The Effect of Differentiated Learning with Think-Tac-Toe Strategy on Students' Learning Outcomes on the Topic of Buffer Solutions

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Abstract. The new curriculum in Indonesia known as Kurikulum Merdeka, emphasizes the importance of differentiated learning. This approach develops learning according to the needs of students who have a diversity of ability levels and different learning styles and interests. This study aims to determine the effect of a think-tac-toe strategy on students' learning outcomes on buffer solution topics. The design of this study was a posttest-only control group design. The sample was randomized using the cluster random sampling technique to be selected as the experimental and control groups. The sample consisted of 66 students from XI classes at SMAN 55 Jakarta. Students were given a VARK learning style questionnaire to identify their learning styles. Student learning outcomes were obtained from a buffer solution post-test of 20 multiple-choice. Post-test data of experimental and control groups were analyzed with the Mann-Whitney U test, which showed significant differences in learning outcomes (Sig = 0.001; <0.05). Similar results were also shown in the comparison by students of visual groups (P = 0.004; <0.05) and reading groups (P = 0.019; <0.05; d = 1.388) using the independent t-test. The students of auditory groups also showed significant differences analyzed by the Mann-Whitney U test (Sig = 0.004; < 0.05). Nevertheless, no significant difference was observed in the students of kinesthetic groups analyzed using the independent t-test (P = 0.08; > 0.05). These results indicate that the think-tac-toe learning strategy effectively improves student learning outcomes.

Keywords: Differentiated Instruction, think-tac-toe learning strategy, learning outcomes, buffer solution.

1 Introduction

The independent curriculum implemented in Indonesia admits the individual differences of students, It is structured to suit the potential, needs, skills, and interests of each individual, or known as individual learning [1]. Implementing individualized learning can be challenging when a class has many student characteristics. Therefore, a learning process that can accommodate individualized learning in a heterogeneous class is needed, it can be done through adaptive learning. [2]. Adaptive learning adjusts the learning process to the background needs of students. One approach that adapts learning to students' conditions is differentiated learning. Differentiated learning is an approach

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that customizes instruction to accommodate the diverse ability levels, learning styles, and interests of students. In a differentiated approach, there are three important elements, such as content, process, and product. By differentiating these three elements, educators can provide meaningful learning for students [3].

Based on the implementation of a Kurikulum Merdeka, which demands learning that adapts to the needs of students, differentiated learning should be implemented in all schools in Indonesia. The results of observations in class XI at SMAN 55 Jakarta show that chemistry learning has not implemented differentiated instruction, the learning process still uses a single method for all the students. Chemistry subjects in schools require differentiated learning to improve the quality of student learning. This is because chemistry is still seen as a difficult subject for students. One of the chemistry topics, buffer solution, contains fundamental scientific concepts involving the basic principles of others such as acid-base, equilibrium, chemical formulas, and stoichiometry. Therefore, students must comprehend both the concepts and mathematical calculations involved [4]. Concept understanding and mathematical calculation skills on the topic of buffer solutions are essential as a foundation for learning other advanced topics, so it requires an effective way of delivering this material to students is needed.

According to Research [5;6], student groups that use differentiated learning according to learning styles experience higher achievement growth and increased interest in learning. Structured learning adapted to students' needs can improve student understanding and ultimately improve learning outcomes. In implementing differentiated learning, you can use the think-tac-toe strategy. This learning approach is adapted from the tic-tac-toe game that provides students with flexible product and performance options according to students' learning preferences [7]. This helps broaden students' understanding of concepts and engages their sense of responsibility and interest [8]. Therefore, this think-tac-toe learning strategy is considered suitable for learning buffer solutions which have many basic chemical concepts integrated in and are still considered less interesting by students.

Based on these issues, this study was conducted to examine the impact of differentiated learning through the think-tac-toe learning strategy on student learning outcomes. The researcher's interest in this topic stems from the limited research that has been done on the use of the think-tac-toe strategy in teaching chemistry topics in Indonesia.

2 Method

2.1 Research Design

This study utilizes a quantitative approach to determine the effect of the independent variable on the dependent variable. The research method used is a true experiment method with a posttest-only control group design.

