International Journal of STEM Education for Sustainability, Vol.5, No.2, 2025, pp. 208-214
e-ISSN 2798-5091. DOI. 10.53889/ijses.v5i2.704

The Implementation of the Flipped Classroom Learning Method to Address Conceptual Understanding on Dynamics Concepts

Submitted 2 July 2025, Revised 29 July 2025, Accepted 31 July 2025

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Abstract

The purpose of this study was to determine how well students understood dynamics principles when using the flipped classroom learning methodology. A pretest-posttest control group was included in the quasi-experimental design of the study. A total of 72 students were separated into two groups, namely the experimental group using the flipped classroom model and the control group with the conventional method. Questionnaires to gauge student impressions and two-tier multiple-choice examinations to gauge conceptual knowledge were the primary tools. According to the research findings, the experimental group's normalized gain value of 0.67 (high category) significantly outperformed the control group's 0.41 (medium category) in terms of conceptual comprehension. The two groups differed significantly ($p < 0.05$) according to the independent t-test. These findings support the effectiveness of the flipped classroom in enhancing conceptual understanding, encouraging active student engagement, and aligning with the principles of the *Merdeka* Curriculum. However, the success of implementing this model is also influenced by the readiness of teachers, students, and adequate technological infrastructure. For other areas of physics, similar models should be developed, and further mixed-methods research is needed to further explore students' experiences.

Keywords: Flipped Classroom, Conceptual Understanding, Dynamics

INTRODUCTION

According to Dogani (2023), the 21st-century educational paradigm demands a shift from passive learning to active learning, which emphasizes direct student engagement. In such circumstances, technology-based and student-centered learning approaches have become a significant focus of educational research (Levitt & Grubaugh, 2023). The flipped classroom model is one pedagogical innovation that is gaining popularity at various levels of education. It is believed to provide better opportunities for students and overcome the challenges of conventional learning (Lu et al., 2023).

The flipped classroom model allows students to learn material outside of class through digital media, such as interactive modules and videos. Meanwhile, discussions, problem-solving, and other active learning activities take up class time (Ahmed & Indurkhya, 2020). Therefore, the teacher's role shifts from imparting knowledge to assisting students in learning. Meanwhile, students are given greater responsibility to oversee their own learning (Subagia, 2020). This strategy aligns with the spirit of the *Merdeka* Curriculum, which prioritizes differentiated learning, the Pancasila student profile, and project-based learning (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2022).

Students struggle to understand the relationship between the concepts of force, mass, and acceleration. This is a significant problem in physical education, particularly in dynamics

(Haryadi & Pujiastuti, 2015; Besa, 2022). Previous research has shown that traditional methods are less effective in instilling conceptual understanding of physics due to their overemphasis on mathematical and procedural aspects (Phanphech et al., 2019). Consequently, alternative learning models are needed to enhance student engagement and understanding of abstract physics concepts (Diani et al., 2019).

Flipped classrooms can improve students' learning motivation, critical thinking skills, and science learning outcomes, according to several studies (Peng et al., 2022; Naing et al., 2023). However, the effectiveness of this model remains debated, especially in secondary education in Indonesia. Teacher readiness, the availability of digital infrastructure, and student characteristics are all crucial factors for the successful implementation of the flipped classroom model (Shikino et al., 2022).

This research is based on the need to determine the effectiveness of the flipped classroom model in high school physics education, particularly with dynamics material, which is known to be highly complex (Haryadi, 2016). In the study, conducted at a high school in Tangerang, Indonesia, a M*erdeka* curriculum was used as the basis for learning. Conceptual understanding was measured using a conceptual diagnostic test both before and after the treatment (Haryadi et al., 2021). Additionally, quantitative and qualitative analysis methods were used. Additionally, this research examines how students perceive their learning experience with the flipped classroom.

This research is important because it can help develop more contextual, technology-based, and participatory physics learning practices. This research is also expected to help physics teachers create lessons that align with the *Merdeka* Curriculum. They can also assist policymakers in creating plans to implement rotational learning in secondary schools.

In general, this field of research has rapidly developed in recent years. However, there is still little research evaluating how the flipped classroom can help secondary school students in Indonesia better understand physics concepts. As a result, by using a systematic methodological approach based on empirical data, this research seeks to fill that gap.

