ENHANCING COGNITIVE LEARNING OUTCOMES ON CARBOXYLIC ACIDS THROUGH NEARPOD-ASSISTED PROBLEM-BASED LEARNING: A STUDY IN ORGANIC CHEMISTRY COURSE

Dede Dalpa Nurlatipah[a], Neneng Windayani[b*], Sari[a], Yulia Sukmawardani[b]

[a]*Department of Chemistry Education, Faculty of Education and Teacher Training, UIN Sunan Gunung Djati Bandung, Bandung, Indonesia 40614*

[b]*Department of Magister Science Education, Postgraduate, UIN Sunan Gunung Djati Bandung, Bandung, Indonesia 40614*

**Corresponding author: nenengwinda.ftk@uinsgd.ac.id*

Abstract

This study aims to investigate the enhancement of students' cognitive learning outcomes through the integration of Nearpod-assisted Problem-Based Learning (PBL) in carboxylic acid material, as well as to describe students' activities, their ability to complete worksheets, and their responses to the use of this media. This study employed a pre-experimental method with a one-group pretest-posttest design and involved 48 fourth-semester students in the Organic Chemistry II course. The results indicate that learning activities were carried out very well (88.76%), students' ability to complete worksheets was also high (average score: 88), and cognitive learning outcomes improved moderately (N-Gain: 0.63), with the highest achievement at the analysis level (C4). A total of 98.3% of students responded positively to the use of Nearpod in learning. These findings indicate that integrating the PBL model and Nearpod is an innovative and effective approach to enhancing cognitive learning outcomes, active participation, conceptual understanding, and higher-order thinking skills while highlighting its potential to improve the quality of chemistry education, particularly on abstract topics.

Keywords: *Problem-based learning; Nearpod; cognitive outcomes; organic chemistry; carboxylic acids*

doi: https://doi.org/10.24815/jcd.v13i1.46010

Received: *May 10, 2025*; ***Revised:*** *June 1, 2025*; ***Accepted:*** *June 2, 2025;* ***Published:*** *5 June 2025.*

Citation IEEE style: D.D. Nurlatipah, N. Windayani, Sari, and Y. Sukmawardani ,"Enhancing cognitive learning outcomes on carboxylic acids through Nearpod-assisted problem-based learning: a study in organic chemistry course," *Chimica Didactica Acta*, vol. 13, no. 1, pp. 54-65, 2025, doi: 10.24815/jcd.v13i1.46010

INTRODUCTION

Chemistry is a field of study that encompasses abstract concepts and is often considered difficult and tedious by students [1]. This is because it requires understanding basic concepts and their relationships with other concepts, which students find challenging [2]. One branch of chemistry that is considered challenging is organic chemistry, particularly the topic of carboxylic acids, which is an abstract concept with concrete examples. This concept is difficult to understand because it involves chemical symbols associated with everyday phenomena [3]. This material is often taught by rote memorization, without deep understanding, leading to difficulties for students and low cognitive learning outcomes [4].

Several findings indicate that students experience difficulties in understanding variations in functional group structures, nomenclature, and relating carboxylic acid material to real-life contexts [5]. A weak understanding of nomenclature also impacts difficulties in learning the synthesis of carboxylic acid compounds [6]. However, research examining learning strategies to enhance students' knowledge and cognitive learning outcomes on carboxylic acid material remains limited. This situation highlights a gap in the chemistry education literature, particularly regarding exploring relevant active learning approaches and using digital technology as a supportive learning medium for this material.

To address these issues, an effective learning strategy is needed to study carboxylic acid material to produce a complete understanding that is well retained in memory [6]. The success of a learning process can be determined by the model, approach, method, and learning media used by an educator [7]. However, in reality, many chemistry lessons still use conventional models, resulting in students becoming more passive and educators having a dominant influence. Therefore, educators must find solutions to improve students' cognitive learning outcomes by designing student-centered teaching and learning activities [8]. With innovation in learning, it is hoped that an active learning situation can be created that supports more profound mastery of the material [9].

One promising solution that can be applied is innovative student-centered learning model, such as Problem-Based Learning (PBL), which encourages students to actively solve problems and connect concepts to real life [10]. The PBL model enables students to find solutions independently through a more engaging learning process, potentially improving learning outcomes optimally [11]. Implementing this model has proven effective in enhancing cognitive learning outcomes, such as in hydrocarbon material, with an average score increase from 69.74 to 78.53 [4]. However, the effectiveness of the PBL model in carboxylic acid material has rarely been studied, even though the characteristics of this concept are highly suitable for this approach.

In the era of globalization and digitalization, education is required to optimally utilize developments in information technology in the learning process [12]. Therefore, in addition to selecting the right learning model, interactive media is also important to help students understand abstract concepts in chemistry learning [13]. Interactive digital media can support chemistry learning, thereby improving students' cognitive learning outcomes [14]. One of the media that can be used is Nearpod, which integrates videos, texts, quizzes, and other interactive activities in a single digital platform that is easily accessible, free, and web-based, so it does not take up storage space [15]. Nearpod has been proven to increase student motivation [16]. By utilizing existing features, such as prepared learning videos inserted into the Nearpod platform, students can watch videos without advertising interruptions, allowing them to focus more on the content being taught [15]. In addition, using videos in learning is recognized as effective in increasing student engagement by visualizing complex processes [17]. According to research by Schweiker et al. (2020), using lightboard videos can help students achieve a deeper understanding when studying organic chemical reactions [18].

Thus, the integration of Nearpod into the PBL model enables a more active and meaningful learning experience, as students not only solve problems but also visualize complex concepts through interactive media. Combining the PBL model and Nearpod is a relevant and promising approach to improving students' cognitive learning outcomes, especially in abstract subjects such as carboxylic acids. This is supported by research by Perlawanan et al. (2023), which showed that using Nearpod in teaching chemical bonding and molecular structures improved students' cognitive learning outcomes from 66.66% to 83.33% [19].

However, to date, no research has examined the integration of the PBL model with interactive digital media such as Nearpod in carboxylic acid material. This opens up opportunities for this study to contribute theoretically to developing PBL models integrated with digital technology while offering practical implications for improving the effectiveness of chemistry learning, especially in complex and abstract material.

The novelty of this study lies in integrating the PBL model with Nearpod media in carboxylic acid material, which has not been widely researched to date. Through this approach, this study is expected to improve students' cognitive learning outcomes in material that is often considered difficult. Specifically, this study aims to describe students' activities and abilities in completing problem-based worksheets assisted by Nearpod, analyze improvements in students' cognitive learning outcomes on carboxylic acid material after the implementation of the PBL model assisted by Nearpod, and describe students' responses after the implementation of the PBL model assisted by Nearpod on carboxylic acid material.

