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EFFECTIVENESS OF THE GUIDED INQUIRY-BASED FLIPPED CLASSROOM LEARNING SYSTEM ON BUFFER SOLUTION MATERIALS ON STUDENTS LEARNING OUTCOMES

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ABSTRACT

This study aims to reveal the effectiveness of the Guided Inquiry-based Flipped Classroom learning System on the buffer solution material on student learning outcomes. This research was conducted with a non-equivalent control group design using a sample of 72 students divided into a control group and an experimental group. The instrument used in this study was a test of students learning outcomes in the form of a written test for student assessment. The test is carried out by giving pretest (Pretest) and posttest (Posttest) questions that have adjusted to the learning objectives. Based on the study's results, the N-Gain Value found in the experimental class was higher than in the control class, with values of 0.82 and 0.70 respectively. From the results of the t-test using the Microsoft Excel application, tcount is 2.47, and the t_{table} with a significance level of 0.05 is 1.99, so t_{count} value is greater than ttablevalue. So can be concluded that using the flipped classroom learning system based on guided inquiry on buffer materials effective improves student learning outcomes.

Keywords: Effectiveness, Flipped Classroom, Guided Inquiry, Learning Outcomes, Buffer Solutions

INTRODUCTION

Education is an effort to create a learning atmosphere and learning process so that students actively develop their potential to have religious, spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation and state. stated [1]. In the Industrial Revolution Era 4.0, there is a trend in the industrial world that combines automation technology with cyber technology, which has had a good impact on the development of educational science. One is the learning system, where knowledge and technology affect teaching aids in schools [2]. In the development of the education system, the world is faced with a crisis due to Covid-

19, which can kill humans and spread very quickly [3]. The crisis condition due to the covid-19 virus requires learning to be done online [4] to impact the learning process for students, teachers and parents or students' families [5].

Online-based learning requires teachers to use a learning system that utilizes technology as an online learning medium so that the learning process becomes more effective. Blended learning is a learning system using technology in its implementation. The concept of Blended Learning is to combine face-to-face learning in the Classroom with online learning [7]. Blended learning has four learning models, one of which is a rotation model. For comparison, the rotation model has four types of submodels: station rotation, Lab Rotation, Flipped Classroom, and Individual rotation [8]

Flipped Classroom is a mixed learning model; the learning process to fulfil learning competencies is carried out in a virtual classroom or outside of school. In contrast, activities and work usually occur at home or school [9]. Learning using flipped classrooms trains students to be active and independent in the learning process. Flipped-classroom provides time outside Classroom to find and study the concepts learned in the Classroom. Students maximize the allocation of time in the Classroom to collaborate with colleagues, practice, and receive teacher feedback on learning progress [11]

The flipped classroom learning system's learning process will be supported using a guided inquiry learning model to encourage students to develop problem-solving and critical thinking skills. In addition, using the guided inquiry learning model makes it easier for students to understand the concept of learning and the effectiveness of interaction, team building, and interest in learning through structured group work [12]. Furthermore, the guided inquiry model with the flipped classroom learning system has a very high category regarding student practicality and teacher assessment [13]. Therefore, to support the online learning process, teachers and students can use the Flipped Classroom learning system with a guided inquiry model [14]. The stages in the learning process using the guided inquiry model include orientation, exploration, concept formation, application and closure [15].

Edmodo is one of the learning management systems (LMS) in which there is various content for education with a Social Network-based education system. Therefore, Edmodo is a safe platform for teachers, students and schools to use during online learning. In addition, the Edmodo feature has a place for giving assignments, quizzes and grades at the end of the lesson [14]. Edmodo is used in the Asynchronous learning stage, which includes four stages of guided inquiry learning: orientation, exploration, concept formation and application. Conversely, the closing stage will occur in the Synchronous learning phase.

Research on the development of a Guided Inquiry-based flipped classroom learning system on the topic of Buffer Solution has been carried out by [17], developed to the assessment stage, and tested for validity and practicality, but has not been tested for effectiveness. Thus it is necessary to test the effectiveness of research developed by previous researchers because the quality of a product developed is seen from three criteria, validity, practicality, and effectiveness [18].

