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The effectiveness of Wordwall and Macromedia Flash on Problem-Based Student Learning Outcomes on Acids-Bases

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Abstract: *Quality education requires a learning system that can develop the potential of students, one of which is through the development of effective learning media and models. However, in practice, learning media are often not used, learning models are monotonous, students' problem-solving abilities are low, and student activities are passive, resulting in low learning outcomes, especially in acid-base material. This study aims to determine the significant differences in learning outcomes between students using Wordwall and Macromedia Flash problem-based media on acid-base material in grade XI, as well as to assess the effectiveness of both media. The research method employed purposive sampling with a Two Group Pretest-Posttest design. Data were collected through cognitive learning achievement tests and analyzed using the Kolmogorov-Smirnov normality test, Levene's test for homogeneity, two-tailed t-test, two-way ANOVA, and N-Gain test with SPSS 26.0. The results of the study indicate that the learning outcomes of students using the Macromedia Flash media with the problem-based learning model were higher than those using the Wordwall media on acid-base material.*

Keywords: *wordwall; macromedia flas ; acid-base; problem based learning*

INTRODUCTION

Quality education plays a crucial role in shaping students' future by optimizing their potential. To achieve this, an effective learning system must be implemented one that is capable of developing students' abilities through innovative strategies. A key determinant of learning success lies in the teacher's capacity to design and utilize appropriate media and learning models that enhance both student learning outcomes and engagement. The main problem in learning in formal education (schools) is the low absorption rate of students. In a more substantial sense, the learning process to date still gives dominance to teachers (teacher centered) and does not provide access for students to develop independently through discovery in their thinking process (Sianturi & Panggabean, 2019)

However, in actual classroom practice, learning media are often underutilized, teaching models remain monotonous, students show limited problem-solving ability, and learning tends to be passive. These conditions contribute to the persistently low student learning outcomes, particularly in complex topics such as acid-base chemistry (Napitupuluh et

al., 2021). As (Suarsani, 2019) highlights, chemistry remains one of the most challenging subjects for high school students. The acid-base topic, in particular, presents difficulty due to its conceptual nature partially abstract, yet not fully observable. Supporting this, (Wicaksono, 2016) found that only 31.6% of students were able to correctly identify acid-base pairs based on Bronsted-Lowry theory, reflecting widespread conceptual misunderstanding. Preliminary observations at SMA Negeri 2 Medan also revealed low learning outcomes in this topic. Interviews with chemistry teachers further confirmed that students struggle to grasp the abstract concepts of acids and bases. Moreover, conventional teaching methods still dominate primarily lectures, Q&A sessions, and assignments without the integration of learning media or innovative models. This leads to minimal student engagement and reduced motivation.

To address this issue, the integration of technology-based learning media is essential. Innovative learning distinct from traditional methods can offer engaging and effective ways of presenting material. One such tool is the Wordwall application, an interactive media platform that supports learning through various game-based activities such as quizzes, matching, and word searches (Agusti & Aslam, 2022).

Its competitive features, such as leaderboard rankings, can stimulate student motivation and positively impact learning outcomes. Wordwall has been widely adopted in countries with advanced education systems like the UK and the US (Maghfiroh, 2018), yet its use in Indonesian classrooms remains limited.

In addition to Wordwall, Macromedia Flash represents another innovative medium. It provides animated visual representations of learning content, helping to simplify complex chemistry concepts. Research by (Nurdin, 2021) demonstrated its effectiveness in enhancing student outcomes in reaction rate material. Given the visual and interactive strengths of Flash, it is assumed to have potential benefits when applied to acid-base learning.

However, media alone are insufficient without an appropriate pedagogical approach. The Problem-Based Learning (PBL) model is a suitable framework that aligns well with these media. As outlined by (Suswati, 2021), PBL promotes active, meaningful learning by engaging students in solving real-world problems, fostering critical thinking, intrinsic motivation, and collaborative skills. It transforms the learning environment from teacher-centered to student-centered, encouraging learners to apply scientific reasoning and take responsibility for their own progress.

The advantages of PBL include: (1) challenging students intellectually, (2) increasing classroom engagement, (3) enhancing knowledge transfer to real contexts, (4) promoting the acquisition of new concepts, (5) fostering self-directed learning, and (6) improving student satisfaction (Suswati, 2021).