METHOD

This study used a pre-experimental method with a quantitative approach and a one-group pretest-posttest design. This design was chosen to measure student performance before and after treatment without a control group, thereby enabling an assessment of learning improvement in the same sample [20]. The treatment given was applying the Nearpod-assisted PBL model to carboxylic acid material. The stages of the research implementation are presented in Figure 1 to provide a systematic overview of the research flow.

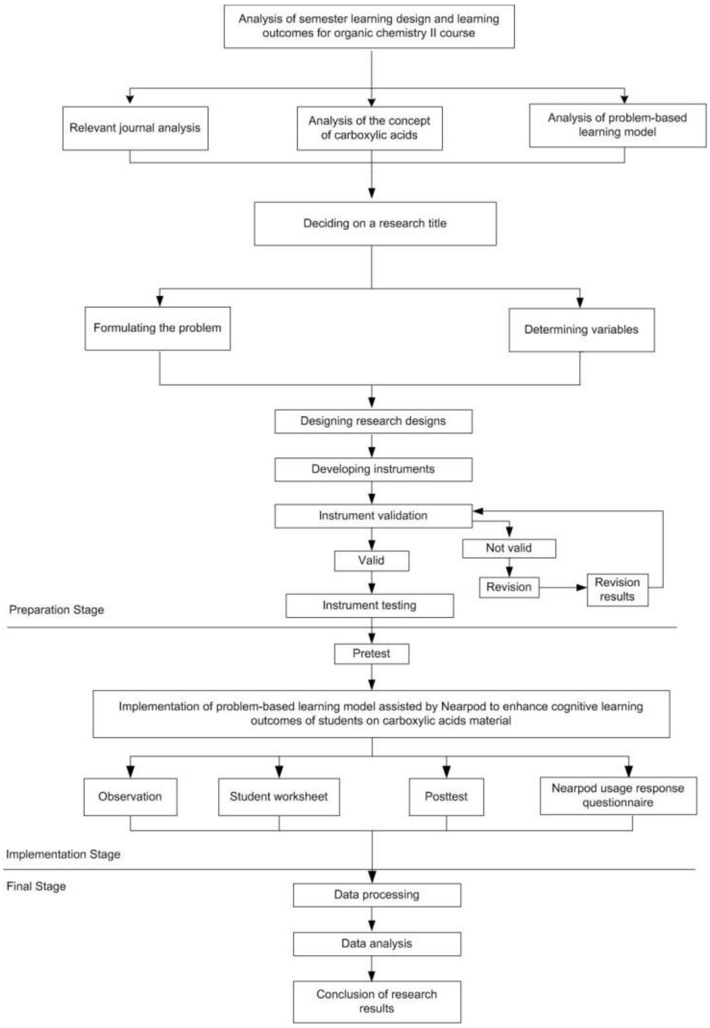

Figure 1. Research procedure

The study participants were 48 fourth-semester students in the Chemistry Education program enrolled in the Organic Chemistry II course during the 2024/2025 academic year at UIN Sunan Gunung Djati Bandung. The sampling technique used was purposive sampling, involving students who were present and met the inclusion criteria: having completed the prerequisite course Organic Chemistry I, never having been taught about carboxylic acids in class, and never having used Nearpod as a learning tool previously. This group was relatively homogeneous regarding academic background and age (20–21 years).

The learning was conducted in one session with five stages according to the PBL model syntax, namely problem orientation, organizing students to learn, guiding group investigation, presenting results, and analyzing and evaluating the problem-solving process. Nearpod media supported the learning process by integrating videos and other interactive features that facilitated active student involvement in the investigation and group discussion process.

Data collection was conducted using four types of instruments that had been validated by three expert lecturers and tested before implementation. Observation sheets were used to observe and assess the implementation of PBL. Worksheets were used to increase student engagement and guide group investigation and problem-solving with the help of Nearpod [21]. Cognitive tests consisted of 10 multiple-choice questions and 2 essay questions covering cognitive levels C3 to C5, used to measure improvements in students' cognitive learning outcomes before and after the treatment. These questions were analyzed using Anates software to assess validity, difficulty level, discriminating power, and reliability, and all items were deemed suitable for use. Additionally, a student response questionnaire was designed using a Likert scale to determine students' responses to using Nearpod in the learning process.

The collected data were analyzed using descriptive and inferential statistics. The percentage of student activity was calculated based on the observation results and classified into five categories of performance (very good to very poor). Student worksheet scores were analyzed quantitatively to assess problem-solving quality and conceptual understanding, and they were categorized based on predefined score ranges. The Shapiro-Wilk test with SPSS software tested pretest and posttest scores for normality. Since the data were not normally distributed (<0.05), the Wilcoxon test was used to determine significant differences between pretest and posttest results. If the significance value is <0.05, H_0 is rejected, and H_a is accepted; conversely, if the significance value is >0.05, H_0 is accepted, and H_a is rejected. Additionally, N-Gain analysis was used to measure the magnitude of cognitive learning improvement, calculated using the following formula:

$$\text{N-Gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

N-Gain results were categorized into three levels: high (>0.7), moderate (0.3–0.7), and low (<0.3) [22]. Meanwhile, student response questionnaire data were analyzed by calculating the percentage of answers on the questionnaire.

RESULTS AND DISCUSSION

Student Activities in Problem-Based Learning (PBL)

Learning begins with contextual questions to stimulate motivation, a pretest, the presentation of learning objectives, and the formation of small groups to discuss and work on problem-based worksheets with the help of Nearpod. This media presents learning videos and interactive features such as matching pairs, time to climb, and draw it, which encourage active student engagement during the learning process [23]. This approach enables students not only to receive information audio-visually through videos but also to actively test and apply their understanding, which has a positive impact on cognitive learning outcomes. Examples of videos on the Nearpod media can be seen in Figures 2 and 3.

Figure 2. Video Display on Nearpod About Apple Cider Vinegar

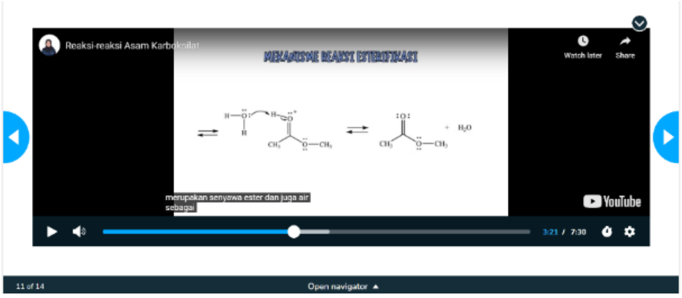

Figure 3. Video Display on Nearpod About Reaction Mechanisms

In addition, the Nearpod features used in this study can be seen in the following image.