Topics Buffer solutions are abstract and complex. The buffer solution is abstract because not all discussion topics can be observed directly (macroscopic and symbolic). However, it is necessary to understand the structure and processes at the particle (atom/molecular) level of the observed macroscopic (submicroscopic) phenomena [19]. Unfortunately, this abstract nature makes it difficult for students to understand the Buffer Solution material [20]. Therefore, a learning system is needed to maximize students' understanding of the topic buffer solution.

The guided inquiry-based Flipped Classroom learning system utilizes technology and teaching materials in the form of student worksheets that cover all three levels of representation to assist students in understanding subject matter with abstract characteristics such as buffer solutions. For example, research on chemical representation-based animation media has been developed by [21] on Arrhenius acid-base materials. A similar analysis was conducted by [22] on the material, determining the reaction rate; teachers and students responded positively to the teaching materials. In another research [23] on the sub-concept of Bohr's atomic theory, teachers and students responded positively to the media and learning schemes used. With the use of technology and teaching materials that cover all three levels of teacher representation, it is easier to explain the lesson, and students easily understand the material taught by the teacher [24].

METHODS

Participants

This research was conducted at SMA N 8 Padang in the even semester of the 2021/2022 academic year. The sampling technique used in this research is the purposive sampling technique. Purposive sampling is a technique with specific considerations [18]. Teacher-assisted sampling in this study in the field of chemistry studies for second-year students, in this research, two classes were selected as research samples; both classes had 36 students in them.

Instrument

This study uses research instruments to test learning outcomes through written tests for cognitive research. The test consists of an initial test (Pretest) and a final test (Posttest). The instrument test is in the form of multiple choice questions, as many as 20 questions with five answer choices adapted to the buffer solution material for Competency Achievement Indicators. Before being used, the instrument passed the validity, reliability, difficulty index, and the test of differentiating power of the questions. The test results were processed and analyzed using Microsoft Excel software. The data obtained after conducting the research were processed using the n-gain test and the hypothesis

Analysis

The research method used in this research is quasi-experimental research in the form of a Non-equivalent Control Group Design, which is carried out by comparing the results of the pretest and posttest of the two classes studied, namely the control class and the experimental class. The design of this research can be seen in Table 1.

Table 1. Design of Research

Class	*Pretest*	Treatment	*Posttest*
(R)*	O_1	X	O_2
(R)	O_3	Y	O_4

Based on Table 1 with (R)* = Experiment class; (R) = control class; X = Learning using certain treatments (Flipped Classroom learning system based on guided inquiry); Y = learning using Student Worksheets from Schools based on The Guided Ikuiri model; O1 = Pretest for the experimental class ; O2 = Final test (posttest) for the experimental class; O3 = Pretest for the control class ; O4 = Final test (posttest) for the Control class [18].

RESULTS AND DISCUSSION

The data obtained in this study are quantitative data taken from student learning outcomes in the cognitive domain. Student learning outcomes are assessed by giving a pretest (pretest) and a final test (posttest) in multiple-choice format, with as many as 20 questions with five answer choices. The correct answer will be given a score of 1 with a value of 5. Wrong answers will be given a value of 0 and 0. The maximum score for students is 20, with a conversion value of 100. The description of the pretest and posttest averages can be seen in Figure 1.

