

## Students' Problem Solving Skills of Physics on the Gas Kinetic Theory Material

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### ABSTRACT

Some research aiming to improve problem-solving skills in physics by various learning models has been performed. So far, there is no comprehensive research that uses Inquiry-discovery learning model to improve problem solving skills (PSS) in physics with the aid of the PhET simulation in the material of kinetic theory of gases. This research aims to investigate the differences of PhET-aided Inquiry-discovery learning using a theoretical review on PSS in the material of kinetic theory of gases between the experimental class and control class. This research is a quasi-experimental study by a post-test only design. The data analysis was performed via a t-test. The analysis results showed students in the experimental get higher PSS class than those in the control class. Also, the students in the experimental class have the highest and lowest initial abilities which were still higher than the students in the control class. Hence, the inquiry-discovery learning model is recommended to enhance students' physics PSS. The implication of this research is to provide information that students can be empowered by inquiry-discovery learning model in improving PSS. Therefore, it is expected that the next researchers can explore students' PSS at each meeting in order to improve students' learning outcomes.

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## 1. INTRODUCTION

Many students face difficulties in problems solving of physics. Such issues include the students' knowledge structure and the character of the problem [1-2]. Prior knowledge of physics will greatly contribute to the prediction of their success in solving the next problems. Differences between students with a low ability (novice) and high ability (expert) in problem solving of physics are how they organize and use their knowledge, and connect one concept with another when solving a problem [3]. Problem-solving skills do not merely depend on students' abilities to recall their knowledge and use a formula but also to analyze systematic information and to make critical reflection [4-5].

In fact, students are sometimes unsuccessful in applying the knowledge obtained during lessons to solve daily problems, especially in physics course [6]. As a product of science, physics closely relates to empirical and theoretical studies [7]. An empirical study shows the acquisition of a physics product based on experiments while the theoretical study shows the acquisition of a physics product through theoretical inquiries. Therefore, in learning physics, students are expected and required to perform practical activities (empirical studies) as efforts to process their temporary acquisition (first ideas) and make logical inference (draw conclusion from information/theoretical review) until they find a solution to the problem in the form of a physics principle [8]. Thus, a physics product should be able to be studied empirically and theoretically so

that it can be deemed as science. Nonetheless, unlike the material of kinetic theory of gases that is abstract, some physics materials cannot be experimented. Thus, it emphasizes theoretical reviews [9].

The material of kinetic theory of gases in the 2013 curriculum of Indonesia is given to 11-grade high school students of Natural Science major. The material is one of the fundamental concepts for Senior High Schools. Such material is a prerequisite to learn the next material, i.e., thermodynamics. Hence, students think that the material of kinetic theory of gases is challenging to understand due to the abstract character of the microscopic matters. The results of the research proved it since it showed 33 % students who have understood the material and 14 % students with misconceptions [10]. Student ability in defining an abstract concept is an essential ability to receive knowledge [11]. Therefore, a great reasoning skill is necessary to understand abstract concepts. Students' reasoning skills can be developed through their visualization improvements such as through texts, sound, images, videos, or simulations [12]. The PhET simulation is specifically designed to support students in developing their conceptual understanding of physics through explorations [13].

PhET (the Physics Education Technology) is a website that provides simulations for learning physics that can be downloaded for free. It can be used for teaching in the classroom or individual learning. PhET Colorado interactive simulation is an interactive simulation media that is fun for students and based on research in the form of software that can be used for clarifying physics concepts or a phenomenon [13]. The previous research findings revealed that the virtual media of PhET could enhance students' learning outcome and it obtained positive responses from them [14-15].

Physics learning aims to develop problem-solving skills based on the constructivist theory where knowledge is not merely transferred by a teacher to students but to be constructed by the students with the assistance from their teacher and their prior knowledge [16-17]. A constructivist learning allows students to understand new knowledge by using their current knowledge through an active mental activity [18]. Hence, physics learning enables students to get direct experiences so that they can construct, understand, and apply the concepts that they learn more efficiently.

Physics is a series of knowledge of natural objects and phenomena obtained through reasoning and from investigations performed by scientists through experiments by using scientific methods. Therefore, physics learning should have been given based on scientific discoveries and approaches. Inquiry-discovery learning as discovery-based learning that applies scientific approach is recommended in the 2013 curriculum. This learning requires students to construct their knowledge and develop their problem-solving skills [19-20].