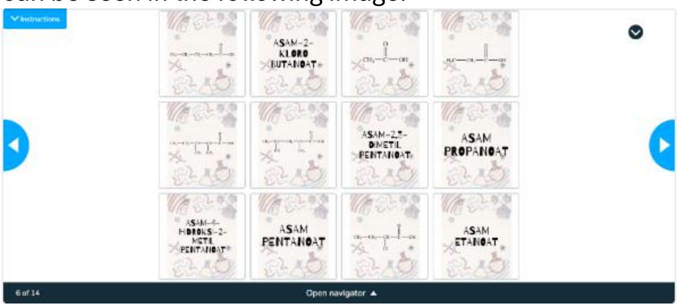

Figure 4. Matching Pairs Feature Display on Nearpod

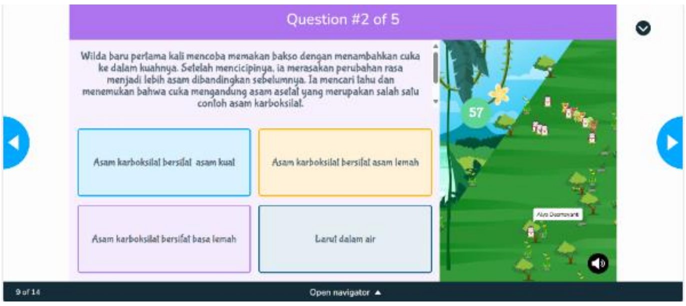

Figure 5. Time to Climb Feature Display on Nearpod

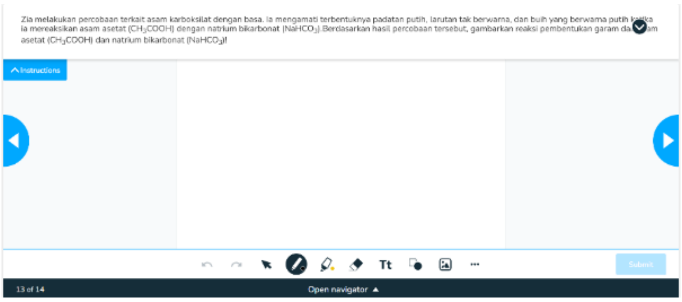

Figure 6. Draw It Feature Display on Nearpod

The implementation of student activities during problem-based learning assisted by Nearpod was observed by two observers using observation sheets. The average percentage of student activity in all stages of PBL was 87.66%, which is categorized as very good. These findings indicate that Nearpod significantly supports increased student activity during learning. Integrating Nearpod into problem-based learning helps students learn independently and encourages collaborative learning and the sharing of understanding. This model is highly suitable for educators, as traditional teaching methods such as lectures are often ineffective. These results align with the research conducted by Supriadi et al. (2020), which showed that applying the PBL model can increase student activity [24]. Additionally, Liu's (2023) research indicated that Nearpod encourages student engagement through interactive features during chemistry learning [25]. The following is a visualization of the observation data on student activities based on the PBL stages:

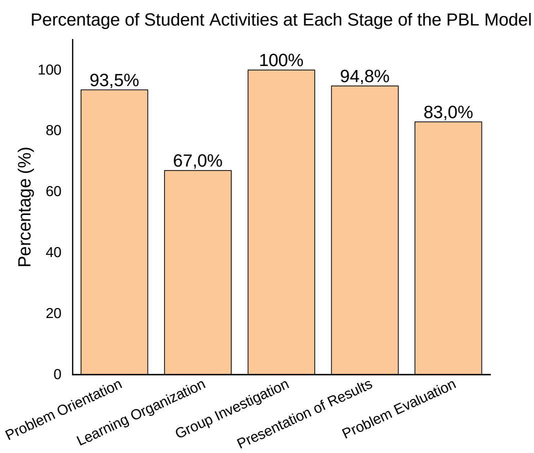

Figure 7. Percentage of student Activities Based on PBL Stages

Based on the graph above, the highest participation occurred in the group investigation stage (100%), followed by the presentation of results (94.8%) and problem orientation (93.5%). The high level of student activity indicates good engagement and cooperation in completing problem-based worksheets with the help of Nearpod media. These findings align with the research by Wiguna et al. (2019), which states that multimedia in the learning process has been proven to create student-centered learning and increase understanding, learning motivation, and learning effectiveness [26]. Meanwhile, the lowest participation occurred in the learning organization stage (67%), which is still considered quite good. The low involvement at this stage was due to the dependence of some students on certain group members in formulating problems and hypotheses. This finding indicates the need to improve student collaboration in the early stages of the PBL process. This is supported by the research of Isnaini et al. (2024), which confirms that a lack of participation, contribution, and interaction among group members can impact low collaboration skills [27].

Students' Ability in Completing Problem-Based Worksheets

The first stage is problem orientation. In this stage, students are instructed to observe the images and text presented in the worksheet about apple cider vinegar. Introducing students to a problem related to carboxylic acids can increase their interest and make it easier for them to understand and formulate solutions to the given problems. This aligns with the research by Yunitasari & Hardini (2021), which states that learning activities during the problem orientation stage in the PBL model can increase interest and encourage students to actively engage in the problem-solving [28]. Student activities during the problem orientation stage can be seen in Figure 8.

Figure 8. Problem Orientation Activities

The second stage is organizing students to learn. In this stage, students are instructed to formulate problems and hypotheses based on the text presented. The results of the students' worksheets in completing this stage obtained an average score of 92, which is categorized as very good. These findings indicate that students can identify, formulate problems and make hypotheses well. These results align with the research conducted by Sajidan et al. (2022), which states that PBL can motivate students to discover and understand concepts, develop problem-solving skills, and improve independent learning skills [29]. The more relevant the problems presented are to real-world contexts, the greater the opportunity for students to identify and solve problems effectively. Student activities in this stage can be seen in Figure 9.

Figure 9. Organizing Students for Learning Activities

The third stage is guiding group investigations. In this stage, students are given eight questions in a worksheet designed to encourage them to investigate issues in depth using Nearpod media to gather information. The average score for students' worksheets in completing this stage was 87.65, which is categorized as very good. This achievement reflects the student's ability to develop conceptual understanding and optimize their thinking skills through group work. Through this approach, students can hone, test, and develop their thinking skills, which ultimately positively impacts their cognitive learning outcomes [30]. These findings align with the research by Indahsari & Habiddin (2024), which states that the application of the PBL model can train students to solve problems through collaborative investigation in groups while also encouraging the achievement of learning completeness through active discussion and cooperation [31]. The artifact of questions and answers provided by students is depicted in Figures 10, Figure 11, and Figure 12.

Based on one of the sample questions and student answers, all three groups provided fairly good answers, especially for points b and c. They were able to explain the effect of substituents on the acidity of carboxylic acids and determine which compound is more harmful to the environment between acetic acid and 2-chlorobutyric acid. These findings are in line with the results of the study by Amador-Balderas et al. (2020), which showed that electron-withdrawing substituents such as -Cl can increase the acidity of carboxylic acids through an inductive effect [32]. However, in point a, group 2 was incorrect in answering the question because it stated that 2-chlorobutanoic acid is a strong acid, whereas it is still classified as a weak acid. Group 3 answered correctly but did not provide further explanation regarding why 2-chlorobutanoic acid is more acidic than acetic acid. Meanwhile, Group 4 provided a correct and complete answer accompanied by appropriate reasoning. This finding indicates that some students have not fully understood that an increase in acidity due to substituents does not necessarily alter the classification of acid strength absolutely.

