The Impact of Project-Based Flipped Classroom (PjBFC) on Critical Thinking Skills

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This study aimed to examine the impact of the project-based flipped classroom (PjBFC) model on online learning with synchronous and asynchronous strategies on student's critical thinking skills. The media used are Zoom meetings and WhatsApp. The research design was quasi-experimental research. The research subjects were students of the Geography Education Study Program taking Metode Penelitian Pendidikan Geografi (MPPG or Geography Education Research Methods) course at one of the universities in Indonesia. The sample was selected using a simple random sampling technique to 30 students divided to 2 groups, experimental group class A and the control group class B. The data collected from the post-test results dan data analyzed using t-test. Normality test and homogeneity test are carried before data analysis. The results showed that the PjBFC model in online learning with synchronous and asynchronous strategies had a significant effect to develop student's critical thinking skills. The PjBFC learning model is a superior learning approach for developing critical thinking skills both theoretically and practically. This study suggests that all relevant lecturers use PjBFC more widely in conducting lectures. Further research is recommended to apply the PjBFC model with different variables to test the generalizability and reliability of the PjBFC model.

INTRODUCTION

In the 21st Century, all aspects of life are influenced by technology, information, and the internet Sari et al. (2021). Currently factories are more likely to use technology than human labor. Therefore, the person operating the technological equipment must be efficient. In order to ensure that technology equipment operators become efficient and skilled, the focus of training on equipping themselves with technology skills is required. According to Ramadhani and Fitri. (2020) technology is an important part of the learning process. 21st Century students must have various skills, such as critical thinking skills, creativity, collaboration, communication, management and Information and Communication Technology (ICT) literacy, problem-solving, socio-cultural competence, ethical awareness, flexibility, and lifelong learning Van Laar et al. (2019). Critical thinking skills are logical and reasonable thinking related to the actions taken. Critical thinking skills include reflective thinking, decision-making, explaining, assessing perspectives, solving issues, concluding, and understanding oneself and the environment Ennis. (2015), Trilling and Fadel. (2009). Professional educators are able to develop students' critical thinking skills by applying appropriate learning models Silviariza et al. (2020). The learning model that can develop critical thinking skills is the Project Based Flipped Classroom (PjBFC) model.

PjBFC is an integration learning model between the Project Based Learning (PjBL) with the flipped classroom (FC). According to Hernaize-Perez et al. (2021), and Paristiowati et al. (2017), the strategy of integrating FBjL and FC will benefit students as it will increase motivation and encourage students to learn independently. Integrating PjBL and FC could compliment the strengths and weaknesses of the two models. PjBL requires a significant amount of time for discussion and mentoring, which is covered by FC. FC has a weakness, which is student supervision when watching videos. It can be overcome by project learning because the stages of research project are visible in the video. Therefore, PjBFC is a better learning model since it combines two advantages. Apart from that, Andrini et al. (2019), Mohamed et al. (2019), Shih and Tsai. (2017), and Deng (2018) mentioned that integration of PjBL and FC model is proven to increase motivation, activity, cooperation, knowledge construction and critical thinking skills. PjBFC motivates students to participate in online learning. As a result, PjBFC is a good fit for students in the twenty-first century who enjoy social media and have familiarity with their cellphones Chicca and Shellenbarger. (2018), and Seibert. (2021). One of the learning topics that is suitable to be applied to the PjBFC model is a research proposal project.

