Trends of Flipped Classroom Studies for Physics Learning: A Systematic Review

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Abstract. This study focused to review the trends of the Flipped Classroom (FC) studies for physics learning. This review seeks to address the overall trends of the existing studies, contribution of integrated model or strategy and media into flipped classroom approach, the advantages of flipping classroom for physics courses, and the challenges of these studies. This structured review examined 33 article journal about flipped classroom for physics learning. The obtained data were analyzed using content analysis method. It was found that the studies in this field were generally carried out at undergraduate students, which pure flipped model, used discussion method and institution website for online media. The implementation of flipping classroom approach in a physics course yielded positive impact on student achievement when compared to traditional classroom. On the other hand, some challenges were identified, such as students' challenges, teacher challenges, and technical challenges.

1. Introduction
The development of information and communication technology in the 21st century is increasing in all fields, including in the field of education. Flipped Classroom (FC) is a new and popular learning model, in which learning activities that are usually carried out in the classroom are turned into home activities, and activities that are usually homework are turned into classroom activities [1]. Interactive activities involving higher order thinking skills are the main activities in the classroom [2]. Abeysekera and Dawson [3] define the flipped classroom as a learning approach that has the following characteristics:

1) move most of the teaching/delivery of subject matter outside the classroom
2) use class time for active and interactive learning activities
3) require students to complete pre- and/or post-class activities in order to fully benefit from in-class activities

In other words, the more specific characteristics of the flipped classroom approach include:

1) Changes in the use of class time
2) Changes in the use of time outside of class
3) Doing activities that are traditionally considered 'homework' in class
4) Doing activities are traditionally considered as 'work in class' outside of class
5) Classroom activities that emphasize active learning, peer learning, and problem solving
6) There are pre-class activities
7) There are post-class activities
8) Use of technology, especially video.
Broadly speaking, the flipped classroom has two stages in its learning, namely pre-class learning and classroom learning. Pre-class self-learning is carried out before class starts which refers to the delivery of knowledge in students' private spaces, usually at this stage teaching materials are given in video format and exercises related to the material being studied. In the next stage, activities are carried out in class in groups or in pairs using discussion, exercise or project methods [2][4]. Flipped classroom is a technology-based learning approach that emphasizes problem solving in peer-assisted learning in the classroom [5][6]. Flipped classroom is seen as a learner-centered learning approach [4]. So that the teacher only acts as a facilitator to motivate, control and provide feedback on the results that students provide[7]. Along with the trend of flipping classroom research, the application of the flipped classroom in various fields of study has been carried out [7], one of which is in learning physics. The view that physics is a difficult subject is always attached to students [8]. Therefore, studying the subject matter before learning in class is one way to increase student understanding. In addition, the use of interesting media can change students' bad perspective on physics. The application of flipping classroom is quite effective in improving student learning outcomes in class [7]. This is also expected in physics learning research. From the results of the identification, several research questions were formed including:

1) What is the trend of flipping classroom research on physics learning from 2016 to 2021?
2) What learning models and methods are usually integrated with the flipped classroom approach?
3) What media and platforms are usually integrated with the flipped classroom approach?
4) What are the benefits of applying flipped the classroom to physics learning?
5) What are the challenges of applying flipped the classroom to physics learning?

2. Method
This study analyzed and synthesized articles about flipped classrooms in physics learning from 2016 to April 2021. Articles were collected using Publish or Perish software using the keywords “flipped” or “flipped physics” in the Google Scholar database. There are several criteria used to select the articles to be analyzed. The criteria are as follows.

| Included | Excluded |
|----------|----------|
| English  | Non-English |
| Journal articles, book chapter | Non-journal article (e.g. proceedings, conference series, book review, web article, theses, etc.) |
| Empirical research | Literature review, meta analysis |
| Physics learning | Non-physics learning (e.g. EFL, math, etc.) |
| Full document | Abstract only |
| 2016 – April 2021 | May 2021 and later |

The first search found 108 articles. Then the articles were selected by reading the abstract and adjusted to the criteria. So that at the final stage, 33 articles were obtained that met the criteria.
3. Results and Discussion

3.1 Flipped Classroom research trends in physics learning

This study analyzes articles on the flipped classroom approach to physics learning from 2016 to mid-2021. Based on the 33 articles collected, flipped classroom research for physics learning was most published in 2018 (n=8) and the last in 2019 (n=4) and in 2021 (n=4). However, because the data was collected only until mid-2021, which indicates that flipped classroom research on physics learning may still increase over time. So it can be observed that there was a significant decline from 2018 to 2019 which issued the fewest publications.

Research in flipped classrooms will mostly be applied in universities. This is because the learning independence factor for university students is quite good compared to high school students.
### Table 2. Learner type.

| Learner type   | Number | Article                                                                 |
|----------------|--------|-------------------------------------------------------------------------|
| Secondary school | 14     | [9][10][11][12][13][14][15][5][16][17][18][19][20][21]                 |
| Undergraduate   | 17     | [22][23][24][25][26][27][28][29][30][31][32][33][34][35][36][37][38] |
| Postgraduate    | 1      | [39]                                                                    |
| Diploma Program | 1      | [40]                                                                    |

### 3.2 Learning models and methods

In several studies it was found that the flipped classroom approach can be integrated with various supportive learning models. However, 73% of the articles analyzed showed that the application of the flipped classroom approach was pure without being integrated with other learning models. However, several studies have integrated the flipped classroom approach with other learning models that support active learning.