Based on the description, it can be concluded that media innovation and learning models are needed that can improve student learning outcomes, especially in acid-base material. Although Wordwall and Macromedia Flash have been used in various studies, research comparing the effectiveness of both in the context of problem-based learning (PBL) on acid-base material is still very limited. Therefore, this study was conducted to answer this problem. Therefore, this study aims to test whether there is a significant difference in student learning outcomes between the use of problem-based Wordwall media and Macromedia Flash, and to analyze the effectiveness of both media in improving learning outcomes on acid-base material in Class XI.

LITERATURE REVIEW

Learning Outcomes

Learning outcomes are the skills that children acquire after completing a learning activity. According to him, children who are successful in learning are able to achieve their learning objectives or teaching objectives (Yandi et al., 2023).

Learning in education is viewed as a conscious and deliberate effort that is well designed to achieve educational goals. In a learning process, students should be encouraged to develop their thinking skills (Siregar et al., 2019).

According to (Nabillah & Abadi, 2019), learning outcomes are the skills that students acquire after a learning experience. The diversity of experiences gained by students includes cognitive, affective, and psychomotor domains. Learning outcomes play an important role in the learning process because they provide teachers with information about students' progress toward learning objectives in subsequent teaching and learning activities.

Problem-Based Learning Model

One learning model that is related to student activity and critical thinking is the Problem-Based Learning (PBL) model (Roza & Damanik, 2022).

Problem-Based Learning (PBL) is a learning model that encourages students to think critically about problems that arise during the learning process and enables them to solve these problems either in groups or individually (Dalimunthe & Ginting, 2022).

According to (Putri & Azhar, 2023), the problem-based learning (PBL) model uses cognitive and constructivist theories to build on what students already know, the skills they have acquired previously, and the knowledge they have gained to solve problems they encounter later on. The problem-based learning (PBL) model is a learning model that builds on students' existing knowledge and skills with new information used in problem-solving efforts.

Wordwall

Wordwall is a game-like application that allows students to complete quizzes, discussions, and surveys. Students who participate in this game do not need a new account; they can access it directly from a web browser (www.wordwall.net) and download the application from the Playstore, which is available on smartphones (Marensi et al., 2023).

Wordwall is a digital gamification-based application with a variety of game and quiz features that educators can use to create learning assessments. This application is suitable for educators and can be used to create learning assessment methods. In addition, this game can be played offline with a printable feature (Surahmawan et al., 2021).

According to(Frada et al., 2024), Wordwall in PBL increases students' motivation and learning outcomes significantly.

Macromedia Flash

Macromedia Flash is computer software that can create attractive and dynamic animations and designs, making it an interactive learning medium. The advantages of Macromedia Flash lie in its animation features and its ability to be presented interactively, which can increase students' interest in learning (Ningsih & Pulungan, 2024).

Based on other sources, (Nainggolan & Mutiah, 2020) Macromedia Flash learning media is a means to improve teaching and learning activities, support the teaching and learning process, help clarify the meaning of the message conveyed, and help achieve learning objectives successfully, correctly, and thoroughly.

Based on the findings (Dhani & Nugraha, 2022), it is said that animation-based Macromedia Flash learning media is

effective in improving students' understanding of chemistry and creativity.

Based on the results of research and discussion (Nurdin, 2021), the use of Macromedia Flash 8-based learning media in the learning model has a direct impact on the learning outcomes of 10th grade students at SMKN Tapango in the main subject of reaction rate. This is due to Macromedia Flash's ability as an interactive program with animated presentations, making it easier for students to visualize and understand complex concepts. Specifically, chemistry learning using Macromedia Flash enhances students' creativity more than direct learning models.

Acid-Base

Acid-base material is inherently challenging for students to comprehend. The macroscopic representation of acids and bases is often conceptualized as follows: acids are substances that taste sour, while bases are substances that taste bitter (Zuhroti et al., 2018).