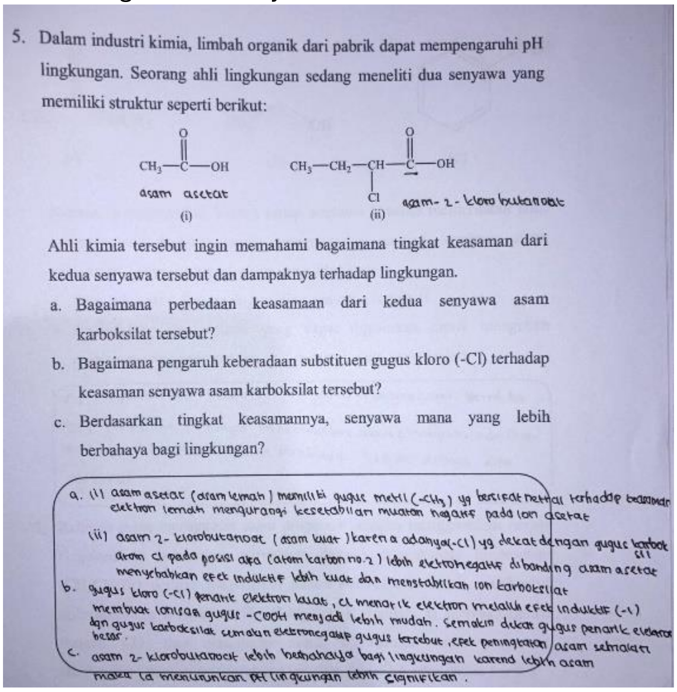

Figure 10. Artifact from group 2

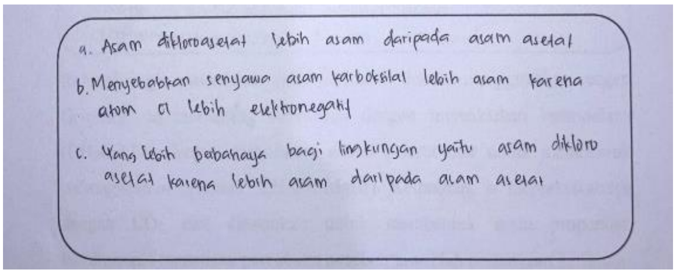

Figure 11. Artifact from Group 3

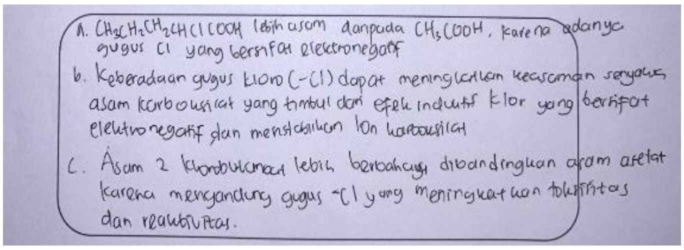

Figure 12. Artifact from Group 4

The fourth stage is presenting the results. In this stage, students are instructed to present the results of their work on the worksheets. A summary of the group presentation assessment is presented in Table 1. Based on the table, the average group presentation score was 88.85, categorized as very good. This achievement reflects students' ability to effectively communicate their understanding of the learning material. These results are consistent with the research by Costa et al. (2023), which indicates that implementing the PBL model can enhance students' communication skills in presenting discussion outcomes orally [33].

Table 1. Group Presentation Assessment Results

Group	Value	Interpretation
1	81.0	Very good
2	86.0	Very good
3	95.0	Very good
4	95.0	Very good
5	88.0	Very good
6	86.0	Very good
7	93.0	Very good
8	88.0	Very good
9	93.0	Very good
10	90.5	Very good
11	88.0	Very good
12	90.5	Very good
13	81.0	Very good
Mean	88.8	Very good

The student activities during the presentation of the discussion results can be seen in Figure 13.

Figure 13. Student activities in presenting the discussion results

The fifth stage is analyzing and evaluating the problem-solving process. In this stage, students were instructed to draw conclusions based on the learning objectives. The results of the students' worksheets in completing this stage obtained an average of 84.6 with a very good category. These findings indicate that students can draw conclusions based on the problem-solving process they have carried out. These results are consistent with Simangunsong's (2023) findings, which state that implementing PBL can improve students' conceptual understanding and problem-solving skills through in-depth investigation and evaluation processes [34]. However, some groups still face difficulties in formulating complete and accurate conclusions. These difficulties may stem from a lack of understanding of the relationship between the problem, the investigative process, and the outcomes obtained.

Thus, the average score for student worksheets across all stages of PBL was 88, with all stages receiving a very good category. This reflects the important role of interactive media in encouraging active student engagement. A summary of the problem-based worksheet assessments is presented in Table 2.

Table 2. Recapitulation of Problem-Based Worksheet Assessment

No	Learning Stages	Average Score	Interpretation
1	Organizing for Learning	92.0	Very good
2	Guiding group investigation	87.65	Very good
3	Presenting Results	88.85	Very good
4	Analyzing and evaluating the problem-solving process	84.6	Very good
Mean		88.0	Very good

Impact on Cognitive Learning Outcomes

Cognitive test scores were analyzed before and after treatment to determine improvements in cognitive learning outcomes. The Shapiro-Wilk normality test showed that the data were not normally distributed ($p<0.05$), as shown in Table 3.

Table 3. Normality Test Results

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-test	0.901	48	< 0.001
Post-test	0.935	48	0.010

The Wilcoxon test showed a significant difference between the pretest and post-test scores ($p<0.001$), indicating an increase in cognitive learning outcomes after implementing the Nearpod-assisted PBL model on carboxylic acid material. The results of the analysis are presented in Table 4.

Table 4. Wilcoxon Test Results

Statistical Test	Z	Asymp. Sig. (2-tailed)
Wilcoxon	-6.052	< 0.001

This improvement was further analyzed by calculating N-Gain with an average of 0.63 (medium category). Students were grouped into three categories based on their Organic Chemistry I scores (high, medium, and low). All three groups showed increased cognitive learning outcomes in the same category, as shown in Table 5.

Table 5. N-Gain Test Result

No	Group achievement	Test		N-Gain Score	Interpretation
		Pre-test	Post-test		
1	High	32.50	75.00	0.63	Medium
2	Medium	37.29	76.21	0.62	Medium
3	Low	36.43	77.14	0.64	Medium
Mean		35.41	76.12	0.63	Medium

These results indicate that integrating the PBL model with the assistance of Nearpod has a positive impact on improving students' cognitive learning outcomes with a medium improvement category on carboxylic acid material. These findings are in line with the results of research by Naumoska et. al (2022) and Perlawanan et. al (2023), which confirm the effectiveness of Nearpod in motivating students to learn, which ultimately contributes to improving chemistry learning outcomes [16], [19]. In addition, the results of research by Uliyandari et al. (2021) stated that applying the PBL model can improve conceptual understanding and critical thinking skills with medium improvement [35].

