The Effectiveness of Acid and Base Android-Based Ludo Chemistry Game Media on Students' Cognitive Learning Outcomes

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Abstract: This research aims to analyze the level of effectiveness of the chemical ludo game on students' cognitive learning outcomes in class XI SMA/MA. This method of research used a Quasi-Experimental with a non-equivalent control group design. The population of this research was students of class XI MIPA SMAN 3 Tualang. The sampling technique in this research was purposive, so class XI MIPA 1 was selected as the control class and XI MIPA 2 as the experiment class. The research instrument used in this study was the learning achievement test. The data analysis technique used was the N-Gain test, and hypothesis testing using the t-test. The results showed that students' learning outcomes in the experimental class increased compared to the control class. It was evidenced by the average post-test score of 64.545 for the experimental class and 79.091 for the control class. The results of the N-Gain test for the experimental class were in the high category, namely 0.73 and for the control class, 0.57 in the medium category. The hypothesis test showed that at the real level $= 0.05$ with dk = 78, the value of count (5.1413) > table (1.8044). Acid and base android-based ludo chemistry game media effectively improved cognitive learning outcomes of class XI SMA/MA students.

Introduction

Acids and bases are either of the materials taught in chemistry lessons, especially in the eleventh grade of Senior High School for natural science majors. The concepts taught in this material include the theory of acids and bases, characteristics of acids and bases, the concept of acidic and basic oxides and amphoterism, measurement of the degree of acidity (pH), acid and base dissociation constants, the way of verifying the acid and base solution and ion balance of acid and base solution. This material contains three knowledge dimensions elements: factual, conceptual, and procedural. Determining the pH of acidic and basic species is an element of the dimension of factual knowledge (Setiadi & Zainul, 2019). Conceptual knowledge contained in this material is the theory of Arrhenius, Bronsted-Lowry, and Lewis and equilibrium reactions of acid and base solutions. At the same time, the procedural knowledge contained in the concept of acids and bases is how to measure the pH of a solution with various indicators. Mastery of these three elements can be increased through training (Suryana et al., 2020).

Practice questions relevant to the material being taught must be given so that students can improve the strengthening of learning material. In addition, Smaldino (2011) states that giving practice questions can optimize students in reinforcing the concepts, principles and procedures contained in the material. Practice questions can also stimulate students to find

information from various sources to improve and optimize the knowledge that students have learned (Cagiltay et al., 2019).

Deployment of questionnaires that have been carried out on three chemistry teachers in three different schools that are: SMAN 2 Tualang, SMAN 3 Tualang, and MAN Insan Cendekia Siak, the practice questions given to students come from textbooks, LKPD (sheets Student Work), and modules. Technology has been applied in providing material, namely using PowerPoint media and animated videos. However, the utilization of technology in the exercise has yet to be implemented.

The utilization of technology in daily life is one of the competencies that students need to master to meet the competency needs in the 21st century, which is closely related to science and technology (Zubaidah, 2016). In addition, it is contained in the Rule of the Minister of Education and Culture of the Republic of Indonesia number 22 in 2016 concerning learning process standards, the application of technology can maximize learning effectively and efficiently. Through the Ministry of Education and Culture (Ministry of Education, Culture, Research and Technology), the government has also involved technology in the implementation of learning evaluation, namely the practice of AKM (Minimum Competency Assessment) using computer technology. So, students need to get used to doing practice questions by involving technology in the learning process (Dewi et al., 2019).

Providing exercise in the learning process can be done by utilizing learning media, one of which is by utilizing game media to increase student participation in exercises. According to Purba et al. (2021), games in learning are very effective in fostering student learning motivation to study the material being discussed because these games encourage students to interact with these games so that students feel the need to improve their abilities in the learning process. So, the game media is called a media that is very prospective in its development. In addition, the use of game media can create an atmosphere that is fun, enjoyable, and easy to understand when mastering material in the classroom (Carrillo et al., 2019).

