Flipped Learning Models and Students’ Scientific Literacy on Physics Achievement Test

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Abstract. This study aimed to determine the influence of flipped learning models and scientific literacy on students’ achievement test. The study used a quasi-experimental research method with two-way analysis of variance (ANOVA). The subjects of this study were Grade 10 high school physics students. The samples were two experimental groups where one group used inquiry flipped learning approach and the other group used mastery flipped learning. Both groups were given a scientific literacy test to separate students into two categories, which were students who had high scientific literacy and students who had low scientific literacy. The research showed that physics achievement test for students who learned by using inquiry flipped learning was similar than those who learned by using mastery flipped learning. Also, the achievement test for students who had high scientific literacy was greater than students who had low scientific literacy. The results of the research test indicated that there is a significant difference in achievement test between students who had high scientific literacy and students who had low scientific literacy.

1. Introduction
Science education in Indonesia has been developed since starting to participate in the Program for International Student Assessment (PISA) in 2000. In 2015, Indonesia is ranked fifth in the development of the education system out of 72 countries who participate in PISA. If Indonesia have continuous development, then in ten years, it is estimated that Indonesian students can compete internationally. Recently, Indonesia got an average PISA 2015 test score below the average score of the Organisation for Economic Co-operation and Development (OECD) countries on the science literacy basis [1]. The PISA assessment framework uses a four-factor approach, namely complexity, familiarity, forming a response and cognitive operation. PISA categorizes the cognitive processes required for the competencies that form the basis of scientific literacy together with consideration of the depth of knowledge required in the assessment of cognitive learning outcomes in the field of sciences including physics topic. PISA defines three scientific literacy competencies, namely scientifically explaining natural phenomena, evaluating and designing scientific investigations, and scientifically interpreting data and evidence. The assessment of students reading texts to understand and answer written questions about scientific literacy raises the problem of the level of reading literacy required. [2] Scientific literacy is that someone can ask, seek, or determine answers to questions that come from curiosity about everyday experiences. This means that a person has the ability to describe, explain, and predict natural
phenomena. Scientific literacy requires the ability to read by understanding articles about science to engage in social conversations about the validity of conclusions [3].

Another fact obtained from preliminary studies by distributing a questionnaire based on needs analysis in one of a private high school in Banten, Indonesia. It was found that students were still low in applying science concepts in everyday life. Questionnaires were distributed to 83 students in class XI senior high school. There are 50.6% of students have not solved problems in everyday life with science concepts, as many as 48.2% of students have not been able to analyze science articles using science concepts. 43.4% of students have not yet demonstrated the understanding of science concepts.

In the analysis of a study related to the results of the Indonesian PISA test, it is suggested that further research is needed in order to improve science learning in Indonesia, one of which is pedagogy using active learning [4]. In recent years, a popular learning model that uses active learning is the flipped classroom learning approach [5] [6]. When using the flipped classroom, students performed significantly on the assessment and were allowed to do 50% more hands-on activities in the classroom [7]. Through flipped classroom, students gain cognitive skills such as the acquisition of knowledge before lessons and focus on application, analysis, synthesis and evaluation [8]. Flipped Classroom has an advantage over more traditional forms of teaching and can be taken to the next level, thus shifting to deeper learning strategies, such as flipped-mastery, or a more project-based model. Flipped Learning is the second stage of the flipped classroom, where teachers can use classroom time to become more content-rich, inquiry-based, and project-based [9].

The need for active learning is also supported by preliminary studies that have been carried out by a researcher. A total of 23 teachers from private schools in Banten filled out a questionnaire on the implementation of Physics learning. 95.65% agree that the subject matter of Physics is easier for students to understand through learning videos than the lecture method. 73.9% of teachers strongly agree that active learning such as discussions, experiments or projects can further enhance 21st century skills than delivering subject matter through teacher lectures. 82.60% of teachers strongly agree that students can better understand learning in the classroom if they have prior knowledge about the material to be taught compared to students who attend without preparation. 91.30% of teachers agree that by watching learning videos before attending class, teachers can carry out active learning. The use of active learning is supported by a research on the effect flipped classroom model on physics lesson had been compared with a traditional teaching approach. This study showed that flipped classroom model can improve physics learning outcome [10]. Research on the implementation of the development of the science literacy with a critical thinking framework aimed to improve the quality of science education [11]. Flipped classroom can be said to be a learning model that assigns homework before coming to class. Class time is spent solving problems, learning concepts and engaging in collaborative learning [12]. These activities will need a cognitive process that can predict academic performance [13].

The Cognitive Level was first presented by Bloom et al. where only one dimension that was ordered in such a way: Knowledge, Understanding, Application, Analysis, Synthesis and Evaluation [14]. Anderson et al. has revised Bloom's Taxonomy. Bloom's Revised Cognitive Taxonomy consists of two dimensions, namely: cognitive process dimensions (remembering, understanding, applying, analyzing, evaluating, making) with sub-categories and knowledge dimensions (factual, conceptual, procedural and metacognitive) [15]. Revised Bloom Taxonomy can be used to plan learning outcomes in physics lesson. Learning outcomes are statements that describe the knowledge or skills that students must acquire at the end of a particular assignment, class, course, or program, and help students understand why the knowledge and skills will be useful to them. They focus on context and the ability to apply knowledge and skills, help students relate education in various contexts, and help guide evaluation and assessment. Good learning outcomes emphasize the implementation and integration of knowledge. Not only focusing on the scope of the material, educational learning outcomes articulate how students will be able to use the material, both in the classroom context and more broadly [16].