Developing research proposals can help students improve their critical thinking abilities. According to Yuan et al. (2020), Romadlon and Sarwono (2021), and Sari et al. (2021), research projects can increase activity, investigation, critical thinking skills, innovative, and improve learning outcomes. *Metode Penelitian Pendidikan Geografi* (MPPG or Geography Education Research Methods) is a required subject for students of the Geography Education Study Program at Tadulako University with the main task to develop research proposals. However, the learning process in MPPG courses has not been effective to develop critical thinking skills. Some problems found during

observation, including: a) students lack in problem-solving skills, b) plagiarism in student's assignment without analyzing and paraphrasing, c) research problems are less updated and less creative, d) learning has been moved to online learning during Covid-19 pandemic. The implementation of online learning suddenly makes lecturers and students unprepared and causes many problems, including; limited internet network, lack of references, difficulty understanding learning materials, not optimal discussions, students lack of focus and difficult to develop critical thinking skills. According to Bdair, (2021), problems found in online learning including: student complaints about the experience, trouble maintaining academic integrity, an unstable internet network, and students participating in other activities while studying. Therefore, the learning quality for MPPG courses must be improved by implementing PjBFC learning synchronously and asynchronously to promote critical thinking abilities.

The PjBFC in MPPG courses, both synchronous and asynchronously, is use to achieve success in online learning and solve challenges of the 2I century. The synchronous and asynchronous strategy provide significant results for increasing student knowledge and attendance Suliman et al. (2022). According to Wannapiroon et al. (2022), Indrastyawati et al. (2020), and also Welter-Ward and Carmona. (2008), the synchronous strategy significantly increases digital competence, is effective for discussion, problem solving, and developing critical thinking skills, and maximum results requires additional time. Furthermore, the synchronous technique has difficulties, such as the fact that the internet network is not evenly distributed and it is hard to schedule a face-to-face meeting. According to Rofiah et al. (2022), the synchronous strategy has limitations, including students' difficulty in understanding learning materials, lecturers' lack of experience in online teaching, and unstable internet connections. Thus, the synchronous technique must be supported by an asynchronous strategy, because students learn autonomously when given a flexible time and place, allowing students to think more deeply and comprehensively. According to Hayati et al. (2019), and Afify, (2019) asynchronous strategies can predict behavior, engagement, increase motivation, develop critical thinking skills in online learning. Therefore, written statements in asynchronous online discussions are effective for developing critical thinking skills. However, the asynchronous technique has limitations, including a lack of engagement and the possibility of errors or variations in interpretation, thus it must be complemented by a synchronous strategy. The synchronous strategy encourages more interaction, communication, and confirmation of student understanding on learning material, so it's important to use both synchronous and asynchronous strategies. According to Fahmi, (2020), online learning becomes effective if synchronous and asynchronous strategies are integrated.

The synchronous and asynchronous strategies are relevant to the PjBFC model because it can be implemented online when integrated with technology and information. Supporting the PjBFC model's success in online learning, it must be integrated with both synchronous and asynchronous strategies. The integration of synchronous and asynchronous strategies in implementing online PjBFC learning model focusses on the student and promotes critical thinking development (Zarouk, M.Y et al., 2019; Zarouk,

M.Y et al. 2020; Sasson et al., 2018; and Ruslan et al., 2021). The implementation of the PjBFC learning model uses the Zoom for the synchronous strategy and the WhatsApp for the asynchronous strategy. Based on Putra, (2020), Zoom meetings and WhatsApp are flexible for lecturers and students, since they do not have to be in the same room. Zoom is a video conferencing application that can be used on a laptop or smartphone. This application can be used for recording, chatting Haqien and Rahman. (2020), discussing, displaying PowerPoints and videos According to Dharma et al. (2017) Zoom, is its capability to make the participants are able to interact written and orally and to share presentation screen through sharing display feature. WhatsApp is a social media application for communicating using text, voice and video (Pakpahan and Fitriani, 2020). The advantages of WhatsApp are that it is simple, secure, and easy to use. Therefore, this study aimed to examine the impact of PjBFC on online MPPG learning with synchronous and asynchronous strategies to develop critical thinking skills. The effectiveness of the PjBFC model can be determined after the impact is established, and it can be utilized in online learning to develop critical thinking skills.

