HYDROGEN
JURNAL KEPENDIDIKAN KIMIA
https://e-journal.undikma.ac.id/index.php/hydrogen/index

August 2024. 12(4)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 793-804

Implementation of Problem-Solving Learning Model to Improve Problem-Solving Skills of MAN 1 Kota Gorontalo Students

Masrid Pikoli*, Siti Fadila Muhtar Amu, Nita Suleman
Chemistry Eduation Study Program, Faculty of Mathematics and Natural Sciences, Gorontalo State University, Jl. Jendral Sudirman, Gorontalo, Indonesia
* Corresponding Author e-mail : pikolimasrid@ung.ac.id

Article History
Received: 21-05-2024
Revised: 19-08-2024
Published: 31-08-2024

Keywords: problem-solving skills, problem-solving model, thermochemical

Abstract
This study aims to improve problem-solving skills in thermochemistry material for 11th Grade MIPA (Mathematics and Natural Science) 2 class of MAN (Islamic Senior High School) 1 Kota Gorontalo students. This study is a class action research conducted in two cycles. The subjects of this study were all students of 11th Grade MIPA 2 class of MAN 1 Kota Gorontalo, which amounted to 40 students. Data collection methode include tests and observations, while data analysis involves qualitative descriptive study. Data was obtained from the test results of students' problem-solving skills and the result of observing teacher and student activities through observation sheets. The results show that problem-solving learning model can improve students' problem solving skills, where the ability to understand the problem from 72% in Cycle I increased to 90.8% in Cycle II. The ability to plan problem-solving increased from 73.5% in Cycle I to 87.7% in Cycle II. The ability to execute the plan increased from 69.8% to 86.6% in cycle II, while the ability to rechek increased from 57.5% in Cycle I to 77.7% in Cycle II. Then, teacher activity increased from 65.71% in Cycle I to 85.71% in Cycle II. Moreover, student activity increased from 61.62% in Cycle I to 80.12% in Cycle II.

How to Cite: Pikoli, M., Amu, S., & Suleman, N. (2024). Implementation of Problem-Solving Learning Model to Improve Problem-Solving Skills of MAN 1 Kota Gorontalo Students. Hydrogen: Jurnal Kependidikan Kimia, 12(4), 793-804. doi:https://doi.org/10.33394/hjkk.v12i4.11646

https://doi.org/10.33394/hjkk.v12i4.11646

INTRODUCTION

In this era of globalization which is full of challenges, the ability to solve problems is one of the main competencies that students must have. The complexity of 21st century problems, which include various social, economic, technological and environmental issues, requires individuals who are adaptive, creative and able to think critically in dealing with various situations (Almazroui, 2023; Erika et al., 2021; Suna et al. , 2022). This applies not only in the world of work but also in everyday life, where decisions taken often require careful consideration and innovative solutions (Abrami et al., 2015). The problems of the 21st century are complex, dynamic and interrelated. Rapid technological change, for example, creates new opportunities and challenges that were previously unimaginable (Hulyadi et al., 2024). Likewise with environmental problems such as climate change, which demand solutions that involve cross-disciplinary thinking. In this context, it is no longer enough for students to just rely on factual knowledge, they must be able to analyze situations, identify problems, and develop creative and effective solutions.

Based on observations at MAN 1 Kota Gorontalo, especially in Chemistry subject, it was found that many students of MAN 1 Kota Gorontalo have not reached the Criteria for Completion of Learning Objectives, which is a score of 70. Only about 50% of students reached KKTP with the highest average score of 73. This is due to the low level of students' ability to solve problem-solving-based problems, students do not get enough problem-solving-based problems, and the

learning model used by teachers is still a conventional model. The ability to solve problems is a basic ability that students must master, especially in abstract and mathematical material. With this problem-solving ability, it can be said that students have acquired skills related to this ability. One way to improve students' chemical problem solving skills is to train them to solve problems related to everyday life (Idrus et al., 2023). According to (Fazzilah & Effendi, 2019), problem solving is when someone finds a way to solve the problem they are facing. According to Polya's theory (Netriawati, 2016), the stages of problem solving ability consist of 4 stages, namely: (1) the problem understanding stage, (2) the planning/strategy selection stage, (3) the implementation/problem solving stage, and (4) the answer rechecking stage.

Chemistry as a subject is a real-life discipline based on the concepts that compose it. Basically, most chemistry concepts are practice-oriented, and the teaching and learning process requires the use of teaching materials. However, the literature shows that in fully teacher-centered classroom teaching, teachers rely too much on words to express and convey chemical ideas, theories, principles, and fact-related skills and abilities to students (Kibga et al., 2022). According to (Lubis, 2021), chemistry is a scientific discipline that develops inductive and deductive analytical thinking skills in problem solving. As a result of teachers not using the right learning methods or strategies, chemistry becomes something that is difficult to understand and less favored by most students.