With the development of science and technology, there have been many developments in the digital version of educational games, especially the Android mobile version. *Android* is the operating system that is most loved by the public because this system gives freedom to developers to create applications (Anggraeni & Rudy, 2013). So that generally, mobile learning media are developed in the Android version. Compared to computer games, android games like this are much liked by students because smartphones are a technology many students have (Hermita, 2021). Developing an android-based ludo chemistry game media is a form of implementing the educational curriculum that wants technology in learning.

Vauzia & Iswendi's research (2022) found that the acid and base android-based ludo chemistry game media is valid and practical. However, this media has not been tested for its effectiveness on student learning outcomes. This research aimed to analyse the effectiveness of the chemical ludo game on students' cognitive learning outcomes in class XI SMA/MA. With this research, it is hoped that the acid and base android-based chemistry ludo game media will effectively improve student learning outcomes.

Research Method

This research used a quasi-experimental method with the Non-equivalent Control Group Design. This design was nearly similar to Pretest-Posttest Control Group Design, but the experimental and control groups were not elected randomly (Sugiyono, 2022). The research design applied to this study can be seen in Table 1.

Table 1. Non-equivalent Control Group Design Research Design

Class	Pretest	Handling	Posttest
Experiment	O_1	X	O_2
Control	O_3	-	O_4

The study involved two sample classes: the experimental and control classes. The differentiation of both classes is in the way of exercise during learning. Students in the experimental class used the Android version of the Ludo chemistry game when doing exercises. Meanwhile, students in the control class only relied on questions in the chemistry ludo game based on Android but were done conventionally. The research was conducted at SMAN 3 Tualang in March for the 2022/2023 school year, to be precise, in the even semester. The population in this research were all students of the eleventh-grade science class at SMAN 3 Tualang four classes. *Purposive sampling* was the sampling technique used in this research. Purposive sampling is a technique with definite considerations (Sugiyono, 2022).

The instrument utilized in this research was the learning achievement test. The test is an instrument used to measure the ability or mastery of measuring objects for a series of materials (Djaali & Pudji: 2008). The learning outcomes test was structured to present the maximum ability of the test takers to master the material discussed in learning activities within a certain period. The test was carried out on two classes of samples. The types of questions used in this test were multiple-choice questions adapted to IPK. The questions used in this study had been tested for validity, reliability, question discrimination and difficulty degree of the questions. Research on learning outcomes was carried out by giving a pretest in the first meeting and posttest in the last meeting as a multiple-choice test with five answer choices according to IPK. Data analysis was performed with the N-Gain test. N-Gain test uses pretest and posttest results which can be analyzed by comparing the first and final test scores in both sample classes. The N-Gain test formula, namely, carries out the value of the results of the learning test:

$$Normalized\ gain\ (g) = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

Interpretation of the normalized gain index (g) categories are presented in Table 2 (Hake, 2014).

Table 2. Normalized Gain Index Interpretation Category

N-Gain *Score*	Interpretation
$0.0 < g < 0,30$	Low
$0,30 < g < 0.70$	Medium
$0.70 < g < 1.00$	High

To prove the truth regarding the alleged parameter value (hypothesis), a hypothesis test was carried out. In order to validate the hypothesis, it is necessary to analyze and utilize processed data (either from the population or a sample) as a foundation for making informed decisions regarding the validation of the hypothesis. Before testing the hypothesis, the data obtained must be tested for homogeneity and normality first. The Kolmogorov-Smirnov (K-S) test did the normality test with an actual level of 0.05. If, Dcount < Dtable, then the data is usually distributed. While if Dcount   Dtable, then the data is not normally distributed. Then, the homogeneity test was carried out by the F test. The F test was carried out by comparing the Fcount value with the Ftable value contained in the F distribution list with a significance level of 5%. If the value of Fcount is smaller than Ftable (Fc < Ft), it means that the two groups have a homogeneous variance and vice versa (Suhartono & Indramawan: 2021).