Literature Review

Project-based Flipped Classroom

PjBFC is a learning integration of project-based learning (PjBL) and flipped classroom (FC) supported by video. According to Béres and Kis. (2018), and Shih and Tsai. (2017) integrating PjBL and FC can develop critical thinking skills, increase motivation and effectiveness of learning outcomes. Project-based learning refers to learning that begins with a specific problem. According to Sasson et al. (2018), Wu and Wu. (2020), and Barak and Yuan. (2021), PjBL promotes active learning, problem solving, and the development of critical thinking abilities. However, PjBL held online requires strategies and other media to be successful. Therefore, PjBL is integrated with FC to create a great learning model, so the integration of PjBL and FC becomes PjBFC. This PjBFC can overcome the weaknesses of PjBL through FC. PjBL has weaknesses including; 1) PjBL requires a lot of time to discuss, solve problems, and provide guidance from lecturers. This weakness is overcome by reversing the class, by reversing the class can deliver material asynchronously using video media. This can provide more time for discussion, troubleshooting, and guidance during synchronization. 2) PjBL is usually done in groups, this causes students to be less responsible in completing projects. This weakness is overcome by giving projects to students individually, so that each student can be responsible for his own project. Meanwhile, the weakness of FC is that it is difficult to control students to watch videos. However, this can be overcome with projects that require students to see the stages of the project on video.

The PjBFC model is designed to support online learning with synchronous and asynchronous strategies to study independently, increase student interaction and produce quality projects to develop critical thinking skills. The PjBFC model is an innovative learning model that integrates information and technology and is suitable for online learning. The advantages of PjBFC include the ability for students to produce high-quality projects, develop critical thinking abilities, study independently, solve problems,

improve literacy skills, and boost engagement. This learning model also practical, effective, efficient, and enjoyable. The steps in PjBFC learning model showed in the following Table 1.

Table 1
Stages of project-based flipped classroom (PjBFC) learning

No	Syntax	Activity
1	Pre-class	Students watch learning videos
2	In-class	Lecturer confirms student understanding, students discuss, apply and analyze material Students listen to learning videos
3	Setting project theme and goals	Students set the theme of the project to solve the problem
4	Planning project completion	Students set the theme of the project to solve the problem Student; reading references, researching, collecting data, observing, interviewing, and writing. Lecturer monitors student progress
5	Completing projects	Students' sketch, analyze, calculate. Lecturer monitors student progress
6	Project reporting and presentation	Students submit projects and presentations

Source : Sumarmi. (2012), and Bergmann J. (2012)

Critical Thinking Skill

Critical Thinking skill is an important basic skill in finding the source of the problem and the right solution Supena et al., (2021). Critical thinking skills are high-level thinking skills that not only understand knowledge but also transform knowledge, reflective thinking and scientific activities including; asking questions, examining, making statements, analyzing, testing, exploring and making decisions Suryanti and Nurhuda. (2021), Sutiani et al. (2021), and Suhirman et al. (2021).

Critical thinking abilities are applicable to all aspects of learning because it expands the learning experiences. Critical thinking are used to formulate goals, think rationally, analyze, and make decisions Li and Ren. (2020). Therefore, students must apply scientific approaches and facts in solving problems. Indicators of critical thinking skills follow the indicators from Ennis, (2015) showed in the following Table 2:

Table 2
Critical thinking indicators

No	Critical Thinking Skill	Indicators
1	Formulating the problem	Formulate problems and provide answers
2	Giving arguments	Provide arguments followed by suggestions
3	Making deduction	Provide explanations from the general to the specific
4	Proceeding induction	Make conclusions about the problem
5	Evaluation	Evaluate based on facts
6	Applying the concept	Determine alternative solutions for problem-solving

Source: Ennis, (2015), and Silviariza et al. (2021)

Critical thinking skills can be developed using PjBFC learning. The development of critical thinking skills in each syntax showed in the following Table 3