In its application, a learning approach usually applies several learning methods in it. The learning methods that are more integrated in the flipped classroom are discussion methods (31%), quizzes (17%) and experiments (11%). The methods of discussion, experimentation, question and answer, demonstration, problem solving, and peer instruction support active learning in the classroom at the in-class stage. Gamification, quiz and simulation methods are usually applied with the help of online platforms and support pre-class activities.
3.3 Learning media and platforms

In flipped classroom-based learning, of course, requires online-based learning media, especially the Learnings Management System (LMS) which is used to support pre-class activities. The LMS platforms found in this study include Moodle, Edmodo, Google Classroom, and institutional websites designed specifically for online learning at these institutions. A total of 13 studies show that the use of special websites designed by institutions or specially designed by researchers is able to support the effectiveness of the application of the flipped classroom approach. Several websites that have been specially developed by institutions/institutions include LAMS (Learning Activity Managenet System), online annotation system and M-learning media. In addition to using the LMS, several studies also use social media such as WhatsApp and blogs to support pre-class learning activities. At the stage of in-class, integrated multiple platforms learning that support active learning, quiz games like Edpuzzle, Kahoot, quizzes, Flipquiz. The platforms are used with the hope to make the learning process more active and certainly fun to motivate students to more contribute during the learning process of physics class.

3.4 Advances by applying flipped the classroom to physics learning.

The application of the flipped classroom has many benefits for learning physics. The findings of this study indicate that the most common benefits of applying flipped classrooms are to improve learning outcomes in learning physics which is often considered difficult.
Table 3. Advances by applying flipped the classroom to physics learning.

| Advances                                   | Number | Sample Article |
|--------------------------------------------|--------|----------------|
| Improve physics learning achievement       | 16     | [34]           |
| Improve students’ motivation               | 5      | [9]            |
| Increase students’ self-direction in learning | 5     | [31]           |
| Positive responses from students           | 5      | [28]           |
| Increase students’ understanding           | 4      | [27]           |
| Increased student participation            | 4      | [13]           |
| Good time management                       | 4      | [23]           |
| Develop interpersonal interaction          | 3      | [21]           |
| Increase students’ interest                | 2      | [15]           |
| Increase positive students’ attitudes      | 2      | [22]           |
| Increase student engagement                | 2      | [37]           |
| Develop specific skills                    | 1      | [30]           |
| Increase students’ awareness               | 1      | [14]           |
| Decrease students’ anxiety                 | 1      | [28]           |
| Active learning                            | 1      | [28]           |

3.5 The challenge of applying the flipped classroom to physics learning

Some studies do not write about the difficulties in implementing the flipped classroom and only focus on the benefits of its implementation. This study analyzes the difficulties in implementing the flipped classroom in physics learning which are grouped into three categories, namely student difficulties, teacher difficulties and technical difficulties (table 4). The results of the analysis show that the most difficult student difficulties or during pre-class activities. Some students do not do pre-class activities well, for example, students do not watch the video material that has been provided by the teacher [10]. Some studies also show that students find it difficult to participate in dynamic and independent learning [17]. The most common problem found from the teacher's point of view is that the flipped classroom approach requires quite a lot of preparation, such as preparing learning videos, homework assignments, and the use of the LMS as a support for pre-class activities [8]. Technology for teachers who will apply this learning approach.

Table 4. The challenge of applying the flipped classroom to physics learning.

| Challenges                                   | Number | Sample Article |
|----------------------------------------------|--------|----------------|
| Students                                    |        |                |
| Students need more motivation to do pre-class activities | 4     | [39]           |
| Students have difficulty in dynamic learning | 4     | [28]           |
| Increase students’ study hours               | 1      | [25]           |
| Students unable to ask questions while pre-class | 1     | [16]           |
| Students do not prefer it                    | 1      | [32]           |
| Teachers                                     |        |                |
| Need more teachers’ preparation             | 7      | [17]           |
| Teachers should be more trained              | 2      | [12]           |
| Teachers have difficulty controlling students’ pre-class activities | 2     | [26]           |
| Time consuming                               | 2      | [27]           |
| Technical                                   |        |                |
| Problem of technology and internet access    | 4      | [13]           |
4. Conclusion

The study is analyzing the study of literature about the flipped classroom approach to learning physics from 2016 to mid 2021. The publication of research on the flipped classroom on learning physics at most that in 2018 but experienced a drastic decline in subsequent years. This approach is applied more at the university level than at the secondary school level. The independence of students at the university level is more supportive in the application of the flipped classroom in physics lessons. In its application, the flipped classroom approach is mostly applied without being combined with other learning models, but several studies explain that the integration of certain learning models can support the implementation of the flipped classroom. The discussion method is the most widely integrated learning method with the flipped classroom, especially in in-class activities. The application of the flipped classroom must be supported by adequate technology and platforms. A total of 13 studies use and implement their respective institution's website as an online platform to support pre-class activities in the flipped classroom.

Basically, the application of flipping classroom in physics learning has a very positive impact, especially in improving physics learning achievement. However, in its implementation, there are several obstacles, especially during pre-class activities. The study shows that there are still many students who are not motivated to participate in pre-class learning activities and follow the subject matter with dynamic methods. The difficulty experienced by the teacher is that it takes more time to prepare before learning activities. The next challenge that is often found in this study is technology and internet access.

The flipped classroom approach has indeed supported the active learning process. However, integrating certain learning models and methods that also support active learning can be a good choice. There are not many studies on integrating the flipped classroom approach with learning models and methods. Therefore, more studies are needed on this matter.

In addition, students who are less motivated in pre-class activities are always a recurring problem and are often found in the application of flipping classrooms. Therefore, it takes a fun way and method of learning in pre-class activities that can also control student participation.

The determination of the articles analyzed in this study is less specific because it is only searched using the Google Scholar database. In addition, the article selection process that only reads the abstract manually can produce different results if analyzed by different researchers. Therefore, an efficient selection method, or tool is needed to select articles.

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