

Implementation of Problem-Based Learning with peer teaching using web gamification to increase students' critical thinking on acid-base material

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Abstract

The problems faced include a dominant teacher-centered learning method, a lack of understanding of acid-base material, unattractive learning media, low problem-solving skills, and low motivation and interest in learning. This study aims to apply a problem-based learning model with peer teaching using web gamification to improve students' critical thinking skills in Class XI MIPA. This study uses a mixed methods method with an embedded design, where 70% of the data is quantitative and 30% qualitative. The results showed that the average pre-test score in the experimental class was 67,67 and in the control class was 60,39. The average post-test score in the experimental class reached 85,03, while in the control class it was 75,73. The analysis of the independent sample T-test showed a significant difference between the experimental and control classes with a value of 0,001. The average comparison of the N-gain test showed that the N-gain result in the experimental class (63,63%) was higher than that of the control class (40,34%). The students' responses indicated that 93,93% strongly agreed, 80% agreed, and 3,63% disagreed. In conclusion, the implementation of PBL with peer teaching and web gamification is effective in improving students' critical thinking skills.

1. Introduction

In the 21st century, learners need to have specific skills: critical thinking, creativity, communication, and collaboration, often referred to as the 4C's. The educational approach in schools has shifted from being teacher-centered to being student-centered, but its implementation has not been fully optimized. Benjamin Bloom classified the results of learning activities into three areas: cognitive, affective, and psychomotor. Therefore, students must develop 4C skills (critical thinking, creativity, collaboration, and communication) (Fingerprint et al., 2022). The expected thinking skills after learning activities include critical thinking.

Critical thinking involves an intellectually active and skilled disciplinary process that includes conceptualizing, applying, analyzing, synthesizing, and evaluating information gathered through observation, experience, reflection, reasoning, or communication. It serves as a guide to belief and action (Marhamah et al., 2020). Developing critical thinking skills is crucial for students as it enables them to produce high-quality work (Habibah et al., 2022). Critical thinking encourages students to think, work, and make connections between their learning and other areas. It also trains students to find accurate and structured solutions and promotes the analysis and evaluation of relevant and valid information (Fingerprint et al., 2022).

Critical thinking for chemistry subjects is very important because the characteristics of chemistry include a wide range of material consisting of facts, concepts, rules, laws, principles, theories, and problems where most of the material consists of abstract concepts such as atomic structure, chemical bonds, and acid-base concepts (Azizah et al., 2022). Based on the results of observations made at the time of Introduction to the School Field (PLP) 2 class XI MIPA at one of the Cirebon City State High Schools, Students' critical thinking skills are still low, this is because students still receive and listening to material from teachers and students always think that chemistry is a difficult, boring, and less relaxing subject. Chemistry learning is usually related to daily life, where this learning contains calculations and concepts so that in learning requires a strong understanding of concepts (Sari, et.al., 2019).

In the field of chemistry education, students often struggle with grasping complex chemical concepts and rely heavily on mathematical calculations to solve problems (Fingerprint et al., 2022). When studying chemistry, students frequently encounter formulas and may mistakenly believe that memorizing these formulas will simplify problem-solving. However, it's important to note that using chemical formulas solely based on their designation is often incorrect. It is the lack of students' understanding of the concepts taught that makes it difficult for students to do the problems (Fajrin et.al., 2020).

In addition, difficulties in learning chemistry are also caused by the complexity of calculations, uncommonly used language, and differences in the reflexes used by chemists in explaining chemical phenomena (Azizah et al., 2022). Students have difficulties in learning Chemistry material, one of which is on the subject of acid-base. In the acid-base theory material, acid-base indicators, and pH calculations are considered the most difficult by students. This difficulty is characterized by the length of time students take to understand the acid-base theory material. This is due to a lack of grades so students who experience difficulties do not get the right solution (Fajrin et al., 2020).

The current chemistry learning models lack student involvement and often create a boring atmosphere. To address this issue, researchers have proposed Problem-Based Learning (PBL) as a more engaging and effective model for acid-base learning (Fajrin et al., 2020). PBL is a learning approach that emphasizes problem-solving and critical thinking, making it a suitable model for 21st-century learning (Haryati et.al., 2023).

The concept of learning media web gamification involves leveraging technology to create a more engaging and visually appealing learning experience. Incorporating web gamification can enhance students' critical thinking abilities, encouraging them to actively engage with learning materials, analyze information, solve problems, express opinions, participate in discussions with peers, and draw conclusions. This approach is in line with the idea that integrating game elements into educational content can greatly benefit students (Ambawani et.al., 2024). Web gamification entails applying gaming strategies to non-game contexts.

In a previous study by Agussalim et.al. (2023), it was found that the motivation to learn chemistry in class X Innovative at UPT SMAN 11 Pinrang increased with the implementation of the problem-based learning model using the peer tutor method. The motivation of students to learn chemistry in class X Innovative increased with each cycle, particularly in the stoichiometry material. The increase was 9%, with student learning motivation elaboration at 73% in the first cycle and 82% in the second cycle. Additionally, research by Aryani et.al. (2021) indicated that the use of web-based digital platforms can facilitate various teaching methods and engage educators and participants actively during the learning process.

The study will implement the Problem-Based Learning with Peer Teaching (PBLwPT) model using Web Gamification. The research aims to enhance the critical thinking skills of students at Cirebon City State High School. The use of Gamification Web will facilitate the application of Peer Teaching, ultimately boosting students' interest and motivation.

2. Method

This study utilized a mixed method and embedded design research. The researcher employed an embedded design, using 70% quantitative data and 30% qualitative methods. The research took place at Cirebon City State High School during the second semester of the 2023/2024 academic year, specifically in class XI MIPA. The study involved two classes: XI MIPA 3 as the experimental class and XI MIPA 4 as the control class, with 33 students in each class. The research focused on the student population at Cirebon City State High School.

The data collection technique involves using learning instruments such as student worksheets containing questions and simple experiments about acid-base materials. The learning steps include pre-test and post-test questions. The research instruments used are observation sheets and questionnaires to gauge students' responses to the problem-based learning model with peer teaching using web gamification, aimed at improving students' critical thinking. Before using the instruments,

an expert validity test, difficulty level test, Differentiating Power Test, validity, and reliability test are conducted using the SPSS version 29.0 application.