2.2 Participant

The population in this study was classes XI of SMAN 55 Jakarta receiving studied chemistry. Cluster random sampling was used to select samples, with Class XI-B chosen as the experimental group and Class XI-C as the control group. The research was conducted in April-May 2024 for five sessions.

2.3 Instrument and Data Collection

The data collection for this study utilized the VARK learning style questionnaire and Post-test of buffer solution. Both classes were given a VARK learning style questionnaire to identify their learning styles before the lesson starts. The learning outcomes of both groups were assessed using a buffer solution posttest which consisted of 20 multiple-choice questions that had been tested for validity, reliability, differentiability, and difficulty level to measure the students' cognitive abilities after learning buffer solution.

2.4 Data Analysis

Post-test results of both classes and each learning style group between classes were analyzed quantitatively using an independent t-test or Mann-Whitney U-test after conducting tests for normality and homogeneity.

3 Result

In both classes, students were given a learning style questionnaire to categorize them based on their learning styles. This was done to compare the learning outcomes between the two classes and to compare the learning outcomes of each learning style group within both classes.

Student learning style data was collected using a 16-item VARK questionnaire to determine the dominant student learning style. The results of the learning style analysis of the students in experimental and control groups are shown in Figure 1.

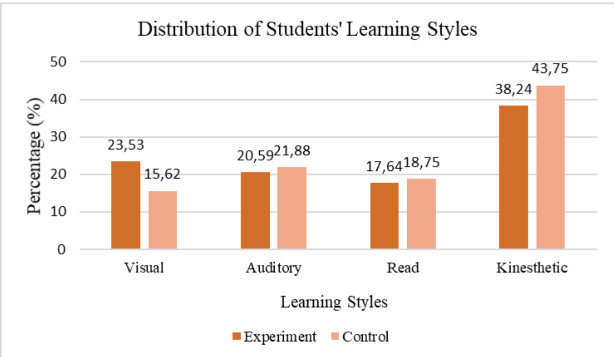

Fig. 1. Distribution of Students' Learning Styles in Experiment and Control Groups.

Data on student learning outcomes were measured using a buffer solution post-test consisting of 20 multiple-choice questions. The learning outcomes of students in the experimental and control groups are shown in Table 1.

Table 1. Post-test Result of Experimental and Control Groups.

Description Statistics	Sample Groups	
	Experiment	Control
Mean	61,01	44,84
SD	13,818	14,227
N	34	32

Based on the results of the parametric pre-requisite test on the post-test data of the experimental and control groups, it was shown that both data weren't normally distributed. Therefore, subsequent post-test analysis was conducted utilizing the Mann-Whitney U non-parametric test. The results of the Mann-Whitney U test on the post-test data of experimental and control students are presented in Table 2.

Table 2. Mann-Whitney U Test Results and Effect Size in Experimental and Control Groups.

Sample Group	N	Mean Rank	Sig	Effect Size (r)
Experiment	34	43,12	<0,001	0,521
Control	32	23,28		

The data analysis of the experimental and control groups showed a value smaller than the 0.05 significance level, indicating a significant difference in learning outcomes between the two groups. The experiment group that was treated with the think-tac-toe strategy had higher learning outcome scores. These results are also supported by measurements using effect size, which obtained a value of 0.52, which indicates the application of the think-tac-toe strategy has a strong effect on student learning outcomes in the experimental group.

The hypothesis test was also performed on each learning style group after normality and homogeneity tests to determine the difference in post-test scores from each learning style in experimental and control groups.

3.1 Visual Learning Style

The post-test data of visual students that were normally distributed and homogeneous were tested using independent sample t-test as shown in Table 3.

Table 3. Independent t-test Results and Effect Size in Visual Learning Style Groups.

Sample Groups	N	Mean	t-value	t-table	P value
Experiment	8	60	3,254	2,160	0,004
Control	5	33			

The results show that the visual students in the experimental group has higher learning outcomes with a significant difference in average scores from the visual students in the control group with the results of t-value > t-table (3.254 > 2.160). These results are also confirmed by the effect size measurement in the visual learning groups amounted to 1.855 which indicates that there is a high influence on the learning outcomes of visual students in the experimental group.

3.2 Auditory Learning Style

The learning outcomes data for the auditory group learning style in both groups were analyzed using the Mann-Whitney U test because the obtained data were not normally distributed. The results of the Mann-Whitney U test on the auditory learning group are shown in Table 4.