Inquiry-discovery is one of the learning models that could improve students' problem-solving skills. The model is a combination of Inquiry and discovery. The inquiry is a process of understanding scientific characteristics by scientific experiments. By experimenting, testing, and searching for information, individuals could see a pattern or connection that leads to findings. Discovery is expected to result in an understanding of knowledge, concept, and generalization. At the same time, such simultaneous investigation and discovery also could develop students' skills in scientific processing and collecting facts [21].

Inquiry-discovery learning in physics is a process to inquire the characteristics and structure of the universe [3]. Inquiry and discovery require students to see daily phenomena, make a hypothesis, perform an experiment like a scientist, and further analyze the phenomena so that students need proper conceptual understanding and proper cognitive skills [22]. Students will get an individual happiness and mutual satisfaction from the activities and other students during the process of discovery when they take part in an investigation [23]. Further, this research aims to identify the impacts of PhET-aided Inquiry-discovery learning with the theoretical review, compared with the conventional learning, on the problem-solving skills of students with high and low prior knowledge.

Inquiry-discovery based learning closely relates to problem-solving process since it is a learning system that can enhance students' problem-solving skills and critical thinking abilities, which are necessary to be applied in their daily lives. Through Inquiry-discovery (ID), students do not only learn how to make inquiry and find the answer but also learn how to make an important inquiry. ID improves students' cognitive skills and assimilates students' skills in other lessons [23]. So far there is no any research on ID with the assistance of Phet simulation for improving students' problem-solving skills in the material of kinetic theory of gases so that this research was conducted. Moreover, this research aimed to investigate the impacts of Phet-aided Inquiry-discovery learning with a theoretical review on the problem-solving skills of students with high and low knowledge compared with the conventional learning.

## 2. RESEARCH METHOD

This research is a quasi-experimental research via a post-test only design. The population of this research consists of students of a school situated in Malang. The samples were taken via purposive sampling

technique, and it resulted in one control class that learned using the conventional approach and the other one for an experiment that learned using PhET-aided inquiry-discovery learning with the theoretical review.

The essay questions were tested to sort the questions that were suitable to assess students' problem-solving skills in physics. The test results were then analyzed based on the validity, distinguishing characteristics, difficulty level, and reliability of the questions. Based on the data analysis of the test results (physics problem-solving skills), seven questions were categorized as feasible for use. Such questions were then given to the students in both experimental and control groups to identify their problem-solving skills in physics in the material of kinetic theory of gases to be then analyzed statistically. The data analysis was performed using a t-test with the assistance of SPSS 19.0 software for Windows.

### 3. RESULTS AND ANALYSIS

The first data analysis was done to identify the initial conditions of the samples before treated by conducting a normality and homogeneity test. The data used in the normality and homogeneity test is the students' test results from the previous material of kinetic theory of gasses. Subsequently, a distinguishing test was done to identify any differences between the experimental and control classes, between students with high abilities in experimental and control class, and between students with low abilities in experimental and control class. The results of the analysis showed that there are no any differences between the samples.

The final analysis was done to the data of physics problem-solving ability test via seven essay questions as the test instruments. Table 1 shows the t-test results.

Table 1. Results of T-Test Analysis on Problem-Solving Skills of Students in Experimental Class and Control Class

Class	N	SD	t-value	P	Sig
Experiment	31	2.01	5.219	0.000	P<0.05
Control	31	2.01			

The statistic test in the form of a t-test aided by SPSS 19.0 for Windows shows a Sig value (2-tailed) that was less than 0.05 namely  $0.000 < 0.05$ , which means that there were differences between the problem-solving skills of students who learned using PhET-aided inquiry-discovery technique with theoretical review and students who learned using the conventional learning technique. Meanwhile, the average values showed that the students who learned using PhET-aided Inquiry-discovery with atheoretical review had higher problem-solving skills than those who learned using the conventional learning technique. Figure 1 shows a chart of the average value of the students' physics problem-solving skills.