Thermochemistry is one of the topics in chemistry that can support individuals in problem solving skills. In the learning process at the senior high school level, thermochemical material has the aim of providing students with the ability to understand the concept of enthalpy change of reaction in thermochemical equations and the determination of various reaction heat. Understanding thermochemical material can be associated with facts seen in everyday life (macroscopic) such as combustion or evaporation events. Then through that event can be associated again with facts that cannot be seen directly (microscopic) such as the form of energy absorbed or released in the thermochemical equation, which is then in order to determine the various heat of reaction phases of enthalpy change formation, or calculate the determination of enthalpy change (symbolic) (Irby et al., 2016).

Students' difficulties or problems in understanding thermochemical material have been proven by several researchers in their research, including; students' difficulties in distinguishing heat and temperature, identifying exotherm and endotherm reactions, and identifying systems and environments in ongoing reactions using calorimeters, calculating enthalpy changes using experimental data (Yalçınkaya et al., 2009). Problem solving in thermochemistry often involves the application of formulas and laws, such as Hess' law, the ability to choose and apply the right formula is part of problem solving. Therefore, it can be said that learning this material requires problem solving skills in order to achieve the learning objectives.

The ability to solve problems is a crucial competency in responding to the complexity of chemical concepts that relate to each concept (Hulyadi & Muhali, 2023). According to many education experts, students who are able to solve problems not only show a deep understanding of the subject matter but also high-level thinking skills (Liline et al., 2024). Students are able to connect various concepts, think critically, and apply their knowledge in different contexts. This ability is very important in preparing students for adult life and the world of work, where they will be faced with complex problems and require innovative solutions (Saygili, 2017; Suna et al., 2022). To foster problem-solving competence in students, problem-based learning is a very effective approach (Amin et al., 2020; Liu & Pásztor, 2022). This approach places students in real situations where they have to solve problems that are relevant to their lives. Through this process, students not only learn about scientific concepts but also how to apply them to solve the problems they face.

(Benzer & Şahin, 2013; Lubis, 2021; Masek, 2012) report that problem-based learning encourages students to work collaboratively, exchange ideas, and develop problem-solving strategies. (Goodyear & Dudley, 2015) states that teachers act as facilitators who guide students in the discovery process, rather than as transmitters of information. In this way, students are trained to think independently, develop analytical skills, and become more adaptive in facing change.

To overcome the above problems, it is necessary to apply a learning model that is in accordance with the material to optimize the effective learning process. In other words, it is necessary to apply the right learning model so that the learning process can increase students' creativity in thinking, creating ideas to help students analyze and solve problems, especially in chemistry. According to (Chotimah & Fathurrohman, 2018), the problem solving learning model will help students improve their creative problem solving skills by using existing knowledge and collaborating with the new knowledge they experience. The problem solving learning model is designed as learning that begins with structuring real-life problems related to the concepts to be taught, students do not only receive information from the teacher, but the teacher must develop students' thinking skills and guide students to play an active role in the entire learning process (Suna et al., 2022).

Based on the description of the problems described, the solution that can be done is to apply the problem solving learning model to thermochemical material. This is because the problem solving learning model focuses on teaching problem solving and has the potential to train students to think creatively in dealing with various problems, both individually and in groups. This study aims to improve students' problem solving ability through problem solving learning model on thermochemical material in 11th Grade MIPA 2 class MAN 1 Kota Gorontalo.

METHOD

This research is a classroom action research with the aim of improving teacher performance, thus improving students' problem solving skills on thermochemistry material. The subjects of this research were students of 11th Grade MIPA 2 class MAN 1 Gorontalo City. The research was conducted in two cycles by applying Problem Solving learning model. The instruments used in this study are teaching modules, Learner Worksheets (LKPD), observation sheets and tests at the end of each cycle. The test used is a problem solving ability test in the form of essay questions that have been validated in the form of validity of the problem solving ability test with the results of the validity level of the question 93% with very valid criteria, and this question instrument has been tested for reliability with the results of Cronbach α = 0.6 with moderate criteria.

