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THE EFFECT OF FLIPPED CLASSROOM AND METACOGNITIVE KNOWLEDGE TO IMPROVE LEARNING OUTCOMES: IN VOCATIONAL SCHOOLS

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Abstract— The flipped classroom is a learning approach that combines pre-class learning and in-class activities. The use of a flipped classroom challenges vocational school students to think quickly in problem-solving, especially during car service contests. The purpose of the study was to investigate the impact of the flipped classroom on the learning outcomes of car chassis maintenance. They used a 2x2 experimental method with a flipped classroom as the independent variable, metacognitive knowledge as the attribute variable, and learning outcomes of car chassis maintenance as the dependent variable. This finding makes a positive contribution to educators who are considering the adoption of problem-based learning in flipped classrooms. Further research is needed to explore this implementation at the student level and broader educational programs.
Index Terms— Flipped classroom, Metacognitive knowledge, Improves learning outcomes, Vocational School

INTRODUCTION

The flipped classroom model can be applied at various levels of education, including both elementary and secondary schools as well as colleges [1]. In the learning process, the flipped classroom model combines pre-class learning and in-class learning [2]. The flipped classroom is a form of blended learning that combines online learning with classroom learning [3]. The flipped classroom encourages students to be active participants during pre-class and in-class learning. [4]. The flipped classroom flips learning from school to home, where assignments are completed, allowing for maximum learning as student learning activities also increase. Students learn the material first outside of the classroom through digital teaching materials, such as videos, articles, or interactive modules. In the classroom, more time is spent on discussions, problem-solving, and other interactive activities to deepen students' understanding [5]. This approach allows students to learn at their own pace. In class, they can clarify complex concepts and apply their knowledge through various activities. A flipped classroom makes a significant contribution to learning [6]. Flipped classrooms are adopted for learning in college[7]. This teaching model is also effective for skill-based learning[8]. Trials in universities have also shown a positive influence on student learning [4]. The use of video is quite effective in flipped classrooms [9]. A flipped classroom can be described as a mixed-learning approach [10]. This learning can help overcome problems in group learning [11]. This model also allows for timely completion of tasks [12]. In flipped classrooms, students participate more actively in learning, making it a student-centered approach [13]. Pre-test delivery also contributes to students' group activity [14].

This study employs a quasi-experimental method with a 2 x 2 factorial treatment design at the second level. The variables of independent variables, namely (flipped classroom and direct instruction) and metacognitive knowledge attribute variables (high and low), as well as bound variables, namely student learning outcomes on Car Chassis Service Method material.

The results of the study showed: that the learning outcomes of how to service the car chassis of students who were taught using the flipped classroom (A1) learning model were higher than those of students who were taught using the direct instruction (A3) learning model; there is an influence of interaction between learning model (A) and metacognitive knowledge (B) in the subject of How to Service a Car Chassis; learning outcomes of how to service a car chassis Students who have high metacognitive knowledge (B_1) who are taught using the flipped classroom learning model (A1) are higher than students who are taught using the direct instruction (A3) learning model; learning outcomes How to Service Car Chassis Students who have metacognitive knowledge of low metacognitive knowledge (B2) there is no difference between those who learn using the STEM learning model (A2) and students who learn using the direct instruction learning model (A3).

This study investigates the impact of learning models and metacognitive knowledge on the learning outcomes of Car Chassis Service Methods for grade XI vocational school students. There were four hypotheses tested, three of which were tested, and one was put forward without being tested. This research was conducted effectively and guided by an experimental research methodology; however, there may be limitations to its practical application. The first limitation of research is that it cannot be generalized to hierarchical material. The attribute variables in this study were limited to the metacognitive knowledge possessed by the students only. The researcher used the

provisions of 27% of the high group and 27% of the low group based on their metacognitive knowledge. The number of samples obtained was nine students with high metacognitive knowledge and nine students with low metacognitive understanding. The sampling technique was applied equally to both the control and experimental classes.

