Implementation of Flipped Classroom Learning Model and Its Effect on Critical Thinking and Communicating Skills of Junior High School Students

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Abstract: The 21st century learning paradigm emphasizes students' ability to think critically, be able to connect knowledge with the real world, master information technology, communicate and collaborate. This study aims to determine how the flipped classroom model affects students' critical thinking and communication skills. The research method is a quasi-experimental form of non-equivalent pretest-posttest control group design with a simple random sampling technique. The population in this study were all students of grade IX of SMP Islam Al-Falah, namely 5 classes, class IX-1, IX-2, IX-3, IX-4 and IX-5., the research sample class IX-5 as the control class and IX-3 as the experimental class. The data collection technique used the FRISCO indicator critical thinking ability essay test and the communication ability assessment observation sheet. The data analysis technique used the one-way MANCOVA test with initial critical thinking and communication skills as covariates. The results of the hypothesis test showed that the value [F $(2,51)$ = 22.777, p <0.001, $\eta p2$ = 0.472]. This means that the significance value of p <0.001 which means <0.05, then H0 is rejected and H1 is accepted, meaning that there is an influence of the flipped classroom model on students' critical thinking and communication skills. The size of the effect size value $\eta p2$ = 0.472, which means that there is a large influence of the flipped classroom model on students' critical thinking and communication skills.

Keywords: Communication skills; Critical thinking skills; Flipped classroom

Introduction

The 21st century is known as the century of knowledge, where the learning paradigm emphasizes the importance of mastering critical thinking skills, information technology, communication, and collaboration (Dwi 2022; Zubaidah 2018). Students are not only required to think critically and solve problems, but must also be skilled in using technology. The curriculum in Indonesia requires student-centered learning with teachers as facilitators, encouraging the development of 4C skills: critical thinking, collaboration, communication, and creativity. However, in many schools, including Al-Falah Junior High School, students' critical thinking and communication skills are still low. Observations show that students have difficulty in presenting arguments, drawing conclusions, and are not active in class discussions. Questionnaire data revealed that only about 45-51% of students demonstrated critical thinking skills, and their communication skills were also low, with many not confident in discussing or understanding explanations. This situation demands a more innovative learning model to improve 4C skills. One model that is considered effective is the flipped classroom. This model requires students to learn independently outside the classroom and be actively involved during classroom learning (Arnyana 2018; Yulianti & Wulandari 2021; Song 2018).

The facts in the field are also proven by the results of teacher interviews, stating that teachers experience obstacles in learning science, especially Biotechnology material, because the material is still abstract and complex even though biotechnology material is often applied in everyday life and biotechnology learning often only focuses on theoretical aspects and provides less space for critical discussion. As explained by Harms (2002) many students have difficulty in understanding abstract biotechnology concepts, and students tend to have misconceptions about the biotechnology process that slow down the development of their understanding.

From several problems described, a more innovative learning process is needed that can support and develop students' critical thinking and communication skills in science learning, especially biotechnology material. One learning model that is believed to be quite supportive and can develop students' critical thinking and communication skills is the flipped classroom learning model(Sania & Sayono, 2022; Astawa et.al., 2021; Bergmann & Sams 2021).

The flipped classroom learning model is an effort to provide solutions to problems of critical thinking skills and communication skills that can be applied in facing 21st century education(Nugraheni et al., 2022 & Agustin, 2019). The results of several studies state that learning using the flipped classroom learning model is better than conventional models in improving 4C skills and other learning achievements(Nouri, 2016; Sigalingging & Budiningsih 2022; Putri et.al 2021). The flipped classroom-based learning model is one of the learner-centered learning models to improve learning effectiveness(Fianingrum & Nindiasari, 2022). Research shows that flipped classroom can improve students' critical thinking and communication skills better than conventional learning models. By involving students directly in the learning process, flipped classroom helps them think deeply, understand the material independently, and communicate more effectively.

Thus, the implementation of the flipped classroom model is expected to be a solution to improve students' critical thinking and communication skills in facing the challenges of 21st century education.

