

THE EFFECT OF FLASH ANIMATION-BASED DISCOVERY LEARNING ON STUDENTS' CHEMICAL BONDING LEARNING OUTCOMES

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Abstract. This study aims to determine the effect of Macromedia Flash-based animation media within the Discovery Learning model on the learning outcomes of Grade XI MIPA students at MA Manongkoki, Takalar Regency, in the subject of Chemical Bonding. The research used a quasi-experimental design with a quantitative approach and employed a posttest-only control group design. The sampling technique was random sampling. The study population consisted of all three Grade XI MIPA classes, with XI MIPA 1 as the experimental group and XI MIPA 2 as the control group. A multiple-choice test was used as the research instrument to collect data on student learning outcomes. Data analysis was conducted using descriptive and inferential statistics. The descriptive results showed that the experimental class achieved a higher average score (83.92) than the control class (71.08). Inferential statistical analysis indicated that the data were not normally distributed; therefore, the Mann-Whitney test was used. The analysis yielded a Zcount value of 3.11, which was greater than the Ztable value of 1.65. Based on these results, it can be concluded that Macromedia Flash-based animation media within the discovery learning model has a significant positive effect on students' learning outcomes in chemical bonding.

Keywords: chemical bonds, discovery learning, learning outcomes, macromedia flash-based animation media,

INTRODUCTION

The quality of education is one of the determinants of a nation's progress. In other words, the progress of a nation or country can be seen from the quality of education in that nation and country. Quality education certainly cannot be separated from the curriculum used in educational institutions. According to Law No. 20 of 2003, the curriculum is a set of plans and arrangements regarding the objectives, content, and learning materials as well as materials used as guidelines for organizing learning activities to achieve certain educational goals.

The government currently mandates the use of the Merdeka Curriculum for teaching in schools. The Merdeka Curriculum is a curriculum with intracurricular learning with diverse content so that students can be more optimal and have enough time to explore concepts and strengthen competencies (Ramadhan et al., 2022). Therefore, in this curriculum, teachers can choose methods, models, and teaching tools that can be adjusted to the learning needs and interests of students so that the learning process will be more flexible and enjoyable.

One learning model that can be applied in the Merdeka Curriculum is the discovery learning model. Discovery learning is a learning model that creates a learning situation that involves students learning actively and independently in finding a concept or theory, understanding, and solving problems with teachers as

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facilitators and guides (Priansa, 2017). Research results of Nugrahaeni et al., (2017) stated that learning using the Discovery Learning model has proven effective in improving student learning outcomes and critical thinking skills. Thus, it can be said that the Discovery Learning model is one of the models recommended in the Merdeka Curriculum, which is able to make learning more active so that student learning outcomes can be improved.

Furthermore, discovery learning such as the Discovery Learning model can be supplemented with learning media. Learning media itself can foster interest in learning, help concentration, and accelerate the process of understanding the material by students (Arsyad, 2017). In this case, the use of media in the discovery learning model not only facilitates the process of discovering concepts but is also able to improve student learning outcomes, which include increasing cognitive knowledge, critical thinking skills, and the ability to store information (Sanjaya, 2012).

Based on information obtained through an interview with one of the chemistry teachers at MA Manongkoki, those educators have implemented the Discovery Learning learning model but have not shown results as expected. This is indicated by the number of students who meet the minimum completion criteria (KKM) of 75 for chemistry subjects in grade XI are still not meeting learning targets. This is because in general students are less interested in learning. This lack of interest causes students to be less active, which ultimately results in learning targets not being achieved.

Efforts that can be made so that students can be actively involved in learning are by maximizing the use of the Discovery Learning model and combining it with learning media that can attract students' attention. The use of learning media in the teaching and learning process can create new desires and interests in students, make learning more enjoyable, and have a psychological impact on students. (Arsyad, 2017). The use of media in learning can also help students understand something abstract in nature (Sanjaya, 2012).