METHOD

Time and Place of Research

This research was conducted in the odd semester of the 2024/2025 academic year, from July to December 2024, following the subject schedule, with a focus on the competence of Light Vehicle Engineering expertise at SMKN 1 Bekasi City. The choice of this research location is due to the fact that there are only two Light Vehicle Engineering (TKR) classes at the XI level, and almost all students have mobile phones for their activities, allowing them to participate in learning as required by the research.

Research Methods

This study uses a quasi-experiment with free variables, and the bound variable is learning outcomes. The free variable is flipped classroom, which is applied to class XI TKR A and direct instruction in class XI TKR C.

Population and research sample

The study population consists of grade XI (eleven) vocational school students for the 2024/2025 school year at a Vocational High School with a concentration in Light Vehicle Engineering in Bekasi City. The target population consists of all students who have been declared to have advanced to Class XI (eleven) of the Light Vehicle Engineering Expertise Concentration at SMKN 1 Bekasi City, Jl. Bintara VIII No. 2 Bintara, West Bekasi, Bekasi City 17134 as many as 68 students.

The sample in this study went through the sample selection stages, including the following: 1) Determining the treatment class, namely choosing a class that uses flipped classrooms and direct instruction using random sampling techniques [15]]. The classes selected for the random sampling technique are Class XI TKR A, with 34 students using STEM; Class XI TKR B, with 34 students using a flipped classroom; and Class XI TKR C, which uses direct instruction. 2) Conducting a metacognitive knowledge test for classes XI TKR A, XI TKR B, XI TKR C to determine the group of students who have high metacognitive knowledge scores and low metacognitive knowledge; 3) Selecting as many as 27% of the number of students who have a high metacognitive knowledge score and the number of students who have a low metacognitive knowledge score in each class [16]]. This article will report on the use of flipped classrooms and direct instruction in STEM, as discussed in the following article.

Table 1 Subject Grouping in Research Design

Class	Number of Samples
A_1B_1	9
A_1B_2	9
A_2B_1	9
A_2B_2	9
Sum	36

Treatment Plan

This experimental research activity aims to provide treatment to students participating in the learning of how to Service a Car Chassis, starting with a metacognitive knowledge test to collect data on the metacognitive knowledge held by students. Students with high and low metacognitive knowledge scores are divided into two classes: two experimental classes (A1) and a control class (A_3). The experimental class is divided into four groups, namely A_1B_1, A_1B_2, A_3B_1, and A_3B_2. In class, A_1B_1 Students have high metacognitive knowledge of learning with the Flipped Classroom, while A1B2 Students have low metacognitive expertise of understanding with the Flipped Classroom. The control class is also divided into two groups: A3B1 students possess high metacognitive knowledge and learn through direct instruction, while A3B2 students have low metacognitive understanding and learn through direct instruction. Keempet, this group was given material on how to service the car chassis.

Table 2 **Design Treatment by Level 2 X 2**

Treatment Variables Variable Moderator	(A)		
	Flipped classroom (A_1)		Direct Instruction (A_3)
Metacognitive knowledge (B)	A_1B_1		

Treatment Variables Variable Moderator		(A) Flipped classroom (A_1)		Direct Instruction (A_3)
	High (B_1)	X_{11k} k = 1, 2, … n_{11}		A_3B_1 X_{11k} k = 1, 2, … n_{11}
	Low (B_2)	A_1B_2 X_{11k} k = 1, 2, … n_{11}		A_3B_2 X_{11k} k = 1, 2, … n_{11}

Internal and External Validity

The researcher controlled the internal validity by ensuring there were no additional learning activities outside the school, limiting the duration of the study to eight meetings, not giving pre-tests, using the same instruments for both groups, excluding data with extreme scores, applying random sampling techniques, excluding subjects who came out of the data analysis, and equalizing the age of participants between groups. External validity was maintained through random sampling from SMK Light Vehicle Engineering students aged 17–19 years, the implementation of treatment under the same conditions for both groups, and not informing participants that they were being studied. Additionally, instructions were given to teachers not to alter the classroom situation during the treatment[17].

Data Collection Techniques

The data collection technique used involves collecting the results of learning outcome tests and self-evaluation questionnaires regarding metacognitive knowledge. The test is obtained from three classes, with different ones for each class. The first class employs a flipped classroom approach, while the second class utilizes direct instruction.