Table 3
Development of critical thinking skills through PjBFC

No	Syntax PjBFC	Strategy	Indicator of Critical Thinking Skill
1	Pre-class	Learn to be independent	Formulating the problem
2	In-class	discussion	Formulating the problem Giving arguments
3	Setting project theme and goals	Independent study and discussion	Giving arguments Making deduction Proceeding induction
4	Planning project completion	Independent study and discussion	Proceeding induction Evaluation Applying the concept
5	Completing projects	Independent study and discussion	Proceeding induction Evaluation Applying the concept
6	Project Reporting and presentation	Presentation	Applying the concept

METHOD

Research Design

The research design was quasi-experimental by comparing two different treatments to the experimental group using the PjBFC model and the control group using PjBL model. This study used randomized pre-test and post-test control group design. The experimental group and the control group have the same characteristics showed in the average score of previous semesters. Both groups were given the same pretest and post-test. The significant difference between the two groups shows in the effect of given treatment Sukmadinata. (2010).

Research Subject

The research subjects were students of the Geography Education Study Program that taking MPPG at one of the universities in Indonesia. The students were grouped into three groups, namely group A, group B and group C with 30 students in each group. The experimental group and the control group were selected using simple random sampling. Obtained group A as the experimental group and group B as the control group. The research was carried out for two months in the second semester of the 2020/2021 academic year, starting from October 28 to December 16, 2020. The topic discussed is preparing research proposals. The research variables divided into two variables: 1) independent variables are the PjBFC model in the experimental group and the PjBL model in the control group, and 2) the dependent variable is critical thinking skill. The learning time using synchronous and asynchronous were divided into 100 synchronous

minutes following the study program's learning schedule, and 100 minutes for asynchronous with flexible schedule.

Instrument and Procedure

Critical thinking skill is measured using indicator adapted from Ennis. (2015) in 10 essay questions. The test instrument is shown in the following Table 4.

Table 4
Test instrument for critical thinking skills

No	Indicator Critical Thinking Skill	Topic	Items
1	Formulating the Problem	Research theme and background	1 and 2
2	Giving Arguments	Research Theory Study	3, 4, and 5
3	Making Deduction	Techniques of data collection and measurement of research data	6 and 7
4	Proceeding Induction	Population and research sample	8
5	Evaluation	Research data analysis	9
6	Applying the concept	Research design	10

Research validity is needed before the research instrument tested. The validity test is tested to 20 students. The results of validity test are shown in the following Table 5.

Table 5
The results of validity test

Item	Questions	r_{xy}	r_{table}	Note
Question 1	Explain the research theme and the background for choosing the theme	0.580	0.444	Valid
Question 2	Explain the research background	0.771	0.444	Valid
Question 3	Explain the urgency of your research	0.737	0.444	Valid
Question 4	Explain the relationship between problem solving and the theory you are using	0.696	0.444	Valid
Question 5	Explain the relationship between your research and previous research	0.621	0.444	Valid
Question 6	Explain your data collection technique	0.474	0.444	Valid
Question 7	Explain your data collection technique	0.560	0.444	Valid
Question 8	Explain how do you select the population, sample, and sample collecting procedure or describe the unit of analysis and key informants (for qualitative research)	0.708	0.444	Valid
Question 9	Explain data analysis procedures and draw conclusions	0.663	0.444	Valid
Question 10	Explain your research design in short	0.542	0.444	Valid

Table 5 shows the questions tested in this study. The instrument validity was measured with a significance of 5% (α) 0.444 using a two-way test.

The reliability test is carried out after the validity test. The reliability test is used Cronbach's alpha with a value of 0.820 and was declared reliable.

Moreover, validity control was also carried out to control the external factors. Validity control includes: 1) determining research subjects to the experimental and control group based on the pre-test results with the closest/almost same score, 2) The same lecturer was assigned to conduct lectures for the experimental and control groups, 3) student has not receive information about the study's topics and schedules.

Data analysis

The formula for calculating the post-test results from the PjBFC learning model and the conventional PjBL model was adapted from (Purwanto, 2010) :

$$n = \frac{\sum B}{smi} \text{ x } n \text{ } max$$

Description: n   : Pre-test/Post-test score
                      $\sum B$: correct answers obtained by students
                      smi   : Ideal maximum score
                      n max : Maximum score 100

Then determine the critical thinking skills level according to Arikunto, (2001), Silviariza et al. (2021) seen in the following table 6.

