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A Meta-Analysis of the Impact of the Flipped Classroom Learning Model on Students' Motivation in Physics Education

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Abstract

The Flipped Classroom learning model is an innovative educational approach with the potential to enhance students' learning motivation. This study aims to synthesize research findings on the impact of the Flipped Classroom model on students' motivation. A meta-analysis was conducted using seven research studies, focusing on the educational levels and calculating effect sizes with Microsoft Excel 2010. The results reveal that the highest effect size was observed at the higher education level, while the lowest effect size was also noted in the same category, suggesting variability within this level. Overall, the findings indicate that the Flipped Classroom model positively influences students' learning motivation. Further empirical research is recommended to validate and strengthen the results of this preliminary meta-analysis.

Keywords: *Flipped Classroom, Learning, Motivation, Physics Lesson*

Introduction

Physics is a subject that is often perceived as challenging and less favored by students, which is evident in the consistently low levels of mastery of physics concepts among learners [1]. This lack of mastery can be attributed to several factors, one of the most significant being students' insufficient motivation towards learning physics [2]. Motivation is a critical determinant of academic success, as it strongly influences not only the effort students put into learning but also the overall quality and quantity of their learning outcomes [3]. Lack of intrinsic and extrinsic motivation significantly hinders students' cognitive and emotional engagement, resulting in reduced understanding and less-than-optimal learning outcomes. To address these challenges, there is a growing need for innovative learning models that can better engage students and enhance their intrinsic motivation to learn, particularly in subjects like physics which students tend to find difficult.

One such innovative learning model that has gained considerable attention in recent years is the flipped classroom [4]. This model is a shift from traditional teaching by reversing the general roles of in-class and out-of-class activities. Unlike lecture learning, where content is delivered in class and students are expected to learn independently at home, the flipped classroom places content delivery outside the classroom. Content is usually in the form of instructional videos or other multimedia learning resources. These materials are made available to students before class, allowing them to study the content at their own pace and in a manner that suits their learning style. Class time is then used for more interactive and

student-centered activities, such as problem-solving, group discussions, and hands-on exercises, where students can apply what they have learned. By focusing on higher-order thinking skills and active learning during class time, the Flipped Classroom model aims to foster deeper engagement, improve understanding, and ultimately boost student motivation and achievement in challenging subjects like physics [6]. Through this approach, students are not only more involved in their learning but are also encouraged to take greater responsibility for their educational progress.

Previous studies have suggested that the Flipped Classroom model can enhance students' motivation to learn physics [7]-[9]. However, these findings remain limited and may not be generalizable across different populations. This highlights the need for further research to examine the impact of the Flipped Classroom model on students' motivation, specifically in the context of physics education. Based on this background, the following research questions were formulated:

1. What is the impact of the Flipped Classroom model on learning physics?
2. Are there differences in the impact of the Flipped Classroom model across educational levels?

Methods

This study aimed to analyze the impact of the Flipped Classroom model on students' motivation in learning physics using a meta-analytic approach to quantitative research. Since its introduction in 1976 by Glass, meta-analysis has become a statistical method for combining data from two or more similar studies, allowing researchers to draw stronger and more comprehensive conclusions by synthesizing diverse findings [10].

Data on the Flipped Classroom model and its effect on students' motivation in learning physics were collected from seven journal articles published between 2016 and 2023. These articles were accessed via the Publish or Perish tool and Scopus database using the keywords: "Flipped Classroom," "Motivation," and "Physics."

The methodology of this research emphasized a rigorous approach to data collection and analysis. Statistical metrics such as correlation coefficients (r), F, or t values were extracted from each article included in the study. When these metrics were not available, the researchers relied on mean scores (M) and standard deviations (SD) reported in the articles to calculate effect sizes. The formula was used to determine the effect size [11], defined as equation 1.

$$ES = \frac{M1-M2}{SD_{pooled}} \quad (1)$$

where

M1: the mean scores of the experimental group
M2: the mean scores of the control group
SD_{pooled}: the combined standard deviation

This formula enabled a consistent measurement of the magnitude of influence across the various studies.

Cohen's classification [12] was applied to interpret the effect sizes, providing a standardized framework for categorization. Effect sizes less than 0.2 were classified as weak, those ranging from 0.2 to 0.5 as moderate, values between 0.5 and 0.8 as strong, and values of 0.8 or greater as very strong.

Microsoft Excel 2010 was used to process the data, calculate effect sizes, and categorize the results accordingly. This systematic approach ensured accurate and consistent analysis, enabling meaningful comparisons of the impact of flipped classroom learning on student motivation in physics across diverse research contexts.

Results and Discussion

This study aimed to analyze the impact of the Flipped Classroom model on students' motivation in learning physics, providing insights for future research on this innovative instructional approach. Data were collected from seven studies conducted over the past seven years, each sourced from reputable international journals. Table 1 shows the source identities.

