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EFFECTIVENESS OF THE CHEMICAL LUDO GAME ON SHIFTING EQUILIBRIUM MATERIAL AND THE FACTORS THAT INFLUENCE ON LEARNING OUTCOMES

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Abstract: This research is a continuation of development research with a 4-D model developed by Rini Fauza and Iswendi with the title Development of Ludo Chemistry Games as Learning Media on Material Shifting Equilibrium and Factors Affecting It Class XI SMA/MA which is valid but has not been tested for practicality and its effectiveness. This study aims to determine the level of practicality and effectiveness of chemical ludo games. The research design was the Pretest-Posttest Control Group Design. The research sample was XI MIPA 1 as the experimental class and XI MIPA 2 as the control class. Practicality data were analyzed with the practicality percentage and effectiveness data with the N-Gain test. The data analysis results on the practicality of teachers and students are in the very practical category. The results of the N-Gain analysis in the experimental class were 80% in the effective category and in the control class 74% in the quite effective category, which was supported by the learning outcomes of the experimental class, which were higher than the control class. The average posttest scores for the experimental and control classes were 84.83 and 81.17, respectively. The learning outcomes of the experimental class increased from the control class where tcount (2.465) > ttable (2.002) at a significant level α = 0.05. Ludo chemistry games as learning media are very practical and effective in improving student learning outcomes in the cognitive domain of class XI SMAN 1 Lubuk Basung.

Keywords: *Practicality, Effectiveness, Chemistry Ludo Game, Shifting Equilibrium, Learning Outcomes*

INTRODUCTION

One of the basic competencies (BC) that must be achieved by students in chemistry class XI SMA subject in odd semesters is BC 3.9 Analyzing the factors that influence shifts in equilibrium and their application in the industry [1]. This material consists of factual, conceptual, and procedural knowledge. Factual knowledge of this material is that changes in concentration, temperature, pressure, and volume affect shifts in equilibrium. Conceptual knowledge of this material is that there is Le Chatelier's principle which can predict the effect of changing conditions on chemical equilibrium. The procedural knowledge of this material is the stages of making ammonia (NH_3) through the Haber-Bosh process. Based on the characteristics of the material, it takes a lot of reading, discussing, and doing exercises to make it easier to understand the material to achieve the learning objectives.

Based on the results of a questionnaire that was given to 6 chemistry teachers from three schools, namely SMAN 1 Lubuk Basung, SMAN 10 Padang, and SMA Pembangunan Laboratory UNP, information was obtained that the exercises given after the learning process were sourced from textbooks, modules, student worksheet and questions made by the teacher himself. The exercises given are individual, less varied, and less able to enhance students' competitive spirit. Meanwhile, varied exercises that contain elements of competition (competition) can increase learning motivation, create a pleasant learning atmosphere, and remain conducive. One of them is by doing exercises in the form of games [2].

Based on the results of a questionnaire that was given to 90 class XII SMA/MA students at SMAN 1 Lubuk Basung, SMAN 10 Padang, and UNP Laboratory Development High School, information was obtained that 100% of students had never used game media in the form of chemical ludo and students liked the learning process while playing, in groups and competing. Children aged 7-18 tend to like games in learning [3]. One alternative is to use educational games. Educational games are all forms of games designed to provide learning experiences for the players [4]. One educational game media that can be used is a modified chemical ludo game.

Practicality is defined as something practical, efficient, easy, and fun to use [5]. Practicality refers to the extent to which teachers and students consider the developed media interesting and can be used under normal conditions [6]. According to Daryanto, several media characteristics can be practical if they are readily available, easy to obtain, easy to use, inexpensive, do not require special equipment, and are understood by the teacher [7].

Effectiveness comes from the word effective, which means having an effect (impression, effect, and influence) that can bring results [8]. Several media criteria can be effective: cost, availability of supporting facilities, compatibility with class size, brevity, ability to be changed, time and effort in preparation,

complexity, usability, and ease of understanding [9]. Learning outcomes are abilities that individuals acquire after the learning process is carried out, which can provide several changes, be it changes in behavior, changes in knowledge, changes in attitudes, understanding, and changes in students' skills so that they become better than before [10]. Bloom stated that learning outcomes are divided into three domains: cognitive, affective, and psychomotor domains [11].

Previous relevant research has shown a positive impact after using game-based media. A study conducted by Fadillah, A, and Iswendi regarding the effectiveness of using chemo-edutainment-based chemical ludo game learning media on atomic structure material on student learning outcomes in class X SMAN 3 Padang. This study shows that using chemical ludo games effectively improves student learning outcomes [12].