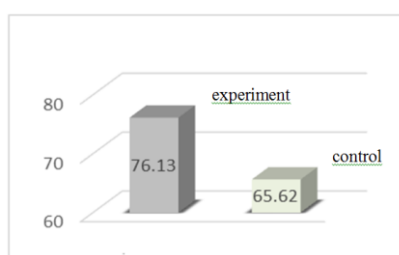


Figure 1. Average problem-solving skills

Such results were due to the stages in PhET-aided inquiry-discovery learning with the theoretical review that could develop some students' skills. For example, the observation stage prepares students to identify the problem to set up the solution subsequently, the manipulation process prepares students to execute the solution through investigation with the assistance of PhET simulation. PhET simulation-aided investigation allows students to quickly understand the material of kinetic theory of gasses, which is an abstract material. PhET simulation is highly efficient to help students in developing their understanding and intuition of abstract phenomena [13]. On the other hand, [25] thought that PhET simulation enables students to explore like scientists and therefore their understanding of the material will be higher and deeper. The generalization stage prepares students to make generalizations from the analysis results in groups. The theoretical review on the verification stage enables the physics product obtained from the analysis to be

knowledge and a solution to other relevant problems. The application stage prepares students to apply the knowledge they obtained. Their abilities to identify a problem, set up a solution, execute the solution and evaluate the results form part of problem-solving skills.

Hence, the problem-solving skills of the students who learned using the PhET-aided inquiry-discovery technique with the theoretical review are higher than those of students who learned using the conventional learning technique.

The t-test results on the second hypothesis showed that the problem-solving skills of the students with initially high knowledge who learned using PhET-aided inquiry-discovery with the theoretical review are higher than those of students who learned using the conventional technique. Table 2 shows the analysis results using t-test. Figure 2 illustrates the average problem-solving abilities of students who learned using PhET-aided inquiry-discovery learning technique with theoretical review and who learned using the conventional learning technique.

Table 2. Results of T-Test Analysis on the Problem-Solving Skills of Students with Initially High Knowledge from the Experimental Class

Class	N	SD	t-value	P	Sig
Experiment	10	4.20	2.244	0.038	P<0.05
Control	10	4.20			

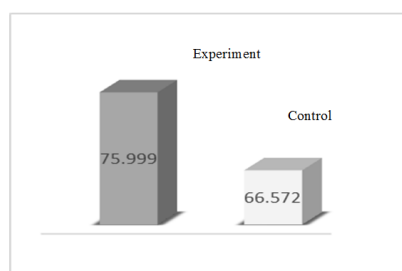


Figure 2. Average score of the problem-solving skills of students with initially high knowledge

Students with initially high knowledge who learn using the conventional learning technique will be more capable of optimizing the clarity of learning materials and improving the time efficiency in learning [26-29]. Such potential needs further development, such as by using PhET-aided inquiry-discovery learning with the theoretical review, which can improve students' problem-solving skills. Thus, the problem-solving skills of students with initially high knowledge who learned using the PhET-aided inquiry-discovery technique with the theoretical review are higher than those of students who learned using the conventional technique.

The t-test performed in the third hypothesis showed that the problem-solving skills of students with initially low knowledge who learned using PhET-aided inquiry-discovery learning technique with theoretical review were higher than those of students who learned using the conventional technique. Table 3 shows the analysis results of the t-test.

Table 3. Analysis Results via T-Test on the Problem-Solving Skills of Students in The Experimental Class with Initially Low Knowledge

Class	N	SD	t-value	P	Sig
Experiment	10	3.58	5.219	0.003	P<0.05
Control	10	3.58			

Figure 3 shows the average value of the problem-solving skills of students with initially low knowledge who learned using PhET-aided inquiry-discovery learning technique and conventional technique.

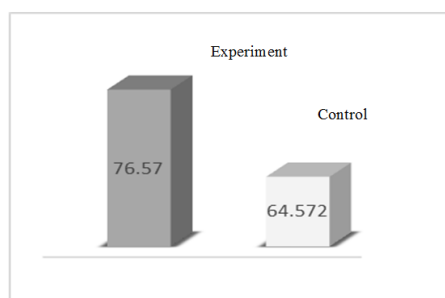


Figure 3. Diagram of average problem-solving skills of students with initially low abilities

Students with initially low abilities who learned using the conventional technique tended to be unconfident and have low motivation to learn since they were not ready to face the material. They also needed longer time to understand the material of the lesson. The learning process became longer since the teacher should explain in detail. Such obstacles cause low problem-solving skills of the students.

PhET-aided inquiry-discovery learning with theoretical review could develop students' problem-solving skills. Such learning technique comprises observation, manipulation, generalization, verification, and application stages that could prepare students to identify a problem, set up a solution, execute the solution, and evaluate the results. Such four skills are part of problem-solving skills.