The concept of acids and bases has been developed for a long time by several chemists: Arrhenius theory, Bronsted-Lowry theory, Bronsted-Lowry theory. Arrhenius theory states that "In an aqueous medium, an acid is a substance that produces hydrogen ions, H^+, and a base is a substance that produces hydroxide ions, OH^-". Arrhenius distinguishes between strong acids and weak bases. Strong acids are completely ionized into H^+ ions, while strong bases are completely dissociated into OH^- ions. The limitation of this theory is that it only applies to reactions in water and cannot explain the production of H^+ ions due to the ionization of weak bases.

Hypothesis is a temporary answer to the research formulation that needs to be tested for truth through analysis. Based on the background, theories that support the theoretical framework, the hypothesis in this study is as follows:

1. Hypothesis 1

Ha_1: There is a significant difference in student learning outcomes between students who are taught with problem-based Wordwall learning media and problem-based Macromedia Flash learning media on Acid-Base material in class XI.

Ho_1: There is no significant difference in student learning outcomes between students who are taught with problem-based Wordwall learning media and problem-based Macromedia Flash learning media on acid-base material in class XI.

2. Hypothesis 2

Ha_2: There is effectiveness in using problem-based Wordwall learning media on acid-base material on student learning outcomes in class XI.

Ho_2: There is no effectiveness in using problem-based Wordwall learning media on acid-base material on student learning outcomes in class XI.

3. Hypothesis 3

Ha_3: There is effectiveness in using problem-based Macromedia Flash learning media on acid-base material on student learning outcomes in class XI.

Ho_3: There is no effectiveness in using problem-based Macromedia Flash learning media on acid-base material on student learning outcomes in class XI.

METHODS

Quantitative research type. The research location is at SMA Negeri 2 Medan, Jl. Karang Sari No. 435, Sari Rejo, Kec. Medan Polonia, Kota Medan, North Sumatra 20157. The research was conducted starting in April 2025. The population for this study consists of all Grade XI students at State Senior High School 2 Medan for the 2024-2025 academic year, comprising 5 classes. The sample used in this study employs purposive sampling. The sample was selected by taking only 2 classes that both had low average learning outcomes. The research

sample was class XI as experiment class I, which was taught using the Wordwall problem-based learning media, and class XI as experiment class II, which was taught using the Macromedia Flash problem-based learning media.

The research design used by the researcher was the Two Group Pretest-Posttest Design (Silitonga, 2011). This study used a quasi-experimental design with the Two Group Pretest-Posttest Design type. In this design, there are two experimental groups. Both groups were given an initial test (pretest) to determine the students' initial abilities, then given different treatments, and after that given a final test (posttest) to determine the improvement in learning outcomes. Experimental Group I used Wordwall media and Experimental Group II used Macromedia Flash combined with the same learning model, namely the problem-based learning model

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experiment I	T_1	X_1	T_2
Experiment II	T_1	X_2	T_2

Information:
X_1 : Learning using problem-based Wordwall learning media on acid-base material.
X_2 : Learning using problem-based Macromedia Flash learning media on acid and base material.
T_1 : Pretest was given to experimental class I before treatment.
T_1 : Pretest was given to experimental class II before treatment.
T_2 : Posttest given to experimental class I after treatment.
T_2 : Posttest given to experimental class IIafter treatment.

Data analysis in this study was conducted to determine the results of the study using statistical analysis, in this study the normality test was carried out with the Kolmagrov-Simnov test. Data is said to be normally distributed if sig> α (0.05) and vice versa if the sig price <α (0.05) then the data is not normal, the homogeneity test was carried out with the Levene's test with a sig value of 0.05. If the sig value> α (0.05) then the data obtained is homogeneous and if the sig value sig <α (0.05) then the data obtained is not homogeneous, the hypothesis test carried out was a two-way t-test (dependent sample t-test) with two-way ANOVA significance level α = 0.05 when the sig result <α (0.05) is obtained then Ha is accepted and H0 is rejected if otherwise, the N-Gain test was carried out to provide an overview of changes in learning outcomes between before and after learning statistical data analysis was carried out with the help of SPSS 26.0 for windows.

In this part, research sampleneed to be clearly explained in this section. It is also necessary to write down techniques for obtaining subjects (qualitative research) and/or sampling techniques (quantitative research).Procedure should be described according to the type of research. How research is carried out and data obtained, needs to be described in this section.For experimental research, the type of design (experimental design) used should be written in this section. Types of data, how data is collected, with instruments where data is collected, and how technical the collection is, should be explained clearly in this section. Then, how to interpret the data obtained, in relation to problems and research objectives, needs to be explained clearly.