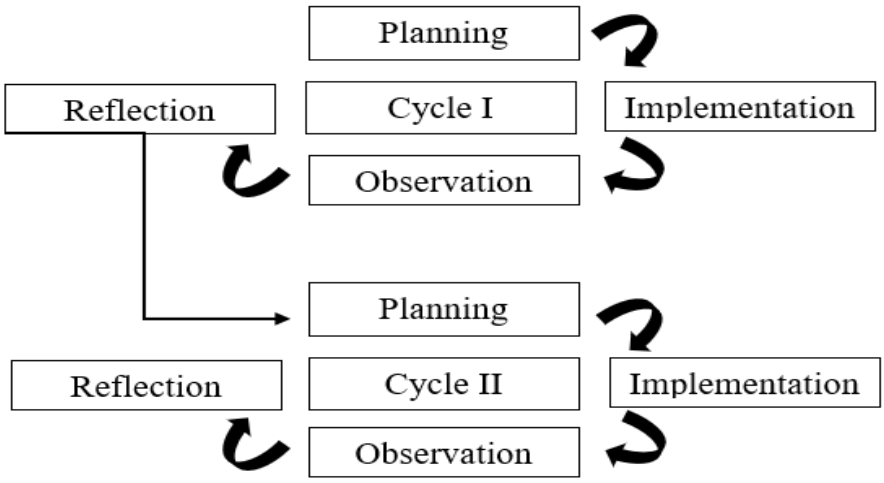

Figure 1. PTK cycle according to Kemmis & Mc. Taggrt in (Arikunto & Suharsimi, 2017)

This research refers to the Kemmis & Mc. Tggrt model (Arikunto & Suharsimi, 2017) which includes four components, namely the preparation stage (planning), implementation of action (action), observation/monitoring (observation) and reflection (reflect). The relationship between the four components is considered a cycle as shown in Figure 1.

- Preparation/planning
  At this stage in cycle I, preparations were made by compiling learning devices in the form of teaching modules, Learner Worksheets (LKPD), observation sheets, and making evaluation tools in the form of problem solving ability tests. In cycle II, the learning tools were rearranged based on the results of the reflection in cycle I.
- Action Implementation
  In the action implementation stage for cycle I and cycle II, it was carried out by applying the problem solving learning model to thermochemical material. The learning stages were carried out in the even semester of the 2023/2024 school year in January 2024 and referred to the learning tools that had been prepared.
- Observation and Evaluation
  At the observation stage, the observer monitors the implementation of learning process activities carried out by researchers at each meeting using teacher activity observation sheets and student activity observation sheets. While the evaluation is carried out at the end of each learning cycle. The assessment is intended to determine/measure students' problem solving skills.
- Reflection
  Reflection is carried out by paying attention to the data obtained in the field, especially the learning process carried out by researchers and all activities carried out by students in the classroom when applying the problem solving learning model. At this stage the researcher collected and analyzed the data obtained during the observation taken from the observation sheet. The researcher then discussed with the observer the results of the observations made, both the gaps and the learning outcomes of cycle I, as a consideration for lesson planning in the next cycle.

Data Analysis

Data analysis techniques in this study used qualitative descriptive analysis techniques. Data analysis to test the hypothesis of classroom action research is carried out gradually and continuously at the end of each learning activity. The data obtained from this study are in the form of experimental results and observation results. After the data is collected, the next step is to analyze and process the data obtained in the field. The data analysis and processing are as follows:

- Teacher Activity
  Data analysis techniques used to analyze teacher and student activities were used using observation sheets and were processed qualitatively and analyzed with the following formula (Pendidikan, 2004):

$$P = \frac{\Sigma_{AG}}{G} \times 100\%$$

  Description:
  P= Percentage of teacher activity
  ΣAG= Number of teacher activity scores achieved
  G= The maximum score of teacher activity
- Student Activity
  The data analysis technique used to analyze student activity using observation sheets and processed qualitatively and analyzed using the following formula:

$$P = \frac{\Sigma_{AS}}{S} \times 100\%$$

Description:
P = Percentage of student activity
ΣAS = Number of student activity scores achieved
S = Maximum number of student activity scores

- Student Problem-Solving Ability Test Result
  According to Polya's theory (Netriwati, 2016), the problem solving ability stage consists of 4 stages, namely: (1) problem understanding stage, (2) planning/strategy selection stage, (3) problem solving plan stage, and (4) answer result rechecking stage with the following formula.
  Student problem solving score =

$$\frac{Student's\ Problem\ Solving\ Score}{Maximum\ Score} \times 100\%$$

Furthermore, the achievement results for each problem solving indicator are put into 5 predicate categories, this is shown in table 1 below.

Table 1. Problem solving indicator results

Presentase Interval	Category
90-100	Very Good
80-89	Good
70-79	Enough
60-69	Lacking
<60	Very Lacking

From the data analysis of problem solving ability, it can be seen the percentage of problem solving ability in each cycle, so that it can be seen the improvement of students' problem solving ability in chemistry learning that is carried out. The results of the data analysis are then described according to the success indicators, namely if the observation of teacher activities and student activities reaches the good category or reaches an average of at least 75% of all aspects observed and the problem solving ability reaches at least 75% in the sufficient category or reaches a decent score according to the completeness criteria.