Table 1. The source identities

Code	Authors	N	Level	Effect of Size
P1	Cagande & Jugar [13]	47	Higher education	1.118
P2	Aşıksoy [14]	61	Higher education	3.150
P3	Aşıksoy & Özdamlı [15]	66	Higher education	0.000
P4	Alarabi, Alqawasmi, & Alsalhi [16]	84	Secondary school	0.150
P5	Hung & Young [17]	89	Higher education	0.017
P6	Joaquin VII & Andal [18]	60	Secondary school	0.792
P7	Bawaneh & Moumene [19]	123	Higher education	0.122

The studies involved a range of sample sizes, from small-scale groups of 21 students to large-scale groups of 1,621 students. The effect sizes (ES) for the studies varied widely, ranging from 0.0 to 3.150, as summarized in Table 2.

Table 2. The effect sizes (ES) of each source

Study	Effect Size (ES)	Effect Size Category
P1	1.118	Very Large
P2	3.15	Very Large
P3	0	Small or Negligible
P4	0.15	Small or Negligible
P5	0.017	Small or Negligible
P6	0.792	Large
P7	0.122	Small or Negligible

The effect sizes reported in the studies varied significantly. Specifically, two studies (P1 and P2) demonstrated a very large effect size, with values exceeding 0.8, indicating a substantial impact of the intervention or learning model. One study (P6) reported a large effect size, falling within the range of 0.5 to 0.8, suggesting a moderate but meaningful effect on the learning outcomes. In contrast, four studies (P3, P4, P5, and P7) reported small or negligible effect sizes, with values less than 0.2, which suggests that the interventions or approaches used in these studies had minimal or no significant effect on the students' learning experiences or achievements. This variation in effect sizes highlights the diverse outcomes of different educational strategies and the need for further exploration into factors that contribute to more effective learning models.

Effect size measures the strength of the relationship between the Flipped Classroom model and students' motivation. It complements significance testing by allowing comparisons across studies with

different scales [20]. In the secondary school group, the studies showed varied effect sizes. One study reported a small effect size [16], while another study showed a large effect size [18]. Additionally, two studies in this group reported very large effect sizes, indicating a significant impact of flipped classroom learning on student motivation in these contexts [13],[14]. In contrast, higher education (college/university) studies primarily exhibited small effect sizes [15],[17],[19]. Three studies in this category reported small effect sizes, suggesting a more limited influence of the flipped classroom approach at the university level. However, two studies in higher education reported very large effect sizes, indicating that the flipped classroom method had a substantial effect on student motivation and learning outcomes in certain higher education settings. The highest effect size (3.150) was found in a study conducted in higher education by Aşıksoy [14], while the lowest (0.0) was reported by Aşıksoy & Özdamlı [15].

The findings suggest that the Flipped Classroom model is particularly effective in higher education settings, as it enhances the efficiency and effectiveness of learning. This model aligns with adult learners' needs, encouraging independent study outside the classroom and focusing on deeper understanding and problem-solving during in-class sessions. The large effect sizes observed in higher education may be attributed to the autonomy and self-regulated learning capabilities of university students, who can effectively engage with pre-class materials. Additionally, the model fosters interactive classroom environments, which are beneficial for enhancing motivation and interest in learning.

In contrast, the smaller effect sizes observed in secondary education could be due to several factors, including students' limited self-regulation skills and the need for more structured guidance in managing pre-class learning materials. The variability in effect sizes across studies underscores the importance of context in implementing the Flipped Classroom model. Differences in study design, sample size, instructional materials, and teacher facilitation may influence the outcomes.

These results emphasize the potential of the Flipped Classroom model to positively influence students' motivation, particularly in higher education. However, further empirical research is needed to explore its effectiveness in secondary education and other contexts. Investigating additional factors such as instructional quality, student readiness, and technological support will help refine the model for broader application. The findings of this meta-analysis provide a foundation for educators and policymakers to consider implementing the Flipped Classroom model, with particular attention to tailoring the approach to the specific needs of learners at different educational levels.

Conclusion

This study highlights the impact of the Flipped Classroom model on students' motivation in learning physics, synthesized through a meta-analysis of seven studies. The results demonstrate that the model generally has a positive influence on students' motivation, with the strongest effects observed in higher education contexts. The large effect sizes in higher education suggest that this instructional approach effectively leverages students' capacity for independent learning and classroom engagement. However, the variability in effect sizes across different educational levels indicates that the success of the Flipped Classroom model depends on factors such as students' readiness, instructional quality, and

contextual implementation. While it proves highly effective in university settings, its application in secondary education may require additional support and adjustments to maximize its potential. Future studies should explore the contextual factors influencing these outcomes to optimize the model's application across diverse educational settings.

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