To find out the effectiveness of media use on learning outcomes in the cognitive domain, it can be seen through the table of average N-Gain effectiveness categories in percentage form. The average effectiveness categories are in table 2 below:

Table 2. Average Effectiveness Category

Average N-Gain (%)	Category
<40	Ineffective
40-55	Less Effective
56-75	Quite Effective
>76	Effective

***Source**:* (Hake, 1999)

RESULT AND DISCUSSION

Before the samples were given treatment, a pretest was administered to determine the students' initial abilities. After the treatment was administered to each experimental class, a posttest was given to determine the students' learning outcomes. The cognitive learning outcomes from the two different learning media are the results of this study. Students' cognitive learning outcomes were measured using a multiple-choice test instrument. The pretest was administered before learning began, and the posttest was administered after learning. The subsequent analysis of cognitive learning outcomes is summarized in the following table 3.

Table 3. Data concerning the cognitive learning outcomes of students

Group	Data	Class	
		Experiment I	Experiment II
Low	Pretest	40.8±13.04	43.44±11.51
	Posttest	71.8 ± 4.05	77.19±3.64
High	Pretest	43 ± 16.19	43.68±9.70
	Posttest	81.5 ± 2.42	86.58±2.91

The objective of this analysis was to ascertain the efficacy of the learning media employed. As demonstrated in Table 2, which presents the learning outcomes data for the low and high groups, the low group obtained a lower pretest score for experimental class I than for experimental class II, with an average of 40.8 ± 13.04 < 43.44 ± 11. 51. In the high-performing group, the pretest scores for Experiment Class I were lower than those for Experiment Class II, with an average of 43.00 ± 16.19 < 43.68 ± 9.70. Conversely, the posttest scores for the low-performing group in Experiment Class I were lower than those for Experiment Class II, with an average of 71.8 ± 4.05 < 77.19 ± 3.64. In the high group, the posttest score of the low-performing class in the first experimental group was lower than that of the high-performing class in the second experimental group, with an average of 81.5 ± 2.42 < 86.58 ± 2.91. Therefore, it can be concluded that the low-ability group in the second experimental class demonstrated higher pretest scores than the first experimental class, and the posttest results indicated that in both groups—the low-ability and high-ability groups—the second experimental class achieved higher scores than the first experimental class.

Normality Test

Table 4. Normality Test

		Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Result	*Pretest* experiment 1	0.121	35	0.200
	Posttest experiment 1	0.187	35	0.063
	Pretest experiment 2	0.217	35	0.082
	Posttest experiment 2	0.225	35	0.093

A normality test was conducted to determine whether the data obtained was normally distributed or not. The normality test in this study used the Kolmogorov-Smirnov test with a significance level of 0.05 using SPSS 26. If the significance value was > 0.05, the data was normally distributed, and if the significance value was < 0.05, the data was not normally distributed. Based on Table 4.5, the data obtained in the pretest of Experiment I yielded a significance value of 0.200 > 0.05, indicating that the data is normally distributed. The posttest of Experiment I yielded a significance value of 0.063 > 0.05, indicating that the data is normally distributed. the pretest of Experiment II yielded a significance value of 0.082 > 0.05, indicating that the data is normally distributed, and the posttest of Experiment II yielded a significance value of 0.093 > 0.05, indicating that the data is normally distributed.

Homogeneity Test

Table 5. Homogeneity Test

			Description
		Sig.	
Outcame Learning	Mean	0.140	Homogeneous
	Median	0.066	Homogeneous

Based on the table above, the obtained significance value is 0.140 > α = (0.05), indicating that the learning outcomes of experimental class I and experimental class

II are homogeneous, or in other words, the data is normally distributed

Hypothesis Testing

Table 6. Hypothesis Test 1

	Sig.	t	Description
Outcame Learning	0.002	-19.285	Significant

The hypothesis testing was conducted using two-way ANOVA with SPSS 26.0 for Windows with a significance level of α=0.05. When the result was sig < α (0.05), H_a was accepted and H_0 was rejected; otherwise, the opposite was true. Based on the statistical test results, a significance value (sig) of 0.002 < significance 0.05 was obtained. This means that there is a very clear or significant difference between the learning outcomes of students who use Wordwall problem-based learning media and students who use Macromedia Flash problem-based learning media.