Unlike previous studies, this study added analysis based on cognitive levels (C3, C4, C5), providing a more in-depth picture of students' ability to apply, analyze, and evaluate organic chemistry concepts, particularly carboxylic acids. The integration of Nearpod in PBL also showed advantages over conventional PBL models, which are limited to discussions without technological support. The interactive features and immediate feedback in Nearpod help students understand the material more effectively and actively engage in problem-solving. This is supported by the research by Dewi et al. (2023), which shows increased student understanding through the application of Nearpod in PBL [36].

These findings recommend that chemistry educators utilize Nearpod to help students understand abstract concepts such as reaction mechanisms. Using this media will be more effective when combined with reflective discussions, thereby increasing interactivity and strengthening conceptual understanding. This approach can also be adapted to other educational levels to develop higher-order thinking skills. Theoretically, this study contributes to the limited literature on the use of Nearpod integrated with the PBL model and expands understanding of the effectiveness of technology in chemistry education.

Compared to similar studies (Naumoska et al., 2022; Perlawanan et al., 2023), this study provides added value by focusing on university students in Indonesia, where the application of technology-assisted PBL models is still developing. Additionally, this study not only evaluates improvements in cognitive learning outcomes but also emphasizes the development of critical thinking skills, thereby contributing new insights to the literature on technology-based learning at the university level.

The Improvement Based on Question Indicators and Cognitive Levels

The improvement in students' cognitive learning outcomes after implementing the Nearpod-assisted PBL model on carboxylic acid material can be analyzed based on the N-Gain value for each question indicator. There are three question indicators at the C3 cognitive level (applying). The first indicator is determining the name of a carboxylic acid compound based on the structure presented, showing medium improvement with an N-Gain value of 0.68. This may have occurred because students watched the first video in the Nearpod media, which visualized examples of carboxylic acid structures and their names. This finding is in line with the research by Setyarini et al. (2017), which states that the use of 3D molecular visualization is effective in enhancing students' understanding when learning chemical structures and compound names [37].

The second indicator at the C3 cognitive level, which is determining the structure based on the name of a carboxylic acid compound, showed a medium improvement with an N-Gain value of 0.3. This was supported by the matching pairs feature in Nearpod, which trained students to match names with compound structures, strengthening their understanding and application of the concept. This finding aligns with the research by Yerimadesi et al. (2016), which states that using computer-based learning media can improve students' understanding when studying the structure and nomenclature of carbon compounds [5].

The third indicator at the C3 cognitive level, namely applying the principle of carboxylic acid solubility in water, showed an increase in the high category with an N-Gain value of 0.93. This increase was supported by the second video in Nearpod, which linked carboxylic acids' physical and chemical properties to everyday phenomena, making it easier for students to understand and apply the concept. This finding is consistent with Pratama et al. (2017), who stated that instructional videos can enhance understanding of chemistry concepts [38].

There are five question indicators at the C4 cognitive level (analyzing). The first and second indicators, which involve analyzing the effect of substituents on acidity and analyzing the acidity sequence of carboxylic acid compounds, show improvement in the high category with N-Gain values of 0.85 and 0.88, respectively. This achievement is supported by the second video in the Nearpod media, which discusses the effect of substituents on the acidity of carboxylic acids. This finding is consistent with the research by Alicia et al. (2021), which states that the Nearpod media can improve student learning outcomes and engagement through its interactive features [39].

The third indicator at cognitive level C4, namely analyzing ways to synthesize carboxylic acids, showed an increase in the high category with an N-Gain value of 0.98. This achievement was supported by applying the PBL model and interactive Nearpod media, which encouraged students to actively explore and solve problems. In addition, a good command of the nomenclature of carboxylic acids will make it easier for students to analyze the appropriate synthesis methods. This finding aligns with the research by Suhanda & Suryanto (2020), which states that understanding the nomenclature of compounds contributes directly to the ability to analyze synthesis pathway [6].

The fourth indicator at the C4 cognitive level, which is analyzing the mechanism of hydrolysis reactions to synthesize carboxylic acids and students were instructed to depict the reaction mechanism, showed an improvement in the medium category with an N-Gain value of 0.59. This achievement is supported by the third video in the Nearpod media, which discusses the synthesis reaction of carboxylic acid compounds and visualizes the reaction mechanism. This finding is consistent with Eckhard et al. (2022), who stated that instructional videos effectively enhance conceptual understanding and student engagement in learning reaction mechanisms [17].

The fifth indicator at cognitive level C4, which is analyzing the mechanism of esterification reactions and students were instructed to draw the reaction mechanism, showed an improvement in the medium category with an N-Gain value of 0.55. This improvement may have occurred because students watched the fourth video on the Nearpod media, which discussed carboxylic acid reactions and visualized the mechanism. This feature allows students to listen to explanations more intently, thereby facilitating the analysis process of the reaction mechanism stages. Additionally, educational media is intended to transform abstract concepts into something observable [40]. This finding aligns with the research findings of Schweiker et al. (2020), who stated that using videos enables students to achieve a deeper understanding when studying organic chemical reactions [18].

However, based on this study's results, some students still have difficulty understanding carboxylic acid material, especially in learning reaction mechanisms. This finding aligns with the statement by Quinn et al. (2020) that organic chemistry is a branch of chemistry that is considered challenging for students, especially in the reaction mechanism section. This is due to the underlying conceptual mix, process-oriented thinking inherent in the discipline, and the representations commonly used to describe reaction mechanisms [41].

At cognitive level C5 (evaluating), there are two question indicators. The first indicator is determining the best decision to maintain the quality of apple cider vinegar, showing improvement in the high category with an N-Gain value of 1.00. This is supported by contextual videos in the Nearpod platform showcasing the application of carboxylic acid concepts in real-life scenarios. Implementing the Nearpod-assisted PBL model encourages students to critically evaluate information and make decisions based on relevant data. These findings align with Puspitasari's (2024) research, which indicates that using this model and media effectively enhances learning outcomes and critical thinking skills [42].

The second indicator in the C5 cognitive level, which is evaluating the correctness of hypotheses related to how to synthesize carboxylic acids based on the compounds presented, showed an improvement in the moderate category with an N-Gain value of 0.4. In problem-based learning, students are required to analyze the structure of the initial compounds, understand chemical reactions, and evaluate the possibility of the correct synthesis pathway. Applying the PBL model encourages students to think critically and deeply when solving problems [42]. In addition, the Nearpod media, which presents interactive videos and quizzes, also increases student engagement in understanding synthesis reactions. These findings are consistent with previous studies showing the effectiveness of Nearpod features in increasing learning engagement [23], [25]. Through this active engagement, students not only memorize reactions but can also evaluate the rationality of the synthesis pathway selection, thereby significantly improving their cognitive abilities at the evaluation level. The Improvements at each cognitive level is depicted in Figure 14.