Chemical bonds represent an abstract subject in the field of chemistry, as the concepts involved cannot be directly observed by the human senses (Ozmen, 2007). The results of research by Sari et al., (2020) regarding students' difficulties in understanding the concept of chemical bonds showed that the percentage of students' difficulties was 35.8% in the sub-material of electron configuration, 35.1% in valence electrons, 55.4% in ionic bonds, 58.7% in covalent bonds, and 54.3% in metallic bonds. Therefore, to explain this matter, this material requires media that can provide a clear depiction for students so that this abstract material can be clearly depicted, one of which is by using Macromedia Flash-based animation media.

Macromedia Flash is a combination of learning concepts with audio-visual technology that is capable of producing new features that can be used in the education (Ritongah & Junaidi, 2018). The advantage of Macromedia Flash is that it is equipped with action scripts (action commands), which can make animated images easy to arrange according to material requirements (Madcoms, 2007). The final result of Macromedia Flash is in the form of offline animation, and the display procedure can be displayed on a computer or laptop and smartphone, making it easier to access (Haeruddin, 2022).

Based on these advantages, Macromedia Flash can be used as a learning medium that can display difficult and rarely observed concepts, such as the formation of ionic bonds, covalent bonds, and metal bonds in an animated display so that it is easier for students to understand. Research by Dwiana et al., (2022) shows that the use of Macromedia Flash media in mathematics subjects in

elementary schools can increase student creativity because the attractive and interactive animation display makes students more involved in the learning process. Kasman et al., (2023) stated that Macromedia Flash can improve student learning outcomes. In addition, research by Saputra & Sari (2018) shows that the use of Macromedia Flash in the Discovery Learning model can increase student activity and understanding of pressure material in junior high schools. Ulfa & Saputra (2019) also found that animated media makes it easier for students to understand mathematics material with a fun approach.

It can be seen that most previous research has been conducted at the elementary and junior high school levels and in subjects other than chemistry. Meanwhile, research integrating Macromedia Flash animation with the Discovery Learning model, specifically on chemical bonding at the high school level, is still very limited. This is despite the fact that chemical bonding is an abstract concept and often presents learning difficulties for students. Therefore, this study is both novel and significant because it offers an alternative, more effective learning strategy by combining the Discovery Learning model and Macromedia Flash animation to improve students' understanding of the concept of chemical bonding.

Based on this description, this study aims to determine the effect of using Macromedia Flash-based animation in the Discovery Learning model on the learning outcomes of 11th grade MIPA students at MA Manongkoki in chemical bonding. The benefits of this study include practical benefits: it provides an alternative learning medium that chemistry teachers can use to help students understand abstract material. Theoretically, it contributes to the development of the Discovery Learning model, combined with interactive animation, as an effective strategy for improving learning outcomes.

METHOD

The type of research used is quasi-experimental research. Quasi-experimental research was chosen because researchers do not have full control over the independent variables and do not randomize subjects completely, but it still allows comparisons between groups to determine the effect of treatment (Sugiyono, 2019). This design is commonly used in educational research because it still allows researchers to evaluate the effectiveness of a treatment in real classroom conditions (Creswell, 2012). This study was conducted with the aim of determining the effect of using Macromedia Flash-based animation media in the Discovery Learning model on the learning outcomes of class XI MIPA MA Manongkoki Takalar District students on the subject of Chemical Bonding.

The population in this study was all students of class XI MIPA MA Manongkoki in the 2024/2025 academic year, consisting of three classes. The sample in this study was taken using the simple random sampling technique. This is based on the fact that all classes have the same level of ability (homogeneous). Of the three classes that were the research population, two classes were randomly selected as sample classes. Class XI MIPA 1 as the experimental class consisting of 28 students, and class XI MIPA 2 as the control class consisting of 25 people.

The research design used is a posttest-only control design. This study compares the experimental class with the control class, which is given different treatments. The experimental class is a class that is given treatment using Macromedia Flash-based animation media in the Discovery Learning model, while the control class is a class that is given treatment without using Macromedia Flash-based animation media in the Discovery Learning model. After being given

treatment to both classes, a posttest is given, which aims to determine the learning outcomes of students.