An alternative learning media has been developed as a chemical ludo game on the material of shifting equilibrium and the factors that influence it by Fauza, R, and Iswendi [13]. This media has been tested to the validity stage but has yet to be tested for its practicality and effectiveness. Therefore, the authors are interested in continuing this research to the stage of determining the level of practicality and effectiveness of the learning media on student learning outcomes.

RESEARCH METHOD

This research is a continuation of development research with a 4-D model. The design of this study is the Pretest-Posttest Control Group Design. The research design can be presented in Table 1.

Table 1. Pretest-Posttest Control Group Design Research Design

Class	*Pretest*	Treatment	*Posttest*
Experiment	O_1	X	O_2
Control	O_3	-	O_4

[14]

This research was conducted in November - December in the even semester of the 2022/2023 school year at Lubuk Basung 1 Public High School. The population of this study was students of class XI MIPA at SMAN 1 Lubuk Basung. The sample selection technique in this study uses Simple Random Sampling. Researchers used two sample class samples, namely class XI MIPA 1 as the experimental class and XI MIPA 2 as the control class.

Research data is information in the form of facts obtained from research and then processed for decision-making. The data used in this study is primary data, which is obtained directly from teachers and students. The practicality test data was obtained by analyzing the practicality questionnaire sheet assessment. The effectiveness test data was obtained from the learning outcomes of the two sample classes through the pretest and posttest.

The research data analysis technique was carried out in two ways, namely practicality and effectiveness data analysis techniques. The practicality data analysis technique uses the practicality percentage formula to see the level of practicality of the chemical ludo game media. The following is the formulation of the practicality percentage formula:

$$P = \frac{\text{the total score obtained}}{\text{highest total score}} \text{ x } 100\% \qquad [15]$$

The table of criteria for calculating practicality data is presented in Table 2.

Table 2. Practicality Criteria

Percentage (%)	Criteria
86-100	Very Practical
76-85	Practical
60-70	Quite Practical
≤54	Very Impractical

The effectiveness data analysis technique using the N-Gain test to see the effectiveness criteria of ludo chemical game media. Here is the N-Gain formulation:

$$\text{N–gain} = \frac{\text{posttest score} - \text{pretest score}}{100 - \text{pretest score}}$$

The N-Gain effectiveness interpretation category table is presented in
table 3.

Table 3. Percentage N-Gain

Percentage (%)	Criteria
≤40	Not Effective
40-55	Less Effective
56-75	Quite Effective
≥76	Effective

[16]

Furthermore, a hypothesis test is carried out to see whether the existing hypothesis is accepted or rejected. Before that, the data obtained were subjected to a normality test to see whether the data were normally distributed and a homogeneity test to see whether the data had a homogeneous variance.

RESULT AND DISCUSSION

Chemical equilibrium can experience a shift due to the influence given to it. Several things namely can explain shifts in chemical equilibrium:

Le Chatelier's Principle

Le Chatelier's principle predicts the effect of changing conditions on chemical equilibrium. Le Chatelier's principle reads:

"If an equilibrium system accepts an action, then the system will hold a reaction so that the effect of the action becomes as small as possible."

Reaction = - Action [17]

Factors That Shift effect equilibrium

In product development it is more focused on three factors, namely:

1) The Effect of Concentration

Suppose in an equilibrium system, the concentration of one of the components in the system is increased. In that case, the equilibrium will shift from the direction of the addition, and if one of the components is reduced, the equilibrium will shift in the direction of the reduction.

2) Effect of Temperature

According to Le Chatelier's principle, if the temperature of an equilibrium system is increased, there will be a shift in the equilibrium towards the reaction that absorbs heat (endothermic reaction).

3) Effects of Pressure and Volume

The gas concentration in a room is inversely proportional to the volume, so increasing the pressure by reducing the volume will increase the concentration of all components. Following Le Chatelier's principle, the system will react by reducing pressure [18].

There are four main stages of the 4-D model, namely: define, design, develop, and disseminate [19]. However, this research is limited to the development stage as follows.

1) Define

The purpose of the definition stage is to establish and define the learning requirements. This stage consists of 5 main steps: front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives.

2) Design

At the design stage, product design is carried out in the form of a chemical ludo game as a learning medium. The stages carried out in the design of the chemical ludo game as a learning medium are as follows:

a. Game Box

The box is made of straw cardboard with a length of 23 cm, a width of 12 cm, and a height of 7 cm. The box design was designed using the CorelDraw X7 application, printed using sticker paper, and then pasted into the created box. The chemical ludo game box is made so that ludo tools in the form of ludo boards, pieces, dice, shaker glasses, question cards, and assessment forms are not scattered and are easy to carry anywhere. The finished box can be seen in Figure 1.