RESULT AND DISCUSSION

Teacher Activity

In the learning process using the problem solving learning model carried out in cycle I, there were 14 aspects assessed in the management of learning carried out by the teacher when implementing learning. These 14 aspects include all teacher activities from the initial activities to the closing activities, which are observed by the observer. Of these 14 aspects, a percentage of 65.71% was obtained, which did not meet the specified work indicators. This is because students have not responded actively to the actions taken by the teacher in learning. The shortcomings in cycle I for teacher activities include: 1) Doing apperception, 2) Presenting the problem, and 3) Inviting students to make conclusions together.

Based on the shortcomings in cycle I, researchers followed up by reflecting and improving in cycle II. Actions taken by researchers in cycle II include: : 1) Designing a practicum to determine enthalpy changes with simple calometric experiments to attract students' interest in learning, 2) Providing more examples of problems, 3) Mastering or dominating the classroom situation during the learning process, 4) Motivating students to be able to give opinions by

giving added value to students to express their opinions in front of the class, and giving added value to groups that can work together and present results well during discussions and practicums, and 5) Giving rewards to students who correctly answer the teacher's questions and to students who dare to conclude the learning material.

Students often encounter difficulties in learning chemistry, including difficulties in understanding chemical concepts, and their problem-solving skills are not maximized so that their problem-solving skills are relatively poor. This makes it less likely that students understand the material presented by the teacher. Lack of teacher motivation also greatly affects student behavior and academic achievement. By motivating students, they can increase their creativity in solving a given problem (Wansaubun, 2019).

After improvements were made and applied in cycle II and analyzed based on qualitative descriptive analysis, there was an increase in the percentage of learning management activities or teacher activities in learning which amounted to 85.71% of the 14 aspects of teacher activity observed. This can be seen in Figure 2.

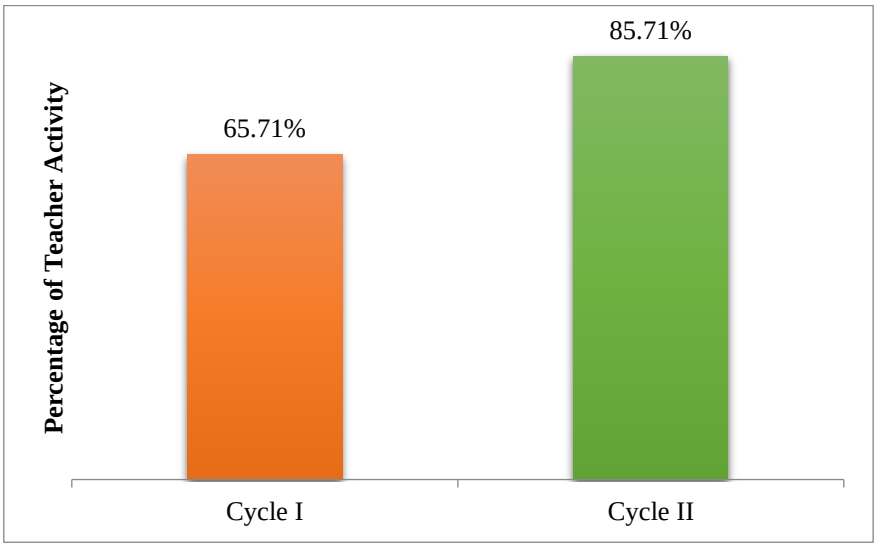

Figure 2. Histogram of Teacher Activity Achievement Result in Cycle I and Cycle II

Good learning outcomes can be achieved if teachers and students together lead the learning process so that the learning achieved can be successful. The success of a learning activity is indicated by the increase in student learning outcomes. At the same time, the use of problem solving learning models can increase student learning activities so that students feel responsible for solving problems in the learning process.

In addition, in this study teachers were able to create active learning that focused on student activities. Baharun (Fajri, 2018) states that active learning is a learning strategy where students are more involved in the exploration and expansion of knowledge to be discussed in learning activities. Student activity plays a very important role in learning. This is in line with Dave Meier's quote in research (Aldi & Purwanti, 2023), “Learning requires action, because without learning activities, good learning cannot occur.” The teaching and learning process includes various activities such as: For example: student participation in class discussions, asking questions, taking notes, listening, reading, and other activities that help students learn”.

Student Activity

Based on the results of research in 11th Grade MIPA 2 class MAN 1 Kota Gorontalo while following the learning process designed using the problem solving learning model, it was found that the percentage of student activity achievement results in cycle I was 61.62% with good criteria. This is because in this cycle there are still three aspects of the eight aspects of student

activity that are still not maximized, namely: 1) Ask the teacher, 2) Expressing opinions, and 3) Listening to explanations/information from the teacher.

