



Flipped Classroom Model to Improve Students' Critical Thinking Skills

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Abstract. Today's students have a characteristic interest in technology. Flipped Classroom is a technology-savvy learning app. Flipped classroom for access to material for more flexibility. The teacher's primary role shifts from the lesson source to the role of the student learning guide. The problem discussed is the difficulty of understanding basic network learning by class XI RPL students at SMKN 2 Cimahi. Learning difficulties include hard-to-understand material, unattractive instruction, abstract material, lack of media, and no preparation for learning. The solution that students want is an LMS-based learning model flipped classroom. The research objective is to develop a flipped classroom model to improve students' critical thinking skills. A flipped classroom model is designed to increase student involvement and the effectiveness of teacher guidance in learning. Moodle Learning Environment is used as an environment for implementing the flipped classroom learning model. Mixed method is a combination of qualitative and quantitative methods used for data analysis. The success of the model is measured based on functional LMS for the flipped classroom, students' critical thinking skills, and students' learning outcomes. The test results show an increase in value of the LMS function for the flipped classroom, students' critical thinking skills, and students' learning outcomes. So, it can be concluded that the flipped classroom learning model can improve students' critical thinking skills.

Keywords: Critical thinking, Cornell Critical Thinking Test, Flipped Classroom, Learning Management System,

Introduction

Today's students are characterised by an interest in technology. Flipped Classroom is an innovative application of technology for learning [1], [2]. Flipped classroom for access to subject matter to make it more flexible [3], [4]. Flipped Classroom applies a blended learning approach that combines synchronous learning and asynchronous autonomous learning. The three main flipped classroom learning activities are: pre-class, in-class, and after class. Learning materials, immersion activities take place outside the

school and material immersion (discussions, problem solving and critical thinking) takes place in the schools. The flipped classroom method applies student-centered learning. Teachers can devote more time in the classroom to engaging, interactive learning activities or more hands-on projects. Teacher primary role changes from a learning resource to a student learning guide [5].

Flipped Classroom's problems are motivation and independence, managing time and mastering technology. Students' motivation and learning independence are required in flipped classroom learning. A low level of student learning, motivation and autonomy will cause many obstacles in the learning process [4], [6], [7]. Time management is also a major obstacle in implementing the flipped classroom [8]. Time management is necessary for effectiveness and efficiency in flipped classroom learning. Technological mastery also plays a major role in setting up flipped classroom. Students and teachers need to be able to use technology such as learning management systems (LMS), online questionnaires, digital materials, and other digital media. Students/teachers who have less ability to master technology are barriers in this learning strategy [2], [9], [10], [11].

This research was conducted on students of class XI RPL SMKN 2 Cimahi who had studied the Basic Network subject. Up to 40 out of 66 students reported that the network basic equipment was considered difficult to understand. They find it difficult in the material IP Address and Gateway. The percentage of reasons why the IP Address material network lesson included: 71% reasoned that the material was difficult to understand, 33% the material was abstract, 37.9% the teacher's presentation was less interesting, 8% did not have any preparation for learning, and 1.5% had no media. Most students want Flipped Classroom-based educational media solutions.

The objective of this research is to develop a flipped classroom model to improve students' critical thinking skills. The flipped classroom model aims to increase student participation and the effectiveness of teacher guidance in learning [8], [12], [13], [14]. The Moodle learning environment is used as a flipped classroom learning model application. This study uses a mixed approach, a combination of qualitative and quantitative methods [15]. Qualitative test results show that the flipped classroom model is functionally achievable and can enhance students' critical thinking skills.

2 Methods

The research methodology is shown in Fig. 1. Fig. 1 is a flipped classroom model design. The stages of this research generally consist of three phases, namely Pre-learning, Learning process, and post-learning on flipped classroom learning [15]. This research was conducted on class students XI RPL SMKN 2 Cimahi with the Basic Network material. The objective of this research is to develop a flipped classroom model to improve students' critical thinking skills. The flipped classroom model is designed to increase student participation and effective teacher orientation in learning. The Moodle learning environment is used as a reverse learning model application.