The heterogeneous collaboration of PhET-aided inquiry-discovery learning with theoretical review allows students in groups to actively state their opinions and their difficulties as well as share their opinions in discussions so that students with initially high abilities could teach their peers who had initially low abilities. Such peer-teaching activity could improve students' abilities and therefore improve their abilities in solving the problem. Hence, the problem-solving skills of students with initially low abilities that learned using PhET-aided inquiry-discovery learning technique with theoretical review were higher than those of students who learned using the conventional technique.

Such finding of this research is supported by [30], [31] in his research entitled "The Effects of Discovery Learning on Students' Success and Inquiry Learning Skills". More invention is also proved by [23] states that inquiry can reduce student misconceptions on materials that are abstract and difficult. Another study also stated that Inquiry-discovery empowered in learning can improve students' learning outcomes with low ability and students' critical thinking skills [9]. Therefore, teachers are expected to embed constructive-based learning in students.

#### 4. CONCLUSION

According to the results of data analysis and discussions, it can be concluded that the problem-solving skills of students who learned using the PhET-aided inquiry-discovery technique with the theoretical review are higher than those of students who learned using the conventional technique. Thus, the inquiry-discovery learning model is potential to improve students' problem-solving skills in physics. The implication of this research is to provide information that students can be empowered by inquiry-discovery learning model in improving PSS. Limitations of the study is students' PSS that was only seen on pretest and posttest. Therefore, it is expected that the next researchers can explore students' PSS at each meeting in order to improve students' learning outcomes.

#### REFERENCES

- [1] J. L. Docktor., N. E. Strand., J. P. Mestre and B. H. Ross, "Conceptual problem solving in high school physics," *Physical Review Special Topics - Physics Education Research*, vol. 11, pp. 1-13, 2015.
- [2] E. Leak., S. L. Rothwell., J. Olivera and B. Zwickl, "Examining problem solving in physics-intensive Ph.D. research," *Physics Review Physics Education Research*, vol. 13(2), pp. 1-13, 2017.
- [3] Matson, J. O and Parsons. S. "Misconceptions about the nature of science, inquiry-based instruction, and constructivism: Creating confusion in the science classroom," *Electronic Journal of Literacy through Science*, vol. 5(6), pp. 1-10, 2006.
- [4] Ding and Harskamp, "How partner gender influences female students' problem solving in physics education," *Journal of Science Education and Technology*, vol. 15(5), pp. 331-343, 2006.

