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The Effectiveness of Problem-Based Flipped Classroom Model in Improving Chemistry Learning Outcomes of Buffer Solution

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Abstract
The concept of buffer solutions is ubiquitous in everyday life, encompassing macroscopic, symbolic, and microscopic representations. Effective learning of these concepts requires students to understand the subject matter, analyze it, and apply their knowledge to real-life situations. This study aimed to assess the impact of problem-based learning in a flipped classroom model on the learning outcomes of 11th-grade science students studying buffer solutions at SMAN 12 Pekanbaru. The study employed a quasi-experimental design with a pretest-posttest control group. The sample consisted of two groups of 11th-grade science students: Group 3 served as the experimental group and Group 4 as the control group. Data was collected through a test and analyzed using t-test in SPSS 22. The results revealed that the problem-based learning approach in the flipped classroom model effectively improved the learning outcomes of 11th-grade science students studying buffer solutions at SMAN 12 Pekanbaru. The experimental group showed an average improvement of 7.394 over the control group, with a significant (α) t-value of 0.013.

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INTRODUCTION

The study of education is crucial in advancing and improving human resources and is a crucial factor in the development of a nation (Indriastuti et al., 2017). In high school chemistry lessons, students learn about the arrangement, structure, properties, changes in matter, and the accompanying energy changes (M. Purba & Sunardi, 2012). The buffer solution is a topic taught to 11th-grade students, requiring not only rote memorization but also understanding and analysis of calculations (Hariani, W., Laliyo, L. A. R., & Musa, 2016). To comprehend the buffer solution, students should have a fundamental understanding of the concepts of acid-base, equilibrium, and salt hydrolysis (Hariani, W., Laliyo, L. A. R., & Musa, 2016).

Interesting and varied learning experiences can enhance students' understanding of concepts and improve learning outcomes (Armiati & Pahriah, 2015). The choice of appropriate teaching methods can facilitate effective learning (Ario & Asra, 2018; Pahriah & Khery, 2017). Utilization of technology in education, such as access to online resources and video technology, can change students' learning experiences by promoting independence (Khery et al., 2020; Khumairah et al., 2020). In the flipped classroom model, teachers provide learning videos before the classroom session, encouraging students to learn actively and independently and affecting learning outcomes (Erlinda, 2019).

The flipped classroom model can improve student outcomes in subjects such as the periodic properties of elements (Kurniasih, 2017) and align with student-centered learning as per the

2013 curriculum (Rizkivany & Mawardi, 2021). Students are tasked with mastering the subject matter before entering the classroom by watching digital videos designed by the teacher (Erlinda, 2019). The flipped classroom approach can also overcome time constraints and improve student readiness for learning (Paristiowati et al., 2020). The problem-based learning approach in a flipped classroom setting includes activities in reverse classrooms with the use of technology and support for authentic learning (Andrini et al., 2019; Dhawo, 2019; Mudhofir, 2021).

This learning approach is student-centered, allowing students to learn at their pace and in their preferred style (Hwang & Chen, 2019). It also enhances students' ability to solve contextual problems and promotes technological literacy (Andrini et al., 2019). The problem-based learning approach in a flipped classroom consists of two stages: the pre-class stage of exploration and the in-class stage of elaboration, confirmation, and evaluation (Steele, 2013). In this model, students attain the cognitive realm of remembering and understanding before entering the classroom and the cognitive realm of applying, analyzing, and evaluating during the in-class stage (Utami, 2017).

The implementation of the flipped classroom model can provide students with opportunities to improve their learning outcomes and independence in learning while reducing their dependence on teachers (Hidayah & Mustadi, 2021). This study aims to determine the improvement in chemistry learning outcomes in the buffer solution subject for 11th-grade students at State Senior High School (SMAN) 12 Pekanbaru through the problem-based learning type of flipped classroom model.

METHOD

The present study is a quasi-experimental design utilizing a pretest-posttest control group design. Participants were divided into two groups: an experimental group consisting of 33 11th-grade science 3 students, and a control group consisting of 33 11th-grade science 4 students. The study was conducted at SMAN 12 Pekanbaru located at Jl. Garuda Sakti Km 3 Bina Widya Village, Bina Widya District in the period of March to April 2022. Table 1 presents the results of the pretest-posttest control group design.

Table 1. Research design

Group	Pretest	Treatment	Posttest
Eksperimental	T_0	X	T_1
Control	T_0	-	T_1

Note:

T_0 : Pretest results of experimental groupes and control groupes

X : Treatment of experimental groupes with the application of problem-based learning type of flipped classroom model

T_1 : posttest results of experimental groupes and control groupes

The research instruments were a pretest and a posttest, which were administered before and after the learning process, respectively. Data analysis involved three steps: normality testing using Shapiro-Wilk, homogeneity testing using Levene, and hypothesis testing using t-test. These analyses were performed using IBM SPSS Statistics 22.

