The Effect of Problem-Based Flipped Learning and Academic Procrastination on Students' Critical Thinking in Learning Physics in High School

I Wayan Santyasa*, Ketut Agustini, I Made Tegeh
Universitas Pendidikan Ganesha
Bali, Indonesia
*santyasa@undiksha.ac.id, ketutagustini@undiksha.ac.id, im-tegeh@undiksha.ac.id

Abstract—Learning physics in SMA cannot be separated from students’ critical thinking activities without delay. Critical thinking will not develop optimally if the learning still tolerates the direct learning model. One of the learning models that are accommodative in developing critical thinking is the problem-based learning model. Both models can be used as pedagogical content for flipped learning, which is termed problem-based flipped learning (PBFL) and direct flipped learning (DFL). This study aims at describing the difference effect between PBFL and DFL on critical thinking (CT) viewed from students' academic procrastination (AP) in learning physics in SMA. Student's AP is a variable of sorting critical thinking skills based on low AP (LAP) and high AP (HAP). The study population was 6 classes of students of class XI SMAN 2 Semarapura. A sample of 4 classes was selected by random assignment technique, which then randomized again to determine 2 classes as PBFL class and 2 classes as DFL class. To collect the students' academic procrastination, the questionnaire is used. Students' critical thinking skills were collected by means of an essay test using a 4-point scale. Data were analyzed using two-way ANACOVA with initial critical thinking skills scores as covariates. Hypothesis testing is carried out at the 5% significance level. The results showed 1) There was a significant difference in the effect between PBFL and DFL on CT (F = 11.769; p <0.05). Students’ CT was higher achieved by students who studied with PBFL than them studied in the DFL model. 2) There is a significant difference in the effect between LAP and HAP on CT (F = 7.006; p <0.05). Higher CT rates were achieved by students who had LAP compared with them had HAP. 3) There is no significant interactive effect between the learning model and AP on CT (F = 1.451; p > 0.05). In learning physics class XI SMA, the two AP categories are accommodating to the PBFL and DFL models.

Keywords—problem-based flipped learning, direct flipped learning, critical thinking

I. INTRODUCTION

Now education has long entered the 21st century. No exception for learning physics in high school. Physics education and learning in this century really need output in the form of specific learning skills. These learning skills include critical thinking skills, problem solving, creative thinking skills, communication, and collaborative thinking [1]. In high school physics learning, these abilities are inevitable for students to achieve. At the same time, students are also led to master information and knowledge. Therefore, learning physics requires skills to acquire, select, and process information. These skills require critical, systematic, logical, and creative thinking [2]. Therefore, we need a physics learning program that can develop critical, systematic, logical, and creative thinking skills.

Physics education and learning in Indonesia, which provide a vehicle for students to develop thinking skills above, still have many obstacles. One of the reasons is the education system which is still focused on examinations [3]. Physics learning tends to focus on lesson content and neglects the development of students' critical thinking skills [4]. The learning model used in physics learning tends to have direct learning (DL) nuances [5]. In DL, the material is sorted in such a way and taught explicitly. This method of learning turns out to have a less than optimal impact on students in developing critical thinking skills [5]. Another fact also states that DL has a low impact on critical thinking skills, creative thinking skills, and collaborative skills among students [6]. This model is called as a conventional learning model which cannot facilitate students in developing critical thinking skills in learning physics, and resulting in low learning achievement [7].

Based on the facts that the DL model is not effective in developing critical thinking, the DL model cannot be maintained in physics learning. One alternative as a substitute is the problem-based learning (PBL) model. The PBL model is appropriate to use in learning physics [8]. PBL is a physics learning reform that can create innovation in developing a new learning atmosphere. Empirically PBL is better than the DL model in physics learning [9,10]. The PBL model provides a learning process to develop higher-order thinking skills such as critical thinking, problem-solving skills, and creative thinking [10,11].

Related to the implementation of PBL in physics learning, it is showed very challenging findings, that although the critical
thinking skills achieved by students learning with the PBL model were higher than the DL models, students' critical thinking skills in physics learning were produced by both models are still in the very low category and have not reached the success criteria [10]. They stated that students in the PBL model were only able to achieve critical thinking skills with \( M = 36.86; SD = 0.561 \), very low category, and DL model with \( M = 33.02; SD = 0.561 \), very low category. These findings indicate that the implementation of PBL in physics learning requires continuous review.