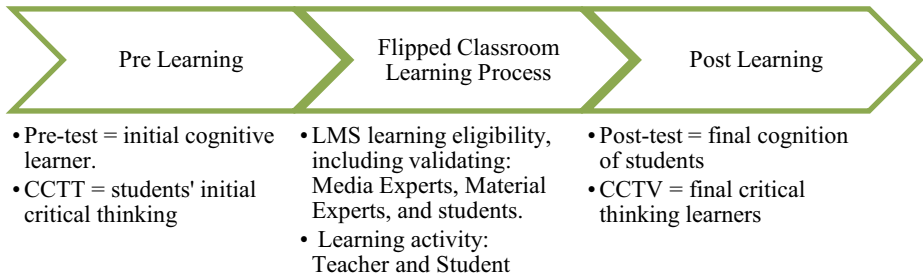


Fig. 1 Flipped Classroom Model learning design.

- Pre-learning

Data collection and analysis in these stages include:

- Pre-test to determine the students' initial state.
- Initial CCTT to test students' critical thinking before they learn.

Pre-Test is done before learning Flipped Classroom. Pre-test 25 multiple-choice questions to determine the original abilities of students. Next, work on the CCTT Critical Thinking Skills questions on 15 questions. Pre-test and CCTT activities were conducted over 60 minutes.

- Flipped Classroom Learning Process

Collecting and analysing data at these stages includes:

- Feasibility of LMSs for learning, including validation: Media Experts, Material Experts, and students.
- Learning activities: Teacher and Student

Implement flipped classroom learning in LMS. The teacher initiates the learning process by dividing each group of students into several groups. When each group is discussing, the teacher starts teaching students one by one for each group based on the information on LMS. After these steps are completed, students are invited to reflect on the lesson.

- Post-learning

Collecting and analysing data at these stages includes:

- Post-test to determine the cognitive capacities of students after learning.
- Final CCTT for evaluating critical thinking of students after learning.

Gain of indices between pre-test and post-test. The post-test is carried out after learning is completed. After the test 25 multiple choice questions with the same capacity indicators as the pretest questions. Furthermore, students received 15 questions from the CCTT with the same capacity indicators as the previous questions. Post-test and CCTT activities took 60 minutes to complete.

Treatment and analytical methods apply pre-experimental design with the type of post-test pre-test group. This study applies a mixed method that combines qualitative and quantitative methods [1], [5]. Qualitative methods of measuring functional LMS for flipped classrooms can enhance students' critical thinking skills. Functional measurements of the flipped classroom model were performed by learning media experts, materials experts, students and teachers. Quantitative methods for measuring the increase in cognitive value of students' critical thinking skills before and after the test. The mean pre-test and post-test values using the Cornell Critical Thinking Test Level X (CCTT): upper group, middle group and lower group respectively. Analysis of research success of the results of both methods. Analyze and process data from the flipped classroom model to improve critical thinking skills of students, including:

2.1 LMS functional analysis of flipped classroom learning

Qualitative methods are used to measure the functional LMS for flipped classrooms if it can enhance students' critical thinking skills. Functional measurements of the reverse classroom model were performed by learning media experts, materials experts, students, and teachers.

2.2 Analyses students' critical thinking.

Analysis of data on critical thinking skills based on the Cornell Administration Manual Critical Thinking [16]. Calculating the score using the correct formulation minus half the error count ($R - \frac{1}{2} W$). An overview of the critical thinking capacity profile is analysed by z-score, and the deviation with.

Z-score to compare the distribution of phenomena and determine the best position of the sample. Initial critical thinking skills from pre-test and critical thinking by the end of the post-test. The mean and deviation were calculated, and then the z-score for each child was calculated by comparing the z-score before the pre-test and the z-score after the post-test after the use of LMS.