Based on the previous description, the authors are interested in conducting research on the influence of flipped learning and science literacy on the physics achievement test. In this study, researchers used
two models of flipped learning, namely inquiry flipped learning model and mastery flipped learning model.

2. **Method**
The study was conducted at one of the private high schools in Banten, Indonesia from May – June 2021. This study used a quasi-experimental method and the design used was 2 x 2 levels of treatment. The method aims to predict conditions that can be achieved in actual experiments, but there is no control or manipulation of all variables. In this research design, there are two independent variables which are learning model and scientific literacy and one dependent variable which is achievement test.

| Table 1. Research design |
|--------------------------|
| Scientific literacy | Flipped Learning Models |
| | Inquiry | Mastery |
| High | A₁B₁ | A₂B₂ |
| Low | A₁B₂ | A₂B₂ |

In this study, one group learned a physics lesson by using the Inquiry Flipped Learning model, and the other group learned by using Mastery Flipped Learning model. Both groups were given scientific literacy test.

The score of the scientific literacy test were then sorted from the highest to the lowest. Based on this value, 27% of the higher score was taken as the high scientific literacy group, and 27% of the lowest score was taken as the low scientific literacy group. After the treatment, a physics achievement test on the Newton’s Laws of Motion topic was given at the end of the meetings. Both instruments had been tested for validity and reliability. Data obtained from these two instruments were tested for analysis prerequisites which are normality and homogeneity test, followed by two-way ANOVA hypothesis test.

3. **Results and Discussions**
The mean scores for physics achievement test on Newton’s Laws of Motion topic in each group are presented in Table 2.

| Table 2. Mean Scores for Each Group |
|------------------------------------|
| Scientific literacy | Flipped Learning Models |
| | Inquiry | Mastery |
| High | 79.38 | 77.75 |
| Low | 67.50 | 66.75 |

Before testing the hypothesis, a normality test and a variance homogeneity test were carried out using IBM SPSS software. The normality test was carried out using the Shapiro-Wilk test, which resulted in a significant value of $p > 0.05$ which means that students’ achievement test data were normally distributed. The homogeneity of the variance by the Levene’s test also resulted in a significant value of $p > 0.05$. This shows that students’ achievement test from two groups of learning models were homogeneous. Then, hypothesis testing was carried out using two-way ANOVA. On Table 3 presents dependent variable ANOVA using IBM SPSS.
Table 3. Two-way ANOVA Output using IBM SPSS

| Source                | Type III Sum of Squares | df | Mean Square | F    | Sig  |
|-----------------------|-------------------------|----|-------------|------|------|
| Corrected Model       | 1059.344a               | 3  | 353.115     | 2.199| .110 |
| Intercept             | 169798.781              | 1  | 169798.781  | 1057.260 | <.001 |
| Learning Models (A)   | 11.281                  | 1  | 11.281      | .070 | .793 |
| Scientific literacy (B) | 1046.531             | 1  | 1046.531    | 6.516 | .016 |
| A * B                 | 1.531                   | 1  | 1.531       | .010 | .923 |
| Error                 | 4496.875                | 24 | 160.603     |      |      |
| Total                 | 175355.000              | 32 |             |      |      |
| Corrected Total       | 5556.219                | 31 |             |      |      |

*R Squared = .191 (Adjusted R Squared = .104).

The testing outputs show that there was no significant difference in achievement test between the learning models ($F = 0.070$ and $p = 0.793$), while there was a significant difference in achievement test between students who had high scientific literacy and students who had low scientific literacy ($F = 6.516$ and $p = 0.016$). Meanwhile, there was no significant interaction between the learning models and scientific literacy. The interaction between learning models and scientific literacy on students’ achievement test is shown in Figure 1.

![Figure 1. Interaction between learning models and scientific literacy on students’ achievement test](image)

The estimated marginal means of inquiry flipped learning model and mastery flipped learning model shows no significant difference is no surprise since both flipped learning models are active learning
model. These results are in line with research on flipped classroom and non-flipped classroom but using a constructivist approach. The learning gains in either condition are most likely a result of active learning style of instruction [17].

The difference in students’ scientific literacy shows a significant difference in the achievement test score. The result obtained are in line with DeBoer which stated that scientific literacy requires the ability to read by understanding articles about science to engage in social conversations about the validity of conclusions [3]. This is because, when students with higher science literacy will more likely to understand physics learning materials better than the students with lower science literacy.

4. Conclusion
Based on the research results obtained from data analysis, it can be concluded that the achievement test for students who learned by using inquiry flipped learning model was similar to students who learned through mastery flipped learning model. Also, there is no significant interaction between the learning models and scientific literacy on students’ achievement test. However, the achievement test for students who had high scientific literacy is greater than students who had low scientific literacy. Therefore, based on hypothesis testing, there is a significant difference in achievement test between students who had high scientific literacy and students who had low scientific literacy.

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