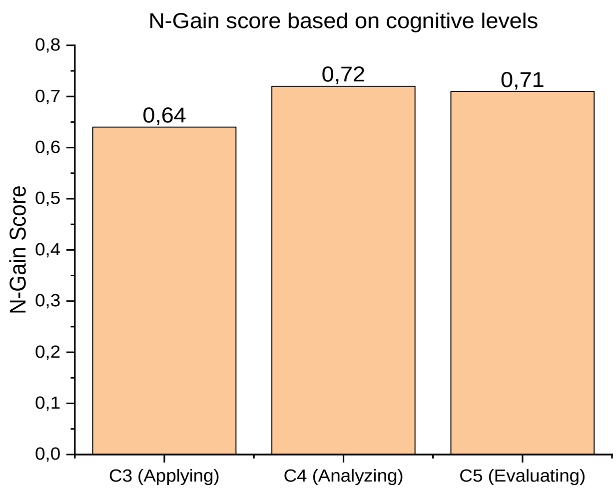

Figure 14. N-Gain Score Based on Cognitive Levels

Based on the graph above, the highest increase occurred at cognitive level C4 (analysis), indicating that implementing the Nearpod-assisted PBL model effectively honed students' analytical skills, such as analyzing reactions and synthesizing compounds. Cognitive level C5 (evaluation) also saw an increase in the high category, reflecting the approach's effectiveness in training students to evaluate and make data-driven decisions. Meanwhile, the increase in cognitive level C3 (application) was in the medium category, indicating that students can relate concepts to their application in real-world contexts. These findings reinforce that the integration of PBL and Nearpod supports basic understanding and encourages students to think at a more complex level.

Response of Students to the Use of Nearpod

The results of the questionnaire analysis show that most students gave positive responses to its application in organic chemistry learning. The results are shown in Figure 15.

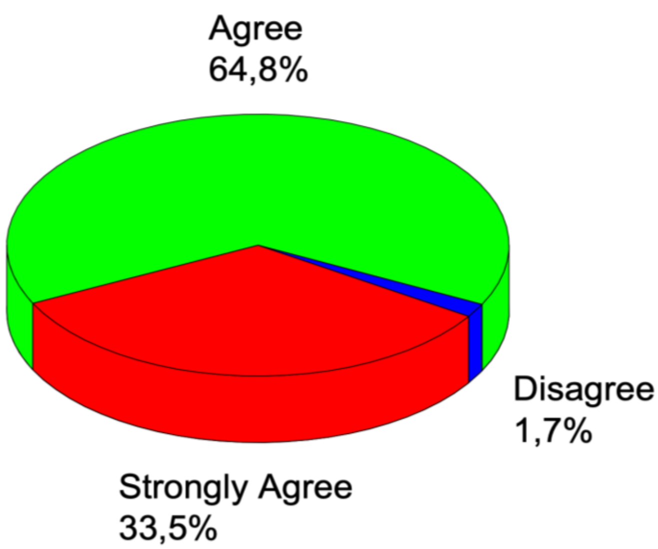

Figure 15. Response of Students to the Use of Nearpod

Figure 15 shows that most students responded positively to using Nearpod, with 33.5% strongly agreeing, 64.8% agreeing, 1.7% disagreeing, and no students (0%) strongly disagreeing. This response indicates that Nearpod is very well accepted as a support for the PBL model. 98.3% of students agreed or strongly agreed with its effectiveness in improving concept understanding, active engagement, clarifying the material presented, and making learning more interesting than conventional methods. This reflects students' enthusiasm for using this media for carboxylic acid material. These findings are in line with the research by Rochmad et al. (2023) and Alicia et al. (2021), which highlighted the role of Nearpod in increasing student interest, motivation, and engagement [39], [43].

Meanwhile, only 1.7% of students disagreed due to technical constraints such as unstable internet connections. This is in line with the findings of Subroto et.al (2023), who stated that one of the main challenges in implementing digital technology-based learning media is dependence on technological infrastructure, particularly adequate internet connections [44]. In addition, some students were less interested in using Nearpod to learn about carboxylic acids and other chemistry topics. This may be due to differences in individual learning styles, where some students prefer conventional methods that are considered easier to understand and do not require additional technological adjustments.

CONCLUSION

This study shows that integrating the PBL model assisted by Nearpod can improve cognitive learning outcomes, conceptual understanding, and active participation of students in learning carboxylic acid material. The improvement in cognitive learning outcomes can be seen from the N-Gain score of 0.63 (medium category), with the highest achievement at the cognitive analysis level (C4). Learning activities were carried out very well, with a percentage of 87.66%, and students' ability to complete worksheets also showed excellent results, with an average score of 88. In addition, 98.3% of students responded positively to using Nearpod media in learning. These results indicate that the combination of the PBL model and interactive digital media such as Nearpod can be an effective solution to help students understand abstract organic chemistry concepts and develop higher-order thinking skills. This study contributes to the development of technology-based chemistry learning in higher education. However, this study has several limitations, such as the absence of a control group, a limited sample size, potential bias due to the researcher acting as the instructor, and reliance on a stable internet connection. Therefore, further research is recommended to use a quasi-experimental design with a control group and explore the application of similar methods on other chemistry topics, such as esters, to obtain more comprehensive and generalizable results.

REFERENCES

[1] B. Setiawan, "Pengembangan Alat Peraga GUFUS Sebagai Sumber Belajar Mandiri Pada Materi Gugus Fungsi," *J. Trop. Chem. Res. Educ.*, vol. 4, no. 1, pp. 36–44, 2022, doi: 10.14421/jtcre.2022.41-04.

[2] L. D. Hammond, L. Flook, C. C. Harvey, B. Barron, and D. Osher, "Implications for educational practice of the science of learning and development," *Appl. Dev. Sci.*, vol. 24, no. 2, pp. 97–140, 2020, doi: 10.1080/10888691.2018.1537791.