Figure 1. Chemistry Ludo Game Box

b. Board and Game Rules

The chemical ludo board game was modified by changing its appearance and adding a summary of the material shifting in equilibrium and the factors that influence it, which contains factual, conceptual, and procedural knowledge in each box. The boxes on the board are numbered to indicate the question number. The chemical ludo board was designed using the CorelDraw X7 application. Game rules are listed on the game board to make it easier to read. This chemical ludo game's board design and rules are printed in A3 size (29.7 x 42 cm). The design is printed using banner material so that it is not easily damaged when wet and is easily folded so that it can be put in a box.

c. Question and Answer Cards

Ludo chemistry as a learning medium is equipped with practice questions that consist of 4 series of questions, namely the red, blue, yellow, and green series. Each series of questions has 32 questions in multiple-choice form. The questions were collected in the form of a booklet which was designed using the Microsoft PowerPoint 2010 application and printed using A4 paper, then cut and bound into a booklet, as shown in Figure 4. Answer keys are displayed directly at the bottom of each question so the coordinator can more easily correct the player's answers.

d. Pawns, Dice and Shaker Cups

The chemical ludo game's dice, pieces, and shaker glass are purchased directly from the ready-to-use market. Dice purchased are modified by changing the number six to number four and the number five to number three so that the numbers three and four appear twice. It is done so that each player has more opportunities to answer questions. Dice, pawns, and knockout glasses can be seen in Figure 2.

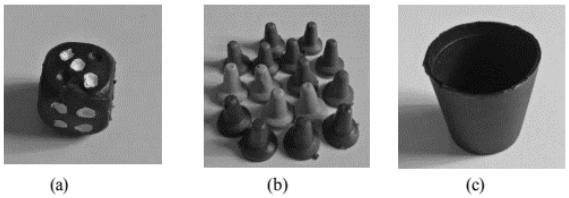


Figure 2. (a) Piece (b) Dice and (c) Shaker Cup

e. Assessment Form

The scoring form contains instructions for scoring each player. Each player who answers correctly will be given 5 points. If the answer is wrong, then it will be passed on to the next player, and if the correct answer is given 3 points. Incorrect answers are not given points and are immediately given by the coordinator for the correct answer.

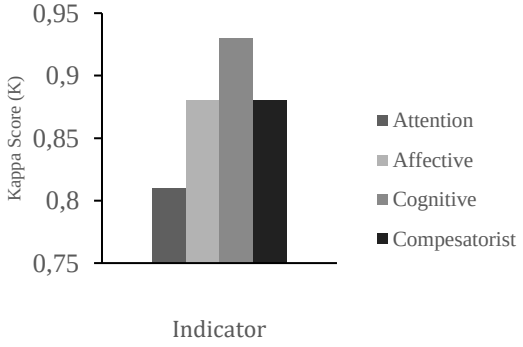
3. Develop

This stage aims to produce learning media on shifting the balance and the factors that influence it, which have been revised based on input from various parties. The steps taken are:

a. Validity

The validity questionnaire of the chemical ludo game as a learning medium on the material of shifting equilibrium and the factors that influence it for class XI SMA is structured based on four media functions, namely the function of attention and affective, cognitive function, and compensatory function and then analyzed using the Kappa Cohen formula.

Figure 3. The function of the media based on the validity test by lecturers and teachers



Based on validation data analysis, chemical ludo has a very high level of Validity with an overall kappa score of 0.83.

a. Practicality

Determining the level of practicality is carried out by teachers and students at SMAN 1 Lubuk Basung. The data obtained from the practicality questionnaire the respondents filled in were then analyzed using the practicality percentage formula. The practicality questionnaire has three aspects: convenience, use, and suitability of the content with the curriculum.

The results of the data analysis on the practicality of teachers and students are presented in table 4.