From the results of the observation of cycle I, as well as teacher activities, researchers reflected and re-planned the actions to be applied in cycle II whose design used a problem solving learning model including: 1) Designing a practicum to determine enthalpy changes with simple calometric experiments to attract students' interest in learning, 2) Providing more examples of problems, 3) Mastering or dominating the classroom situation during the learning process, 4) Motivating students to be able to give opinions by giving added value to students to express their opinions in front of the class, and giving added value to groups that can work together and present results well during discussions and practicums, and 5) Giving rewards to students who correctly answer the teacher's questions and to students who dare to conclude the learning material. After reflection and improvement in the lesson plan in cycle II, there was an increase in student activity from 61.62% in cycle I to 80.12% in cycle II and included in the good criteria. The increase can be seen in Figure 3.

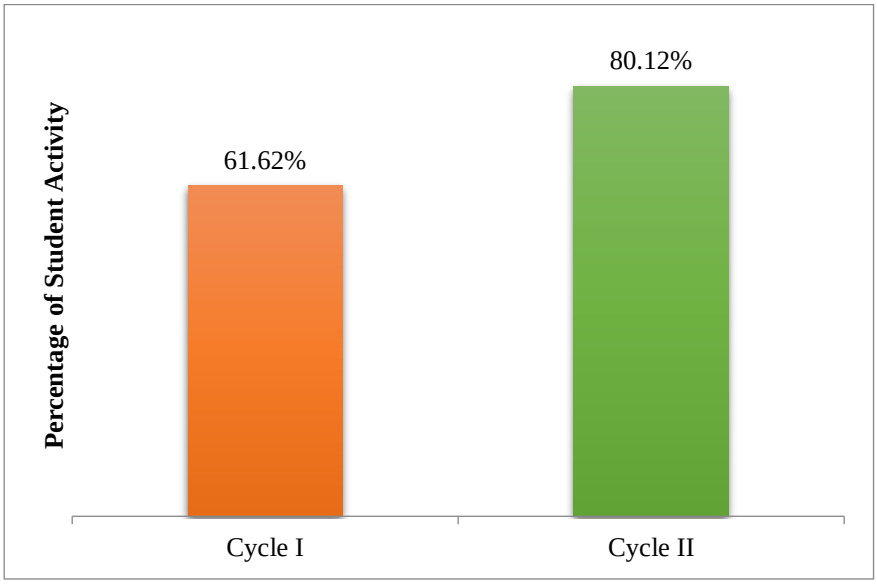

Figure 3. Histogram of Student Activity Outcomes in Cycle I and Cycle II

Based on Figure 3, it can be seen that student activity in cycle I has not yet reached the specified work indicators. Some aspects that were not maximized in cycle I were improved by researchers in cycle II so that there was an increase. The learning improvement process carried out is that the teacher invites students to be more courageous in participating during learning by encouraging and motivating students to ask questions, carry out discussion activities, and provide greater opportunities for less active students so that they are not embarrassed to participate, and provide rewards to students who have participated.

Based on research conducted by (Maspupah et al., 2020), stated that the application of the problem solving learning model in learning will motivate students to play an active role in learning activities. The advantages of the problem solving learning model are: it can develop students' sense of responsibility, each student has an equal opportunity to express their opinions so that students feel valued, higher prices and have the opportunity to develop confidence in their point of view. The learning process by using a problem solving model based on daily life problems encountered by students will help students be more motivated to ask questions and express opinions, as well as exchange ideas and information with group friends.

This is also reinforced by the opinion of (Erika et al., 2021), when applying the problem solving model, students will be involved in learning activities to think systematically, be able to design discoveries, think creatively and practically, investigate well, and be able to evaluate and

interpret findings. With the problem solving learning model, students will be faced with various problems that challenge them to try to connect existing knowledge.

Students' Problem Solving Ability

Problem solving ability is obtained based on the results of problem solving ability-based tests given at the end of each cycle, each cycle of which applies the problem solving learning model in the learning process, especially on thermochemical material. Data on the value of students' problem solving skills including understanding the problem, planning problem solving, implementing problem solving plans, and checking back are presented in Figure 4 below.