The instruments used were student activity observation sheets and multiple-choice questions. These observation sheets were arranged based on the syntax in the Discovery Learning learning model. In addition, in multiple-choice questions, each question has five alternative answers and only one correct answer. The learning outcome test instrument used was an objective test that had been validated by experts. After that, the data obtained was processed to determine the item validation, including determining the difficulty index, discriminatory power, validity, and reliability of the questions. The results of the item validation obtained 25 valid questions, which were then used to measure student learning outcomes at the end of chemistry learning on chemical bonding material.

The data analysis techniques in this study consisted of descriptive statistical analysis and inferential statistical analysis. Descriptive statistical analysis included individual completeness, class completeness, and indicator completeness, while inferential statistical analysis was used for hypothesis testing. Before conducting the hypothesis testing, prerequisite tests were conducted, including normality and homogeneity tests. The normality test was conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests, while the homogeneity of variance test used the Levene test. If the data were normally distributed and the variances were homogeneous, a parametric test (t-test) was used. However, if one of the requirements was not met, a non-parametric test, namely the Mann-Whitney test, was used. In this study, the test results showed that the data were not normally distributed and not homogeneous, so the hypothesis testing was conducted using the Mann-Whitney test. The flow of this research can be seen in Figure 1.

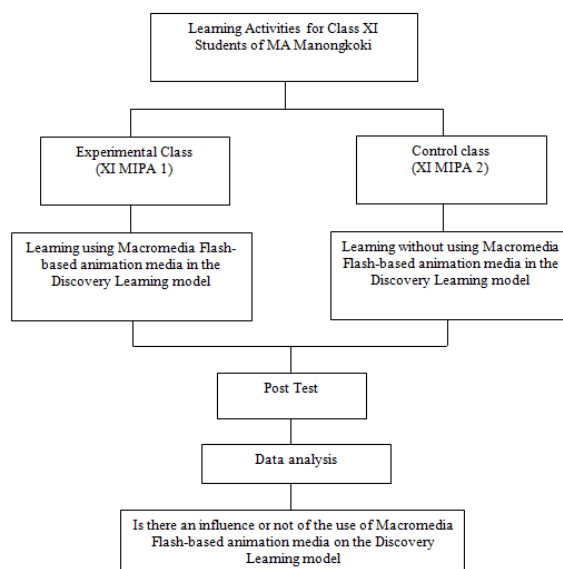


Figure 1. Research flow

RESULTS AND DISCUSSION

The research results obtained during the research process were analyzed using descriptive and inferential analysis techniques. Student learning outcomes based on the descriptive statistical analysis can be seen in Table 1.

Table 1. Results of descriptive statistical analysis of student learning outcomes in the experimental class and control class

No.	Statistics	Statistical Values	
		Experimental Group	Control Group
1.	Number of Students	28	25
2.	maximum score	92	88
3.	minimum score	68	44
4.	Mean	83.92	71.08
5.	Median (Me)	87.50	74.51
6.	Modus (Mo)	89.50	76.54
7.	Standard Deviation	8.4	13.10

Based on the descriptive analysis results in Table 1 above, the average learning outcome for students in the experimental class was 83.92, while the average learning outcome for students in the control class was 71.08. These results indicate that the average learning outcome for the experimental class was higher than that for the control class. This difference indicates that the combination of a discovery-based learning model and interactive visual media can improve learning outcomes, particularly in understanding abstract material such as chemical bonds.

The Discovery Learning model encourages students to be active in the learning process through systematic steps: providing stimulus, identifying problems, collecting data, processing data, and drawing conclusions (Priansa, 2017). In this study, this model was strengthened by the use of Macromedia Flash animation media, which presented chemical concepts through engaging and easy-to-understand videos, images, and text. The use of animation media in each stage of Discovery Learning was proven to support active student engagement. For example, in the stimulus and problem identification stages, animation captured students' attention and helped them visually recognize problems. During the data collection and processing stages, animation provides concrete and in-depth information, making it easier for students to connect concepts and draw conclusions. This is supported by the findings of Saputra & Sari (2018), who stated that the integration of Macromedia Flash animation media into the Discovery Learning model significantly increased student engagement and understanding. Dwiana et al. (2022) also demonstrated that animation media supports creative and participatory thinking processes in learning.