The results of the validation test for the learning instruments showed that 91% of the learning instruments were valid, based on expert validation. The difficulty test, consisting of four questions, categorized one question as easy (3) and the rest as medium (1, 2, 4, and 5), with the following difficulty scores: question 1 (0.63), question 2 (0.69), question 3 (0.72), question 4 (0.56), and question 5 (0.38). In the Differentiating Power Test, question 1 (0.567) and question 2 (0.580) were classified as good, while question 3 (0.417) was also good, and question 4 (0.277) and question 5 (0.428) were classified as sufficient. This indicates that the questions had good and sufficient discriminating power among students. The validity test, using the person correlation formula, was found to be valid as a whole, with the calculated value greater than the table value at $N = 33$, with a significance level of 0.05 at 0.3338. The Alpha Cronbach value obtained was 0.702, which is greater than the reference value of 0.60, indicating that the question instruments used in the study are reliable.

The data analysis process involved conducting initial tests to check for data normality using the Smirnov-Wilk test and for data homogeneity using the Levene test, both at a significance level of 0.05, using IBM SPSS Statistics 29 software. The research hypothesis was assessed using an independent two-sample t-test at a significance level of 0.05, in addition to the N-Gain test. In the N-Gain test, a g value of 0.7 or higher indicates a high category, a g value between 0.3 and 0.7 indicates a medium category, and a g value below 0.3 indicates a low category. This research was conducted to apply a problem-based learning model with peer teaching using web gamification to improve students' critical thinking using pre-test and post-test questions. The results of this research are the answer to the predetermined formulation of the problem, so that it can strengthen the hypothesis.

3. Results and Discussion

3.1. Implementation of Problem-Based Learning Learning Model with Peer Teaching Using Web Gamification that can Improve Students' Critical Thinking

Implementation of learning Implementation This research applies a Problem Based Learning (PBL) learning model combined with peer teaching and web gamification in an experimental class (XI MIPA 3) consisting of 33 students. This learning was carried out in 3 meetings with a duration of 40 minutes each so that the total learning time was 120 minutes. Before starting the learning cycle, the researcher made observations on the activities of teachers and students in the classroom.

The control class has a different structure from the experimental class, which consists of the implementation of a pre-test, the delivery of material only using problem-based learning without a peer teaching approach, the implementation of simple experiments and the evaluation of written tests (post-test). After learning in the control class using the learning stages using the PBL model only, The results of the observations carried out in the control class were carried out in groups. In group one, 87%, group 2 is 89%, group 3 is 82%, group 4 is 82% and group 5 is 85%. During the research in the classroom, the class control is very conducive and students are actively involved in the learning process so that the results of the assessment of the observation sheet based on their group meet the criteria, which have been determined. Therefore, the average assessment of the control class group is above 80, which means that it is good.

In this study, although the application of Problem Based Learning in the control class has given quite good results, there is still room for significant improvement. The reason is that in the control class, teaching methods are still not varied and the use of learning media still does not take advantage of educational game-based technology that attracts students' visuals, makes students more active during learning, and improves understanding in a fun way without pressure. One way to maximize learning outcomes is to combine PBL with peer teaching methods equipped with web-based gamification at the end of learning. This approach is expected to create a more active and fun

classroom atmosphere, as well as encourage the improvement of students' critical thinking skills who will be treated in experimental classes.

The experimental class, it was carried out for 3 meetings, including: Implementation of pre-test, provision of problem topics, delivery of materials, implementation of simple experiments, evaluation of learning with web gamification media. After learning in the control class using the learning stages using the PBL model with a peerteaching approach using web gamification. The results of observations made in the control class were carried out in groups. In group one, 93%, group 2 is 97%, group 3 is 94%, group 4 is 92% and group 5 is 91%. During the research in the experimental class, the class is very conducive and students are actively involved in the learning process so that the results of their observation sheet assessment meet the criteria, which have been determined. Therefore, the average assessment of the experimental class group is above 90, meaning that it is very good or satisfactory. It can be concluded that the application of problem-based learning with peer teaching using web gamification media in the experimental classroom is very successful as seen from the results of student observation.

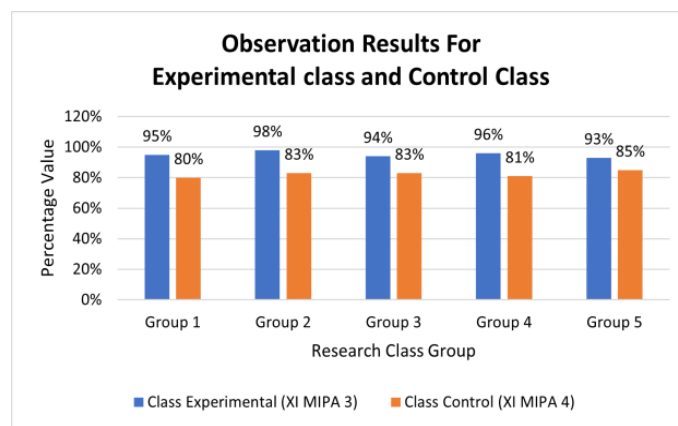


Figure 1. Observation

In addition to evaluating the observation sheet, we also assessed the Student Worksheet (LKPD) provided to both the experimental group and the control class. The purpose of distributing the Student Worksheet (LKPD) to each group is to improve the students' understanding of the subject matter, analytical skills, and problem-solving abilities. Using the LKPD, we aim to promote active student participation in the learning process, both individually and in groups.