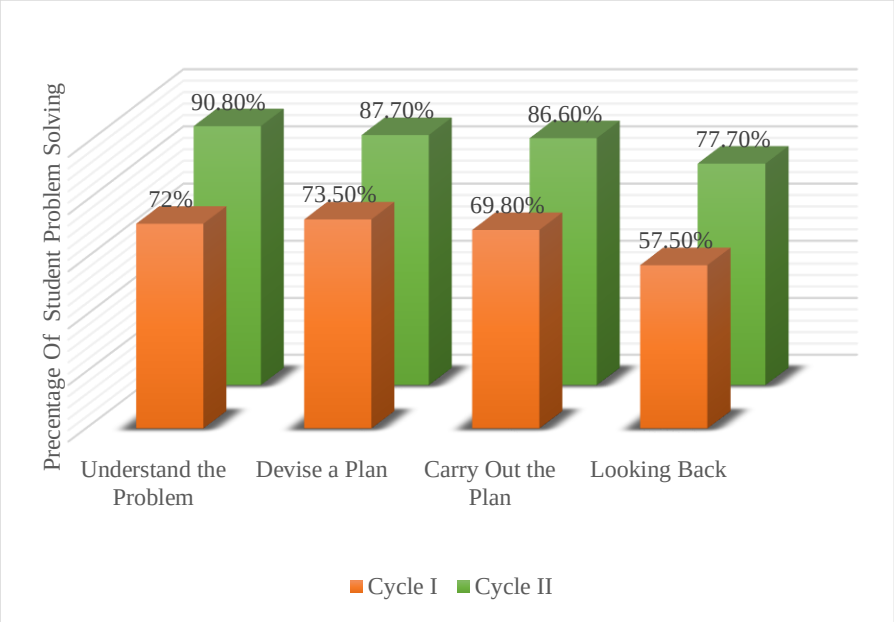

Figure 4. Histogram of Students' Problem Solving Ability Score

Based on Figure 4. it can be seen that in cycle I the ability to understand the problem, make a problem solving plan, implement a problem solving plan, and check back successively amounted to 72%, 73.5%, 69.8%, and 57.5%. The low ability of students in understanding, planning, implementing, and looking back at the results of problem solving shows that students find it difficult to determine the formula to be used to solve the given problem. This result is in line with Sugarto's findings in research (Ijirana et al., 2020) that the stage of making a solution plan has a high level of difficulty, when compared to other stages. Furthermore, students' problem solving skills have increased after reflection and improvement of learning design planning in cycle II using the problem solving learning model. In cycle II for problem solving skills in understanding problems, planning problem solving, implementing problem solving plans, and checking back obtained scores of 90.8%, 87.7%, 86.6%, and 77.7% respectively. This can prove that students' problem solving skills using the problem solving learning model can be well trained. This is in line with the results of research conducted by (R. R. Putri et al., 2020) the implementation of the problem solving model on redox reaction material increased problem solving ability by 47.43%.

The increase occurred because the teacher guided students in the optimal use of practicum tools and materials, especially in the calorimeter tool used by students during practicum. So that students understand better when receiving sample problems from the teacher, and students are more active in learning. According to (Nursidah et al., 2019), guidance is needed to gain hands-on experience and avoid mistakes during the practicum process. In addition, according to (F. R. Putri et al., 2019), practicum can train skills.

Students understand the problem by writing all the problems or known things in the problem completely. Students then make a problem-solving strategy plan by building old knowledge with new knowledge and gathering information from learning resources. According to (Aryanti & Kusasi, 2016), knowledge building is needed when planning problem solving strategies. In addition, according to (Dasrita, 2018), students need to gather information from learning resources to plan problem-solving strategies. Students solve problems according to the planned strategy. According to (Saygili, 2017), problem solving is done by gathering information from learning resources and linking it to problem solving strategies. Then, students re-examine how to solve the problem. According to (Hasan, 2019), this is done by evaluating the steps of problem solving to draw conclusions.

Based on the results of the research conducted that in cycle II on the ability to check back obtained a value of 77.7% and was in the sufficient category, this happened because the concepts used by students were still wrong. and there are still many students who do not write the conclusion of problem solving.

Reinforced by research (Ijirana et al., 2020) At the re-examination stage, students must be able to provide logical evidence to connect the results obtained with their own concept understanding, so it requires more time and higher-level thinking skills in problem solving. When students are able to reflect on the results of problem solving, then they are not only able to solve problems, but also apply the facts, laws, and principles they have learned and think critically, Self-Organization. Students who can think critically and also have the ability to analyze information obtained in everyday life.

CONCLUSIONS

Based on the results of the analysis and discussion, it can be concluded that the application of the problem solving learning model can improve students' problem solving skills in thermochemical material. This is indicated by an increase in the ability to understand the problem, plan problem solving, implement the plan, and check back successively from cycle I of 72%, 73.5%, 69.8%, and 57.5% to 90.8% for the ability to understand the problem, 87.7% plan problem solving, 86.6% implement the solution plan, and 77.7% for the ability to check back in cycle II. Teacher activity increased from cycle I of 65.71% to 85.71% in cycle II. Student activities increased from cycle I of 61.62% to 80.12% in cycle II.