Homogeneity Test and Normality Test

Group Variance Homogeneity Test A_1 and Groups A_3

Hypotheses tested:

H_0 : $\sigma^2_{A1} = \sigma^2_{A3}$

H_1 : not H_0

Based on the results of the calculation, it was obtained that $F_{count} = 2.12$, which is smaller than Ftable (0.05; 17:17) = 2.27, so H_0 Is Accepted. This means that the two treatment groups have the same variance (homogeneous).

Table 3 **Variance Homogeneity Test**

Group	L_{count}	L_{table}	Information
A_1	0,1104	0,200	Normally Distributed
A_3	0,0949	0,200	Normally Distributed

Normality Test

Group A1 Normality Test

The criteria used in the normality test is that the sample of learning outcome scores of students who use flipped classrooms comes from a normally distributed population if $L_{count} < L_{table}$. Value counting results L_{count} The largest is 0,1104, L_{table} To n = 18 with a significant degree 0,05 Was 0,200. Thus, it can be concluded that data A_1 has a Normal distribution.

Group Normality Test A_3

The criteria used in the normality test are that the sample of the learning outcome scores of students who use direct instruction comes from a normally distributed population if $L_{count} < L_{table}$. The results show that the largest Lcount is 0.0949, Ltable to n = 18, with a significant degree of 0.05, which is 0.200. Thus, it can be concluded that the data follows a normal distribution.

RESULTS AND DISCUSSION

Result

Based on data collected from 18 students, it is known that the learning outcome score of students who use flipped classrooms obtained the highest score of 27, the lowest score of 8, the average score of 19.44; the median score of 21.50; the value of the mode of 22; the variance of 35.908; the standard deviation of 5.992. The description of the learning outcomes of students who use flipped classrooms is arranged in the frequency distribution table as follows:

Table 4 **Group Frequency Distribution A_1**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	8	-	11	7,5	11,5	2	2	11,11%
2	12	-	15	11,5	15,5	3	5	16,67%
3	16	-	19	15,5	19,5	3	8	16,67%
4	20	-	23	19,5	23,5	4	12	22,22%
5	24	-	27	23,5	27,5	6	18	33,33%
						18		**100%**

The frequency distribution of student learning outcome scores using flipped classrooms in Table 4 can be shown in the form of the following histogram graph:
Figure 1 **Histogram Graph of Frequency Distribution Group A1**

Based on data collected from 18 students, it is known that the learning outcome scores of students who use direct instruction were obtained with the highest score of 20, the lowest score of 6, the average score was 13.00, the median score was 12.50; the mode score was 17; the variance was 16,941; the standard deviation was 4,116. The description of the learning outcomes of students who use direct instruction is arranged in the frequency distribution table as follows:

Table 5 **Group Frequency Distribution A_3**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	6	-	8	5,5	8,5	3	3	16,67%
2	9	-	11	8,5	11,5	4	7	22,22%
3	12	-	14	11,5	14,5	3	10	16,67%
4	15	-	17	14,5	17,5	6	16	33,33%
5	18	-	20	17,5	20,5	2	18	11,11%
						18		**100%**

The frequency distribution of student learning outcome scores using direct instruction in Table 5 can be shown in the form of the following histogram graph:
Figure 2 **Histogram Graph of Group A Frequency Distribution$_3$**
Based on data collected from 27 students, it is known that the learning outcome score of students with high metacognitive knowledge ranges from a high score of 27 to a low score of 6, with an average score of 17.56, a median value of 19.00, a mode value of 7, a variance of 43,949, and a standard deviation of 6,629. The description of the learning outcome scores of students who have high metacognitive knowledge is arranged in the frequency distribution table as follows:

Table 6 **Group Frequency Distribution B_1**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	6	-	9	5,5	9,5	4	4	14,81%
2	10	-	13	9,5	13,5	4	8	14,81%
3	14	-	17	13,5	17,5	5	13	18,52%
4	18	-	21	17,5	21,5	5	18	18,52%
5	22	-	25	21,5	25,5	5	23	18,52%
6	26	-	29	25,5	29,5	4	27	14,81%
						27		**100%**