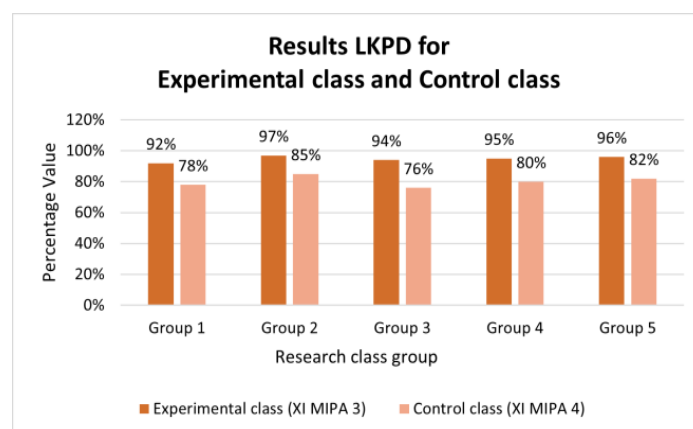


Figure 2. LKPD Results

In the experimental class and the control class, there was a significant difference in the students' worksheets to find out the students' critical thinking and the learning model used. The acquisition of LKPD scores that are above average can be concluded by the simplicity of simple experiments and problem-based models to make students have a deeper understanding of acid-base.

It can be concluded that in this study, the application of the problem based learning (PBL) learning model using a peer teaching approach using web gamification as a learning medium after completing the learning process in the experimental classroom is very successful to be used in improving understanding, students play an active role and think critically on the acid-base chemistry mater and the class becomes more fun than With the control class only using the learning model. So of the two classes, the one with the highest average score, namely the experimental class, means that it is more successful than the control class that only uses the PBL model.

3.2. Experimental Class and Control Class

The difference between the experimental class and the control class can be identified through a series of pre-order tests which include normality test, homogeneity test, T-test, and N-gain test. Below are the data obtained from the results during the study, which are as follows:

Grades Pre-test post-test scores of experimental class and control class

In this study, research results were collected using pre-test and post-test instruments consisting of 5 description/essay questions. The pre-test and post-test scores were used to determine the success after the treatment. The pre-test and post-test values were utilized as prerequisite tests, including normality test, homogeneity test, t-test, and N- gain test. The data from the learning outcomes of the experimental class and the control class, including the average score, the highest score, and the lowest score of the pre-test and post-test results, are illustrated in Figure 3

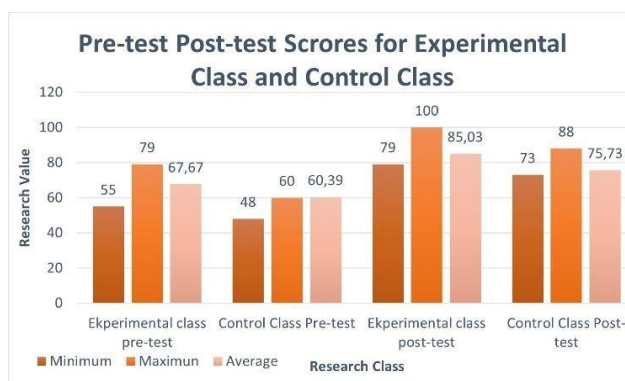


Figure 3. Pre-test and post-test

Based on the results of the analysis, there was a difference in the value of the pre- test and post-test results of the experimental class and the control class. The pre-test and post- test scores of the experimental class had significant differences compared to the control class. In the experimental class, the average pre-test score was 67,67 while in the control class it was 60.39. The average post-test score of the experimental class is 85.03 while the average score of the control class is 75,73 in this case can answer the second problem formulation, namely, there is a significant difference between the experimental class and the control class as seen from the results of the pre-test and post-test scores during the research.

Normality Test

The normality test uses pretest and posttest values. This normality test uses the Smirnov test with the SPSS 29.0 application. Based on the SPSS one-sample-Smirnov test application, a probability number or asyim sig (2-tailed) was obtained.

Table 1. Data normality test

Research Data	N	Shapiro-wilk		Conclusion
		Statistics	Father	
Pre-test checks	33	0,937	0,55	Usual
Post-Test Control	33	0,953	0,160	Usual
Pra-Test Experiments	33	0,981	0,809	Usual
Post-test Experiment	33	0,912	0,11	Usual

So the normality test concludes that the data of pre-test and post-test values in the experimental class and control class have a $>$ value of 0.05 so the data comes from a normally distributed population.

Homogeneity Test

The second pre-condition test is the homogeneity test, the initial value used is the pre-test and post-test values in the experimental class and the control class. The homogeneity test serves to determine whether the population is homogeneous or not. The data obtained from the study using the SPSS version 29 application and Ms. Excel are sig based on mean 0,420, sig based on media 0,419, sig based on median and with adjusted df 0,419 while sig based on trimmed mean 0,415. Based on the homogeneity test data, it can be concluded that the samples of the experimental class and the control class come from the same or homogeneous population. The determination of homogeneously distributed data can be seen from the $>$ value of 0,05.

T-test

The data obtained during the study was sig (2-tailed) 0,001 which means $<$ 0.05 which means H_a is accepted, which means there is a significant difference $<$ in students' critical thinking skills after implementing the Problem-Based Learning (PBL) and Peer Teaching (Peer Tutor) learning models using web gamification learning media on acid-base material in class XI MIPA Cirebon City State High School while H_o was rejected, which means that there was no significant difference in students' critical thinking skills after implementing the Problem-Based Learning with Peer Teaching (PBLwPT) learning model using web gamification learning media on acid-base material in class XI MIPA Cirebon City State High School. The difference between the experimental class and the control class lies in the treatment given. In the control class, students only use the Problem-Based Learning (PBL) model. Meanwhile, in the experimental class, students used the PBL model with a Peer Teaching approach which was improved with technology-based learning media in the form of web gamification. This web gamification is an educational game that can improve the affective, cognitive, social, and psychomotor aspects of students.