2.3 Analysing learning outcomes.

Analysis of learning outcome data was performed based on pre-test and post-test. The processing of pre-test and post-test data was carried out by normality tests, homogeneity tests, and significance tests to see the effect of applying LMS to flip classroom learning on students' critical thinking skills. If the data is normal and homogeneous, then a parametric statistical test will be used, namely the t test, whereas if the data obtained is not normal and homogeneous, then a non-parametric statistical test will be used, namely the Mann-Whitney test. Test normality, uniformity and meaning with version 16 of the SPSS application. For increase in students' critical thinking skills before and after the application of the LMS-based flipped classroom model, it is measured based on the normalized gain with the category of assessment results in Table 1.

Table 1 Normalised gain category.

Gain Value (g)	Category
$g < 0,30$	Low
$0,30 \leq g \leq 0,70$	Average
$g \geq 0,70$	Height

3 Flipped Classroom Learning Model

The discussion included developing and implementing the flipped classroom model.

3.1 Development of a reverse learning model.

The model was developed using the Moodle LMS. Development steps include needs analysis, learning process plan (RPP) and research instruments, LMS design and LMS development. The reverse learning model produces artifacts such as lesson plans, critical thinking instruments, learning success instruments, student response instruments, and LMS design.

RPP refers to Indonesia's standard curriculum. RPP is the standard for the implementation of learning and LMS design. The Critical Thinking Instrument applies a standardized instrument known as the Cornell Critical Thinking Test (CCTT). According to the CCTT Admin Manual, reliability for Level X ranged from 0.67 to 0.90. Instrument for successful learning in the form of multi-choice questions. As many as 50 questions as possible. The reliability of the 0.876 questions with very high criteria and is suitable to be used as a measurement tool for learning output data.

Instruments for student responses to learning, to know student responses to learning, use model implementation. Student responses are categorized into attitude statements such as strongly disagree, disagree, agree, and strongly agree with the conditions that happen during the learning process. The attitude statement becomes a scale from 1 to 4, the details are strong disagreements = 1, disagree = 2, agree = 3 and strongly agree = 4.

The LMS design is based on the learning lesson plan functionality that has been made. Fig. 2 illustrates the LMS design based on the functionality of the flipped classroom lesson plan. LMS Components and Functional Flipped Classroom learning, namely:

Experiential Engagement. In a classroom with no LMS support. This initial step is to find students' initial abilities in IP Address lessons, explain the material to be studied, explain the flipped classroom learning process, pre-test data collection, and critical thinking skills with CCTT.

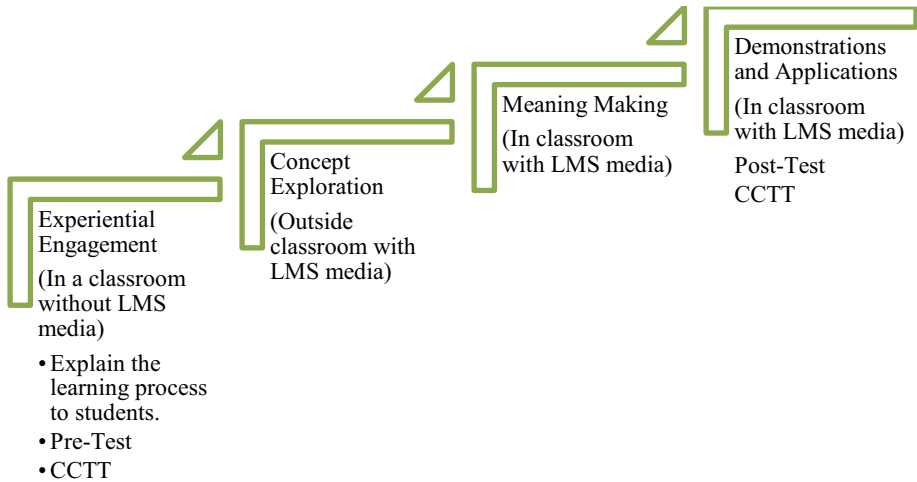


Fig. 2 LMS components and flipped classroom function learning.