In line with the rapid development of technology today, the implementation of both PBL and DL in learning physics shoes is integrated into learning with network mode. One of them is flipped classroom learning or flipped learning (FL). The effectiveness of FL in learning various fields of study in high school has been proven by several previous research results [12-18]. The PBL model that is integrated as flipped learning (FL) pedagogy content is termed problem-based flipped learning (PBFL). The PBFL model has proven its effectiveness as a learning approach to promote learning about hyperthyroidism in the endocrinology internship [19]. In its implementation, the PBFL model is compared with the direct flipped learning (DFL) model. The effectiveness of the PBFL model in supporting the growth of critical thinking is shown by previous studies [20-23].

Physics learning has very unique and complex characteristics, which require continuous problem-solving activities, empowerment of higher order thinking skills, and metacognition. These characteristics often cause students to often delay their learning activities. The attitude of delaying doing study assignments is termed academic procrastination [24]. Academic procrastination is often the cause of student failure in achieving learning achievement [25,26]. They stated that a high academic procrastination has a greater chance of failure, whereas a low academic procrastination has a lower chance of failure in learning. The low academic procrastination will make students achieve higher learning achievement [27]. In learning physics class X senior high school, it is stated that students who have low academic procrastination show higher learning outcomes than those who have high academic procrastination [28].

Based on the problem background described above, this study proposes a problem which is formulated as follows: "Is there a difference in the effectiveness of the problem-based flipped learning model compared to the direct flipped learning model in achieving critical thinking viewed from students' academic procrastination attitudes in physics learning of class XI of the senior high school?"

**A. Problem-Based Flipped Learning Model**

The term problem-based flipped learning (PBFL) is a combination of two terms, namely problem-based learning (PBL) and flipped learning (FL). PBL is an accommodating learning model to develop students' critical thinking skills in learning physics [10]. The purpose of using PBL is so that students have the ability to think critically, analytically, systematically and logically to determine alternative problem solving through empirical data exploration to foster scientific attitudes [29]. PBL apart from being a facility for students to build knowledge, can also be used to improve students' problem-solving abilities, critical and creative thinking skills in learning physics [30]. PBL uses learning strategies by restructuring problems designed for the acquisition of critical thinking skills, team participation skills, problem-solving skills, and independent learning strategies [31]. PBL is an independent learning, student-centered, independent style that is guided by a teacher or facilitator [32]. PBL is innovative learning that serves students as active learners [8]. In the PBL model, students are encouraged to take the initiative in building their own knowledge [33]. The PBL model provides a learning environment that empowers the potential for students' initial knowledge, because students entering the classroom have been able to present a unique and different framework for learning [34,35]. The characteristics of PBL have great potential for students to develop critical thinking skills in learning physics in senior high school.

The rapid development of technology today makes it possible to integrate PBL into FL with the term PBFL. The PBFL model steps are shown in Table 1.

**TABLE I. PBFL MODEL STEPS [19]**

| Steps               | Teacher                        | Students                  |
|---------------------|--------------------------------|---------------------------|
| Before class meeting| • Present pre test             | • Answer pre test         |
|                     | • Prepare the relevant videos and supplementary materials | • Watch videos and read material on their own time |
| After class meeting | • Present post test            | • Answer post test        |
|                     | • Post survey                  | • Answer question         |
|                     | • Ask the unsolved problems    |                           |

**B. Direct Flipped Learning**

The term direct flipped learning (DFL) comes from direct instruction (DI) which is integrated into flipped learning (FL). DI is affiliated with the instructional approach and curriculum materials developed by Sigmund Freud and Carl Rogers in the late 1960s [36]. Learning is carried out specifically and explicitly, based on the classic behaviorist stimulus / response / conditioning model developed by B. F. Skinner. The learning program is in the form of a linearly programmed learning model, namely the subject matter is designed step by step, a lesson-by-lesson approach that follows a predetermined sequence of skills and is then given to students through e-learning. This linear learning program aims to streamline the time of students doing assignments, and to strengthen student behavior positively. The learning program which becomes e-learning content is more focused on efforts to present curriculum material. Presentation of the material is followed by
giving assignments, giving tests, and conducting assessments in accordance with the predetermined learning objectives. Evaluation results are followed by feedback for changing behavior, ability grouping, and emphasis on academic skills. Operationally, the DFL model is applied in the following stages: motivating students, delivering subject matter, forming student groups, students learning in groups, students reporting discussion results, teachers evaluating student reports.