N-gain Test

In the N-gain test, the results of the experimental class and the control class, namely:

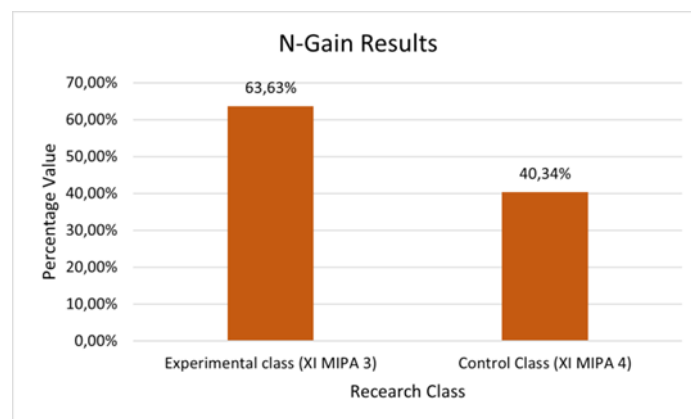


Figure 4. N-gain results

The experimental class N-Gain test has a percentage of 63, 63%, with a sufficient category. This shows that the Problem-Based Learning with Peer Teaching (PBLwPT) model can have a positive influence on improving students' critical thinking skills. On the other hand, the control class that applied the PBL learning model only achieved an N-gain score of 40,34%, with the category of adequate. This significant difference in results shows that the Problem Based Learning with Peer Teaching (PBLwPT) model is superior in improving students' critical thinking skills compared to the Problem Problem-Base Problem- Based Based Learning learning model.

3.3. Students Responses to the Problem-Based Learning (PBL) Learning Model with Peer Teaching Using Web Gamification

The results of student responses were obtained from questionnaires or questionnaires. Data from the results of questionnaire responses or students' opinions can be measured using a Likert scale. The respondent's answer can be in the form of a statement of Strongly Agree (SS) worth 5, Agree (S) worth 4, Disagree (KS) worth 3, Disagree (TS) worth 2, Strongly disagree (STS) worth 1 (Cahya et al., 2024).

The average result of the percentage of students who gave an assessment was 93.93% strongly agree, 80.0% agree, 3.63% disagree, while disagree and strongly disagree 0%. From the data, it can be concluded that the application of the problem-based learning model (Problem-based learning) with the approach Peer Teaching on acid-base material successfully. This learning method that involves problems and peer tutoring approaches is preferred by students. They were intrigued by simple experiments using tools and materials from everyday life as well as final assessments using Web Gamification, which makes the learning process more interesting and fun. This approach also encourages students to think more critically in expressing opinions during learning.

Activities This study involved two classes, namely the experimental class and the control class, with different learning schedules. In each class, students are divided into five groups. In the experimental class, the researcher consistently and structurally applied the syntax of learning based on Problem-Based Learning (PBL) combined with peer teaching Using gamification web. This approach is in accordance with the formulation of the research problem that focuses on improving students' critical thinking skills in acid-base material. Meanwhile, in the control class, only PBL-based learning is applied without additional peer teaching and gamification web. The purpose of providing these different treatments is to find out the difference between the PBL approach and peer teaching Using gamification web and the PBL approach alone in improving students' critical thinking skills.

In the research in the control class XI MIPA 4, treatment was given using a problem-based learning model without a peer teaching approach and web gamification media. The syntax of the problem-based learning model is the Orientation of students to problems, Organizing students to learn, guiding individual and group investigations, developing and presenting results, and analyzing and evaluating the problem-solving process. In the first syntax, is the orientation of students to problems, namely doing pre-tests and providing problems related to acid-base theory in daily life, namely about products used daily and about the pH of the water from each house. Furthermore, organizing students, in this second syntax, is the provision of acid-base material to students. The provision of acid-base material is to answer the problems given at the beginning of learning, in addition to being able to identify a product by knowing the properties of acid-base. Acid has properties with a sour taste, changing red litmus to blue and acidic pH from 0-6 while the basic properties are slippery when touched by hands, changing the color of red litmus to blue with an alkaline pH indicator of 8-14 and making groups randomly without being determined from the pre-test score. In the third syntax, which is to guide individual and group investigations, in research, which is to guide in groups, students carry out experiments, namely simple experiments to get explanations and solve problems. A simple experiment uses ingredients used in daily life such as shampoo, liquid body soap, liquid soap for clothes (liquid detergent), toothpaste, apples, vitamin C, packaged coffee, soft drinks and vinegar.

In the apple sample, it is acidic because apples contain natural acids such as malic acid ($C_4H_6O_5$) and citric acid ($C_6H_8O_7$), while in the vitamin C sample, it is acidic because it contains ascorbic acid ($C_6H_8O_6$), the next sample, namely packaged coffee, is acidic because it contains caffeine ($C_8H_{10}N_4O_2$), the soft drink sample is acidic because it contains carbonic acid (H_2CO_3) and two other acids, namely phosphoric acid (H_3PO_4), and citric acid ($C_6H_8O_7$), the vinegar sample is acidic because it contains acetic acid (CH_3COOH). Next is the shampoo sample including alkaline because the pH of shampoo is far from the natural pH of the scalp and when tested, it tastes bitter. In the liquid bath soap sample, it is alkaline because of its properties, namely When tested, it tastes bitter and is made of Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH) which is a strong alkali or alkaline. Furthermore, the toothpaste sample is alkaline because it contains Sodium Fluoride (NAF) which is a weak base and a high pH in alkaline compounds can control the pH of acid in the mouth so

that the state of the mouth becomes neutral. The last sample, which is liquid soap for clothes (liquid detergent), is alkaline because it contains Potassium Stearate (C₁₈H₃₅O₂K), and glycerol (C₃H₅(OH)₃).

This simple experiment is in accordance with the direction of the LKPD and there are questions related to acid-base so that there is discussion in the group and can improve students' critical thinking. The purpose of this simple experiment is to provide students with a better understanding of the properties of acids and bases as well as how to identify them and answer problems at the beginning of learning more clearly and in detail because they have done a simple experiment. Through this simple experiment, students can directly observe the color change using the litmus paper indicator and the universal indicator. In addition, students measure the pH meter to find out the pH of the water from each different water source and use bottled drinking water with different brands, so that they can improve critical thinking for different water pH reasons. Furthermore, the fourth syntax is to develop and present, in this study the teacher gives directions to the students, in planning and preparing appropriate tasks after the practicum such as the final report, filling out the LKPD is contained in figures 4.2, 4.3, 4.4, 4.5, 4.6, 4.7 and making a video. Furthermore, the last syntax is to analyze and evaluate by evaluating their investigation and the processes they use.