The above results are also supported by the analysis of observations conducted by two observers in the experimental and control classes, which were then summed and averaged. The results of the percentage of student activity based on the steps of the Discovery Learning model can be seen in Table 2.

Table 2. Percentage of student activities

Group	Activity A	Activity B	Activity C	Activity D	Activity E	Activity F
Experiment	84.37%	83.48%	81.65%	80.65%	82.88%	78.87%
Control	72.00%	67.67%	67.67%	65.33%	70.00%	62.83%

The observation data for activities in Table 2 above show that students in the experimental class demonstrated high participation across all stages of discovery learning. Observation activity reached 84.37%, indicating that students were highly focused when the animation was presented during the stimulus stage. Problem identification activity, at 83.48%, indicated that students were able to understand the

given situation and formulate problems based on the visual presentation. In the activities of proposing conjectures (81.65%) and collecting data (80.65%), students actively developed hypotheses and sought appropriate information, supported by the visual representation of the animation. Data processing activity (82.88%) reflected students' ability to interpret information. In the final stage, the conclusion-drawing activity was recorded at 78.87%, indicating that most students were able to correctly conclude concepts based on the previous process.

In contrast, the level of student activity in the control class was lower and uneven, with observation activity at only 72.00%, problem identification at 67.67%, and conclusion drawing at 62.83%. This indicates that without strong media support, students experience difficulty understanding and internalizing abstract chemistry concepts. This finding is consistent with Ratnadilla et al., (2023), who stated that Macromedia Flash animations increase student interest, attention, and motivation. Furthermore, research conducted by Nurdin (2021) indicates that the use of Macromedia Flash-based animation media can improve student learning outcomes. The high level of activity in the experimental class directly reflects the effectiveness of the Discovery Learning steps and the support of animation media. When students are given the freedom to explore information with clear visual guidance, they tend to be more actively involved in the thinking process and discussions. This also impacts learning outcomes and the overall achievement of learning objectives (LO).

Based on the achievement scores for individual learning objectives at MA Manongkoki, the experimental group included 23 students with achieved learning outcomes and 5 students with unachieved learning outcomes. The control group included 16 students with achieved learning outcomes and 9 students with unachieved learning outcomes. The achievement of individual learning objectives can be seen in Table 3.

Table 3. Achievement of individual learning objectives

Group	Frequency Achieved	Frequency Not Achieved
Experiment	23	5
Control	16	9

Similar to the observation results, the Learning Objectives (LO) or Achievement of Learning Objectives data also showed better results in the experimental class. Of the 28 students, 23 (82.14%) achieved individual mastery, while in the control class, only 16 of 25 students (64%) did so. Overall, the experimental class achieved 7 of the 9 LOs, while the control class achieved only 4. This success demonstrates that Discovery Learning steps can be optimally implemented when supported by media that represents the material. Wijayanti et al., (2023) explain that interactive animation media can improve student concept retention, particularly in abstract chemistry material. Ozmen (2007) also stated that difficulties in understanding chemical bonds often arise due to limited visualization in conventional learning.

However, two LOs were not achieved in the experimental class: LO 4 (physical characteristics of ionic compounds) and LO 8 (compound polarity). This failure was due to the limitations of the media used, which did not explain in detail the differences in the characteristics of ionic, polar covalent, and metallic compounds and did not include visual illustrations of electronegativity in Macromedia Flash. As a result, students experienced difficulties during the discussion stage, and the incomplete information in the media made it difficult for

them to draw accurate conclusions. Ulfa & Saputra (2019) emphasized that media effectiveness depends on the comprehensiveness of its content and that media must be designed according to learning objectives. Kasman et al. (2023) also added that learning media needs to be adapted to the complexity of the material to optimally support active learning.