Method

The research method is a quasi-experimental form of non-equivalent pretest-posttest control group design with simple random sampling technique (Sugiyono 2021). The research was conducted at Al-Falah Islamic Junior High School in Jambi City, in the even semester of the 2023/2024 school year. This study was conducted to examine the effect of the Flipped Classroom learning model on critical thinking skills and communication

skills. The population in this study were all students in class IX of Al-Falah Islamic Junior High School, namely there were 5 classes, class IX-1, IX-2, IX-3, IX-4 and IX-5. The research sample was class IX-5 and IX-3 with a total of 56 students, namely 28 students each from class IX-5 as the experimental class and class IX-3 as the control class.

Students' critical thinking and communication skills were measured using test instruments (essays) and observation sheets. The instrument measures critical thinking skills using indicators proposed byEnnis (2011) namely focus, reason, inference, situation, clarity, and overview (FRISCO). While the observation sheet of communication skills assessment is used to measure communication skills with indicators: receiving information, assessing information, and communicating information properly and effectively (Braun 2021; Wachidah 2021).

Data analysis techniques in this study used descriptive statistics and inferential statistics (Arifin 2011). Descriptive statistics are used to present the research data obtained on the critical thinking and communication skills of students by conducting pretests and posttests in experimental and control classes (Arikunto 2016. While inferential statistics are used for prerequisite testing of research hypotheses.

The Mankova test is used to test the hypothesis, the MANCOVA (Multivariate Analysis Covariate of Variance) used is one-way MANCOVA (Mankova one path) because it has one dependent variable and two independent variables to test the main effect and interaction effect.

According to Mertler & Vannatta Reinhart (2017), the one-way MANCOVA assumption test are the dependent variable data is in the form of an interval or ratio scale (continuous or scale data), the independent variable is in the form of categorical data that divides the data into at least two unrelated groups, observation independence, there are no significant outliers, the residual data is normally distributed, the variance of one group with another group is homogeneous, the covariate must be linearly related to the dependent variable, and there must be homogeneity of regression slope.

Result and Discussion

Critical Thinking Ability Data

The average pretest and posttest scores in the experimental and control classes increased. The average pretest score in the experimental class was 43.21 and in the control class was 43.10, indicating that both classes had similar initial abilities with a very small difference in average scores, namely 0.11. However, in the posttest, the average score of the experimental class increased to

81.80, while the control class to 70.60, which showed a significant difference in the final ability with an average difference of 11.20. This shows that after being treated, the increase in the average score from pretest to posttest in the experimental class (38.59) is greater than the control class (27.50), which indicates the effect of the flipped classroom model on improving critical thinking skills (see Table 1).

The categories of students' KBK posttest results in the experimental and control classes are listed in Table 2. The KBK scores of the experimental class were higher than the control class. This shows that the very critical category 67.9% dominated the experimental class, while the critical category 75% dominated the control class (see table).

Table 1. Pretest and posttest data of students' critical thinking skills

Class	Average Pretest	Average Posttest	Difference
Experiment	43.21	81.80	38.59
Control	43.10	70.60	27.50

Table 2. Categories of students' KBK posttest results in experimental and control classes

Category	Interval	N	%Experimental Class	N	%Control Class
Very Critical	80-100	19	67.90	5	17.90
Critical	60-79	7	25.00	21	75.00
Moderately Critical	40-59	2	7.10	2	7.10
Less Critical	20-39	-	0	-	0
Not Critical	0-19	-	0	-	0