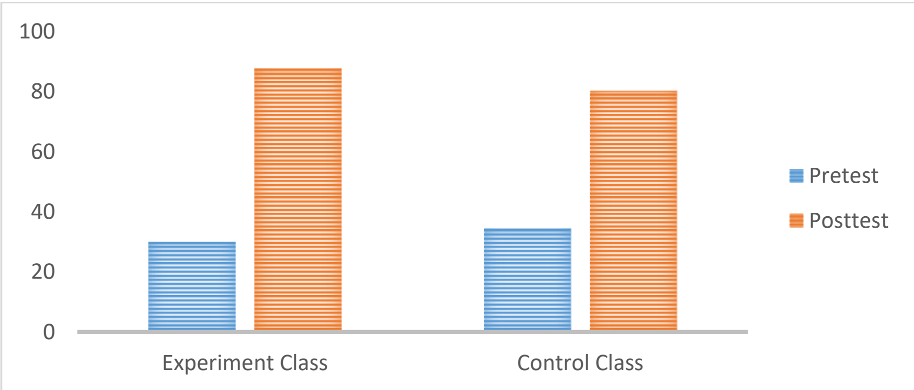

Figure 1. Graph Description Of The Average Of The Pretest And Posttest Scores

The N-Gain test was carried out to know the increase in students' conceptual mastery of the material studied before and after the learning process. The average results of the N-Gain test can be seen in Table 2 below.

Table 2. N-Gain Test Results Data from The Pretest And Posttest Values Of The Sample Class

Class	n	N-Gain	Category
Experiment	36	0,82	high
Control	36	0,70	high

The results of the calculation of normalized gain (N-gain) are then interpreted using classification with the criteria of high (g 0.7), medium (0.7 > g > 0.3), and low (g 0,3) [25]. The N-Gain of the Control Class is 0.70 in the high category, and the N-Gain of the Experimental class is 0.82 in the high sort. This data shows that the N-Gain of the Experimental Class is higher than the Control Class's, so this also shows that The guided inquiry-based Flipped Classroom learning system has a high level of effectiveness in improving student learning outcomes.

The normality test is to determine the normality of the data. At the same time, for the decision-making criteria, information is said to be normally distributed if L_{table} > L0, and the data is not normally distributed if Ltable < L0. The data from the normality test can be seen in Table 3.

Table 3. Normality Test Results Data From The Pretest and Posttest Values of The Sample Class

Class	A	L_0	L_t	Information
Experiment	0,05	0,132	0,147	Normal
Control		0,146		

Based on the results of data processing, the L_0 value from the control class is 0.146, and the L_0 value from the Experiment class is 0.146, so this value is smaller than the L_t value, which is 0.147, which means that the difference between the Pretest and Posttest values of the two sample classes is normally distributed.

A homogeneity test was conducted to determine whether the two research data had homogeneous variance. A homogeneity test was carried out using the F test to obtain F_{count} and F_{table} at a significant level of 0.05. The data can be homogeneous if the F_{count} value is smaller than the F_{table} value. The results of the homogeneity test of the difference between the pretest and post-test scores of the two classes can be seen in Table 4.

Table 4. Homogeneity Test Results Data From The Pretest and Posttest Values of The Sample Class

Class	N	S^2	F_{count}	F_{table}	Information
Experiment	36	377,95	1,279	1,757	Homogeneous
Control	36	483,23			

F_{count} obtained is 1.279, while the value of F_{table} is at a level of 0.05, with the number of many as 72 students is 1.757. So it can be seen that the value of $F_{count} < F_{table}$ shows that the data on the difference between the pretest and post-test scores of students from the two sample classes has a homogeneous variance. After the normality and homogeneity tests were carried out, the hypothesis was tested using the t-test (independent sample t-test). The decision-making criteria are H0 if the value of tcount ttable and H_0 is rejected if the value of $t_{count} > t_{table}$. The results of hypothesis testing can be seen in Table 5.

Table 5. Data on The Results of Hypothesis Testing from The Pretest and Posttest Values of The Sample Class

Class	n	X	t_{count}	t_{table}	Information
Experiment	36	57,78	2,47	1,99	H_0 Rejected H_1 Received
Control	36	45,69			

The difference in the Posttest-Pretest scores on student learning outcomes from the two sample classes shows that the t_{count} value is 2.47 and t_{table} with a significance level of 0.05 is 1.99, so the t_{count} value is greater than the t_{table} value. This paper shows that H0 is rejected. In other words, the learning outcomes of the experimental class that applied the Flipped Classroom Learning System based on Guided Inquiry were higher than the control class that used conventional learning systems or those usually implemented by schools.