- [5] M. I. Farisi., D. Sambada and T. Prakoso, "The student's reflective-inquiry competencies on problem solving, " *Journal of Education and Learning*, vol. 11(1), pp. 17-26, 2017.
- [6] G. Friege and G. Lind, "Types and qualities of knowledge and their relations to problem solving in physics," *International Journal of Science and Mathematics Education*, vol. 4(3), pp. 437-465, 2006.
- [7] Q. Tang, "Current Challenges in Basic Science Education, " USA: Education Sector, pp. 10-101, 2009
- [8] M. Sayyadi., A. Hidayat and Muhardjito, "Pengaruh strategi pembelajaran inkuiri terbimbing dan terhadap kemampuan pemecahan masalah fisika pada materi suhu dan kalor dilihat dari kemampuan awal siswa," *Jurnal Inspirasi Pendidikan*. vol. 6(2), pp. 866-875, 2016.
- [9] W. Wartono., M. N. Hudha and J. R. Batlolona, "How are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theoretical overview?, " *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 14 (2), pp. 691-697. 2018.
- [10] T. Nurhuda., D. Rusdiana and W. Setiawan, W, "Analyzing students' level of understanding on kinetic theory of gases, " *IOP Conf. Series: Journal of Physics: Conf. Series*, vol. 812, pp. 1-6, 2017.
- [11] Wijayanti., Y. S. Kusumah and Suhendra, "How to solve polyhedron problem?, " *IOP Conf. Series: Journal of Physics: Conf. Series*, vol. 895, pp. 1-6, 2017.
- [12] R. B. Syaifulloh and B. Jatmiko, B, "Penerapan pembelajaran dengan model guided discovery dengan lab virtual phet untuk meningkatkan hasil belajar siswa kelas xi di SMAN 1 Tuban pada pokok bahasan teori kinetik gas, " *Jurnal Inovasi Pendidikan Fisika*, vol. 3(2), pp. 174-179, 2014.
- [13] S. B. McKagan., K. K. Perkins., M. Dubson., C. Malley., S. Reid., R. LeMaster and C. E. Wieman, "Developing And Researching Phet Simulations For Teaching Quantum Mechanics, " *Journal of Applied Physics*, vol 40(1), pp. 1-13, 2008.
- [14] D. Bodemer., R. Ploetzner., I. Feuerlein and H. Spada, "The active integration of information during learning with dynamic and interactive visualizations, " *Learning and Instruction*, vol. 14(3), pp. 325-341, 2004.
- [15] J. van der Meij and T. de Jong, "Supporting students' learning with multiple representations in a dynamic simulation-based learning environment, " *Learning and Instruction*, vol. 16(3), pp. 199-212, 2006.
- [16] R. M. Felder and R. Brent, "Understanding student differences, " *Journal of Engineering Education*, vol. 94(1), pp. 57-72, 2005.
- [17] Pardimin and S. A. Widodo, "Increasing skills of student in junior high school to problem solving in geometry with guided, " *Journal of Education and Learning*. vol. 10(4), pp. 390-395, 2016.
- [18] E. F. Redish, "A Theoretical framework for physics education research: modeling student thinking, " *The Proceedings of the Enrico Fermi Summer School in Physics, Course CLVI, Italian Physics Society*, 2004.
- [19] M. Ceberio., J. M. Almudi and A. Franco, "Design and application of interactive simulations in problem-solving in university-level physics education, " *Journal of Science Education and Technology*, vol. 25(4), pp. 590-609, 2016.
- [20] J. Milbourne, and E. Wiebe, "The role of content knowledge in ill-structured problem solving for high school physics students, " *Research in Science Education*, vol. 48(1), pp. 65-179, 2018.
- [21] N. M. Shamsudin., N. Abdullah and N. Yaamat, "Strategies of teaching science using an inquiry based science education (ibse) by novice chemistry teachers. " *Procedia - Social and Behavioral Sciences*. vol. 90, pp. 583- 592, 2013.
- [22] M. R. Matthews, "Constructivism and science education: a further appraisal, " *Journal of Science and Technology*, vol. 11(2), pp. 121-134, 2002.
- [23] B. Tompo., A. Ahmad and M. Muris, "The development of discovery-inquiry learning model to reduce the science misconceptions of junior high school students, " *International Journal of Environmental & Science Education*, vol. 11(12), pp. 5676-5686, 2016.
- [24] H. Miller., K. McNeal., B. Herbert, "Inquiry in the physics geology classroom: Supporting students' conceptual model development, " *Journal of Geography in Higher Education*, vol. 34(4), pp. 595-615, 2010.
- [25] F. Ajredini., N. Izairi and O. Zajkov. "Real experiments versus phet simulations for better high-school students' understanding of electrostatic charging, " *European Journal of Physics Education*, vol. 5(1), pp. 59-79, 2013.
- [26] M. Leasa., Talakua, M. and J. R. Batlolona, "The development of a thematic module based on numbered heads together (NHT) cooperative learning model for elementary students in ambon, moluccas-indonesia", *New Educational Review*, vol 46(4), pp. 174-185.
- [27] M. Leasa and A. D. Corebima. "The effect of numbered heads together (NHT) cooperative learning model on the cognitive achievement of students with different academic ability, " *Journal of Physics: Conference Series*, vol. 795, pp. 1-9, 2017
- [28] M. Leasa., A. D. Corebima., Ibrohim and H. Suwono, "Emotional intelligence among auditory, reading, and kinesthetic learning styles of elementary school students in ambon-indonesia, *International Electronic Journal of Elementary Education*, vol. 10(1), pp. 83-91, 2017.
- [29] T. Laurens., F. A. Batlolona., J. R. Batlolona and M. Leasa. "How Does Realistic Mathematics Education (RME) Improve Students' Mathematics Cognitive Achievement?," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 14(20), pp. 569-578, 2018.
- [30] G. Balim, "The effects of discovery learning on students' success and inquiry learning skills, " *Eurasian Journal of Educational Research*", vol. 35, pp. 1-20, 2009.
- [31] W. Wartono., J. R. Batlolona., Sholikhhan, C. Huda, "Influence of discovery learning-based empiricaltheoretical study assisted by animation phet on the physics problem-solving in high school," *Advances in Social Science, Education and Humanities Research*, vol. 164, pp. 47-51, 2018.