The frequency distribution of learning outcomes scores of students who have high metacognitive knowledge in Table 6 can be displayed in the form of the following histogram graph:
Figure 3 **Histogram Graph of Frequency Distribution of Group B1**
Based on data collected from 27 students, it is known that the learning outcome score of students with low metacognitive knowledge obtained the highest score of 24, the lowest score of 2, the average score of 14.89, the median value of 16.00, the mode value of 17, the variance of 23,718, and the standard deviation of 4,870. The description of the learning outcomes score of students who have low metacognitive knowledge is arranged in the frequency distribution table as follows:

Table 7 **Group Frequency Distribution B_2**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	2	-	5	1,5	5,5	1	1	3,70%
2	6	-	9	5,5	9,5	1	2	3,70%
3	10	-	13	9,5	13,5	9	11	33,33%
4	14	-	17	13,5	17,5	8	19	29,63%
5	18	-	21	17,5	21,5	5	24	18,52%
6	22	-	25	21,5	25,5	3	27	11,11%
						27		**100%**

The frequency distribution of learning outcomes scores of students who have low metacognitive knowledge in Table 7 can be shown in the form of the following histogram graph:
Figure 4 **Histogram Graph of Frequency Distribution of Group B2**
Based on data collected from 9 students, it is known that the A1B1 score ranged from 21 to 27, with an average score of 24.22, a median value of 24.00, a mode value of 26, a variance of 4,694, and a standard deviation of 2,167. The description of the A1B1 score is compiled in the frequency distribution table as follows:

Table 8 **Group Frequency Distribution A_1B_1**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	21	-	22	20,5	22,5	3	3	33,33%
2	23	-	24	22,5	24,5	2	5	22,22%
3	25	-	26	24,5	26,5	3	8	33,33%
4	27	-	28	26,5	28,5	1	9	11,11%
						9		**100%**

Score frequency distribution A_1B_1 Table 8 can be shown in the form of the following histogram graph:
Figure 5 **Histogram Graph of Group Frequency Distribution A_1B_1**
Based on data collected from 9 students, it is known that the highest score was 16, the lowest score was 6, the average score was 10.89, the median value was 12.00, the mode value was 7, the variance was 13,111, and the standard deviation was 3,621. The description of the A3B1 score is arranged in the frequency distribution table as follows:

Table 9 **Group Frequency Distribution A_3B_1**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	6	-	8	5,5	8,5	3	3	33,33%
2	9	-	11	8,5	11,5	1	4	11,11%
3	12	-	14	11,5	14,5	3	7	33,33%
4	15	-	17	14,5	17,5	2	9	22,22%
						9		**100%**

Score frequency distribution A_3B_1 Table 9 can be displayed in the form of the following histogram graph:
Figure 6 **Histogram Graph of Group Frequency Distribution A_3B_1**
Based on data collected from 9 students, it is known that the highest score, A1B2, was obtained at 22; the lowest score was 8; the average score was 14.67; the median value was 14.00; the mode value was 8; the variance was 20,250; and the standard deviation was 4,500. The description of the A1B2 score is arranged in the frequency distribution table as follows:

Table 10 **Group Frequency Distribution A_1B_2**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	8	-	11	7,5	11,5	2	2	22,22%
2	12	-	15	11,5	15,5	3	5	33,33%
3	16	-	19	15,5	19,5	3	8	33,33%
4	20	-	23	19,5	23,5	1	9	11,11%
						9		**100%**

Score frequency distribution A_1B_2 Table 10 can be shown in the form of the following histogram graph:

Figure 7 **Histogram Graph of Group Frequency Distribution A_1B_2**

Based on data collected from 9 students, it is known that the scores A_2B_2 didapatkan skor tertinggi 24; skor terendah 2; skor rata-rata 14,89; nilai median 16,00; nilai modus 2; varians 43,861; simpangan baku 6,623. Deskripsi skor A_2B_2 disusun dalam table distribusi frekuensi sebagai berikut:

Table 11 **Group Frequency Distribution A_2B_2**

Number	Interval Classes			Border		Frequency		
				Under	Above	Absolute	Cumulative	Relative
1	2	-	7	1,5	7,5	1	1	11,11%
2	8	-	13	7,5	13,5	3	4	33,33%
3	14	-	19	13,5	19,5	3	7	33,33%
4	20	-	25	19,5	25,5	2	9	22,22%
						9		**100%**

Score frequency distribution A_2B_2 Table 11 can be displayed in the form of a histogram graph as follows:

Figure 8 **Histogram Graph of Group Frequency Distribution A_2B_2**

DISCUSSION

Differences in Learning Outcomes of How to Service Student Car Chassis Using Flipped Classroom (A_1) and Students Using Direct Instruction (A_2)

The statistical hypothesis is as follows:

Ho : $\mu_{A1} = \mu_{A2}$

H_1 : $\mu_{A1} > \mu_{A2}$

The further test count using the Tukey test results was obtained as follows:

Table 12 **Group Comparison A_1 With A_2**

No	Groups Compared	dk	Q_{count}	Q_{table} $\alpha = 0,05$	Information
2	A_1 dengan A2	2 : 18	6,14 **	2,97	Signifikan

Learning outcome scores of students who use flipped classroom (A_1) Compared to the learning outcomes scores of students who use direct instruction (A_2), Obtained Q_{count} = 6,14 and $Q_{table\ (0,05;2:18)}$ = 2,97. Thus, Q_{count} is greater than Qtable, so that H0 is rejected. It can be interpreted that there is a significant difference in the average score of student learning outcomes between the flipped classroom and direct instruction. In other words, the average score of the learning outcomes for students who use flipped classrooms ($\bar{Y}A1 = 19.44$) is higher than those using Direct Instruction ($\bar{Y}A3 = 13.00$).

Thus, the research hypothesis that the average learning outcomes of students who use a flipped classroom are higher than those who use direct instruction is acceptable.

Interaction Between (A) and Metacognitive Knowledge (B) on Learning Outcome Scores of Car Chassis Service (Y)

The statistical hypothesis is as follows:

Ho : A x B = 0

H1 : A x B ≠ 0

Based on the results of the two-path variance analysis on the interaction between metacognitive knowledge and student learning outcome scores, the price of F_{count} interaction = 10.695 and $F_{table\ (0.05;\ 2:48)}$ = 3.19. Based on the Sig. Value in the Tests of Between-Subjects Effects table for lines A * B with the condition that if it is less than 0.05, the test result is SIGNIFICANT or H0 is rejected. In the Table, it can be seen that the Sig. value for row A * B is 0.000; less than 0.05 then H_0 rejected so that H_1 Accepted. The conclusion is that there is an interaction between metacognitive knowledge and student learning outcomes. The interaction between metacognitive knowledge and student learning outcomes is illustrated in the following figure.

Figure 9 **Visualization of the Interaction Between and Metacognitive Knowledge in Its Influence on Learning Outcomes of Car Chassis Service**

Differences in Learning Outcomes of How to Service Car Chassis Students Using Flipped Classroom and Students Who Use Direct Instruction in the Group of Students Who Have High Metacognitive Knowledge

The statistical hypothesis is as follows:

Ho : $\mu_{A1B1} = \mu_{A3B1}$

H_1 : $\mu_{A1B1} > \mu_{A3B1}$

The further test count using the Tukey test results was obtained as follows:

Table 13 **Group Comparison A_1B_1 With A_3B_1**

No	Groups Compared	dk	Q_{count}	Q_{table} $\alpha = 0,05$	Information
2	A_1B_1 dengan A_3B_1	4 : 9	8,95 **	4,42	Signifikan

From the results of the count, the learning outcome score of students who have high metacognitive knowledge and use flipped classroom (A_1B_1) compared to the learning outcome scores of students who have high metacognitive knowledge and use direct instruction (A_3B_1), Obtained Q_{count} = 8,95 and $Q_{table\ (0,05;4:9)}$ = 4,42. Thus, Q_{count} is greater than Q_{table}, so that H_0 is rejected. It can be inferred that there is a difference in the average score of learning outcomes between students who have high metacognitive knowledge in a grid and those in a flipped classroom versus direct instruction. In other words, the average learning outcome score of students who have high metacognitive and use a flipped classroom ($\bar{Y}A1B1 = 24.22$) is higher than that of those who have high metacognitive knowledge and use direct instruction ($\bar{Y}A3B1 = 10.89$).
Thus, the research hypothesis that the average learning outcomes of students who possess high metacognitive knowledge and utilize a flipped classroom are higher than those of students who use direct instruction is acceptable.