Discussion

This study measures the effectiveness of applying the Flipped Classroom Learning System Based on Guided Inquiry on Buffer Solutions on Student Learning Outcomes in the second year of high school. This learning system combines The Guided Inquiry learning model with the Flipped Classroom learning system, which technology supports in the implementation process. The LMS (Learning Management System) used in the learning process uses this learning system, namely Edmodo, which is used in the Asynchronous learning stage by using teaching materials in the form of student worksheet (LKPD), which Which has been developed by [17]. In contrast, the researcher can maximize learning in the Classroom at the Synchronous stage.

The pretest was conducted to determine the student's initial understanding of the content on the topic of buffer solutions [26]. After learning ends, a Final Test (Posttest) is conducted to determine the mastery of student content on the topic of buffer solutions after participating in the lessons. According to [26], the learning process can be good if the final test score is higher than the initial test. The buffer solution was carried out in both sample classes with different learning systems. The experimental class uses the Inverted Classroom Learning System Based on Guided Inquiry developed by [17]. the control class uses a conventional learning system or what is commonly applied in learning at school.

Students who study using the Flipped Classroom Learning System Based on Guided Inquiry have two teaching phases, the first phase is Asynchronous, and the second phase is synchronous by following the learning steps according to the Guided Inquiry learning model. The steps of guided inquiry learning consist of 5 stages: orientation, exploration, concept formation, application, and closing [15]. This guided inquiry learning process is student-centred by creating a small group that collaborates. Students will explore each existing concept with the help of media such as pictures, videos, and tables, then proceed with answering key questions. Key questions are a significant component of the guided inquiry learning process.

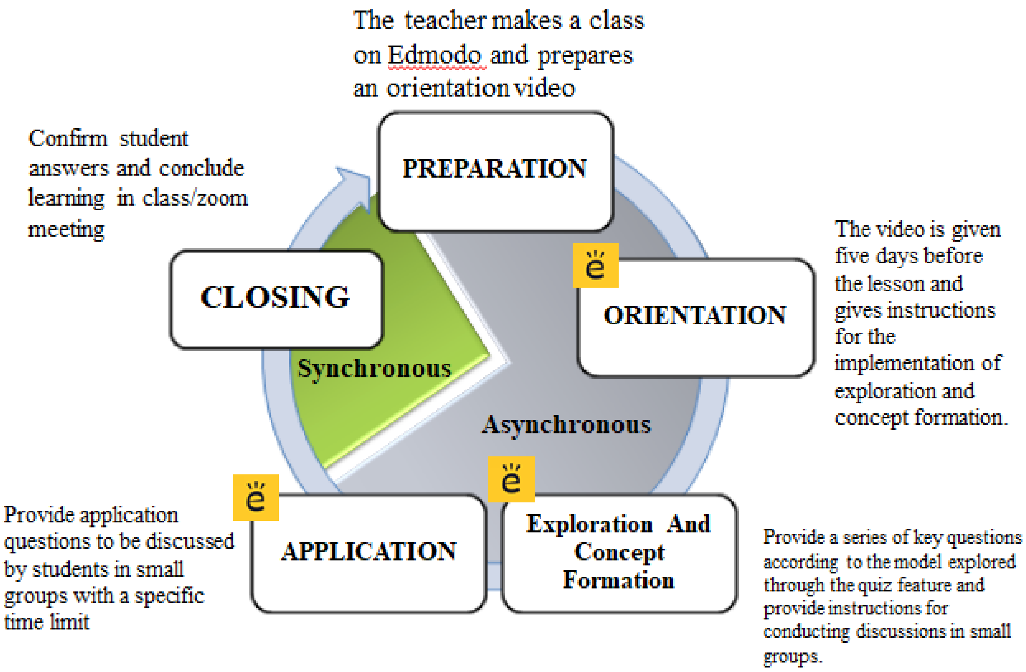

Figure 2. Guided Inquiry-Based Flipped Classroom Learning Cycle [27]

Figure 2 shows The guided inquiry-based Flipped Classroom learning cycle. In the combination of The guided inquiry learning model with the flipped Classroom, maximizing the use of Edmodo at the asynchronous learning stage combines four stages of guided inquiry learning: orientation, exploration, concept formation, and application. In contrast, the closing stage will occur in the Synchronous learning phase. In the Synchronous Phase, researchers have the opportunity to implement it directly in the Classroom.