Students are interested in simple experiments using tools and materials from everyday life as well. Such as research conducted by Toucan et al., (2024), simple experiments are one of the learning methods where the delivery of lesson materials is carried out by providing opportunities for students to conduct experiments as an application of the concepts that have been learned. Experiment is one of the effective learning methods by including the active role of students in it which is useful in improving memory and understanding of learning. Learning using simple experiments is very helpful in improving students' understanding because the interaction in the learning process occurs directly (Baunsele et al., 2020).

Results were obtained before the learning process took place by using a problem-based learning model without a peer teaching approach and web gamification media, namely a pretest score with an average class score of 60.39 while after carrying out the learning process the average score of the posttest was obtained 75.73 which means that there is a difference but not significant and the average score of the minimum control class with the provisions of the Minimum Criteria Provision (KKM) thus the average class is classified as students who are quite well following the learning. This is because the control class does not use a peer teaching approach and at the end of the learning process the use of evaluation without using technology-based media, namely games, so that later it will be much more fun and improve student learning outcomes. The use of the learning model, although in accordance with the 21st century, without using technology-based media approaches and utilization, will get different learning outcomes.

In the control class research that only uses the Problem-Based Learning (PBL) model, there are several weaknesses. Without additional support such as peer teaching or learning technology, PBL can be lacking in maintaining student motivation and engagement. Learners may face difficulties in solving problems independently without additional guidance from their peers, which can hinder deep understanding and collaboration. In addition, without interactive elements such as gamification, learning can feel monotonous and less interesting, potentially reducing students' interest in learning and active engagement. As a result, learning outcomes may not be optimal and various aspects of skills such as affective, social, and psychomotor may not develop properly.

In the learning process in the experimental classroom, the learning strategy needed in the 21st century is to use a problem-based learning model with peer teaching using web gamification. In the learning model, the syntax of the problem-based learning model is student orientation to problems, organizing learning students, guiding individual and group investigations, developing and presenting results, and analyzing and evaluating the problem-solving process. In the first syntax, namely the orientation of students to the problem, namely giving pre-test questions and providing problems related to acid-base theory in daily life, namely about products used daily and measuring the pH of water from each house and bottled drinking water with different brands whether it has an acidic pH or not. Furthermore, organizing students, in this second syntax, namely the provision of acid-base material to students, the provision of acid-base material is to answer the problems given at the

beginning of learning, in addition to being able to identify a product by knowing the properties of acid- base. Acid has properties with a sour taste, changing red litmus to blue and acidic pH from 0-6 while alkaline properties are slippery when touched by hands, changing the color of red litmus to blue with an alkaline pH indicator of 8-14. As well as the formation of heterogeneous groups, in one group there are the highest, medium and low values. In the third syntax, which is to guide individual and group investigations, in research, which is to guide in groups, students carry out experiments, namely simple experiments.

The simple experiment carried out is by using LKPD directions according to critical thinking indicators, PBL models and peer teaching approaches. A simple experiment using ingredients used in daily life such as apples, packaged coffee, vinegar, soft drinks, dish soap, shampoo, liquid soap, toothpaste, liquid soap for clothes (liquid detergent) or (liquid socline), vitamin C using red and blue litmus paper indicators and universal indicators while the second simple experiment was to find out the difference in the pH of each water. Students bring water sources from their homes and use bottled drinking water with different brands.

In the apple sample, it is acidic because apples contain natural acids such as malic acid ($C_4H_6O_5$) and citric acid ($C_6H_8O_7$), while in the vitamin C sample, it is acidic because it contains ascorbic acid ($C_6H_8O_6$), the next sample, namely packaged coffee, is acidic because it contains caffeine ($C_8H_{10}N_4O_2$), the soft drink sample is acidic because it contains carbonic acid (H_2CO_3) and two other acids, namely phosphoric acid (H_3PO_4), and citric acid ($C_6H_8O_7$), the vinegar sample is acidic because it contains acetic acid (CH_3COOH). Next is the shampoo sample including alkaline because the pH of shampoo is far from the natural pH of the scalp and when tested, it tastes bitter. In the liquid bath soap sample, it is alkaline because of its properties, namely When tested, it tastes bitter and is made of Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH) which is a strong alkali or alkaline. Furthermore, the toothpaste sample is alkaline because it contains Sodium Fluoride (NAF) which is a weak base and a high pH in alkaline compounds can control the pH of acid in the mouth so that the state of the mouth becomes neutral. The last sample, which is liquid soap for clothes (liquid detergent), is alkaline because it contains Potassium Stearate ($C_{18}H_{35}O_2K$), and glycerol ($C_3H_5(OH)_3$).

In this simple experiment, students better understand the difference between acids and bases from simple experiments and are encouraged to actively learn to be involved with each other, solve problems, discuss together and make conclusions. By applying a simple experiment stage and discussion with LKPD effectively and using PBL models and peer teaching on acid- base material can create an active, fun and meaningful learning process for students and can clarify understanding, solve problems more clearly and for a long time, acid-base material can be remembered for a long period of time compared to theory alone.

Simple experiments in chemistry using simple materials around us can increase participants' interest in the importance of science, especially chemistry. In addition, this activity can increase knowledge about chemistry which is not only related to harmful substances and reactions (Husayn et.al., 2018). The use of practicum methods applied to students can have an influence on students' science process skills and critical thinking skills (Commissioners et al. 2024). Furthermore, in the fourth syntax stage, namely developing and presenting, in this study the teacher gives directions to students in planning and preparing appropriate tasks after the practicum such as the final report, filling out the LKPD is in figures 4.2, 4.3, 4.4, 4.5, 4.6, 4.7 and making a video and the last syntax is analyzing and evaluating by evaluating their investigation, the processes they use and the evaluation of learning using media games. PFinal Assessment Using gamification web, which makes the learning process more interesting and fun. This approach also encourages students to think more critically in expressing opinions during learning. Gamification is useful as a learning resource, media, and a fun assessment tool for students. Games It can be used through a laptop or smartphone. In web gamification, there are images, audio, animations and interactive games that can keep students interested (Misliyanti et.al., 2023).