Some of the hypotheses in this research are controversial. However, there is a belief that the flipped classroom can significantly enhance conceptual understanding. Conversely, this model is ineffective for students with low learning motivation or limited access to technology (Shikino et al., 2022). This difference of opinion formed the basis for this study to evaluate previous findings in a more specific context.

The authors of this study argue that students learning through the flipped classroom model will better understand the concept of dynamics compared to students learning through the conventional model. This hypothesis was tested using a quasi-experimental design with a pretest-post-test control group.

Based on the background, this study aims to evaluate the effectiveness of the flipped classroom learning model in improving students' understanding of dynamics concepts, as well as to evaluate student engagement and response to the model. The primary findings of this study indicated that students had a better understanding of the concepts and were more engaged in learning after using the model.

METHOD

The pretest-posttest control group design is a quasi-experimental method used in this study. The subjects of this study were 11th grade students of Mathematics and Natural Sciences at one of the high schools in Tangerang, Indonesia. To select two classes, each with 36 students, a purposive sampling technique was used. 11th grade students of Mathematics and Natural Sciences 1 were selected as the experimental group using a flipped classroom model, and 11th grade students of Mathematics and Natural Sciences 2 were selected as the control group using a conventional method.

The study lasted three weeks, with six sessions. The experimental group was taught dynamics material through digital modules and videos before the sessions, while class sessions focused on problem-solving and discussion. The control group received direct instruction through lectures and periodic problem-solving exercises.

The primary instrument used was a two-tiered multiple-choice test that examined understanding of previously validated dynamics concepts. For each experimental group, a perception questionnaire and pretests and post-tests were used to collect data. Independent t-tests were used to examine differences in understanding improvement between groups after testing for normality and homogeneity of the data.

RESULTS AND DISCUSSION

How students' understanding of dynamics is affected by the implementation of the flipped classroom model is the subject of this study. To measure the experimental and control groups, pretests and post-tests were used. The data obtained were analyzed to determine score improvement and the effectiveness of the learning model by calculating normalized gain values. Table 1 shows the average scores for the pretest and post-test for each group.

Table 1. Average Pretest and Post-test Scores

Group	Pretest (Average)	Posttest (Average)	Difference
Experimental	43,61	81,39	37,78
Control	44,03	67,22	23,19

As evidence that the flipped classroom model helps people understand dynamic concepts better, this table shows that the experimental group experienced an average increase of 37.78 points, while the control group only experienced an increase of 23.19 points. The effectiveness of the learning is measured using the normalized gain, with the formula:

$$\mathrm{N-Gain} = \frac{(Posttest\ Score - Pretest\ Score)}{(Maximal\ Score - Pretest\ Score)}$$

Table 2. Normalized Average Gain

Group	Average Gain	Effectiveness Category
Experimental	0,67	High
Control	0,41	Medium

Based on the data in Table 2, the experimental group achieved an average gain of 0.67, which falls into the "high" category, while the control group achieved a gain of 0.41, categorized as “medium”. This shows that the implementation of the flipped classroom model is more effective than conventional learning in improving conceptual understanding.

Table 3. Independent t-Test Results on Gain Scores

Variable	Group	N	Mean	Std. Deviation	Sig. (2-tailed)	t	df
Gain Score	Experimental	36	0,67	0,12	0,000	6,482	70
	Control	36	0,41	0,14			

According to the independent t-test results on the increase in comprehension of the dynamics concept, the significance value (Sig. 2-tailed) derived from the data in Table 3 was 0.000, which was less than the significance level of 0.05. The conclusion that there is a statistically significant difference between the experimental group utilizing the flipped classroom model and the control group using the traditional method is supported by the computed t-value of 6.482 with 70 degrees of freedom (df). The control group's average gain score was 0.41 with a standard deviation of 0.14, whereas the experimental group's average gain score was 0.67 with a standard deviation of 0.12. Therefore, it can be concluded that, compared to conventional teaching methods, the use of the rotational learning model is significantly more effective in enhancing students' understanding of dynamic concepts.

The research results show that students who learn through the flipped classroom model significantly understand concepts better than students who learn through conventional methods. These findings answer the research question of whether implementing the flipped classroom model can truly enhance conceptual understanding as stated in the initial hypothesis.