After obtaining data that was typically distributed and has a homogeneous variance, the hypothesis test that was applied was the t-test or independent sample t-test. The statistical hypothesis is formulated as follows:

$$H_o : \mu_1 \leq \mu_2$$
$$H_1 : \mu_1 > \mu_2$$

Information:

μ_1 = average score in the experimental class

μ_2 = average score in the control class

H_0 = Student learning outcomes in the experimental class are smaller or the same as the control class

H_1 = Student learning outcomes in the experimental class are higher than the control class

Results and Discussion

At the time of the research, the experiment and control classes were given a pretest before teaching acids and bases. The pretest was done to know the students' initial knowledge regarding the material discussed during the learning process. Pretest data was also needed to examine which parts of the material need to be taught in-depth or not so that learning can run effectively. The research data is as follows in Table 3.

Table 3. Research Data

No	Statistics	Control Class		Experiment Class	
		Pretest	**Posttest**	**Pretest**	**Posttest**
1.	Samples total	33	33	33	33
2.	Total score	680	2130	680	2595
3.	Mean	21	64.545	22	79.091
4.	Highest score	35	90	35	95
5.	Lowest score	10	25	10	60
6.	Standard Deviation	7.88	12.95	8.19	7.85
7.	Variants	62.12	61.68	67.09	167.76
8.	Ranges	25	65	25	30
9.	Median	20	65	20	80

After the pretest was given to the two sample classes, acid and base material learning activities were carried out. The two sample classes were given the same treatment, such as the material taught, reference books, time duration, teaching methods and questions given on exercise. In the control class, exercises were given by giving questions in printouts on the same paper as the Android-based chemistry ludo game application. The exercise was also carried out for 45 minutes in the fifth meeting. After the exercise, each sample class was given a posttest to assess students' learning outcomes on cognitive grounds. Then the pretest and posttest results were processed and analyzed for research conclusions.

Posttest is done to know the learning outcomes obtained by students after being given handling. The posttest values in the control and experimental classes are in Table 6. The posttest mean in the control class was 64.545, and the posttest mean in the experimental class was 79.091.

Table 4. The significance of Posttest and Pretest Score

Class	Pretest	Posttest	Significance
Control	21	64.545	43.545
Experiment	22	79.091	57.091

Based on the posttest mean in the two sample classes, the posttest score for the experimental class was higher than the control class. A significant difference in the posttest mean scores of

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the two sample classes can be seen in Table 7. The significance in the control class was 43.545, while the experimental class had a significance of 57.091, so the significance of the experimental class was higher than that of the experimental class. Based on comparing the two sample classes' two significance values, giving different treatments to each sample class affects student learning outcomes.

Table 5. Percent Completeness of Sample Class

Class	Minimum Completeness Criteria	Average	Completeness Percentage (%)
Control	75	64.545	84
Experiment		79.091	24

According to Badriyah (2015), one of the requirements for the effectiveness of a media is that at least 75% of student learning outcomes meet the Minimum Completeness Criteria (KKM). The KKM score set by the school was 75. From a study on posttest data for each student in the control class, 8 out of 33 students achieved the KKM, so the percentage of completeness of the control class learning outcomes was 24%, with a mean value of 64.545. While in the experimental class, 28 of 33 students reached the KKM. So, the experimental class percentage completeness learning outcomes was 84% with an average value of 78.638.

N-Gain Test

The result of the normality check for experiment class & control class can be seen in Table 6.

Table 6. N-Gain average of Both Sample Class

Class	N-Gain Average	Criteria
Control	0.73	High
Experiment	0.57	Medium

Table 3 showed that the average N-Gain of the experimental class was 0.73, which is included in the high criteria. In contrast, the control class had an average N-Gain of 0.57 in the medium criteria. So the experimental classes have a good increase in cognitive learning outcomes compared with the control class.