Figure 1 compares the post-test scores on six critical thinking ability indicators (FRISCO):Focus, Reason, Inference, Situation, Clarity, and Overview, between the experimental and control groups.
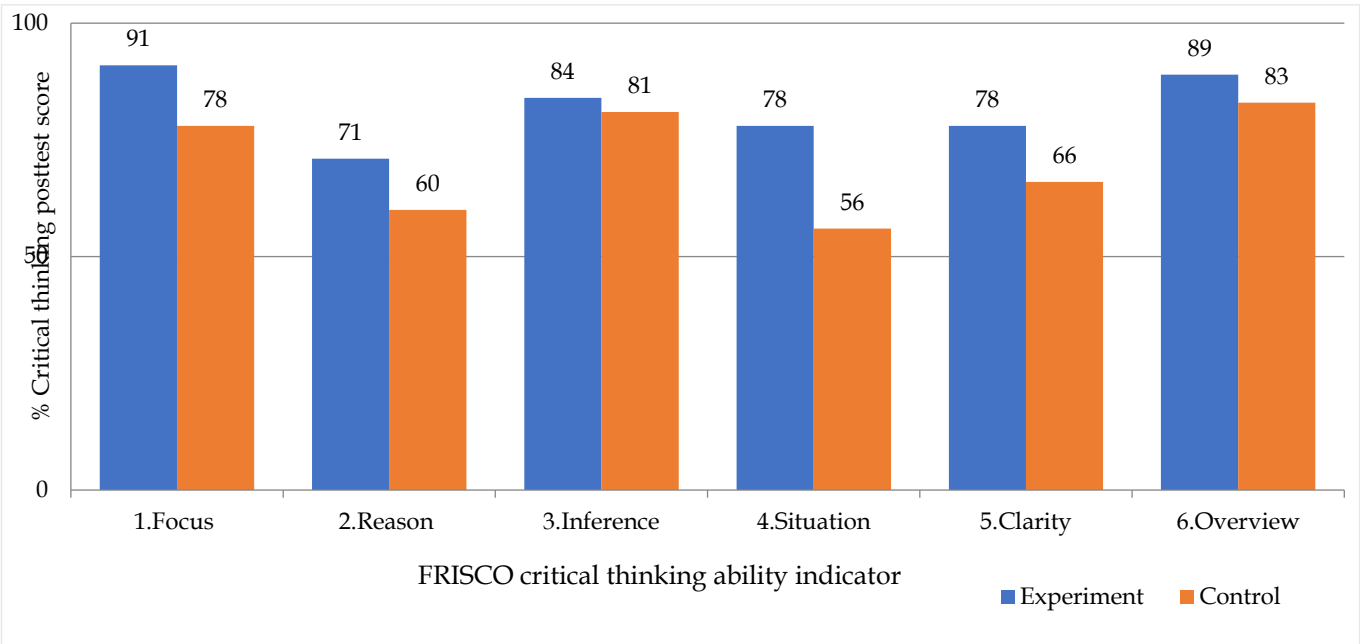

Figure 1. Diagram of percentage (%) of students' posttest score on each KBK indicator

In each indicator, the experimental group consistently outperformed the control group: Focus (91% vs 78%), Reason (71% vs 60%), Inference (84% vs 81%), Situation (78% vs 56%), Clarity (78% vs 66%), and Overview (89% vs 83%). These results indicate that the intervention in the experimental group was more effective in improving critical thinking skills.

Communication Skill Data

The average pretest score in the experimental and control classes was the same, namely 46.90, indicating equal initial ability. After treatment, the posttest score of the experimental class increased to 84.10, while the control class reached 71.10, with a final difference of 13.00. The increase from pretest to posttest was greater in the experimental class (37.20) than the control class (24.20). The pretest-posttest results of students' communication skills are shown in Table 3.

Table 3. Pretest and posttest data of communication skills

Class	Average Pretest	Average Posttest	Difference
Experiment	46.90	84.10	37.20
Control	46.90	71.10	24.20

The categories of the posttest results of students' communication skills in the experimental and control classes are listed in Table 4. The value of communication skills of the experimental class is higher than the control class. This shows that the 71.5% Very Good category dominated the experimental class, while the 85.8% Good category dominated the control class.