RECOMENDATIONS

In learning, teachers must have an innovative attitude in the teaching and learning process so that students are interested in participating in learning. In addition, teachers should use many different learning methods during teaching. One of them uses a problem solving learning model to improve chemistry problem solving skills in the classroom.

ACKNOWLWDGMENTS

The author is grateful to the supervisor, the school, teachers, and students and all those who have participated in this research.

BIBLIOGRAPHY

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for Teaching Students to Think Critically: A Meta-Analysis.

Review of Educational Research, *85*(2), 275–314. https://doi.org/10.3102/0034654314551063

Aldi, & Purwanti, R. (2023). Meningkatkan Aktivitas Dan Hasil Belajar Muatan PPKN Menggunakan Model PATRI Pada Siswa Sekolah Dasar. *Jurnal Ilmiah Pendidikan Dasar*, *08*, 568–585.

Almazroui, K. M. (2023). Project-Based Learning for 21st-Century Skills: An Overview and Case Study of Moral Education in the UAE. *The Social Studies*, *114*(3), 125–136. https://doi.org/10.1080/00377996.2022.2134281

Amin, S., Utaya, S., Bachri, S., Sumarmi, S., & Susilo, S. (2020). Effect of Problem Based Learning on Critical Thinking Skill and Enviromental Attitude. *Journal for the Education of Gifted Young Scientists*, *8*(2), Article 2. https://doi.org/10.17478/jegys.650344

Arikunto, & Suharsimi. (2017). *Penelitian Tindakan Kelas Edisi Revisi*. Jakarta : Bumi Aksara.

Aryanti, R., & Kusasi, M. (2016). Pembelajaran Kimia Berbasis Problem Solving Menggunakan Laboratorium Rill dan Virtual Ditinjau dari Gaya Belajar dan Hasil Belajar pada Materi Larutan Elektrolit dan Nonelektrolit. *QUANTUM Jurnal Inovasi Pendidikan Sains*, *2*(7), 135–138.

Benzer, E., & Şahin, F. (2013). The effect of project based learning approach on undergraduate students' environmental problem solving skills. *Elementary Education Online*, *12*, 383–400.

Chotimah, & Fathurrohman, M. (2018). *Paradigma Baru Sistem Pembelajaran dari Teori, Metode, Model, Media, Hingga Evaluasi Pembelajaran*. Yogyakarta: Ar-Ruzz Media.

Dasrita, Y. (2018). Meningkatkan Hasil Belajar Kimia Siswa Kelas XI SMA Negeri 1 Bangkinang Melalui Metode Pembelajaran Problem Solving. *Jurnal Pendidikan Tambusai*, *2*(5), 1116–1126.

Erika, Kurniawan, D. A., & Astalini. (2021). Literatur Review: Penerapan Sintaks Model Pembelajaran Problem Solving Pada Kurikulum 2013. *Jurnal Pendidikan*, *5*(1), 147–153.

Fajri, Z. (2018). Bahan Ajar Tematik Dalam Pelaksanaan Kurikulum 2013. *Pedagogik*, *05*(01), 100–108.

Fazzilah, E., & Effendi, K. N. (2019). Strategi Pemecahan Masalah Siswa Kelas VIII Pada Soal PISA Like. *Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika*, 883–891.

Goodyear, V., & Dudley, D. (2015). "I'm a Facilitator of Learning!" Understanding What Teachers and Students Do Within Student-Centered Physical Education Models. *Quest*, *67*(3), 274–289. https://doi.org/10.1080/00336297.2015.1051236

Hasan, B. (2019). The Analysis of Students' Critical Thingking Ability with Visualizer-Verbalizer Cognitive Style. *International Journal of Trends Education Research*, *2*(3), 142–147.

Hulyadi, H., Bayani, F., Ferniawan, Rahmawati, S., Liswijaya, Wardani, I. K., & Swati, N. N. S. (2024). Meeting 21st-Century Challenges: Cultivating Critical Thinking Skills through a Computational Chemistry-Aided STEM Project-Based Learning Approach. *International Journal of Contextual Science Education*, *1*(2), Article 2. https://doi.org/10.29303/ijcse.v1i2.609

Hulyadi, H., & Muhali, M. (2023). Reducing Student Misconceptions Through Problem-Based Learning with a Computational Chemistry-Assisted Question Map Approach. *Jurnal Penelitian Pendidikan IPA*, *09*, 11207–11217. https://doi.org/10.29303/jppipa.v9i12.5936

Idrus, T., Pomalato, S. W., Ismail, S., & Mohidin, A. D. (2023). Pengembangan Instrumen Kemampuan Pemecahan Masalah Matematika Peserta Didik Di SMA. *Jambura Journal of Mathematics Education*, *4*(1), 63–74. https://doi.org/10.34312/jmathedu.v4i1.16404

