar Kerja Peserta Didik berbasis Model Problem Based Learning (PBL) untuk Meningkatkan Keterampilan Pemecahan Masalah pada Materi Interferensi Celah Ganda. Jurnal Pendidikan Fisika Universitas Negeri Medan, 10(1), 48–54.

Finkelstein, N., Adams, W., Keller, C., Perkins, K., & Wieman, C. (2006). High-Tech Tools for Teaching Physics: The Physics Education Technology Project. Physics Education, 2(3), 110–121. http://jolt.merlot.org/vol2no3/finkelstein.htm.

Gunantara, G., Suarjana, M., & Riastini, P. N. (2014). Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematika Siswa Kelas V. Jurnal Mimbar PGSD Universitas Pendidikan Ganesha, 2(1), 1–10. https://doi.org/10.23887/jjpgsd.v2i1.2058.

Hastuti, A., Sahidu, H., & Gunawan, G. (2016). Pengaruh Model PBL Berbantuan Media Virtual Tehadap Kemampuan Pemecahan Masalah Fisika. Jurnal Pendidikan Fisika dan Teknologi, 2(3), 129–135. https://doi.org/10.29303/jpft.v2i3.303.

Irawan, P., Susanna, & Hamid, T. (2017). Perbedaan Hasil Belajar Melalui Model Problem Based Learning dan Direct Instruction Siswa Kelas X MAN Suak Timah Kabupaten Aceh Barat. Jurnal Ilmiah Mahasiswa (JIM) Pendidikan Fisika, 2(1), 114–121. http://www.jim.unsyiah.ac.id/pendidikan-fisika/article/view/2209.

Jauhari, T., Hikmawati, & Wahyudi. (2016). Pengaruh Model Pembelajaran Berbasis Masalah Berbantuan Media Phet Terhadap Hasil Belajar Fisika Siswa Kelas X SMAN 1 Gunungsari Tahun Pelajaran 2015 / 2016. Jurnal Pendidikan Fisika Dan Teknologi, 2(1), 7–12. https://doi.org/10.29303/jpft.v2i1.282.

Kusumaningtias, A., Zubaidah, S., & Indriwati, S. E. (2013). Pengaruh Problem Based Learning dipadu Strategi Numbered Heads Together terhadap Kemampuan Metakognitif, Berpikir Kritis, dan Kognitif Biologi Siswa Kelas XI SMA Negeri 5 Malang. Jurnal Penelitian Kependidikan, 23(1), 33–47. https://www.researchgate.net/publication/322467159.

Lidinillah, D. A. M. (2013). Pembelajaran Berbasis Masalah (Problem Based Learning).

Manik, D. S., & Sinurya, J. B. (2019). Pengaruh Model Problem Based Learning berbantuan Laboratorium Virtual terhadap Peningkatan Kemampuan Pemecahan Masalah Fisika Siswa SMAN 5 Medan. Jurnal Ikatan Alumni Fisika Universitas Negeri Medan, 5(2), 35–39. https://doi.org/10.24114/jiaf.v5i2.12554.

Medriati, R. (2013). Upaya Peningkatan Hasil Belajar Fisika Siswa Pada Konsep Cahaya Kelas VII6 Melalui Penerapan Model Pembelajaran Problem Based Learning (PBL) Berbasis Laboratorium di SMPN 14 Kota Bengkulu. Prosiding Semirata FMIPA Universitas Lampung, 131–139.

Nurjannah, A. (2017). Pengaruh Model Problem Based Learning terhadap Peningkatan Pemecahan Masalah Siswa pada Pembelajaran Fisika di SMPN 1 Pante Ceureumen Aceh Barat. (Skripsi). Universitas Islam Negeri Ar-Raniry Darussalam, Banda Aceh.

Nursita, Darsikin, & Syamsu. (2015). Pengaruh Model Pembelajaran Berbasis Masalah Terhadap Kemampuan Pemecahan Masalah Hukum Newton pada Siswa Kelas X SMA Negeri 4 Palu. JPFT (Jurnal Pendidikan Fisika Tadulako Online), 3(2), 18. https://doi.org/10.22487/j25805924.2015.v3.i2.4472.

Polya, G. (1985). How Solve It: New Aspect of Mathematical Method. New Jersey: Princeton University Press.

Schmidt, H., Rotgans, J., & Yew, E. (2011). The process of problem-based learning: what works and why'. Med. Educ. 45(8), 792–806.

Sellavia, P., Rohadi, N., & Putri, D. H. (2018). Penerapan Model Problem Based Learning Berbasis Laboratorium untuk Meningkatkan Keterampilan Proses Sains Peserta Didik di SMAN 10 Kota Bengkulu. Jurnal Kumparan Fisika, 1(3), 13–19. https://doi.org/10.33369/jkf.1.3.13-19

Shoimin, A. (2017). 68 Model Pembelajaran Inovatif dalam Kurikulum 2013. Yogyakarta: Ar-Ruzz Media.

Sugiyono. (2019). Metode Penelitian Kuantitatif, Kualitatif, dan R&D (2nd ed.). Bandung: Alfabeta.

Ukhtikhumayroh, & Rahmatsyah. (2020). Efek Model Problem Based Learning (PBL) Berbantuan Alat Praktikum terhadap Kemampuan Pemecahan Masalah pada Materi Pokok Elastisitas dan Hukum Hooke. INPAFI (Inovasi Pembelajaran Fisika), 8(4), 83–88. https://doi.org/10.24114/inpafi.v8i4.21144.