Table 4. Categories of posttest results of KKOM students in experimental classes and control classes

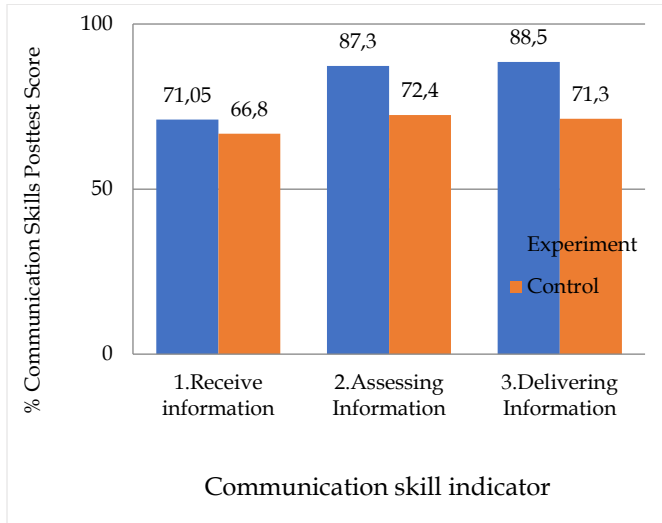| Category	Interval	N	%Experimental Class	N	%Control Class
Very good	80-100	20	71.50	2	7.10
Good	60-79	8	28.50	24	85.80
Good enough	40-59	-	0	2	7.10
Less Good	20-39	-	0	-	0
Not good	0-19	-	0	-	0

Figure 2. Diagram of percentage (%) of students' posttest score on each KBK indicator

In the control class, the indicators of receiving information (66.8%), assessing information (72.4%), and conveying information (71.3%) showed that the highest score was on assessing information and the lowest on receiving information. Overall, the experimental group showed higher scores on all communication indicators, indicating that the intervention in the experimental group was more effective.

Before presenting the results of One-Way MANCOVA, basic assumptions such as multivariate normality of residuals, homogeneity of variance-covariance, and linearity between dependent variables and covariates should be tested. Once valid, the results of the analysis are presented in tables, showing the differences between groups taking into account the effect of covariates.

Multivariate Normality Test Residual Data Results

The Kolmogorov-Smirnov test shows the residual significance values for Post_KBK [D(56) = 0.058, p = 0.200] and Post_Communication [D(56) = 0.080, p = 0.200] are above 0.05, so the assumption of normality is met (see Table 5).

Table 5. Results of mulivariate normality test of residual data

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Residual for Post_KBK	.058	56	.200*	.977	56	.351
Residual for Post_Komunkasi	.080	56	.200*	.982	56	.568

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Homogeneity of Variance and Covariance Test Results (Matrix Covariance)

Box's M value is 8.185 (p = 0.049) indicating that there is homogeneity of variance and covariance (matrix covariance), the assumption is met if p> 0.001 (see Table 6).

Table 6. Results of mulivariate normality test of residual data

Box's Test of Equality of Covariance Matricesa	
Box's M	8.185
F	2.619
df1	3
df2	524880.000
Sig.	.049

The Results of the Linearity Assumption Test between the KBK Posttest Data and the Communication Posttest in Both Classes