Concept Exploration. Outside the classroom with LMS media. Students are instructed to access the applications that have been made and learn about the IP address concept independently outside of school, researchers will continue to guide students with the help of forums and discussions.

Meaning Making. In classroom with LMS media. Students who come to class, discuss the work assigned by researchers, teachers also help students understand IP addresses.

Demonstration and Application. Outside the classroom with LMS media. If the process of understanding the material has been completed, the researcher will invite students to present their understanding, after which the researcher will take post-test data and critical thinking skills with CCTT.

3.2 Implementation of the Flipped Classroom learning model

Flipped Classroom with LMS Moodle is implemented in the XI RPL class of SMKN 2 Cimahi students who have studied the basics of networking. Instruments for data collection via questionnaires and interviews. Questionnaires were provided to students and teachers were surveyed. Students' critical thinking skills are assessed using the CCTT, which consists of 76 questions. For this study, which focuses on the ability to think deductively, using 14 questions. The learning test is based on Bloom's cognitive ability. The subject being tested has IP and gateway addresses, which are composed of 25 multiple-choice questions.

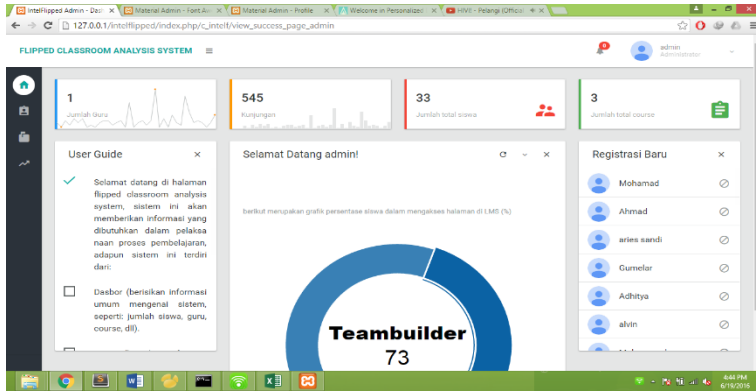


Fig. 3 Flipped Classroom Learning Dashboard

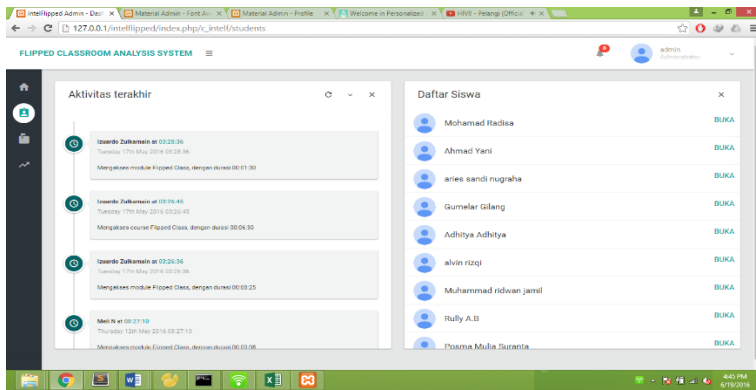


Fig. 4 Interface for Students

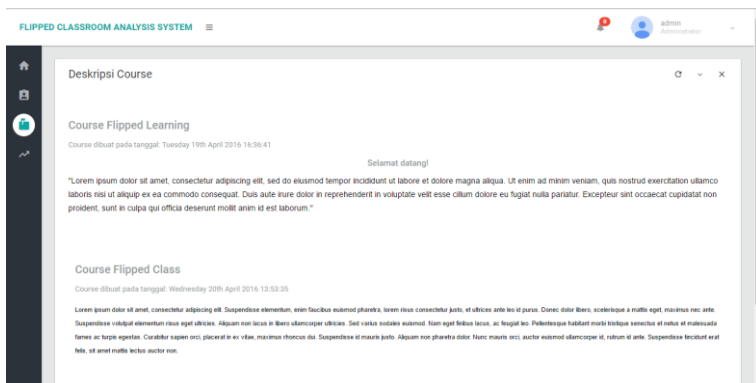


Fig. 5 Learning Materials



Fig. 6. Flipped Classroom Learning Analysis

4 Results and Discussion

Results and discussion of the Flipped Classroom model to improve students' critical thinking skills, including: 1) Functional LMS for flipped classroom learning; 2) Students' critical thinking skills; 3) Student learning outcomes.