RESULTS AND DISCUSSION

The pretest was conducted to assess the students' initial proficiency in buffer solution subject matter. The results of Shapiro Wilk's normality test, performed using SPSS 22, are presented in Table 2 for the pretest data of the experimental and control groups. The significance value of both the experimental group (0.098) and the control group (0.062) was found to be greater than 0.05, indicating that the data was distributed normally. Subsequently, a homogeneity test was performed, and the results, presented in Table 3, showed a significance value of 0.331 (greater than 0.05), indicating homogeneous data distribution.

Table 2. Shapiro-Wilk’s normality test through SPSS 22 for pretest data

Group	Shapiro Wilk		
	Statistics	**Df**	**Sig.**
Experimental	0,945	33	0,098
Control	0,945	33	0,062

Table 3. Levene’s homogeneity test through SPSS 22 for pretest data

Levene statistics	df1	df2	Sig.
0,959	1	64	0,331

The results of the Shapiro-Wilk's normality test for the pretest and posttest difference data are presented in Table 4. Both the experimental group (0.227) and the control group (0.338) showed a significance value greater than 0.05, indicating that the data was normally distributed. Table 5 shows the results of the independent sample t-test for the difference in posttest and pretest values of the experimental and control groups, performed using SPSS 22. The significance value of 0.013 (less than 0.05) suggests that the hypothesis that there is a difference in the chemistry learning outcomes between the experimental group using the problem-based learning type of flipped classroom model and the control group is accepted.

Tabel 4 Shapiro Wilk normality test through SPSS 22 for different pretest-posttest data

Group	Shapiro Wilk		
	Statistics	**Df**	**Sig.**
Experimental	0,958	33	0,227
Control	0,964	33	0,338

Table 5. Hypothesis test results

		t-test		
		df	**Sig. (2-tailed)**	**Mean difference**
Different of pretest-postest	Pooled variance	64	0,013	7,394
	Separated variance	63,245	0,013	7,394

The present study investigated the impact of the problem-based learning (PBL) type of flipped classroom model on student learning. This model involves pre-class learning outside the classroom, where students work individually on problems and buffer solution materials provided by the teacher through learning videos and textbooks (Mudhofir, 2021; Savanur et al., 2021). In the classroom, students engage in group discussions, present their results, and individually evaluate their learning through questions provided by the teacher (Mudhofir, 2021; Savanur et al., 2021).

The results showed that students in the experimental group spent more time in discussion compared to the control group. Additionally, students in the experimental group were more focused on answering and working on the problems due to their prior exposure to the learning materials through learning videos. In contrast, the learning process in the control group started with a teacher-led explanation of the learning materials, which resulted in the teacher having to guide the students more during group discussions. Furthermore, the problem-solving abilities of the experimental group were higher than those of the control group, aligning with previous findings that students who learn through the PBL flipped classroom model exhibit improved problem-solving skills compared to those in the traditional flipped classroom model (Arnata et al., 2020).

The pre-class learning stage in the experimental group allowed for the cognitive domains of remembering and understanding (C1 and C2 of Bloom's Taxonomy) to be covered before entering the classroom, while the cognitive domains of applying, analyzing, and evaluating (C3, C4, and C5 of Bloom's Taxonomy) were carried out in the classroom. Conversely, the control group only carried out the cognitive domains inside the classroom. This difference in learning treatment and motivation between the experimental and control groups led to higher learning achievement in the experimental group.

The increased student learning outcomes in the experimental group were attributed to their exposure to the learning materials through learning videos, which allowed for repeated viewing and a longer time for students to understand the learning materials. The flipped classroom learning model improved student learning outcomes, problem-solving skills, and student satisfaction, as reported in previous studies (Nhạc, 2021; Nouri, 2016; Susanti et al., 2018). Furthermore, the flipped classroom approach allowed for self-study, improved learning experiences, such as individual tasks and teamwork, and better preparation for in-class learning (S. E. E. Purba et al., 2021; Andrini et al., 2019; Nwosisi et al., 2016; Chis et al., 2018). In conclusion, the PBL type of flipped classroom model demonstrated superiority in enhancing student learning outcomes and problem-solving abilities compared to traditional learning models (Erita et al., 2021).

CONCLUSION

In conclusion, based on the results of data analysis and discussions, it can be established that the problem-based learning type flipped classroom learning model is effective in improving chemistry learning outcomes in the buffer solution lesson for 11th-grade students at SMAN 12 Pekanbaru. The hypothesis test results obtained from SPSS 22 showed a significant difference in the chemistry learning outcomes between the experimental group and the control group, with an average increase of 7.394 in the experimental group compared to the control group. The significance of this result is indicated by the low t-value of 0.013. This study highlights the potential of problem-based learning as a teaching method in improving student performance in chemistry and underscores the need for continued exploration and implementation of innovative teaching strategies in the classroom.

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