Table 4. Mann-Whitney U Test Results and Effect Size in Auditory Learning Style Groups.

Sample Groups	N	Mean Rank	Sig
Experiment	7	10,50	0,004
Control	7	4,50	

In Table 4, a p-value of 0.004 is smaller than the significant level of 0.05 so it is explained that there is a significant difference in learning outcomes for auditory students in both groups. These results are further supported by the effect size measurement, which obtained a value of 0.736, indicating a high effect on the learning outcomes of auditory students in the experimental group.

3.3 Read Learning Style

The post-test results on students with read learning styles were analyzed using an independent t-test after fulfilling the requirements of homogeneous and normally distributed data. The results of the independent t-test on the read learning styles of students are shown in Table 5.

Table 5. Independent t-test Results and Effect Size in Read-Learning Style Groups.

Sample Groups	N	Mean	t-value	t-table	*P*
Experiment	6	62,50	2,405	2,179	0,019
Control	6	42,50			

Table 5 shows that the significance value in the read-learning style groups is 0.019. This value is smaller than 0.05 and the value of t-value > t-table (2.405 > 2.179) indicates a significant difference in the post-test scores of the read-learning style groups. The effect size measurement for the read-learning groups is 1.388, these results indicate that there is a high effect on the difference in learning outcomes of read students in the experimental class.

3.4 Kinesthetic Learning Style

Post-test results of kinesthetic students in both groups were analyzed using an independent t-test, as shown in Table 6.

Table 6. Independent t-test Results and Effect Size in Kinesthetic Learning Style Groups.

Sample Groups	N	Mean	t-value	t-table	*P*
Experiment	13	59,23	1,445	2,052	0,08
Control	14	51,43			

In Table 6, the significance value obtained is greater than the significance level of 0.05 (P = 0.08). This result indicates that there is no difference in the average posttest scores of kinesthetic students in both groups.

4 Discussion

During the learning process of buffer solution in the control group, the students seemed less engaged during the group discussions. They were more focused on finding quick solutions, often by dividing tasks and copying answers from their friends, which didn't optimize the exchange of information within the group. In addition, most of the students in the control group had characteristics of a kinesthetic learning style, which was to do a trial-and-error process in answering the questions. According to Fleming, the trial-and-error learning process is one of the ways that people with kinesthetic learning styles use to process information [9]. This can be reflected in the average post-test results of kinesthetic students, which are better than those of other learning styles in the control group.

In the experiment group, kinesthetic students had the lowest average learning post-test results compared to other students. This is because kinesthetic students learning activities are more focused on social activities such as learning through games or games-based learning and simple experiments that emphasize teamwork. Time efficiency can also affect the learning outcomes of kinesthetic students because of the many activities they have to do, making the time used to process understanding shorter compared to other learning groups. This is different from learning activities carried out by visual, auditory, or read-learning style students, who can directly process information without going through activities first, thus making the understanding process longer. The difference in time used to process understanding in learning can affect students' learning outcomes, so students with less time to understand the material, such as kinesthetic students, have lower average post-test results.

The research results were obtained from the overall group of learning styles, aligning with previous research indicating a connection between learning styles and students' academic performance. It has been proven that matching instructional learning preferences with students' learning styles can develop students' abilities, resulting in higher final grades [9]. Additionally, in the experimental class, it was observed that students were more disciplined and active in following the learning process. Visual and read students in the experimental group appeared disciplined in following instructions to answer worksheets and were focused on solving problems individually. Auditory students seemed to follow the instructions on the worksheets and actively participated in small group discussions. On the other side, kinesthetic students appeared active and enthusiastic in carrying out the instructions for answering questions. According to a study conducted [11], using the think-tac-toe strategy is attractive to students and can increase their learning motivation. Furthermore, the think-tac-toe strategy gives students more responsibility and control over their learning, allowing them to actively participate directly in the learning process [12].

5 Conclusions

This study shows that there are differences in learning outcomes in the experimental group treated with differentiated learning with the think-tac-toe strategy based on learning style, which gives a higher average score of learning outcomes compared to the group of students who were not treated with the think-tac-toe strategy in the control group. It concludes that differentiated learning with the think-tac-toe strategy has a positive effect in improving student learning outcomes on the topic of buffer solution.

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