C. Academic Procrastination

Academic procrastination is a type of delay that is done by students when working on formal tasks related to the academic field [37]. Solomon and Rothblum mention six academic fields to see the types of tasks that are often delayed by students [37], namely: 1) writing assignments, 2) learning assignments, 3) reading assignments, 4) doing administrative tasks, 5) attending meetings, 6) delays in overall academic performance. Milgram states that procrastination consists of four dimensions [37], namely: 1) a series of procrastination behaviors, 2) resulting in substandard behavior, 3) involving a number of tasks that are perceived as important for procrastinators to do, 4) resulting in an unpleasant emotional state. In summary, the dimensions and indicators of academic procrastination can be seen in Table 2.

| No | Dimension | Indicator |
|----|-----------|-----------|
| 1  | A series of delaying behaviors | Delay in academic assignments |
| 2  | Produce substandard behavior | Lags in working on tasks |
| 3  | Involves a number of tasks that are perceived as important for procrastinators | Do other activities that are more fun |
| 4  | Produce an unpleasant emotional state | Emotional anxiety |

D. Critical Thinking

Critical thinking is “sensible reflective thinking that focuses on deciding what to believe or do [39]. In deciding what to believe and do, a person is assisted by a set of critical thinking skills. When students think critically, they are encouraged to think for themselves, formulate hypotheses, analyze and synthesize events, to go further by developing new hypotheses and testing them based on empirical facts [40]. In other words, critical thinking students look like scientists who are doing research, formulating questions, rejecting such information, being active, thinking analytically and synthesis, evaluating information and explaining it properly, treating the mind that is open and aware of the thought process. Every student must have effective critical thinking skills, and they must not accept what the teacher says. Therefore, teachers must critically provide learning facilities that can encourage students to think critically.

II. METHODS

This study used a non-equivalent pretest posttest control group design. The study population was 6 classes of students of class XI SMAN 2 Semarapura-Klungkung-Bali. A sample of 4 classes was selected by random assignment technique, which then randomized again to determine 2 classes as experiment group, namely class XI MIPA 3 and XI MIPA 4, and 2 classes as control group namely class XI MIPA 2 and class XI MIPA 6. This study examines one independent variable, namely the flipped learning model, which is divided into two categories, namely problem-based flipped learning (PBFL) and direct flipped learning (DFL). In addition, this study also examines one moderator variable, namely academic procrastination, which is divided into two levels, namely low academic procrastination (LAP) and high academic procrastination (HAP). The dependent variable measured was students' critical thinking skills in physics learning for class XI senior high school. The research was conducted in 5 times meetings, each meeting with a duration of 135 minutes.

Student academic procrastination data were collected using a LIKERT model questionnaire. In this study 35 items of an academic procrastination questionnaire were developed using a 4-point scale. Before being used, the questionnaire was tested in order to analyze the internal consistency of the items using the product moment correlation and its reliability was determined by using Cronbach's alpha [41]. There 31 items were obtained which were feasible to be used in the study with the distribution of item-total correlation coefficients moving from \( r = 0.3 \) to \( r = 0.7 \) with the criteria of 1 item with a low correlation index, 27 items with a moderate correlation index, and 3 items with high correlation index. The reliability of the 31 items of the procrastination questionnaire was 0.919, falling into the very high category.