[3] N. Windayani, I. Hasanah, and I. Helsy, "Analisis Bahan Ajar Senyawa Karbon Berdasarkan Kriteria Keterhubungan Representasi Kimia," *JTK (Jurnal Tadris Kim.*, vol. 3, no. 1, pp. 83–93, 2018, doi:

10.15575/jtk.v3i1.2682.
[4] Herlina, “Penerapan Problem Based Learning Untuk Meningkatkan Hasil Belajar Kimia Pada Materi Hidrokarbon,” *PENDIPA J. Sci. Educ.*, vol. 4, no. 3, pp. 7–13, 2020, doi: 10.33369/pendipa.4.3.7-13.
[5] F. Yerimadesi; Syukri; Aulia, “Media Pembelajaran Berbasis Komputer Untuk Materi Struktur Dan Tata Nama Senyawa Karbon Kelas XII SMA,” *EKSAKTA*, vol. 1, no. 2, pp. 17–24, 2016, doi: https://doi.org/10.1128/AEM.70.2.837-844.2004.
[6] S. Suhanda & Suryanto, “Peningkatan Pemahaman Siswa Pada Konsep Senyawa Turunan Alkana Melalui Learning Cycle 5E Berbantuan Peta Konsep,” *J. Inov. Pendidik. Kim.*, vol. 14, no. 2, pp. 2652–2664, 2020.
[7] S. B. Siregar, “Penerapan Model Problem Based Learning (PBL) Untuk Meningkatkan Hasil Belajar Kimia Siswa Kelas XII MIPA 5 SMA Negeri 17 Bandung,” *J. Ilm. Indones.*, vol. 4, no. 9, pp. 1–23, 2019, doi: https://dx.doi.org/10.36418/syntax-literate.v4i9.716.
[8] U. Suswati, “Penerapan Problem Based Learning (Pbl) Meningkatkan Hasil Belajar Kimia,” *Teach. J. Inov. Kegur. dan Ilmu Pendidik.*, vol. 1, no. 3, pp. 127–136, 2021, doi: 10.51878/teaching.v1i3.444.
[9] H. A. B. Bara *et al.*, “Effectiveness Of A Problem-Based Learning Module On Salt Hydrolysis In Improving Student Learning Outcomes,” *Chim. Didact. acta*, vol. 12, no. 02, pp. 91–96, 2024, doi: http://dx.doi.org/10.24815/jcd.v12i2.41972.
[10] T. B. Noviantika, “Problem Based Learning (Pbl) Model on Students’ Learning Outcomes in Hydrocarbon Materials,” *J. Pembelajaran Sains*, vol. 6, no. 1, p. 48, 2023, doi: 10.17977/um033v6i1p48-51.
[11] T. D. Sinaga and S. Tarigan, “The Influence of Problem Based Learning and Discovery Learning Models on Student Learning Outcomes on Chemical Bonding Material,” *Indones. J. Adv. Res.*, vol. 3, no. 4, pp. 507–518, 2024, doi: 10.55927/ijar.v3i4.8972.
[12] M. Amiruddin, Sari, R. Aisyah, and F. S. Irwansyah, “Interactive learning multimedia based on multiple representations on acid-base solutions,” *AIP Conf. Proc.*, vol. 3058, no. 1, Apr. 2024, doi: 10.1063/5.0206430/3280961.
[13] C. Rahmi, A. Fitria, V. Santika, and S. Rahmawati, “Analisis Pengembangan Media Dalam Pembelajaran Kimia,” *Lantanida J.*, vol. 10, no. 1, p. 10, 2022, doi: 10.22373/lj.v10i1.13355.
[14] D. P. E. Putri and A. Muhtadi, “Pengembangan multimedia pembelajaran interaktif kimia berbasis android menggunakan prinsip mayer pada materi laju reaksi,” *J. Inov. Teknol. Pendidik.*, vol. 5, no. 1, pp. 38–47, 2018, doi: 10.21831/jitp.v5i1.13752.
[15] S. N. Risky, R. Auliya, S. Anjarwati, U. H. A’liyah, and M. S. Hadi, “Pemanfaatan E-Media Nearpod dalam Meningkatkan Kemampuan Matematis dan Motivasi Peserta Didik,” *J. Ilm. Mandala Educ.*, vol. 9, no. 2, pp. 1017–1023, 2023, doi: 10.58258/jime.v9i2.4952.
[16] A. Naumoska, K. Rusevska, A. Blazhevska, and M. Stojanovska, “Nearpod as a tool for increasing students’ motivation for learning chemistry,” *Int. J. Educ. Learn.*, vol. 4, no. 1, pp. 89–99, 2022, doi: 10.31763/ijele.v4i1.616.
[17] J. Eckhard, M. Rodemer, S. Bernholt, and N. Graulich, “What Do University Students Truly Learn When Watching Tutorial Videos in Organic Chemistry? An Exploratory Study Focusing on Mechanistic Reasoning,” *J. Chem. Educ.*, vol. 99, no. 6, pp. 2231–2244, 2022, doi: 10.1021/acs.jchemed.2c00076.
[18] S. S. Schweiker, B. K. Griggs, and S. M. Levonis, “Engaging Health Student in Learning Organic Chemistry Reaction Mechanisms Using Short and Snappy Lightboard Videos,” *J. Chem. Educ.*, vol. 97, no. 10, pp. 3867–3871, 2020, doi: 10.1021/acs.jchemed.0c00619.
[19] H. Perlawanan, Andi Tahta; Alimin; & Sellimin, “Penerapan Media Nearpod Untuk Meningkatkan Hasil Belajar Peserta Didik,” *J. Pemikir. dan Pengemb. Pembelajaran*, vol. 5, no. 3, pp. 1–6, 2023.
[20] J. W. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*. California: Sage Publications, 2018.
[21] D. S. Hafsah, N. Aznam, and E. Rohaeti, “The Development of Electronic Student Worksheets Based on Problem-Based Learning and Its Impact on Motivation and Problem-Solving Skills,” *J. Penelit. Pendidik. IPA*, vol. 10, no. 9, pp. 6984–6992, 2024, doi: 10.29303/jppipa.v10i9.8873.
[22] R. Sundayana, *Statistika Penelitian Pendidikan*. Bandung: ALFABETA, 2016.
[23] M. Hakami, “Using Nearpod as a Tool to Promote Active Learning in Higher Education in a BYOD Learning Environment,” *J. Educ. Learn.*, vol. 9, no. 1, p. 119, 2020, doi: 10.5539/jel.v9n1p119.
[24] S. Supriadi, W. Wildan, and D. Laksmiwati, “Implementasi Model Pembelajaran Berbasis Masalah dan Pengaruhnya terhadap Perkembangan Karakter Mahasiswa,” *J. Penelit. Pendidik. IPA*, vol. 6, no. 1, pp. 63–68, 2020, doi: 10.29303/jppipa.v6i1.323.
[25] X. Liu, “Improve Interactivity in Online Learning: Take Nearpod as an Example,” *J. Educ. Humanit. Soc. Sci.*, vol. 8, pp. 1954–1960, 2023, doi: 10.54097/ehss.v8i.4622.
[26] D. Wiguna, F. S. Irwansyah, N. Windayani, H. Aulawi, and M. A. Ramdhani, “Development of android-based chemistry learning media oriented towards

generic science skills," *J. Phys. Conf. Ser.*, vol. 1157, no. 4, 2019, doi: 10.1088/1742-6596/1157/4/042047.