A similar situation occurred in the control class, which failed to achieve five of the nine learning objectives. Students in this class struggled to understand the process of covalent bond formation, Lewis structures, and metallic bonding. Furthermore, Learning Objective 4, which deals with the physical characteristics of ionic compounds, falls into the C5 category, which demands higher-order thinking skills. To answer these questions, students must truly understand the concepts in depth, not simply memorize them. Meanwhile, LO 8, which explains the polarity of a compound, is also included in the LO that does not meet the competency standards. This is because students do not understand the prerequisite material, namely electronegativity. Students do not yet understand which elements have higher electronegativity values, so they make mistakes in determining an element's tendency to attract electrons. As a result, many students answered incorrectly on questions related to compound polarity. This weakness can be attributed to the learning media used in the control class, which was only a textbook without visual support. The absence of visual elements makes it difficult for students to visualize abstract concepts, so their thinking processes and conceptual understanding do not develop optimally. This indicates that the Discovery Learning model is less effective if it is not supported by representative media. Nurdin (2021) emphasized that in learning abstract concepts such as chemical bonds, visual media not only supports understanding but also strengthens students' memory. Azriah (2018) also stated that Macromedia Flash-based media can improve memory and learning interest because it presents information in a strong visual format. Research conducted by Muhammad (2012) also stated that Macromedia Flash can improve students' memory of abstract things.

Inferential statistical analysis was then used to test the research hypotheses. Hypothesis testing began with prerequisite tests, namely normality and homogeneity tests. The results of the learning outcomes test showed that the data for the experimental and control groups were not normally distributed, and both groups had non-homogeneous variances. After conducting the prerequisite tests, the hypothesis was tested. Hypothesis testing could not be performed using a parametric test (t-test), so a non-parametric statistical test (Mann-Whitney test) was used. The results of the hypothesis testing on learning outcomes yielded a calculated Z value of 3.11 and a Z value of 1.65 at a 0.05 confidence level. Because $Z_{\text{value}} > Z_{\text{table}}$, H_1 is accepted and H_0 is rejected. Based on these results, it is clear that Macromedia Flash-based animation media in the Discovery Learning model has an effect on the learning outcomes of 11th grade MIPA students at MA Manangkoki, Takalar Regency, on the topic of chemical bonds.

Based on the research results, the experimental class demonstrated higher average posttest scores, student learning activities, and achievement of learning objectives compared to the control class. Thus, it can be concluded that the use of Macromedia Flash-based animation media in the Discovery Learning model can improve the learning outcomes of class XI MIPA students at MA Manangkoki, Takalar Regency, on the subject of chemical bonds. This is in line with research by Ulfa & Saputra (2019), who stated that the use of animation media in learning is strongly influenced by the suitability of the learning approach used, especially those that emphasize independent knowledge construction, such as discovery learning. In

addition, research conducted by Aditiay & Pratiwi (2021) stated that Macromedia Flash animation can improve student learning outcomes. Support for the effectiveness of Macromedia Flash animation media is also strengthened by the results of research by Setiadi (2018), which showed a significant increase in students' cognitive, affective, and psychomotor learning outcomes in learning buffer solution chemistry. In addition, Asmawati & Dalming (2019) also proved that Flash animation media that is systematically designed and adapted to students' needs is able to visualize abstract material effectively and increase learning motivation. Sharfina, et al. (2021) also stated that the application of a learning model using Macromedia Flash animation media can improve student learning outcomes, with a cycle I completion percentage categorized as very poor (40%) and a cycle II completion percentage categorized as good (85%).

CONCLUSION

Based on the results of data analysis and discussion, it was concluded that there is an influence of Macromedia Flash-based animation media in the discovery learning model on the learning outcomes of class XI MIPA students of MA Manongkoki, Takalar Regency, on the main material of chemical bonds. Therefore, Macromedia Flash-based animation media can be used in the Discovery Learning model to improve student learning outcomes.

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