Students' critical thinking skills were collected by means of an essay test using a 4-point scale. First of all, 25 critical thinking items were developed. After being tested, 12 items were determined as research instruments. Based on the test results, these critical thinking skills items have a moving difference power index (DPI) from DPI = 0.25 to DPI = 0.71, with the criteria of 4 low DPI items, 5 medium DPI items, and 3 high DPI items. The item difficulty index (IDI) of the 12 test items moved from IDI = 0.22 to IDI = 0.67 with the criteria of 3 easy items, 4 moderate items, and 5 difficult items. The total-item correlation index of the 12 items is calculated using the moment product correlation, and the results move from \( r = 0.31 \) to \( r = 0.62 \), with the criteria of 3 items with low correlation index, 8 items with moderate correlation index, and 1 item with high correlation index. The 12-item reliability index of the critical thinking skills test was analyzed using Cronbach's alpha, and the result was Cronbach's alpha = 0.783 with the high category.

Data were analyzed using a two-way ANACOVA with initial critical thinking skills scores as covariates. Before ANACOVA, an assumption test was carried out. The covariance analysis was based on 3 assumption tests, namely 1) test of data distribution normality using Kolmogorov test and
Shapiro-Wilk statistics; and 2) homogeneity test of variance between groups using Levene's Test of Equality of Error Variance; and 3) linearity test between covariates and dependent variables using test of linearity. Hypothesis testing is carried out at the 5% significance level.

### III. RESULTS

The results of descriptive analysis are presented in Table 3. In this table, it appears that there is a descriptive difference in the average score of students' critical thinking skills who learn with PBFL and DFL, as well as between those who have low and high academic procrastination.

| TABLE III. DESCRIPTIVE RESULTS |
|-------------------------------|
| PBFL                          | DFL                          |
| LAP                           | LAP                          |
| $M_1 = 51.64$                 | $M_1 = 38.68$                |
| SD $= 13.34$                  | SD $= 8.09$                  |
| $M_2 = 40.14$                 | $M_2 = 33.73$                |
| SD $= 14.02$                  | SD $= 9.58$                  |
| HAP                           | HAP                          |
| $M_1 = 45.89$                 | $M_2 = 36.21$                |
| SD $= 14.72$                  | SD $= 9.10$                  |

The data normality test based on the learning model is shown in Table 4 and based on academic procrastination in Table 5. Based on Table 4 and Table 5, it appears that the Pre critical thinking (PreCT) data and critical thinking (CT) data in all groups are normally distributed.

| TABLE IV. TEST OF NORMALITY BASED ON MODEL |
|------------------------------------------|
| Source | Model | Kolmogorov-Smirnov | Shapiro-Wilk |
|        |       | Statistic | df | Sig. | Statistical | df | Sig. |
| PreCT  | PBFL  | .112      | 44 | .200 | .978        | 44 | .546 |
| DFL    | .093  | 44        | .200 | .977 | 44          | .522 |
| CT     | PBFL  | .118      | 44 | .137 | .956        | 44 | .090 |
| DFL    | .101  | 44        | .200 | .971 | 44          | .332 |

| TABLE V. TEST OF NORMALITY BASED ON ACADEMIC PROcrastination |
|---------------------------------------------------------------|
| Source | Acacproc | Kolmogorov-Smirnov | Shapiro-Wilk |
|        |          | Statistical | df | Sig. | Statistical | df | Sig. |
| PreCT  | .086     | 44          | .200 | .967 | 44           | .245 | .086 |
|        | .107     | 44          | .200 | .968 | 44           | .250 | .107 |
| CT     | .150     | 44          | .014 | .970 | 44           | .315 | .150 |
|        | .109     | 44          | .200 | .967 | 44           | .238 | .109 |

The results of the homogeneity analysis of variance are shown in Table 6, which states that the variance between treatment groups is homogeneous. Similarly, the compact test results as shown in Table 7, found $F = 2.513$ with the number sig. $= 0.064$ which is greater than 0.05, so the variance between groups is homogeneous.