This test analyzes the scatterplot and uses linear regression to ensure a linear relationship between the dependent variable and the covariates. Figure 7 shows the linearity test results for the KBK and Communication posttest variables in both classes, illustrating the extent to which the linearity assumption was met. The scatter plot shows that there is linearity between the KBK posttest score and the communication posttest score in both the control and experimental classes.
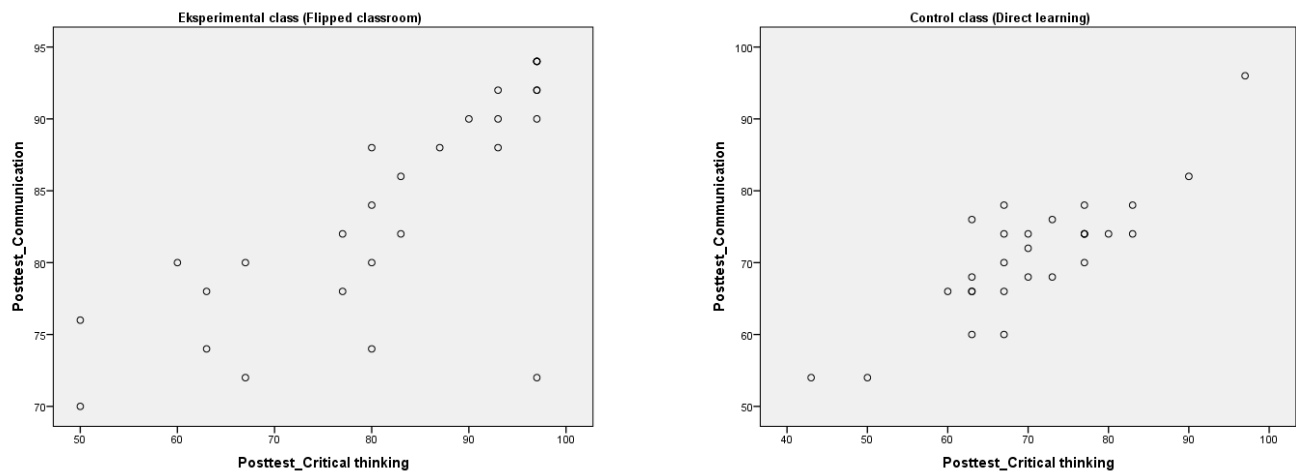
Figure 3. Scatter plot graph of linearity test of KBK posttest data and KKOM posttest in both classes

The Results of the Linearity Assumption Test between the KBK Pretest Data and the KBK Posttest as Well as the Communication Pretest and Communication Posttest in Both Classes

The linearity test between pretest and posttest data was conducted to assess whether there was a linear relationship between the abilities measured before and after the intervention on two variables: Critical Thinking Skills and Communication Skills (see Figure 4).
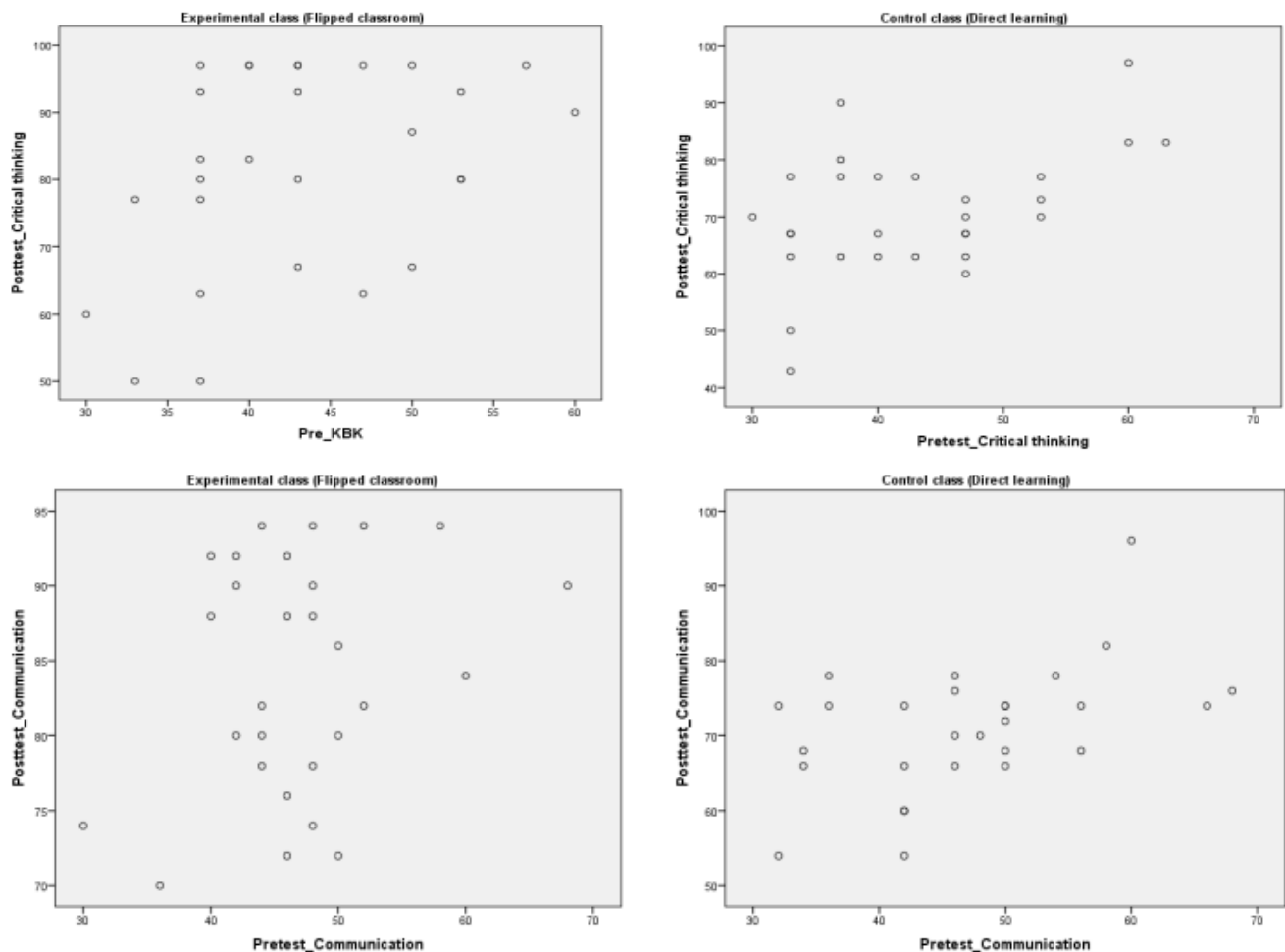