Normality Test

The result of the normality check of both sample classes can be show in Table 7.

Table 7. Normality Test Results

Class		D_{count}	D_{table}	Conclusion
Control	0.05	0.2350	0.1086	Data distribute normally
Experiment			0.0520	

Based on data processing, it was found that the D_{table} value was higher than the D_{count} value. So it can be said that both samples are normally distributed.

Homogenity Test

The result of the homogenity check of experiment class and control class can be show in Table 8.

Table 8. Homogenity Test Results

Class		F_{count}	F_{table}	Conclusion
Control	0.05	1.4746	1.8044	Homogeneous data
Experiment				

Based on F test that F_{count} was 1.4746 while F_{table} was 1.8044. For degrees of freedom the numerator dk = 32, the denominator degrees of freedom dk = 32 and the significance level was 0.05 or $F_{(0.05)(32.32)}$ was 1.8044. It can be concluded that $F_{count} < F_{table}$ so the different between the pretest and posttest values in both samples have homogeneous variances.

Hypothesis Test

Homogenity check result of experiment class and control class can be show in Table 8.

Table 9. Hypothesis Class Results

Class	X Mean	Significance	t_{count}	t_{table}
Control	64,545	0.05	5.1413	1.8044
Experiment	79,091			

Based on data processing, it was found that the tcount was 5.1413 and at a significant level of 0.05, the ttable was 1.8044. The test criterion is H0 are accepted if tcount < ttable. The price of t was outside the acceptance area of H0, so H0 was rejected at a real level of 0.05, and H1 was accepted. So that the learning outcomes of the control class were lower than experiment class

Based on the data processing, using Android-based chemical ludo game media on acids and bases can effectively increase student learning outcomes in the cognitive domain. Exciting and fun games can trigger the active participation of students, and students feel free from the pressure of doing the exercises. It follows Erna (2022), who states that applying games in the learning process can increase students' interest in being active, thinking logically, and being sporty and trigger a sense of fun in learning. Besides this, learning by involving games can provide exciting experiences to students in carrying out exercises. It is supported by Hamdani's statement (2011) that games in learning can supply a catchy impression for learners to realize a concept and reinforce the concept, making the learning atmosphere more delightful. Then it is supported by Isnawati's statement (2013), which states that attractiveness is one of the criteria for selecting learning media. Interesting learning media for students will make students passionate about being bound in the learning activity. When using the chemistry ludo game media, students become interested in doing exercises without comment and like the game. So, this chemical ludo game effectively increases student participation in the exercises.

Chemistry ludo game media of android-based can generate motivation in execution exercises to reinforce the concepts. It is related to Hidayatno et al. (2018) that games play is essential for building motivation in the learning activity. Enthusiasm and motivation situations formed in learning activities will have more effective learning outcomes. Games can build a learning atmosphere that is dynamic, full of enthusiasm and generates enthusiasm from learners. So that learning objectives can be reached efficiently and effectively in a happy atmosphere even though discussing material matters that are difficult or heavy (Hidayat, 2016).

Using the chemistry ludo game android-based media in its application can help students repeatedly reinforce the concepts. When playing, the questions that will appear in the game application for one player will be visible to all players so that other players will indirectly read the questions and participate in predicting the correct answer. After getting the correct answer, all players can also find the correct answer when the application displays the answer on the smartphone screen, likewise for the next player. In addition, in this game, there is a chance that four students can find one question. With repetition in the game, most students can know and remember the answer to questions that could not be responded to before. It is related to Sanjaya (2013), which states that repetition, practice, and reinforcement are efforts to strengthen mastery of the lesson. In addition, Pratama (2022) explained that games can create different experiences for students, so this experience makes students' memories of the material presented in games last longer compared to conventional

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learning. So, it can be concluded that this chemistry ludo game of android-based media effectively reinforces students' concepts so that learning outcomes increase.