The first stage, orientation, is the initial stage to prepare students to learn. At this stage, students gain initial knowledge in the form of learning objectives. This motivation can build interest and arouse students' curiosity and apperception, namely prior knowledge related to the ability to be learned. At this stage, students watch an orientation video prepared on Edmodo.

In the next stage, the exploration and concept formation stage, students observe the model given to Edmodo by using the quiz feature. Giving quizzes refers to the teaching materials used, namely the Student Worksheet (LKPD) buffer solution developed by [17]. The model is in the form of pictures or data tables. After observing the given model, students then enter the concept formation stage. Finally, students answer key questions based on the displayed model. Through these key questions, students will be required to think critically and connect with concepts that help them gain understanding based on what they have learned. An example of a model at the exploration and concept formation stage can be seen in Figure 3.

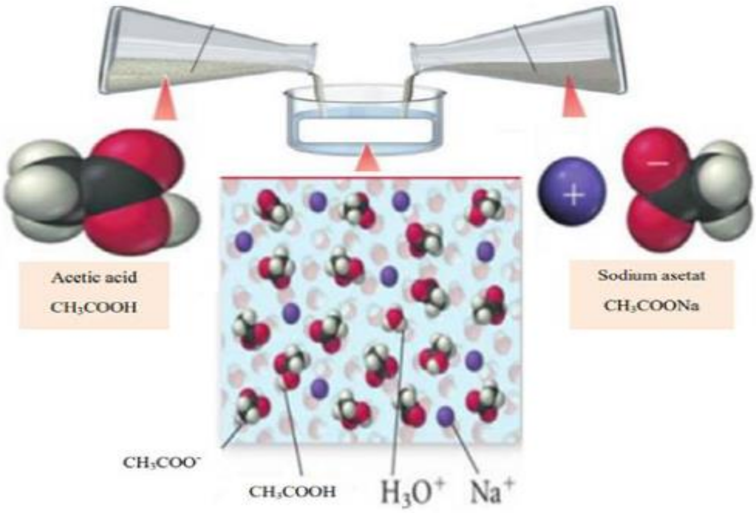

Figure 3. Exploration and concept formation Model 1

Figure 3 shows the model used in the exploration and concept formation stages in the buffer solution. In this model, the solution components are displayed, represented in the form of an image in a container. Next, several key interrelated questions are given so that they can form students' concepts and understanding when answering them correctly. Next, students will conduct discussions with their respective groups to answer these key questions and conclude the results of the discussion so that students can find concepts independently. This stage is based on the concept that learning is not just memorizing a few words or information, but learning is doing and gaining certain experiences by the expected goals.

Figure 3 aims to make students understand what a buffer solution means and the types of buffer solutions. A buffer solution is a solution of a weak acid or a weak base with its salt, and both must be present. Buffer solutions can withstand changes in pH by adding a small amount of acid or base [29]. Students gain this understanding by exploring the model and answering key questions based on the model. Table 6 will explain how students acquire their concepts at the exploration and concept formation stages.

Table 6. Student answers based on the model

Student 1	Student 2	Student 3
Based on model 1, known as a buffer solution, firstly, the compound CH_3COOH is determined as a species that acts as an acid and a compound CH_3COO^- a species that serves as a conjugate base (it's salt) based on the	Based on model 1, known as a buffer solution, the determination of conjugate acid-base is based on the Bronsted-Lawry acid-base theory. In this case, CH_3COOH is acid, and CH_3COO^- is a conjugate base.	Based on model 1, known as a buffer solution, CH_3COOH is an acid, and H2O is a base, according to Bronsted-Lawry. $CH_3COOH \rightarrow H^+ + CH_3COO^-$ H2O (l) ↔ H+ (aq) + OH-