Figure 4: Scatter Plot Graph of Linearity Test of KBK pretest and posttest data and KKOM pretest and posttest in both classes.

The scatter plot shows that there is linearity between the KBK pretest score and the KBK posttest score in both control and experimental classes. In addition, it is also known that there is linearity between the pretest score and the communication posttest score in both control and experimental classes.

Homogeneity Results of Regression Slope in Each Posttest Data

Table 7 presents the F value and significance value (p-value) of the interaction between pretest, posttest, and class.

Table 7. Homogeneity results of regression slope in each posttest data (Tests of Between-Subjects Effects)

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Post_Critical thinking	4482.356a	5	896.471	6.739	.000
	Post_Communication	3220.800b	5	644.160	11.802	.000
Intercept	Post_Critical thinking	65.194	1	65.194	.490	.487
	Post_ Communication	84.514	1	84.514	1.548	.219
Kelas	Post_ Critical thinking	4.766	1	4.766	.036	.851
	Post_ Communication	483.837	1	483.837	8.865	.004
Pre_KBK	Post_ Critical thinking	495.346	1	495.346	3.723	.059
	Post_ Communication	60.369	1	60.369	1.106	.298
Pre_Komunikasi	Post_ Critical thinking	508.500	1	508.500	3.822	.056
	Post_ Communication	71.974	1	71.974	1.319	.256
Kelas * Pre_KBK *	Post_KBK	367.696	2	183.848	1.382	.261
Pre_Komunikasi	Post_ Communication	102.353	2	51.176	.938	.398
Error	Post_ Critical thinking	6651.626	20	133.033		
	Post_ Communication	2728.914	50	54.578		
Total	Post_ Critical thinking	336569.000	56			
	Post_ Communication	342920.000	56			
Corrected Total	Post_ Critical thinking	11133.982	55			
	Post_ Communication	5949.714	55			

The test results informed that the regression slope in both the KBK posttest data [F(2,20) = 1.382, p = 0.261] and the communication posttest data [F(2,50) = 0.938, p = 0.398] were homogeneous. Assumptions are met if p> 0.05.

Based on the results of the assumption tests that have been carried out, everything has been fulfilled, so that hypothesis testing can be continued using one-way MANCOVA. Hypothesis testing results using One-Way MANCOVA and calculation of effect size.