Table 7. Hypothesis Test 2

	Mean	Std.Deviation	Description
N-Gain Score	0.54	0.12013	H_0 is accepted.
N-Gain Percent	54.84	12.01258	

Hypothesis 2 was tested using the N-Gain test in SPSS 26.0 for Windows with the pretest and posttest scores of the experimental class. According to the table above, the N-Gain score was 0.54, and the N-Gain percentage was 54%. According to the N-Gain Score effectiveness criteria, which fall into the "insufficient" category, H_0 is accepted.

Table 8. Hypothesis Test 3

	Mean	Std.Deviation	Description
N-Gain Score	0.68	0.10665	H_a is accepted.
N-Gain Percent	68.16	10.66515	

The third hypothesis was evaluated using the N-Gain test in SPSS 26.0 for Windows, employing the pretest and posttest scores of students in the experimental class II. As illustrated in the above table, the N-Gain Score was 0.68, and the N-Gain percentage was 68%. According to the established effectiveness criteria, the N-Gain Score is classified as moderately effective, thereby supporting the conclusion that H_a is accepted.

The results showed that the use of Wordwall and Macromedia Flash learning media combined with the Problem-Based Learning model had a different impact on student learning outcomes on acid-base materials. Both experimental classes experienced an increase in learning outcomes, but a more significant increase was seen in the class that used Macromedia Flash media. This is in line with the opinion of (Nurdin, 2021) and (Nainggolan & Mutiah, 2020) who state that Macromedia Flash, with its visual display and interactive animation, can help students understand abstract chemical material. In contrast, Wordwall as a game-based media provides a fun learning experience and increases student engagement (Marensi et al., 2023), but its effectiveness in improving cognitive learning outcomes is still limited.

Based on the N-Gain calculation, Wordwall showed less effectiveness (54.85%), while Macromedia Flash was quite effective (68.16%). This finding reinforces the view that the selection of learning media must be adjusted to the characteristics of the material. In this case, acid-base materials that require more complex visual representations are more suitable to be delivered through media such as Macromedia Flash.

From the analysis based on students' initial ability, it was found that high ability students benefited more from using Macromedia Flash than Wordwall. The low standard deviation of the posttest in the high group showed that the achievement of learning outcomes in the Macromedia Flash class was more evenly distributed, indicating the success of this media in reaching various levels of students' academic abilities.

Overall, these findings support previous literature regarding the effectiveness of problem-based learning models in improving learning outcomes (Putri & Azhar, 2023) as well as the

importance of integrating technology-based interactive learning media in supporting students' conceptual understanding (Yandi et al., 2023); (Surahmawan et al., 2021).

Based on other findings (Juniar & Barus, 2020), Macromedia Flash strengthens students' cognitive and psychomotor aspects in understanding acids and bases.

Thus, it can be concluded that problem-based Macromedia Flash media is more effective than Wordwall in improving student learning outcomes on acid-base materials.

CONCLUSION

The findings of the research indicate that students who are taught using Macromedia Flash media with a problem-based learning model demonstrate higher learning outcomes in comparison to students who are taught using Wordwall media with a problem-based learning model. This observation is supported by the results of the cognitive domain learning analysis with grouping or hypothesis testing. The final learning outcomes of students (posttest) who utilized Macromedia Flash-based problem-solving media were 82.28, while those who employed Wordwall-based problem-solving media attained a final learning outcome of 74.57.

The results of this study indicate that the use of Wordwall and Macromedia Flash problem-based media significantly affects students' learning outcomes in acid-base material. This finding contributes to the development of science in the field of chemistry education, especially in the use of technology-based interactive media combined with problem-based learning models. This study also strengthens the theory that learning that integrates technology and problem-based approaches can increase students' cognitive engagement and learning motivation in abstract chemistry topics. Thus, these results can be used as a basis for the development of more effective chemistry learning strategies in the future, as well as expanding comparative studies between media in the context of active learning.

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