After being given different treatments, the results of the study showed that the application of the PBL model with peer teaching in this study improved the critical thinking ability and learning outcomes of students in the experimental class, namely XI MIPA 3. Based on the results of the pretest

score of the experimental class, the score before the learning process continued was obtained with an average score of 67.67, while the posttest score was obtained after carrying out the learning process with an average score of 85.03, which means that it shows a significant increase in the score obtained from students. The average posttest score of the experimental class shows a score with the average class above the Minimum Criteria Provision (KKM) value, thus the average class is classified as a student who is able to follow learning well. As well as the posttest answers of students in the experimental class can determine the pH in the products used around, find out the differences between household products regarding acid or base theory, describe the calculation answers accompanied by chemical reactions and the order in answering the calculation questions correctly.

This is because the learning process in the experimental classroom uses the learning strategies needed in the 21st century, namely using a learning model problem based learning with peer teaching in experimental class research. Type problem based learning Problem-based make students think critically, because students are required to be able to formulate a problem on their own and then collect the data they get and the learning model Problem Based Learning (PBL) is considered to be able to improve students' critical thinking skills (Marhamah et.al., 2020). Type problem based learning successfully improve student activities and learning outcomes (Maulana et.al., 2021). Previous research by Maulana et al., (2021), there is a real difference in student learning outcomes between the use of the learning model Problem Based Learning (PBL) with a conventional learning model with no using Problem Based Learning (PBL) in improving learning outcomes. The PBL model is a model that is able to develop critical thinking skills, problem-solving, and invite students to actively build their own knowledge. The process of knowledge discovery that is actively carried out can have a positive effect on students' memory of the knowledge that has been obtained by students (Suyanta, 2020).

In addition to the learning model, the use of the peer teaching approach can affect the learning outcomes of students in the experimental classroom because they feel comfortable and not tense during the chemistry learning process in the classroom. The peer teaching or peer tutor approach can increase the learning achievement obtained is also higher and by getting along with good peers, it will support the maximum learning process and high learning achievement. Researchers use the peer teaching approach because this method can strengthen students' understanding of concepts through explanations and discussions with peers. In addition, peer teaching improves communication and collaboration skills, as well as encourages students' sense of responsibility and confidence in the teaching and learning process. This method also makes learning more interesting and motivating, so that it can improve learning outcomes.

This was strengthened by previous researchers, namely Selly (2021), with the research title "Learning peer teaching (peer tutor) to improve chemistry learning outcomes in electrochemistry materials", that the learning method with peer teaching (peer tutor), allows students not only to be used as learning objects but also for students to become learning subjects, where students are invited to become tutors or learning resources and a place to ask questions for their peers. In addition, it was further strengthened by the previous researcher in the latest year, that peer tutors include learning strategies based on active learning, where in addition to helping their friends learn, students can also learn the learning material in more depth (Kaimuddin et.al., 2023). In previous research by Colorful (2024), the results showed that the completeness of students' learning was classically included in the category of completeness with a percentage of 86.21% with the Minimum Completeness Criteria (KKM) in MAN 1 Dumai, which was 70 for redox reaction equalization material. The results of the first and second cycle tests show that the application of the peer tutor learning model can improve the learning outcomes of redox reaction equalization material for grade XII students. MIA 1 at MAN 1 Dumai. From previous research and researchers, the assessment of students was above the value of 85. Learning activities can be more fun by utilizing technology that is increasingly rapid in the 21st century today, namely the use of learning media gamification web. Media gamification web used after the learning process takes place. The use of media at the end of learning as an evaluation of how far students understand the material that has been delivered and as an additional value for students when the exercises are still low and when working on evaluation questions becomes fun, active and not saturated because of using media games with attractive visuals. This educational game-based media is generally used as an intermediary in attracting the attention and interest of students by presenting learning like playing games (Mattawang, 2023). Gamification helps students to stay

engaged and concentrate on the tasks given, thereby increasing understanding and achievement of learning outcomes. The use of gamification as one of the technological approaches in learning makes a significant contribution in enriching the learning experience of students (Latip et al., 2024). Research by Isaiah et al., (2023), there is a significant influence, namely 88% of students are very active in the game and are very enthusiastic when playing games made through the media word wall. The use of this media can increase understanding of the material and remember what has been conveyed.

It can be concluded from the discussion above that the experimental class experienced a very significant difference in value, namely from the average of the class pretest 67.67 and after the end of the learning process posttest The average class is 85.03, meaning that the score is above the value of the Minimum Criteria Provisions (KKM). Application of learning media problem based learning with peer teaching Using media-based gamification web It is very appropriate to use because it can improve critical thinking and understanding in students. In addition, research conducted previously by Agussalim et.al., (2023), the motivation to learn chemistry in class X Innovative at UPT SMAN 11 Pinrang increased with the implementation of the learning model problem-based learning with the peer tutor method. The motivation to learn chemistry of students of class X Innovative increased every cycle in stoichiometry material. The increase was 9%, with the elaboration of students' learning motivation in the first cycle of 73% while the learning motivation of students in the second cycle was 82%. As well as research conducted by Aryani et.al., (2021) Declares that the use of glueification web-based digital can be usedIacupuncture Various meis permsInnan and meis which can be dUse Educators for Membersfish Mater ratingi and so that the participants of theIdik active during the learning process. Researchers Dariyo (2023), the result of the calculation using the Effect Size obtained on the students' learning outcomes is 1.9 so the large criterion is Effect Size classified as high with a percentage value of 79.4%. Learning using media games In the experimental class, it has a high influence on students' interest in learning. Account Effect size Learning interest obtained a score of 1.1 which is included in the high category and has an influence of 58.9. Thus learning using media games has a high influence on the learning outcomes and interests of students in the classroom and is feasible to be used or applied.

The difference between the experimental class and the control class can be identified through a series of prerequisite tests which include normality test, homogeneity test, T-test, and N-gain test with data that has been obtained during the learning process at the research site, namely SMAN 8 Cirebon. The first test of the pre-qualification test is the normality test which has been carried out using the SPSS application version 29.0 Ms.Excell obtained the sig results from the shapiro-wilk test because the data was less than 50 with the experimental pre-test sig val Shapiro-wilkue of 0,809, the experimental post-test sig value was 0.11 while the control pre-test sig value was 0,55 and the post-test sig value control is 0.160. So the data on pre-test and post-test scores in the experimental class and the control class have a > value of 0,05 so the data comes from a normally distributed population.