Bronsted-Lawry acid-base theory. CH_3COOH (aq) + H_2O (l) ↔ CH_3COO^-(aq) + H_3O^+(aq) Furthermore, identifying species that act as acid is a weak acid. Then from the grouping of these species, the components of the buffer solution, a weak acid (CH_3COOH) with its conjugate base (CH_3COO^-), and the type of the buffer solution, an acid buffer solution. Conclusion: an acid buffer solution is a solution that contains a weak acid and its conjugate base	CH_3COOH (aq) + H_2O (l) ↔ CH_3COO^-(aq) + H_3O^+(aq) CH_3COOH is identified as a type of weak acid. Based on the grouping of these species, the components of the buffer solution were determined, namely a weak acid (CH_3COOH), H2O, and it's salt (CH_3COONa). as well as the type of buffer solution, namely an acid buffer solution Conclusion: an acid buffer solution is a solution that contains a weak acid and its salt	Then the species that act as acid are identified, CH_3COOH, a type of weak acid. Based on this grouping, the component of the buffer solution is CH_3COOH and is a type of acid buffer solution Conclusion: an acid buffer solution is a solution that contains a weak acid and its salt

Based on the answers from the three students above, student one can answer the key questions correctly. Student two can also answer correctly even though, in grouping the components of the buffer solution, student 2's answer is slightly different from student one's but has the same conclusion. Student three answered incorrectly on the grouping component of the buffer solution, which only included CH_3COOH as a component of the buffer solution, but had the correct conclusion. support and think critically and get their understanding based on what has been learned.

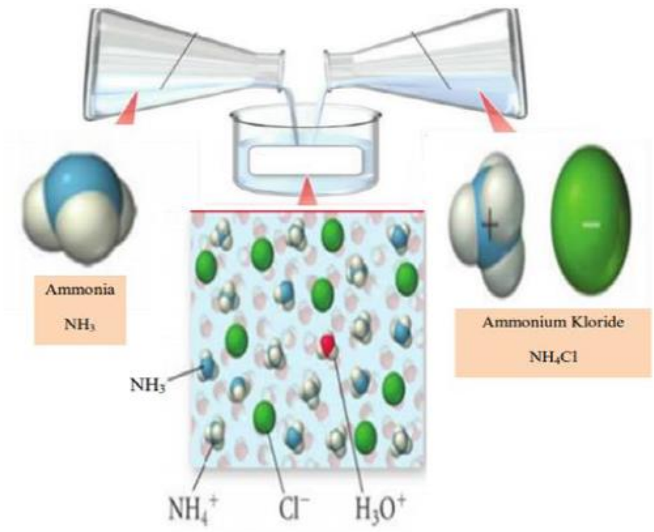

Figure 4. Exploration and concept formation Model 2.

Figure 4 shows model 2 related to the definition and types of alkaline buffer solutions. Then the answers obtained by student one, student two, and student three can suggest that a base buffer solution is a solution that contains a weak base and its conjugate acid. Students start by distinguishing the solution components in the model, including a weak base (NH_4OH) and a conjugate acid (NH_4^+) derived from NH_4Cl salt. Based on the two models above, students can think critically, analyze and explore models by answering key questions to find their concepts about buffer solutions' definition and types of buffer solutions according to the report put forward [29].

The next stage is the application stage, where students work on the questions that have been provided so that student understanding is more robust and trains students' abilities to solve problems related to concepts that have been obtained previously. Students work on practice questions in groups with their respective groups. The learning characteristics using The guided inquiry model involve students playing an active role in learning that emphasizes questions, data analysis, and critical thinking. If the concepts applied to the practice questions are successful, students can integrate them with other ideas. [15].

The last stage, closing, is carried out synchronously in the Classroom with the teacher; at this stage, the students convey the concepts obtained orally, and the teacher confirms or reinforces the ideas related by the students. In addition, before concluding, students have more time to discuss with the teacher to perfect their understanding of the material being studied.

The data analysis showed increased student learning outcomes in the two sample classes. The data processing results showed that the increase in student learning outcomes in the experimental Class was higher than in the control class. The experiment class has a difference in Pretest-Posttest scores of 57.78, while the control class has a difference in Pretest-Posttest scores of 45.69. The increase in learning outcomes in the experimental Class was 87.78, and the increase in learning outcomes in the control class was 80.28. This data shows that applying the Flipped Classroom Learning System Based on Guided Inquiry on the buffer solution material is more effective in improving student learning outcomes.