Prior to flip classroom learning, student groups were formed first. Students' groups in order: upper group, middle group and lower group. Group boundaries are calculated from the average of the original student scores and the deviation from the results in Table 2.

Table 2 Group Boundary Calculation

\bar{x}	S
62.91	11,40

Group limits obtained:

- Upper group = $62.91 + 11.40 = 74.31$
- Lower group = $62.91 - 11.40 = 51.51$

Distribution of student groups is as follows:

- Upper group: students with a score > 74.31 , namely 4 people
- Middle group: students with scores between 51.51 and 74.31, namely 25 people
- Lower group: students with a value of < 51.51 , namely 4 people

The normality test used the chi square test and used a significant level of $\alpha = 0.05$. The test criteria are as follows:

- If $\chi^2_{obs} \leq \chi^2_{table}$ then the data is normally distributed
- If $\chi^2_{obs} > \chi^2_{table}$ then the data is not normally distributed

Table 3. Pre-test Normality Test Results

Group	Pertest		Distribution
	χ^2_{obs}	χ^2_{table}	
Upper	2,34	7,18	Normal
Middle	10,71	35,415	Normal
Lower	2,82	7,815	Normal

Table 4. Post-test Normality Test Results

Group	Post-test		Distribution
	χ^2_{obs}	χ^2_{table}	
Upper	1,12	7,815	Normal
Middle	33.31	37,653	Normal
Lower	0,19	5,991	Normal

The pre-test normalization results are presented in Table 3, and the post-test normalization results are presented in Table 4. Data from the upper, middle, and lower groups were usually distributed. The next step is to calculate the homogeneity test.

The purpose of the homogeneity test is to determine if the data variable is homogeneous or non-homogeneous. Homogeneity testing uses the Bartlett test because the samples for each group are different. The homogeneity test uses a meaningful level $\alpha = 0.05$, with the following test criteria:

- If $\chi^2_{obs} \leq \chi^2_{table}$ then the data is homogeneous
- If $\chi^2_{obs} > \chi^2_{table}$ then the data is not homogeneous

Table 5 Homogeneity of Pre-Test and Post-test

Data	χ^2_{obs}	χ^2_{table}	Homogeneity
Pre-test	135,47	5,42	H1 accepted
Post-test	133,89		H1 accepted

Table 5 shows the homogeneity of the data. As a result, the upper, middle and lower groups share similar characteristics.

4.1 LMS Functionality for Flipped Classroom Learning

LMS functionality for Flipped Classroom learning is measured based on 1) Online learning media expert; 2) Online learning materials expert; 3) Student satisfaction of LMS services; and 4) Flipped classroom learning process activities (students and teachers). LMS feasibility is measured using the rating scale shown in Table 6. The results of the LMS feasibility test for Flipped Classroom learning.

Table 6. Scoring scale

Score	Category
20	Not very good
40	Not good
60	moderate
80	good
100	Very good

Experts in e-learning media. Table 7 shows the feasibility of LMSs. LMS media feasibility for flipped classroom learning has been tested by 3 media experts. Media experts give an average value of 80.67%, so we can conclude that LMS media work well for flipped learning in class.