[27] M. Isnaini, G. TTrimulyono, and Z. Hikmah, "Implementasi Model Problem Based Learning (Pbl) Dalam Meningkatkan Kolaborasi," *Learn. J. Inov. Penelit. Pendidik. dan Pembelajaran*, vol. 4, no. 3, pp. 501–507, 2024, doi: 10.51878/learning.v4i3.3127.

[28] I. Yunitasari and A. T. A. Hardini, "Penerapan Model PBL Untuk Meningkatkan Keaktifan Peserta Didik Dalam Pembelajaran Daring Di Sekolah Dasar," *J. Basicedu*, vol. 5, no. 4, pp. 1700–1708, 2021, doi: 10.31004/basicedu.v5i4.983.

[29] Sajidan., Suranto., I. R. W. Atmojo, D. Y. Saputri, and R. Etviana, "Problem-Based Learning-Collaboration (Pbl-C) Model in Elementary School Science Learning in the Industrial Revolution Era 4.0 and Indonesia Society 5.0," *J. Pendidik. IPA Indones.*, vol. 11, no. 3, pp. 477–488, 2022, doi: 10.15294/jpii.v11i3.30631.

[30] E. Mukharomah, S. Hidayat, S. Handaiyani, and A. Kartika, "Pengaruh Penerapan Model Pembelajaran Problem Based Learning (Pbl) Terhadap Kemampuan Kognitif Mahasiswa Pada Mata Kuliah Pengetahuan Lingkungan," *Biosf. J. Biol. dan Pendidik. Biol.*, vol. 6, no. 1, 2021, doi: 10.23969/biosfer.v6i1.3973.

[31] N. D. Indahsari and Habiddin, "Penerapan Model Pembelajaran Problem Based Learning (PBL) untuk Meningkatkan Keterampilan Kolaborasi Siswa SMP," *J. Pembelajaran, Bimbingan, dan Pengelolaan Pendidik.*, vol. 4, no. 7, pp. 389–400, 2024, doi: 10.17977/um065.v4.i7.2024.5.

[32] J. A. Amador-Balderas, M. A. Martínez-Sánchez, R. E. Ramírez, F. Méndez, and F. J. Meléndez, "Analysis of the Gas Phase Acidity of Substituted Benzoic Acids Using Density Functional Concepts," *Mol. 2020, Vol. 25, Page 1631*, vol. 25, no. 7, p. 1631, Apr. 2020, doi: 10.3390/MOLECULES25071631.

[33] A. M. Costa, N. Escaja, C. Fité, M. González, S. Madurga, and E. Fuguet, "Problem-Based Learning in Graduate and Undergraduate Chemistry Courses: Face-to-Face and Online Experiences," *J. Chem. Educ.*, vol. 100, no. 2, pp. 597–606, 2023, doi: 10.1021/acs.jchemed.2c00741.

[34] A. D. Simangunsong, "Implementation of The Problem Based Learning (PBL) Learning Model To Improve Skills Creative Thinking of Students on The Material Coligative Properties of Solutions," *Edunesia J. Ilm. Pendidik.*, vol. 4, no. 2, pp. 483–494, 2023, doi: 10.51276/edu.v4i2.396.

[35] M. Uliyandari, Emilia Candrawati, Anna Ayu Herawati, and Nurlia Latipah, "Problem-Based Learning To Improve Concept Understanding and Critical Thinking Ability of Science Education Undergraduate Students," *IJORER Int. J. Recent Educ. Res.*, vol. 2, no. 1, pp. 65–72, 2021, doi: 10.46245/ijorer.v2i1.56.

[36] S. N. R. Dewi, L. Sugiarti, and D. D. Saputri, "Peningkatan Pemahaman Dan Reduksi Miskonsepsi Dengan Model Problem Based Learning Berbantu Nearpod Dan Live Worksheet," *J. Bionatural*, vol. 10, no. 2, pp. 63–72, 2023, doi: 10.61290/bio.v10i2.245.

[37] M. Setyarini, L. Liliasari, A. Kadarohman, and M. A. Martoprawiro, "Efektivitas Pembelajaran Stereokimia Berbasis Visualisasi 3D Molekul Untuk Meningkatkan Kemampuan Spasial," *J. Cakrawala Pendidik.*, vol. 36, no. 1, pp. 91–101, 2017, doi: 10.21831/cp.v36i1.11082.

[38] A. Pratama, S. Ulfa, and D. Kuswandi, "Pemanfaatan Video Pembelajaran," *Pros. TEP PDs*, vol. 3, no. 2007, pp. 80–87, 2017, [Online]. Available: http://jurnal.sar.ac.id/index.php/J-PEMAS

[39] H. Alicia, T. Fardisah, and D. Z. Muhtarisatul, "Efektivitas Penggunaan Nearpod Terhadap Peningkatan Minat Belajar Mahasiswa Pada Mata Kuliah Termodinamika," *J. Pendidik. Teknol. Inf.*, vol. 4, no. 2, pp. 63–71, 2021, doi: https://dx.doi.org/10.37792/jukanti.v4i2.291.

[40] R. N. Eli and Sari, "Pembelajaran Sistem Koloid Melalui Media Animasi Untuk Meningkatkan Aktivitas Dan Hasil belajar Siswa," *JTK (Jurnal Tadris Kim.*, vol. 2, no. Desember, pp. 135–144, 2018, doi: https://doi.org/10.15575/jtk.v3i2.3713.

[41] S. A. F. Quinn, F. M. Watts, M. N. Petterson, S. R. Archer, E. P. S. White, and G. V. Shultz, "Exploring Student Thinking about Addition Reactions," *J. Chem. Educ.*, vol. 97, no. 7, pp. 1852–1862, 2020, doi: 10.1021/acs.jchemed.0c00141.

[42] G. L. Puspitasari, "Efektivitas Model Problem Based Learning (PBL) Berbantuan Media Nearpod pada Pembelajaran Fisika untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Kelas X SMA Negeri 1 Godong," *Dharma Acariya Nusant. J. Pendidikan, Bhs. dan Budaya*, vol. 2, no. 2, 2024, doi: https://doi.org/10.47861/jdan.v2i2.1273.

[43] M. Rochmad, Umalihayati, and P. Dayurni, "Pengaruh Penggunaan Media Interaktif Menggunakan Nearpod Untuk Meningkatkan Motivasi Belajar Siswa Kelas X Pada Mata Pelajaran TIK di SMA Al-Mubarok Kota Serang," *Innov. J. Soc. Sci. Res.*, vol. 3, no. 4, pp. 4925–4932, 2023.

[44] D. E. Subroto, Supriandi, R. Wirawan, and A. Y. Rukmana, "Implementasi Teknologi dalam Pembelajaran di Era Digital: Tantangan dan Peluang bagi Dunia Pendidikan di Indonesia," *J. Pendidik.*

West Sci., vol. 1, no. 07, pp. 473–480, 2023, doi: 10.58812/jpdws.v1i07.542.