Table 4. Practicality Percentage

No	Aspect	Teachers	Students
1	Convenience	97.2 %	87.2 %
2	Use	100 %	91.7 %
3	Compatibility with the curriculum	100 %	87.5 %
	Average	99.07 %	88.8 %

Table 4 shows that the practicality of the chemical ludo game media based on the responses of teachers and students has an average value of 99.07% and 88.8% with very practical criteria. Based on this description, the chemical ludo game media on the material of the shift in equilibrium and the factors that influence it have fulfilled the three characteristics of practical media: ease of use and content conformity with the curriculum [20-21].

b. Effectiveness

The effectiveness test is a continuation of the previous stage. Effectiveness data were obtained through student learning outcomes in the initial (pretest) and final (posttest) tests. The initial test determines students' abilities, while the final test determines students' learning outcomes after treatment. The following are students' average pretest and posttest in the two sample classes presented in table 5.

Table 5. Average Pretest and Posttest Sample Class

Class	Pretest	Posttest
Experiment	27	84.83
Control	28.67	81.16

Table 5 shows that the average pretest scores for the experimental and control classes were 27 and 28.67. It means that the initial abilities of students in the two sample classes are similar. The average posttest scores for the experimental and control classes were 84.83 and 81.16. It means there is an increase in student learning outcomes in the experimental class after treatment.

The data obtained from the pretest and posttest were then analyzed using the N-Gain test. N-Gain aims to determine the increase in student learning outcomes before and after learning. The results of the percentage of N-Gain in both sample classes are presented in table 6.

Table 6. Percentage N-Gain

Class	Percentage (%)	Criteria
Experiment	80	Effective
Control	74	Quite Effective

Table 6 shows that the percentage of N-Gain in the experimental class was 80% with effective criteria, while in the control class, it was 74% with sufficiently effective criteria.

Before testing the hypothesis, the researcher conducted normality and homogeneity tests. The normality test results are presented in Table 7.

Table 7. Sample Class Normality Test Results

Class	α	L_{count}	L_{table}	Conclusion
Experiment	0.05	0.121	0.161	Normal
Control		0.096		

Table 7 shows that $L_{count} < L_{table}$ in both sample classes at a significant level of 0.05. It shows that the data of the two sample classes are normally distributed. This normality test's basis for decision-making uses the Liliefors test [22-23]. The homogeneity test results are presented in the table.

Table. 8 Sample Class Homogeneity Test Results

Class	α	F_{count}	F_{table}	Conclusion
Experiment Control	0.05	1.418	1.861	Homogenous

Table 8 shows that at a significant level (α) of 0.05, the value of $F_{count} = 1.418$ and $F_{table} = 1.861$, so it is known that the value of $F_{count} < F_{table}$ means that the two sample classes have a homogeneous variance [24].

Based on the normality test and homogeneity test, it was found that the data of the two sample classes were normally distributed and had a homogeneous variance so that hypothesis testing could be continued with the t-test, which is presented in table 9.

Table 9. Results of the Sample Class Hypothesis Test

Class	α	T_{count}	t_{table}	Conclusion
Experiment Control	0.05	2.465	2.002	Hypothesis accepted

Table 9 shows that tcount = 2.465 and ttable = 2.002 at a significant level of 0.05, so the value of $t_{count} > t_{table}$. It means that H_0 is rejected and H_1 is accepted. In other words, the learning outcomes of the experimental class are higher than the control class.

The effectiveness of using chemical ludo games as a learning medium in shifting equilibrium and the factors influencing it can be seen in the students' mastery of the material. It can be measured through the percentage of learning completeness and the percentage of N-Gain. Based on the study results, the percentage of completeness obtained by students, by calculating the number of students who reached the minimum completeness criteria (MCC) set by the school, namely 78. In the experimental class, the posttest scores of students were obtained from as many as 28 out of 30 students who achieved KKM, so the percentage of completeness is 93.33%. In the control class, the posttest scores of 23 out of 30 students who achieved the MCC were obtained, so the percentage of completeness was 76.67%. It is consistent with the statement that one of the conditions that must be met to determine the effectiveness of a media is a minimum of 75% of student learning outcomes in the complete category or meets the minimum completeness criteria (MCC) [25].

Based on the percentage of N-Gain, there is an increase in student learning outcomes after using the ludo chemical game media as an alternative for practice and can solidify concepts. It means that the use of chemical ludo game media in the learning process can increase students' understanding of the material shifting in equilibrium and the factors that influence it because game media is an educational tool that is educational and fun so that students can find knowledge by playing.

CONCLUSION

Based on the results of data processing and analysis, it was found that the chemical ludo game as a learning medium for material shifting in equilibrium and the factors that influence it is very practical and effective and can improve student learning outcomes in the cognitive domain of class XI SMAN 1 Lubuk Basung. It is supported by data from hypothesis testing where t_{count} (2.465) > t_{table} (2.002) so that H_0 is rejected and H_1 is accepted.

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