Table 7 LMS Eligibility

No	Aspect	Number of Items	Number of Testers	Ideal Score	Score	Percentage
1.	Presentation Design	3	3	45	35	77,88%
2.	Ease of Interaction	3	3	45	40	88,99%
3.	Accessibility	2	3	30	23	76,67%
4.	Reusable	1	3	15	12	80,00%
5.	Compliance Standards	1	3	15	12	80,00%
Average					24,4	80,67%

Expert online learning materials. Table 8 illustrates the feasibility of materials in LMS for flipped classroom learning. Material experts give an average value of 81.07%, so it can be concluded that the LMS material for flipped classroom learning is good.

Table 8. Feasibility of learning materials in LMS.

No	Aspect	Number of Items	Number of Testers	Ideal Score	Score	Percentage
1.	Quality of content/material	4	2	40	30	75%
2.	goal alignment	14	2	140	125	89,29%
3.	Feedback and adaptation	1	2	10	8	80%
4.	Motivation	1	2	10	8	80%
Average					42,75	81,07%

Student satisfaction of LMS services. Student satisfaction with LMS services for Flipped Classroom learning is shown in Table 9. The data was taken based on the student response questionnaire instrument. The ideal score (criterion) is the reference for the best value. There are 33 respondents, 17 questions, each question is valued at 4, so the ideal score (criterion) is $33 \times 17 \times 4 = 2244$. The results of the student survey are presented in the table below:

Table 9. Student satisfaction with LMS services

No	Item	Ideal Score	Score	Percentage
System Interface				
1	e-learning system is easy to use	132	100	75.76%
2	User friendly system	132	120	90.91%
3	Content provided by e-learning is easy to understand	132	110	83.33%
4	Functioning of the eLearning system is stable.	132	120	90.91%
5	e-learning system makes it easy to find the content you need	132	120	90.91%
Learning Communication				
6	e-learning system makes it easier for students to discuss with other students	132	130	98.48%
7	The system makes it easier for users to access content shared in the community	132	120	90.91%
8	The system makes it easy for students to discuss with the teacher	132	130	98.48%
9	The system makes it easy for students to share learning outcomes	132	120	90.91%
Content				
10	The system provides up-to-date content	132	98	74.24%
11	The system provides content that really fits the user's needs	132	99	75.00%
12	The system provides sufficient content	132	98	74.24%
13	The system provides useful content	132	90	68.18%
Personalization				
14	The system allows you to study the content you need	132	120	90.91%
15	The system allows you to choose what you want to study	132	120	90.91%
16	The system allows you to control the learning progress	132	99	75.00%
17	The system allows you to monitor learning progress and performance	132	100	75.76%
Total		2244	1894	84.40%

The student satisfaction score on the LMS for Flipped Classroom learning was 1894 with a percentage of 84.40%, included in the "good and very good" interval category. The Learning Communication aspect has the highest score of 98.48%, which is in line with the validation of media experts who have a high score on the Goal Alignment indicator. While the learning and content communication aspects received the most content replies, 68.18%, this was due to several barriers on the screen. Barriers to the internet connection sometimes turn off and on, making access to learning communication and loading content hampered.

Flipped classroom learning activities (students and teachers). Flipped classroom learning activities (students and teachers) are measured based on processing observation sheet data. The observation sheet was filled in by 3 observers who observed the Flipped Classroom learning process at LMS from start to finish. The results of the datasheet data management are presented in Table 10.

Table 10. Flipped classroom learning activities

Flipped Classroom Learning Activities	Teacher	Student
Introduction	12	12
Core activities	44	42
Closing	20	17
Amount	78	71
Percentage	100%	91,02%

Critical Thinking Analysis. Gain Index Analysis is used to determine the increase in students' critical thinking after using the LMS. The results of the gain index analysis carried out are as follows:

Table 11. Critical Thinking per Group

Group	\bar{x} Pretest	\bar{x} Posttest	\bar{x} Gain	Category
Upper Group	2,75	7,25	0,4	Moderate
Middle Group	2	3,15	0,10	Low
Lower Group	-3,5	1	0,25	Low

Both pre-test and post-test results are described in Table 11. The mean pre-test and post-test values for the upper group were 2.75 and 7.25, with a gain of 0.4. The mean pre-test and post-test values in the mid group were 2 and 3.15, with a gain of 0.10. And the mean values before and after the test in the lower group are -3.5 and 1 at a gain of 0.25. Based on this explanation, we can conclude that there is an increase of critical thinking skills among students.