The learning system's effectiveness level can be measured from the N-Gain Score through the data from the students' pretest and posttest results. The N-Gain value shows increased student learning outcomes before and after learning the buffer solution material. According to [25], the value of the N-Gain or gain score is divided into three levels: high, medium, and low. Based on the research data analysis, the average N-Gain value of the Experiment class is 0.82, and the control class is 0.70, so the average N-Gain value of the two sample classes is in the high category, but the experimental class has a high value. Therefore, the average is higher than the control class, with a difference of 0.12. This data shows that the Flipped Classroom learning system based on guided inquiry on the buffer solution material is more effective on student learning outcomes.

After the comparison of the average N-Gain is calculated, then the hypothesis is tested using the t-test. The t-test can be done because the data from the students' pretest and posttest results are normally distributed and homogeneous. H0 is rejected if t_{count} is greater than t_{table}. This test shows t_{count} (2.47) and t_{table} (1.99) values. This data means that H0 is rejected because t_{count} is greater than t_{table}. The results of this t-test show that the mastery of concepts and the improvement of learning outcomes in the experimental class are higher than in the control class because the learning system in the Experiment Class uses the Flipped Classroom learning system based on guided inquiry on the buffer solution. The guided inquiry-based Flipped Classroom learning system on buffer solution material effective can be used to improve student learning outcomes.

Research that is relevant to this research includes a study conducted by [30] titled "The Influence of Inquiry-Based Learning learning model with the Flipped Classroom Learning System on Self Efficacy and Ion Equilibrium Learning Outcomes in Salt Solutions," that the results of n-gain (learning outcomes) of the control class and Experiment class were 0.72 and 0.83, respectively. Thus, using The guided inquiry learning model with the Flipped Classroom Learning System was proven to improve student learning outcomes. The results of this study are also in line with the results of research conducted by [31] under the research title "Effectiveness of LMS-Based Blended Learning with Inquiry Learning Models on Static Fluid Materials on Student Concept Mastery." The results of n-gain mastery of concepts students from the control and experimental classes were 0.7 and 0.84, respectively. This data shows that using LMS-Based Blended Learning with the Inquiry Learning Model effective increases students' mastery of concepts.

Chemistry learning requires more understanding than memorization, so learning approaches or strategies improve students' ability to understand a concept [32]. The Flipped Classroom learning system based on Guided Inquiry is solution-based in chemistry learning. Besides utilizing technology and maximum learning time because learning can be adjusted during the Asynchronous phase, a guided inquiry-based flipped classroom learning system on buffer solution material using teaching materials in the form of Student Worksheet (LKPD) inputted into the Edmodo application has an attractive appearance. They were equipped with Key-questions that make students think critically and help students find concepts, equipped with an orientation video containing prerequisite material from the buffer solution material. The use of teaching materials in the Student Worksheet (LKPD) oriented to the Blended Learning Learning system is very helpful for students, especially in learning in this millennium era [33]. A guided inquiry-based flipped classroom learning system on buffer solution material using teaching materials in the form of student worksheets (LKPD), which has been developed by [17], already contains the composition of teaching materials following the characteristics of the buffer solution.

Where the topic buffer solution has abstract and complex properties, using buffer solution worksheets with multiple representations (Macroscopic, sub-macroscopic and symbolic levels) can answer the challenges of abstract and concrete buffer solution materials.

The characteristics of the material can trigger difficulties for students to understand the buffer solution material. For example, students tend to understand the buffer solution material only from a macroscopic perspective, so they cannot understand the dynamic interactions in the buffer solution. This difficulty can trigger a misconception in students [34].

CONCLUSION

Based on the study results, the Flipped Classroom learning system based on Guided Inquiry on the buffer solution material effectively improves student learning outcomes. Furthermore, the increase in student learning outcomes supports the effectiveness of the learning system after applying the Flipped Classroom system based on Guided Inquiry, and the N-Gain value of the experimental class is higher than the control class.

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