Table 6
Qualifications for critical thinking skill level

Qualifications	Score	Qualification
A	80 – 100	*Highly Critical*
B	66 -80	*Critical*
C	56 – 65	*Quite Critical*
D	41 -55	*Less Critical*
E	0 -40	*Not Critical*

Source : Arikunto, (2001), and silviariza et al. (2021)

Hypothesis testing was conducted using t-test to compare between pre-test and post-test scores at the 0.05 significance level. Prior to hypothesis testing, prerequisite tests were performed with Kolmogorov-Smirnov and Levene test, and it was found that the data were normally distributed.

FINDINGS

Critical thinking skills score are obtained from activities during the treatment process. The results of the study are as follows:

Critical thinking skills experiment group and control group

The score from the pre-test and post-test research in the experimental group are presented in the frequency distribution table for critical thinking skills. The data results are shown in Table 7.

Table 7
Frequency distribution of pre-test and post-test results of experimental group and control group

Qualification	Experimental Group		Control Group	
	Frequency of Pre-test Results	Frequency of Post-test Results	Frequency of Pre-test Results	Frequency of Pre-test Results
Highly critical	0	9	0	0
Critical	11	19	12	17
Quite Critical	14	2	16	12
Less critical	5	0	2	1
Not critical	0	0	0	0

Table 7 shows that post-test result in experimental group has the highest score in Highly Critical category with 9 students, and post-test result in experimental group with 17 students.

Hypothesis testing

Normality test and homogeneity can be seen in the following Table 8 and 9.

Table 8
Tests of normality in pre-test and post-test

	Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning Outcomes	Pre-test Control Group	.181	30	.013	.933	30	.058
	Post-test Control Group	.109	30	.200*	.941	30	.100
	Pre-test Experimental Group	.120	30	.200*	.944	30	.114
	Post-test Experimental Group	.109	30	.200*	.941	30	.100

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

Table 8 shows that the pretest and post-test results of experimental and control group is normally distributed with significance of Shapiro Wilk > 0,05. The homogeneous test was conducted. The results of the homogeneous test can be seen in the following Table 9.

Table 9
Test of homogeneity variance in the control and experiment group post-test

		Levene Statistic	df1	df2	Sig.
Learning Outcomes	Based on Mean	1.447	1	58	.234
	Based on Median	.932	1	58	.338
	Base on Median and with adjusted df	.932	1	52.445	.339
	Based on trimmed mean	1.508	1	58	.224

Table 9 shows that the significance of mean value is 0.234 > 0.05. Therefore, the post-test variance in the control group and the experimental group was homogeneous.

Also, significant differences can be seen in the difference in the post-test mean values of the control group and the experimental group, as shown in the following Table 10.

Table 10
Group statistics of post-test mean values for control and experiment class

	Groups	N	Mean	Std. Deviation	Std. Error Mean
Learning Outcomes	Post-test Control Group	30	77.73	4.955	.905
	Post-test Experimental Group	30	83.93	6.136	1.120

The post-test mean value of the experimental group is 83.93, higher than the control group is 77.73. There is a significant difference in the learning mean values of the experimental class and the control class. It is indicated that the PjBFC model has a higher critical level development than the PjBL model.

Furthermore, the independent sample t-test was carried out as shown in the following Table 11.

Table 11
Independent samples test results of critical thinking skills

		Levene's Test for Equality of Variances		t-test for Equality of Means							
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
									Lower	Upper
Learning Outcomes	Equal Variances	1.447	.234	-4.306	58	.000	-6.200	1.440	-9.082	3.318
	Equal Variances not Assumed			-4.306	55.535	.000	-6.200	1.440	-9.085	3.315

Based on the independent sample t-test, a significance of 0.000 <0.05 was obtained for the (2-tailed) significance. The result found a significant different in mean value of experimental group and control group. It is interpreted that there are significant different of critical thinking development in experimental group and control group.