| TABLE VI. TEST OF HOMOGENEITY VARIANCE |
|----------------------------------------|
| Source | Based On | Levene Statistic | DF1 | DF2 | Sig |
| PreCT  | Mean      | 0.001            | 1   | 86  | 0.990 |
|        | Median    | 0.002            | 1   | 86  | 0.964 |
|        | Median and with adjusted df | 0.002 | 1 | 85.818 | 0.964 |
|        | Trimmed mean | 0.001 | 1 | 86 | 0.991 |
| CT     | Mean      | 0.008            | 1   | 86  | 0.930 |
|        | Median    | 0.001            | 1   | 86  | 0.977 |
|        | Median and with adjusted df | 0.001 | 1 | 85.210 | 0.977 |
|        | Trimmed mean | 0.005 | 1 | 86 | 0.944 |

| TABLE VII. LEVENE'S TEST OF EQUALITY OF ERROR VARIANCES |
|--------------------------------------------------------|
| Dependent Variable: CT                                  |
| $F$ | df1 | df2 | Sig. |
| 2.513 | 3 | 84 | .064 |

The result of the analysis showed that linearity statistics had the value of $F = 31.2$ with the level of significance of 0.01 < 0.05 and deviation from linearity statistics showed the value of $F = 1.0$ with the level of significance of 0.5 > 0.05, so that the covariate was linear to the dependent variable of critical thinking skill.

Because the assumption test has shown that ANACOVA can be done, the following is the result of the Test of between subject effects from ANACOVA, as in Table 8.

| TABLE VIII. TEST OF BETWEEN SUBJECT EFFECTS |
|---------------------------------------------|
| Source | Type III Sum of Squares | df | MS | $F$ | Sig. |
| PreCT  | CT | 2260.163 | 1 | 2260.163 | 21.08 | 0.000 |
|        | Error | 8198.655 | 83 | 107.213 | 0.000 |
| Model  | 1831.367 | 1 | 1831.367 | 11.76 | 0.006 |
|        | Error | 155.471 | 999 | 155.625 | 0.000 |
| Acacproc | 1086.911 | 1 | 1086.911 | 7.006 | 0.025 |
|        | Error | 157.140 | 1.013 | 155.144 | 0.000 |
| Model* | 155.590 | 1 | 155.590 | 1.451 | 0.232 |
| Acacproc* | 8898.655 | 83 | 107.213 | 0.000 |

Based on Table 8, the following findings can be presented. 1) From the source of the influence of PreCT on CT, it appears that the statistical value was $F = 21.081$ with sig = 0.001. Number sig. this is less than 0.05, so the preCT covariate significantly affects CT. 2) Based on the source of the influence of the model on CT, it is revealed that the statistical value of $F = 11.769$ with sig = 0.006. Number sig. is <0.05, so it can be stated that there is a difference in the effect between PBFL and DFL on CT.

| TABLE IX. COMPARISON MEAN BASED ON MODEL |
|-----------------------------------------|
| Source | Mean | SD | Lower Bound | Upper Bound |
| PBFL  | 43.89 | 14.72 | 42.507 | 48.721 |
| DFL   | 36.21 | 9.10 | 33.370 | 39.584 |
By comparing the mean CT values of PBFL and DFL in Table 9, it appears that PBFL has a higher effect than DFL in achieving CT. Comparison mean based on Acaproc can be seen in Table 10.

| Source | Mean | SD  | Lower Bound | Upper Bound |
|--------|------|-----|-------------|-------------|
| LAP    | 45.16| 12.72| 41.468      | 47.697      |
| HAP    | 36.94| 12.29| 34.394      | 40.623      |

3) Based on the source of acaproc’s influence (Table 8) on CT, it was found that F = 7.006 with the number sig. = 0.025. Number sig. is <0.05, so it is stated that there is a difference in the effect between LAP and HAP on CT. By comparing the mean CT values of LAP and HAP, it appears that students who have LAP tend to be able to achieve higher CT than those who have HAP. 4) Based on the source of influence of the * acaproc model (Table 8), it appears that F = 1.451 with the number sig. = 0.232. Number sig. > 0.05, so it can be stated that there is no interactive effect between learning models and academic procrastination on critical thinking skills. The interaction profile is not significant at the sig. 5% is shown in Figure 1.

![Graph showing estimated marginal means of CT](image)

Fig. 1. Profile of interaction between learning models and academic procrastination, not significant at 5% significant level.