After conducting a normality test the results of the data obtained by the researcher are normal data, the reason is that the values we get from the research obtained spread with a good pattern. Most students get scores around average, a few very high, and a few very low, so these values are said to be normally distributed. In the previous research by Afriany, (2024), learning outcome data Pre-Test Eksperimen Sig valued at 0.097, Post-Test Eksperimen Sig worth 0.113 and Pre-Test Control Sig valued at 0.070 and Post-Test Control Sig worth 0.090. Both the experimental class and the control class have a Sig value of > 0.05, so it can be concluded that the data is normally distributed.

Furthermore, the second pre-condition test is the homogeneity test, the initial values used are the pre-test and post-test values in the experimental class and the control class. The homogeneity test serves to determine whether the population is homogeneous or not. The data obtained from the study using the SPSS version 29 application and Ms. Excell are sig based on mean 0.420, sig based on media 0.419, sig based on median and with adjusted df 0.419 while sig based on trimmed mean 0.415. Based on the homogeneity test data, it can be concluded that the samples of the experimental class and the control class come from the same or homogeneous population. The determination of homogeneously distributed data can be seen from the > sig value of 0.05. The homogeneity test calculation uses the SPSS application version 29.0.

The reason for this study to produce homogeneous data after conducting a homogeneity test, is because the participants studied have similarities, such as age, education level, or background. Homogeneity can also occur if the measurement tools and conditions when collecting data are the same for all participants. In addition, the use of teaching methods or a uniform curriculum across participants can also produce similar data. This homogeneity is important so that differences in research results are more likely to be caused by the factors being studied than by other uncontrolled factors. As in the previous research by Lust et.al., (2024), data homogeneity test results pre-test dan post-test in the control class and the experimental class, the significance was 0,207. So it can be concluded that the data is homogeneous. Therefore, the research data can be used for research samples.

The third pre-condition test is the T-test or hypothesis. The data obtained during the study was sig (2-tailed) 0.001 which means 0.05 which means H_a is accepted, which means that there is a <significant difference in students' critical thinking skills after implementing the Problem- Based Learning (PBL) and Peer Teaching (Peer Tutor) learning models using web gamification learning media on acid-base material in class XI MIPA while H_o was rejected, which means that there was no significant difference in students' critical thinking skills after implementing the Problem-Based Learning with Peer Teaching (PBLwPT) learning model using web gamification learning media on acid-base material in class XI MIPA. The difference between the experimental class and the control class lies in the treatment given. In the control class, students only use the Problem-Based Learning (PBL) model. Meanwhile, in the experimental class, students used the PBL model with a Peer Teaching approach which was improved with technology-based learning media in the form of web gamification. This web gamification is an educational game that can improve the affective, cognitive, social, and psychomotor aspects of students.

This is reinforced by previous research by Afriany (2024) with the research title "The Effect of the Problem-Based Learning (PBL) Model on the Learning Outcomes of Participants in the biogeochemical cycle material in class X of SMA Negeri 1 Darangdan". The results of the research showed significant differences in student learning outcomes between classes that participated in learning by applying the learning model Problem-Based Learning (PBL) with classes that follow conventional learning. And also the value Sig. (2-tailed) < 0.05 is 0.001. Therefore, it can be concluded that the Problem-Based Learning (PBL) learning model is successful in student learning outcomes.

In the last test, the pre-qualification test, namely the N-Gain test, the experimental class has a percentage of 63.63%, with the category of adequate. This shows that the model Problem Based Learning with Peer Teaching (PBLwPT) is able to have a positive influence on improving students' critical thinking skills. On the other hand, the control class that applied the PBL learning model only achieved an N-gain score of 40.34%, with the category of adequate. This significant difference in results indicates that the model Problem-Based Learning with Peer Teaching (PBLwPT) is superior in improving students' critical thinking skills compared to the learning model Problem-Based Learning. Like the previous researcher, namely Afriany (2024), it can be seen Problem-Based models on students' understanding of class X graphic design subjects majoring in multimedia SMK Batik 2 Surakarta". The results of the study obtained the N-Gain results of the experimental class, which was 52,1% in the adequate category while in the control class, which was 20,3% in the low category so the experimental class succeeded in measuring the extent of the improvement of students' understanding after treatment. Meanwhile, the research conducted by the researcher had a higher N-Gain value compared to the previous researcher.

Students' responses to the problem-based learning (PBL) learning model with a peer teaching approach using web gamification in the classroom during the learning process. The average result of the percentage of students who gave assessments was 93.93% strongly agree, 80.0% agree, 3.63% disagree, while disagree and strongly disagree 0%. From the data above regarding the response strongly agreeing has a percentage value of student response, which is 93.93% of the reason, because it uses the Problem-Based Learning with Peer Teaching model, in addition to that, it is improved by the use of technology-based learning media, namely web gamification, which is an educational game so that it can attract students' visualization and is fun so that the student's response is very agreeable or successful in the treatment given in the experimental class.

This is like what was done by Princess (2022) with the research title "Development of PBL-based learning media integrated with confident character to improve high school mathematics problem solving", in this research the response of students with an open questionnaire of 85% regarding the development of PBL-based media, it can be concluded according to research the students' responses that the development of PBL-based learning media can improve problem-solving in mathematics materials at the high school level. Meanwhile, the research conducted by the researcher had higher open questionnaire results compared to the previous researcher, which means that the response of students with a percentage value was very agreeable, namely 93.93%, that the application of the PBL model with a peer tutor approach and the use of educational game-based media can improve students' critical thinking. Strengthened by Nasihah et al., (2019), This learning method that involves problems and peer tutor approaches is preferred by students. Peer tutors in the problem-based learning model have a significant influence on critical thinking skills.