Multivariate Test Results

Multivariate tests assess the combined effects of independent variables on multiple dependent variables simultaneously. In this study, we tested the effect of class (control and experimental) on the posttest results of KBK and communication (see Wilks' lambda results).

Table 8. Hypothesis test results of students' critical thinking and communication skills (Multivariate Tests)

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Pillai's trace	.472	22.777a	2.000	51.000	<.001	.472
Wilks' lambda	.528	22.777a	2.000	51.000	<.001	.472
Hotelling's trace	.893	22.777a	2.000	51.000	<.001	.472
Roy's largest root	.893	22.777a	2.000	51.000	<.001	.472

Each F tests the multivariate effect of Kelas. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.
a. Exact statistic

Multivariate test results showed that there was a large effect of flipped classroom learning model on students' final critical thinking and communication skills after controlling for students' initial critical thinking and communication skills [F(2,51) = 22.777, p < 0.001, ηp2 = 0.472].

Univariate Test Results

Univariate tests were conducted to evaluate the effects of independent variables (control class and experimental class) on each dependent variable (KBK posttest and communication posttest) separately. This test provides a more detailed picture of how each dependent variable is affected by group.

Table 9. Hypothesis test results for each variable (Univariate Tests)

Dependent Variable		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Post_KBK	Contrast	1761.236	1	1761.236	13.047	.001	.201
	Error	7019.321	52	134.987			
Post_Komunkasi	Contrast	2361.274	1	2361.274	43.368	.000	.455
	Error	2831.267	52	54.447			

The F tests the effect of Kelas. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

The univariate test results show that there is a big influence of flipped classroom learning model on students' final critical thinking ability after controlling students' initial critical thinking ability [$F(1,52) = 13.047$, $p = 0.001$, $\eta p^2 = 0.201$]. In addition, it is also known that there is a large effect of flipped classroom learning model on students' final communication after controlling students' initial communication [$F(1,52) = 43.368$, $p < .001$, $\eta p^2 = 0.455$].

The findings showed that the flipped classroom significantly improved students' critical thinking and communication skills, even after controlling for initial ability. Multivariate analysis yielded an $F(2,51) = 22.777$ value with $p < 0.001$ and $\eta p^2 = 0.472$, confirming the great impact of the flipped classroom. This model allows students to study the material at home, so the class can be focused on discussion, collaboration and problem-solving, which encourages critical thinking and communication skills. The high ηp^2 value indicates the flipped classroom is highly effective in improving these abilities.

The Effect of Flipped Classroom Model on Students' Critical Thinking Skills

Based on the one-way Mancova hypothesis test, the flipped classroom model significantly affected students' critical thinking skills, with a large effect size value [$F(1,52) = 13.047$, $p=0.001$, $\eta p^2 = 0.201$]. The average posttest in the experimental class (80.50) was higher than the control class (70.60), indicating a large effect of the flipped classroom on critical thinking skills.

Indicators of critical thinking skills showed that the flipped classroom improved students' focus (91% vs 78%), reasoning (71% vs 60%), inference (84% vs81%), situation (78% vs 56%), clarity (78% vs 66%), and overview (89% vs 83%) compared to the PBL method. This model allows students to study the material at home and spend more time on discussion and problem solving in class, improving critical thinking skills.

Based on the characteristics and stages in the flipped classroom learning model, it appears that the flipped classroom learning model can lead students to develop their critical thinking skills in the learning process. The learning process becomes learner-centered and teachers can optimize their role as facilitators and mediators(Inayah et al., 2021; Foldnes, 2016; Ajmal 2021). The next learning process is presenting the results of

group discussions. In line with what Patandean dan Indrajit (2021) stated, there are several advantages that are the reason why we need to use the flipped classroom learning model, including: Increased Interaction and Exploration: Flipped classroom provides more time for interaction, material clarification, in-depth concept exploration, and active learning practices (Lo & Hew 2017; Maolidah 2017). Learning Process Effectiveness: Learning time is optimized for collaboration, skill development, presentations, and problem solving.Independent Learning at Home: Learners learn material at home through videos, websites, or apps, so that in class they can receive full assistance from the teacher if they experience difficulties. Interactive Relationships: Learning engages learners more, increasing interaction between educators and learners. Time Efficiency: Teachers focus on explaining difficult material, making class time more efficient. Teacher Creativity: Teachers become more creative in creating technology-based learning modules, helping learners' understanding.