DISCUSSION

Implementing online PjBFC model with synchronous and asynchronous strategies has a significant effect on critical thinking skills. The result showed that the mean value of post-test in of the experimental group was 83.93 higher than the control group of 77.73. According to Bdair, (2021), Osborne et al. (2018), and Aliman et al. (2019) online

media, supported by a combination of synchronous and asynchronous strategies, effectively develop critical thinking skills and student collaboration. s

The observation results of PjBFC implementation in each syntax showed that: 1) in pre-class syntax, the implementation could increase motivation, student independence, and preparing for synchronous classes. 2) In during-class syntax, while implemented synchronously, students become active in asking questions and are motivated to explore their knowledge more deeply. 3) In syntax Setting, students designed project themes and goals, independent study and discussion. Students also grew their sensitivity to problems in the surrounding environment, and were able to formulate problem solving goals, think rationally for problem solving, give arguments, and make conclusions on the problem discussed. 4) In planning project completion syntax, students were independently start completing their projects but remain under the lecturer guidance. At this stage, students conducted discussions, evaluation, applied concepts and theories, and conducted analysis to make hypothesis. 5) In completing projects syntax, students carried out projects writing, calculation and analysis, while the lecturer monitored student progress and continues to provide guidance. At the end, students will develop responsibility, able to evaluate based on facts, concepts and theories and apply concepts to determine alternative problem solving. 6) In project reporting and presentation syntax, students submit research proposal projects and present the results. In this stage, students are trained for discipline, responsibility, and communication. Therefore, based on these observations, the PjBFC model in the MPPG course can develop critical thinking.

The experimental class is compared to the control class using the PjBFC model that was created by integrating PjBL and FC and including both synchronous and asynchronous strategies, while the control class uses the PjBL model with the synchronous strategy. The observation found that implementing PjBFC in MPPG courses will require significant discussion and guidance. However, it is not a problem because PjBFC is a is a project-based learning model that is implemented in reverse. The advantage of flipping classes is that students can study asynchronously before classroom meeting synchronously. Students confirm understanding and ask questions within a synchronous process, which allows for additional time for discussion and guidance during the synchronous process. The lecturer's strategy to get all students to view the video is to create project assignments that include video tutorials, so that students cannot complete projects without seeing the video. The strategy to increase responsibility are assigning project assignments as individual tasks.

The PjBL model requires a lot of discussion and guidance time in the control class, but there is a lack of discussion and guidance time during synchronous because time is spent up explaining the subject. There are no pre-class stages and no use of video media in the control class, which means that students have no preparation to the synchronous session. This results in the control class lacking information and digital literacy abilities, as well as a lack of a motivation to explore deeper knowledge. Therefore, critical thinking development and the project of compiling research proposals are lower in the control class than in the experimental class.

Integrating the PjBL model with FC into PjBFC is effective in improving learning achievement and developing critical thinking than the conventional PjBL model Paristiowati et al., (2017). The application of the PjBFC model in online MPPG courses using synchronous and asynchronous strategies has resulted in improving the quality of online learning, developing critical thinking and completing research proposal projects on time with maximum results. The data analysis results indicated that the PjBFC model is better at developing critical thinking than the PjBL model. Therefore, the findings of this study can be used as a reference for teachers and lecturers that the PjBFC model with synchronous and asynchronous strategies can develop critical thinking.

CONCLUSION

According to the result of the study, the PjBFC model is effective at developing critical thinking abilities in online MPPG courses. Also, the PjBFC model is an alternative learning model that can build critical thinking to face the 21st century challenge. It is recommended to the policy makers to upgrade the communication network facilities throughout the country Republic of Indonesia in order to facilitate the implementation of online learning. This research is limited to the MPPG course, so further research is recommended to apply the PjBFC model with different variables to test the generalizability and reliability of the PjBFC model.

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