The chemical ludo game was played in groups. In the chemical ludo game, there were four pieces of different colors. Each color piece was held by 2-3 students so that each student could work together to solve the problems in the game. It follows Mardati (2015), which states that game media can lead to collaboration and interactive relationships with study partners and motivate students to be active in learning. Then, the ludo game has the potential to increase student involvement and interest and create a sense of mutual need and collaboration within each group of students (Ulhusna et al., 2020).

The utilization of technology in daily life is one of the competencies that students need to master to be able to meet competency needs in the 21st century. Along with the development of science and technology, there have been many developments in digital versions of educational games, especially the Android mobile version. Android-based learning media is one of the applications of 21st-century learning styles. Developing android-based chemical ludo games as learning media is a form of implementing the educational curriculum that wants technology in learning. This type of learning media can help improve students' academic abilities through learning outcomes in the cognitive domain and students' learning motivation (Calimag et al., 2014). In addition, Android-based learning media can be used as an effective and efficient learning medium because it can be carried anywhere and train students' abilities or knowledge of learning material (Myori et al., 2019).

The use of learning media using technology close to students today can trigger students' interest in accessing the material in the application so that students' learning intensity will increase. Purmadi (2016) reveals that student learning intensity supports student success in teaching and learning activities. The intensity of learning is very important, bearing in mind that with adequate effort and study routines, students become more organized and quickly get bored in teaching and learning activities, especially in subjects with lots of formulas and high understanding.

Media use is one factor in increasing student learning outcomes and understanding in the experimental class. Based on the average learning outcomes obtained, the average value of the experimental class is higher than the control class. It indicates that media use in the learning process can positively impact. According Audie (2019), using learning media can increase student achievement. Students can increase participation in the learning process because learning media can foster learning motivation to generate enthusiasm, leading to increased student learning outcomes.

During the research, there were obstacles experienced in the implementation of learning, namely when downloading game applications on Android was quite time-consuming. Before doing the exercise, the researcher gave 15 minutes to download the game application. Because most students' smartphone memory is insufficient, researchers have instructed students to clear their memory before the exercise occurs.

Several previous studies can be used to increase knowledge related to research activities. This research is in a similar field of research as previous studies. Based on Lubis & Ikhsan (2015) android-based learning media has characteristics, namely attractive, flexible and practical visualization that can be utilized wherever and whenever and has varied evaluation questions, so students can study over again the matter by itself unattached by time and place and can improve memory for the studied matter. Then, based Ma et al. (2018) learning media of smartphone-based, especially on the Android system, has many benefits in the learning process in class. After that, to increase the worth of the functions and benefits of

smartphones in the learning process, student academic performance can also be improved by actively involving them anywhere and anytime. Jabbour (2014) said that using technology as media learning can increase learning motivation and make studying more exciting and fun. One of the reasons for increasing students' cognitive abilities is an increase in learning motivation through learning media that can develop students' scientific competencies, such as solving problems in a game (Tsai, J. C., 2020). Then supported by research by Indriliza & Iswendi (2019), in the experimental class, there was an increase in the mean degree of learning outcomes when compared to the control class because learning using game media is something fun to do and entertaining to increase active participation of students in the learning situation and this affects the improvement of student learning outcomes.

Conclusion

According to the findings of the study, the utilization of acid and base chemistry ludo games on an Android platform has proven to be highly effective in enhancing students' cognitive learning outcomes in the experimental class, categorizing it as high. Conversely, the control class achieved moderate outcomes. The hypothesis test results further indicated that at a significance level of 0.05, the calculated t-value (5.1413) was greater than the critical t-value (1.8044), leading to the rejection of the null hypothesis (H0) and acceptance of the alternative hypothesis (H1).

Recommendation

This research recommends that chemistry teachers use the chemical ludo game as a choice of media used in concept reinforcement so students can act actively in the learning process. Future researchers are expected to control and guide students so that study time can be used effectively so that the ludo chemistry game android media can help students in concept reinforcement.

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