These results are consistent with previous research that shows flipped classroom is effective in improving students' critical thinking skills. This model creates a student-centered learning process and increases interaction and exploration of the material, which ultimately has a positive impact on students' critical thinking skills (Cahyono 2017; Cobena& Surjono 2022; Lisnawati 2020; Suci et.al., 2021).

The results of this study are in line with previous studies which state that more time spent discussing and developing knowledge will train and develop students' critical thinking skills(Al-zoubi, 2021;Putra, 2021;Widyasari et al., 2021; Ariyanti et.al., 2021). However, in implementing this model, not all students can adapt quickly. There are several students who experience obstacles in the learning process which are indicated by low assessments of their critical thinking skills. This is due to several things, including the lack of familiarity of students with the approach and their educational background which is centered on teachers being the cause of this challenge. The participants in this study had never been exposed to flipped classroom learning before, so they tend to have difficulty adjusting. Usually, they are used to teachers who regulate learning, so they lack the initiative to regulate their own learning

process (Albalawi 2018; Alfina et.al., 2021; Ariyanti et.al., 2021; Astawa 2022)..

The Effect of Flipped Classroom Model on Students' Communication Skills

The results of the one-way Mancova hypothesis test showed that the flipped classroom model had a significant influence on students' communication skills, with a large effect size value [$F(1,52) = 43.368$, $p < 0.001$, $\eta p^2 = 0.455$]. The experimental class that used the flipped classroom showed a higher average value of communication skills compared to the control class.

The flipped classroom model improved communication skills as students studied the material at home before class, so they were better prepared to actively participate in the discussion (Anwar & Musdi 2019; Astri et.al., 2022;). During the learning process, students in the experimental class had more discussions, presented ideas and worked on collaborative tasks, which contributed to the improvement of their communication skills.The analysis showed higher scores in communication indicators: receiving information (71.05% vs 66.8%), assessing information (87.3% vs 72.4%), and conveying information (88.5% vs 71.3%) in the experimental group compared to the control group.

On the receiving information indicator, the flipped classroom allows students to access materials at home, which helps them understand the information better and ask questions in class (Murugan 2020; Zeynep 2016; Hodiyanto 2020). On the assessing information indicator, students engage in critical discussion and evaluation of materials, which strengthens their ability to critically assess information. On the conveying information indicator, students get more opportunities to present their work, improving their oral and written communication skills. This is in accordance with the opinion ofWagner (2020) andSuastra & Margunayasa (2023) that in the before stage, students will gain knowledge about the material to be studied. The benefit is that students receive initial provision that makes them more active and communicative during learning.

The flipped classroom model creates a more interactive and collaborative learning environment, encouraging students to be more active in receiving, assessing and conveying information (Zuwirna 2016). This is in line with the findings that this model not only improves students' communication skills but also facilitates problem solving, as students can more freely express their ideas and thoughts through an integrated task format, such as essay questions.

Conclusion

The research findings lead to the conclusion that there is a big influence of flipped classroom learning

model on students' final critical thinking and communication skills after controlling students' initial critical thinking and communication skills [$F(2,51) = 22.777$, $p < 0.001$, $\eta p2 = 0.472$] on Biotechnology Science material. This leads to the rejection of H_0 and acceptance of H_1. Based on this statement, it indicates that the hypothesis of the Mancova test is fulfilled.

Author Contributions
R.S.: preparation of initial draft, results, discussion methodology, analysis, conclusion; J.S. and A.S.: review, proofreading, and editing. All authors have read and approved the published version of the manuscript.

Conflicts of Interest
The authors declare no conflict of interest.

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