Differences in Learning Outcomes of How to Service Car Chassis Students Using Flipped Classroom and Students Who Use Direct Instruction in the Group of Students Who Have Low Metacognitive Knowledge
The statistical hypothesis is as follows:
Ho : $\mu_{A2B2} = \mu_{A3B2}$
H_1 : $\mu_{A2B2} < \mu_{A3B2}$
The further test count using the Tukey test results was obtained as follows:

Table 14 **Group Comparison A_1B_2 With A_3B_2**

No	Groups Compared	dk	Q_{count}	Q_{table} $\alpha = 0,05$	Information
5	A_1B_2 dengan A_3B_2	4 : 9	0,30 ^{ns}	4,42	Insignificant

From the results of the count in Appendix 8, page 334, the learning outcome score of students who have low metacognitive knowledge and use flipped classroom (A_1B_2) compared to the learning outcome scores of students who had low metacognitive knowledge using direct instruction (A_3B_2), Obtained Q_{count} = 0,30 and $Q_{table\ (0,05;4:9)}$ = 4,42. Thus, Q_{count} is smaller than Q_{table}, so that H_0 is accepted. It can be inferred that there is no statistically significant difference in the average score of learning outcomes for students with low metacognitive knowledge between the flipped classroom and direct instruction. In other words, the average learning outcome score of students with low metacognitive knowledge who use flipped classrooms ($\bar{Y}A1B2 = 14.67$) is slightly lower than that of students with low metacognitive knowledge who use direct instruction ($\bar{Y}A3B2 = 15.11$).
Thus, the research hypothesis that the average learning outcomes of students with low metacognitive knowledge who use a flipped classroom are lower than those of students who use direct instruction is not yet supported.

3.1. Subsection 1

This study employs the Lilliefors test as a data normality test, which is a requirement for normally distributed data. The normality test counts through the following steps: (1) Sorting the scores of learning outcomes of How to Service the Car Chassis from the smallest score to the largest score in column Y; (2) Count the average score of learning outcomes How to Service a Car Chassis using the formula:
$\bar{Y}$ = [18, p. 54] (1)
With the adverb $\bar{Y}$ is the average score, is the sum of the scores of the sample, and n is the number of samples; (3) Calculate the standard deviation(s) with the formula:
s = [18, p. 64] (2)
(4) standardize the data to Z-score in column Zi using the formula:
Z_i = [18, p. 146] (3)
(5) Obtain the Zt value by searching on the list F on the Zi value; (6) calculate the theoretical cumulative distribution using the standard distribution table to get the value F(Zi). If Zi is negative, then F(Zi) = 0.5 – Zt, If Zi is positive, then F(Zi) = 0.5 + Zt, 0.5 comes from F(0) = 0.5; (7) count s(Zi) using the formula:
$S(Z_i)$ = [18, p. 146] (4)
(8) count [$F(Z_i)$ - $S(Z_i)$] harga multak dari selisih $F(Z_i)$ and $S(Z_i)$
If Ho: the hypothesis of data derived from a normal and distributed population H_1 : The hypothesis of data coming from a population that is not normally distributed with the test criteria, i.e., accept Ho if Lo < L_{table}, or minus Ho if L_o > Lt_{able}.

3.2. Subsection 2

The data homogeneity test is one of the recommended requirements to check the variation of the data obtained, ensuring the same statistical diversity of the data. Data homogeneity testing was performed to compare the variance of two data groups. The homogeneity test serves to convince and ensure that the data groups come from the same sample. This study uses the F-test with the following statistical counting formula:

F_{count} = [18, p. 160] (5)

With the caption = most significant variance and = most minor variance.