IV. DISCUSSION

Physics learning in senior high school which tends to use the direct learning (DL) model should be immediately abandoned, especially in an effort to facilitate students in developing critical thinking skills. One of its substitutes is the problem-based learning (PBL) model. The two models can be integrated as pedagogical content of flipped learning (FL), so that the two learning models in this study are termed problem-based flipped learning (PBFL) and direct flipped learning (DFL). The purpose of this study was to analyze the differences in the main effect and interaction between PBFL and DFL on students’ critical thinking skills viewed from students’ academic procrastination attitudes in learning physics in senior high school.

The results of the analysis of the main effect of the learning model show that there is a significant difference in the effect of PBFL and DFL on students’ critical thinking skills. Students who studied with the PBFL model showed a significantly higher critical thinking skill than those who studied with the DFL model. The results of this study are in accordance with the results of previous studies [10,42-44]. The advantage of the PBFL model compared to the DFL model is because in the PBFL model students are more involved in learning to empower critical, analytical, systematic and logical thinking to determine alternative problem solving through empirical data exploration to foster scientific attitudes [29]. Although the PBFL model is superior to the DFL model in achieving critical thinking, the results shown are inadequate. The results on the PBFL are indicated by an average value of M = 45.89; SD = 14.72 in the low category, the more so the results shown by the DFL model are M = Mt2 = 36.21; SD = 9.10 in the very low category. This result is relatively greater than the results of previous studies [10], which in the PBL model only achieved critical thinking skills with an average value of M = 36.86; SD = 0.561, very low category, and DL model with M = 33.02; SD = 0.561, very low category. This is because students are not used to learning to solve non-routine problems which are packaged in the PBFL model. These results indicate that the PBL or PBFL model must be continuously implemented intensively in learning physics in order to facilitate students to achieve more optimal critical thinking skills.

The results of the analysis of the main effect of academic procrastination attitudes show that there is a significant difference in the effect of low academic procrastination (LAP) and high academic procrastination (HAP) on students’ critical thinking skills in learning physics in senior high school. Students who have LAP show critical thinking skills is significantly higher than students who have HAP. The results of this study are in accordance with previous studies [28]. Quantitatively, the average value of critical thinking skills that can be achieved by students who have LAP is M = 45.62 with SD = 12.72, in the low category, while those achieved by students who have HAP are M = 36.94; SD = 12.29 with very low category. In physics learning in high school, students who have more LAP who have HAP should be guided continuously not to procrastinate in doing their study assignments.

The results of the analysis of the interactive effect of the learning model (PBFL v.s DFL) and academic procrastination (LAP v.s HAP) on critical thinking skills show that in achieving critical thinking skills, the two learning models do not interact significantly. These results indicate that both the PBFL and the DFL models accommodate students’ LAP and HAP in physics learning. These results reinforce the thesis that students undoubtedly need guidance in order to minimize their
academic procrastination attitudes in learning physics in senior high school.

V. CONCLUSION AND SUGGESTION
There is a significant difference in the effect between PBFL and DFL on students’ critical thinking skills. Students who learn with the PBFL model show a significantly higher critical thinking skill than those who learn with the DFL model. The implication is that the PBL or PBFL model must be continuously and intensively implemented in physics learning in order to facilitate students to achieve more optimal critical thinking skills.

There is a significant difference in the influence between low academic procrastination (LAP) and high academic procrastination (HAP) on students’ critical thinking skills in learning physics in senior high school. Students who have HAP show critical thinking skills is significantly higher than that achieved by students who have HAP. In physics learning in high school, students who have more LAP or HAP should be guided continuously not to procrastinate in doing their study assignments.

There is no interactive effect between the learning model (PBFL v.s DFL) and academic procrastination (LAP v.s HAP) on critical thinking skills. Both PBFL and DFL models accommodate students’ LAP and HAP in physics learning. The implication is that students undoubtedly need guidance in order to minimize their academic procrastination attitudes in learning physics in senior high school.

ACKNOWLEDGMENT
Thank you to the Principal of SMAN 2 Semarapura Klungkung Bali for the permission given to do the research, thanks to Gede Bayu Adipura and Kadek Nopri Aryan, they are the Physics Teachers of SMAN 2 Semarapura Klungkung Bali who became collaborators of this research. Lastly, thanks to the Ganessa University of Education Research Institute for the fees provided.

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