4.2 Student Learning Outcomes

Tests were conducted on student learning test data, including the Normality Test, Uniformity Test, Hypothesis Test and Gain Index Analysis. Gain Index analysis to determine the increase in student learning outcomes after the flipped classroom learning with LMS media. The gain index analysis results include:

Table 12. Index Gain Pre-Test & Post-Test

Group	\bar{x} Pretest	\bar{x} Posttest	\bar{x} Gain	Category
Upper Group	82	90,00	0,44	Moderate
Middle Group	61,4	65,1	0,13	Low
Lower Group	44,00	48,00	0,10	Low

Tabel 12 menjelaskan bahwa nilai rerata pretest dan posttest. Kelompok atas nilai rerata pretest dan posttest adalah 82,00 dan 90,00 dengan gain 0,44. Kelompok tengah nilai rerata pretest dan posttest adalah 61,4 dan 65,1 dengan gain 0,13. Kelompok bawah nilai rerata pretest dan posttest adalah 44,00 dan 48,00 dengan gain 0,10.

4.3 Analisis dan Diskusi

Analysis and discussion include discussion on:

1. Functional LMS for flipped classroom learning,
2. Students' critical thinking skills, and
3. Student learning outcomes.

LMS functional test results for flipped classroom learning.

LMS functional test results for flipped classroom learning. Learning media experts score of 80.7%. Materials experts give an 81.07% value. And the student satisfaction rating is 84.40%. LMS functional user values for flipped classroom learning fall into the "good and very good" interval category.

Students' critical thinking skills. Student critical thinking evaluation results were calculated using the Cornell Critical Thinking Test Level X (CCTT). Upper group 81.00 & 2.75. The middle group is 61.4 and 2. And the lower group is 44 and -3.5. Mean post-test value with CCTT. The upper group stands between 90 and 7.25 with an average gain of 0.4 (average). The middle group is between 65.1 and 3.15, with a 0.1 (moderate) average gain. And the lower group is between 48 and 1 with an average gain of 0.25 (low). Based on the test data, it can be concluded that flipped classroom learning increases students' critical thinking skills. As well, there is an increase in the learning value of upper-, middle- and lower-class students.

Student learning outcomes. There is an increase in student learning outcomes in the application of the flipped classroom learning model. The increase value is shown by the mean value of pretest and posttest. In the upper group, the average pretest and post-

test were 82.00 and 90.00, with a gain of 0.44. The middle group's pretest and posttest mean values were 61.4 and 65.1 with a gain of 0.13. The lower group's mean pretest and posttest were 44.00 and 48.00 with a gain of 0.10. Testing the flipped classroom model shows an increase in the functional value of the LMS, students' critical thinking skills, and student learning outcomes. The conclusion is that the flipped learning model improves students' critical thinking skills.

5 Conclusion

A flipped Classroom learning model of this research is to improve students' critical thinking skills. The flipped classroom model is designed to increase student involvement and the effectiveness of teacher guidance in learning. This study uses the Moodle learning environment as an application of the Flipped Classroom learning model. The results of LMS functional testing for flipped classroom learning by learning media experts, material experts, and student satisfaction fall into the "good and very good" interval category. Students have increased critical thinking skills. CCTT calculations show an increase in the gain value of the upper, middle, and lower groups. Student performance has increased as well. Mean pretest and post-test results increase in upper, middle, and lower group gain values.

The LMS-based flipped classroom learning process still needs to be improved. The flipped classroom learning framework depends on the conditions of the students and their LMS media. It is therefore necessary to innovate a framework that is able to adapt to the conditions of students and the available LMS technological resources. In addition, it is necessary to innovate to collect data automatically, in order to speed up the analysis process of the flipped classroom learning process.

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