Ijirana, Gayatri, G., & Absari, M. (2020). Analisis Kemampuan Pemecahan Masalah Kimia Siswa Kelas XI di SMAN Kota Palu Sulawesi Tengah. *Jurnal Dinamika Pendidikan*, *13*(3), 255–263. https://doi.org/10.33541/jdp.v12i3.1295

Irby, S. M., Phu, A. L., Borda, E. J., Haskell, T. R., Steed, Nicole., & Meyer, Z. (2016). Use of a card sort task to assess students' ability to coordinate three levels of representation in chemistry. *Chemistry Education Research and Practice*, *15*(2), 18–26.

Kibga, E. S., Gakuba, E., & Sentongo, J. (2022). Learners' Active Engagement in Searching and Designing Learning Materials through a Hands-on Instructional Model. *International Journal of Learning, Teaching and Educational Research*, *21*(8), 92–108. https://doi.org/10.26803/ijlter.21.8.6

Liline, S., Tomhisa, A., Rumahlatu, D., & Sangur, K. (2024). The Effect of the Pjb-HOTS Learning Model on Cognitive Learning, Analytical Thinking Skills, Creative Thinking Skills, and Metacognitive Skills of Biology Education Students. *Journal of Turkish Science Education*, *21*(1), 175–195.

Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, *45*, 101069. https://doi.org/10.1016/j.tsc.2022.101069

Lubis, H. (2021). Penerapan Model Pembelajaran Problem Solving untuk Meningkatkan Hasil Belajar Kimia Siswa Kelas XI SMA. *Jurnal Inovasi Pembelajaran Kimia*, *2*(2), 66–75. https://doi.org/10.28926/briliant.v2i2.46

Masek, A. (2012). *The Effect of Problem Based Learning on Critical Thinking Ability: A Theoretical and Empirical Review*. https://www.semanticscholar.org/paper/The-Effect-of-Problem-Based-Learning-on-Critical-%3A-Masek/4f472dc06281c45f765dc945599e92525b4c5679

Maspupah, M., Istiqomah Alwahdah, R., & Sa'adah, S. (2020). Analisis Kemampuan Pemecahan Masalah pada Materi Perubahan Lingkungan dengan Model Pembelajaran Problem Solving. *Jurnal Program Studi Pendidikan Biologi*, *0417*(1), 17–26.

Netriawati, N. (2016). Analisis Kemampuan Mahasiswa dalam Pemecahan Masalah Matematis Menurut Teori Polya. *Jurnal Pendidikan Matematika*, *7*(2), 181–190.

Nursidah, Suharto, B., & Rusmanyah. (2019). Penerapan Model Guided Discovery Learning untuk Meningkatkan Keterampilan Berpikir Kritis dan Hasil Belajar. *Jurnal Vidya Karya*, *34*(1), 26–38.

Pendidikan, D. N. (2004). *Pedoman Pembelajaran Ketuntasan*. Depdiknas.

Putri, F. R., Suharto, B., & Rusmansyah. (2019). Penerapan Model Pembelajaran Inkuiri Terbimbing Terhadap Hasil Belajar Peserta Didik Pada Materi Koloid. *Journal of Chemistry and Education*, *3*(2), 47–54.

Putri, R. R., Suharto, B., & Kusasi, M. (2020). Meningkatkan Kemampuan Pemecahan Masalah dan Hasil Belajar Melalui Model Pembelajaran Problem Solving Materi Reaksi Reduksi dan Oksidasi. *Journal of Chemistry And Education*, *4*(1), 1–6.

Saygili. (2017). Examining the Problem Solving Skills and the Strategies Used by High School Students in Solving Non Routine Problems. *E-International Journal Education Research*, *8*(2), 91–114.

Suna, R., Mohidin, A. D., Katili, N., Abdullah, A. W., & Majid, M. (2022). Pengaruh Model Pembelajaran Problem-Solving Terhadap Kemampuan Berpikir Kreatif Siswa Pada Materi Pola Bilangan. *Research in the Mathematical and Natural Sciences*, *1*(2), 43–51. https://doi.org/10.55657/rmns.v1i2.68

Wansaubun, W. A. (2019). Upaya Meningkatkan Kreativitas dalam Memecahkan Masalah dengan Menggunakan Model Pembelajaran Creative Problem Solving (CPS). *Arfak Chem*, *2*(2), 243–248.

Yalçınkaya, E., Taştan, Ö., & Boz, Y. (2009). High School Students' Conceptions about Energy in Chemical Reactions. *Pamukkale University Journal of Education*, *26*, 1–11.