In addition, the analysis of the open questionnaire filled out by students indicates that problem-based learning (PBL) with a peer teaching approach that utilizes web-based gamification is an innovative method for them, considering that this approach has never been applied before by educators in schools. In the learning process, ice breaking activities began to increase students' focus and enthusiasm before entering the core of the material. This activity involves exploring the concept of acids and bases through a series of simple experiments using tools and materials commonly found in everyday life, such as apples, soft drinks, vinegar, vitamin C, packaged coffee, toothpaste, shampoo, liquid detergent, liquid soap, and dish soap. In addition, students also conducted experiments to compare the pH of water using samples from various household water sources and different brands of bottled beverages. The experiment is designed to provide an in-depth understanding of the properties of acids and bases and their identification techniques so that learners can gain significant practical insights into these basic chemical concepts.

Simple experiments conducted through Student Worksheets (LKPD) in the Problem-Based Learning (PBL) and Peer Teaching models not only improve students' knowledge and understanding of acid-base theory, but also significantly develop their critical, creative, communicative, and collaborative thinking skills. In this process, students are encouraged to be actively involved in learning, solve problems, and make decisions based on the data and analysis they do. With the effective application of experiments and discussions through LKPD, the PBL and Peer Teaching models are able to create active, fun, and meaningful learning experiences.

It aims to provide a deeper understanding of acid-base theory by involving simple experiments. This process is very important in the context of PBL, where students learn from first-hand experience and get answers to problems more clearly. The application of simple experiments can train process skills in the form of skills in observing, classifying, communicating, measuring, predicting, and inferring. In addition, learning carried out using practicum is considered to be able to provide good motivation for students' interest in learning so that students will more easily understand the material taught, especially abstract chemistry materials (Commissioners et al., 2024). Thus, this research not only provides new insights but also becomes the first experience for students.

In addition, there was also an Assessment of the Student Worksheet (LKPD) showing significant differences between the experimental class and the control class. The LKPD in the experimental class received an excellent assessment, while the LKPD in the control class was assessed as good, by the critical thinking criteria that had been validated by validators from chemistry education lecturers and chemistry teachers. In addition to the LKPD assessment, students in both classes were also given additional tasks after conducting a simple experiment, which included making a final report and making an interesting video about the experiment process, using each individual's voice. This assignment is designed to improve students' critical thinking skills through discussion, and expressing opinions to deepen their understanding of the material and encourage a deeper understanding of the experimental process. The creation of reports and videos will take advantage of technology that is developing rapidly in today's century. Thus, this activity aims to strengthen students' critical and communication skills in the context of chemistry learning. In addition to the questionnaire as a student response, there are interviews conducted by students, there are several points of interview results, namely:

- a. **Increased Motivation and Enthusiasm for Learning:** The problem-based learning model with peer teaching and web gamification presents interesting, challenging, and relevant learning for students. This approach allows them to actively engage in the learning process by solving meaningful and real-life-related problems. This triggers their intrinsic motivation to learn and increases their enthusiasm for learning.
- b. **Increased Engagement and Active Participation:** Web gamification in problem-based learning with peer teaching brings fun and interactive game elements. This makes students more involved in learning and actively participate in group discussions and activities. They no longer feel bored or passive in learning, but are enthusiastic and eager to contribute.

The researcher experienced several obstacles during the learning process in the experimental and control classes, including the application process carried out by the teacher starting from the preparation stage, the implementation of learning, and in the assessment stage. In previous researchers Farhana et al., (2023) This model is difficult to apply to learning because this model uses a group learning system in which when learning takes place a group of children with high abilities should be expected to help their friends who are less often become selfish and a group of children with low abilities do not care about themselves, this obstacle occurs because teachers are less able to stimulate the atmosphere in the classroom and it is difficult to determine the right problem in solving the problem. Another obstacle experienced by teachers when using the PBL model is about how to explain to students to make reports about problems that have been solved previously and about how to direct students to be able to solve the problems that have been given. Teachers' readiness to prepare mature devices is also often an obstacle in using this model in the learning process (Farhana et al., 2023). Therefore, teachers must prepare learning tools properly and efficiently until the determination of the problems used is adjusted to the conditions of students' abilities.

The advantages of using the PBL model have proven successful in preparing students to face real-world challenges, based on previous research by Martin et.al., (2024) where they must apply their knowledge and skills in complex and ambiguous situations. Through PBL, learners learn to work in teams, communicate effectively, and integrate various sources of information to achieve sustainable solutions. PBL competency therapy offers an engaging and meaningful approach to learning, its successful implementation requires a strong commitment from all stakeholders and attention to the factors that influence the success of PBL-based learning. In the experimental class and control class that was used as a research sample, the Problem-based learning (PBL) model was applied for the first time so that students were not used to following the stages of the learning process. This is a challenge and obstacle for researchers during the learning process. However, thanks to the help and input from the chemistry teacher, the researcher managed to complete the research well and on time.

4. Conclusion

Implementation of the Learning Model Problem-Based Learning (PBL) approach Peer Teaching which is equipped with Web Gamification got a positive response from students. The students showed significant improvements in various aspects of learning. First, this learning model has succeeded in increasing students' motivation to learn. By using media Web Gamification, students feel more motivated to be involved in the learning process because the learning atmosphere becomes more interesting and fun. Second, student involvement in teaching and learning activities has also increased. They are more active in participating and interacting both with fellow students and with teachers. Third, the understanding of the learning material becomes better. PBL which prioritizes real problem solving allows students to associate theory with practice so that they can more easily understand the concepts taught. This study concluded that there was a significant and positive difference in the application of the "Problem-Based Learning with Peer Teaching using web gamification" model in improving students' critical thinking on acid-base material. The data showed that the experimental class had a significant increase in values compared to the control class. The results of the pretest and posttest of the experimental class were 67.67 and 85.03, respectively, while the control class was 60.39 and 75.73, respectively. The independent test technique of T-test and N-Gain samples showed a significant difference with a sig value (2-tailed) of 0,001. The N-Gain result in the experimental class was 63.63%, while the control class was 40.34%. The response of students

to this model was also very positive, with the percentage of strongly agreeing reached 93.93%. This shows that this learning model is effective in improving students' critical thinking skills and understanding of acid-base materials.

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