Count the homogeneity of the group of cells of the experimental design with the formula:

B = [18, p. 160] (6)

is the combined variance of the whole group, is the variance of each group, DK is the sum of the degrees of freedom of each group (n – 1), and K is the number of groups.

Furthermore, the value of B = chi-square (χ^2) compared to the value of (χ^2) of the Table at the significance level of 0.05. The test criterion is to accept Ho if $\chi^{2count} < \chi^{2table}$, or subtract Ho if $\chi^{2count} > \chi^{2table}$ [18]. Ho: the data hypothesis of each sample group has a homogeneous variance, and H1: the data hypothesis is that there is a heterogeneous variance sample group.

3.2.1. Subsub section 1

Table 15 **Counting the Sum of Squares of Some Sources of Variance**

B	A			
	$\bar{Y}_1$		$\bar{Y}_3$	$\bar{Y}_b$
	$\bar{Y}_4$		$\bar{Y}_6$	$\bar{Y}_b$
	$\bar{Y}_1$		$\bar{Y}_{A3}$	$\bar{Y}_t$

Statistik Hypothesis

The statistical hypothesis of this study is formulated as follows:

The First Hypothesis

Ho : $\mu_{A1} = \mu_{A3}$

H_1 : $\mu_{A1} > \mu_{A3}$

Second Hypothesis

Ho : A x B = 0

H1 : A x B ≠ 0

Third Hypothesis

Ho : $\mu_{A1B1} = \mu_{A3B1}$

H_1 : $\mu_{A1B1} > \mu_{A3B1}$

Fourth Hypothesis

Ho : $\mu_{A2B2} = \mu_{A3B2}$

H_1 : $\mu_{A2B2} < \mu_{A3B2}$

Information:

Ho : Null hypothesis of the statement to be tested

H_1 : Alternative hypotheses or working hypotheses as opposed to zero hypotheses

A : Learning Model

B : Metacognitive knowledge

μA_1 : Average learning outcomes of how to service car chassis students who use the flipped classroom

μA_3 : Average learning outcomes of how to service car chassis students who use direct instruction

μB_1 : Average learning outcomes of how to service car chassis Students who have high metacognitive knowledge

μB_2 : Average learning outcomes of how to service car chassis Students who have low metacognitive knowledgeability

μA_1B_1: The average learning outcome was achieved by students using a flipped classroom approach with high metacognitive knowledge.

μA_3B_1 : The average learning outcomes of students who are taught using direct instruction with students with high metacognitive knowledge

μA_1B_2 : The average learning outcome was learned using flipped classroom students with low metacognitive understanding.

μA_3B_2 : The average learning outcomes of students who are learning using direct instruction with students with low metacognitive knowledge.

CONCLUSION

The results of the fourth hypothesis test concluded that the average learning outcomes of students who use a flipped classroom are higher than those of students who use direct instruction. Students who learn using a flipped classroom transfer information from the school and assimilate it into their schoolwork, which allows them to be

more active and participatory in classroom learning, in other words. In flipped classrooms, learning is carried out with students learning more dominantly and actively [19]. Direct instruction provides students with the opportunity to learn the material step by step, following the teacher's instructions, which aligns with cognitive theory. This theory states that human behavior is always based on cognition, the act of knowing or thinking about someone directly involved in gaining insight for problem-solving [20]. The flipped classroom can be significant for students, enabling even those with limited metacognitive knowledge to adapt [21]. Students are also more actively participating in learning[22]. The effectiveness of flipped classrooms has been shown to improve the learning outcomes of students with low metacognitive knowledge[23]

Learning how to Service a Car Chassis also involves characteristics such as perception, readiness, imitation, habituation, proficiency, and natural movement, which are related to the development of skills learned in school. This process enables individuals to carry out specific tasks under the direct supervision of teachers. A flipped classroom approach can be used to learn how to Service a car chassis through direct instruction. When the flipped classroom and direct instruction approaches were applied to two different classes, the results showed that the average learning outcomes for servicing a car chassis were higher for students who used the flipped classroom approach, as their level of activity was higher.

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