Scientifically, the higher reinforcement score of the experimental group (0.67) compared to the control group (0.41) can be explained by the cognitive mechanisms present in the flipped classroom model. By reading textbooks, students have the opportunity to independently acquire basic knowledge before face-to-face meetings. Furthermore, the purpose of classroom learning activities is to increase active interaction between teachers and students, expand discussion space, and improve conceptual understanding. This method is in line with the theory of social constructivism, which emphasizes the importance of active participation and cooperation in the learning process.

The results of this study align with previous studies. For example, Peng et al., 2022 and Naing et al., 2023 found that flipped classrooms can significantly improve student achievement because they allow for deeper participation in learning. This model also increases students' desire to learn, especially in science education, according to the research (Dori et al., 2020). Therefore, the findings of this study reinforce the existing empirical evidence regarding the advantages of the flipped classroom model, particularly in enhancing students' understanding of abstract physics concepts such as dynamics.

However, these results also indicate how prepared teachers and students are to implement this model. Technology infrastructure, digital literacy skills, and students' readiness to manage their study time are necessary. Self-directed learning outside the classroom initially posed challenges for some students. Therefore, the flipped classroom model does not only rely on the learning design; the overall learning ecosystem is also crucial for success.

Both physics teachers and curriculum developers benefit from this research. The spirit of the *Merdeka* Curriculum, which emphasizes independent learning, competency strengthening, and differentiated learning, aligns with the flipped classroom model. By utilizing technology and digital media, teachers can enhance students' learning spaces outside the classroom and improve important interactions within the classroom.

Further research can focus on the long-term application of this model and on conceptual physics materials such as harmonic motion, fluids, or dynamic electricity. Studies that combine qualitative methods can also further explore students' learning experiences and implementation issues in the field. Additionally, school-based or regional comparative research could provide a better understanding of how effective this model is in various settings.

Overall, this research contributes to the development of new approaches to technology-based physics learning. It has been shown that the flipped classroom model can improve student understanding of the material, increase active student participation, and support learner-centered education.

CONCLUSION

The research findings indicate that the flipped classroom method aligns with current educational trends, which emphasize the use of technology, active student participation, and self-directed learning. Consequently, this model is worthy of consideration as a strategic alternative for the development of physics education and other conceptual fields.

Research on the implementation of the flipped classroom should be conducted at various educational levels and over a longer period of time. Mixed-methods research that combines quantitative and qualitative approaches can also provide a better understanding of students' learning experiences and the challenges faced when implementing this model in various contexts.

ACKNOWLEDGMENT

The authors would like to express his gratitude to the Directorate of Research and Community Service (DPPM), Ministry of Higher Education, Science, and Technology, of the Republic of Indonesia for funding this research through *Penelitian Tesis Maguister* Scheme year 2025.

REFERENCES

Ahmed, M. M. H., & Indurkhya, B. (2020). Investigating cognitive holding power and equity in the flipped classroom. *Heliyon*, *6*(8). https://doi.org/10.1016/j.heliyon.2020.e04672

Besa, E. (2022). *Dynamics-aktion II . Propuestas en el Taller de Proyectos de Diseño y más allá Dynamics-aktion II . Pedagogical dynamics and beyond*. 103–130.

Diani, R., Irwandani, I., Al-Hijrah, A.-H., Yetri, Y., Fujiani, D., Hartati, N. S., & Umam, R. (2019). Physics Learning through Active Learning Based Interactive Conceptual Instructions (ALBICI) to Improve Critical Thinking Ability. *Jurnal Penelitian Dan Pembelajaran IPA*, *5*(1), 48. https://doi.org/10.30870/jppi.v5i1.3469

Dogani, B. (2023). Active learning and effective teaching strategies. *International Journal of Advanced Natural Sciences and Engineering Researches*, *7*(4), 136–142. https://doi.org/10.59287/ijanser.578

Dori, Y. J., Kohen, Z., & Rizowy, B. (2020). Mathematics for Computer Science: A Flipped Classroom with an Optional Project. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(12), 1–20. https://doi.org/10.29333/ejmste/9149

Haryadi, R. (2016). Analisis Motivasi Belajar Terhadap Hasil Belajar Mahasiswa Pada Mata Kuliah Fisika Dasar Berdasarkan Golongan Darah. *Biodidaktika: Jurnal Biologi Dan …*, *11*(1).

Haryadi, Rudi, Nuraini, H., & Kansaa, A. (2021). Pengaruh Media Pembelajaran E-Learning Terhadap Hasil Belajar Siswa. *AtTàlim : Jurnal Pendidikan*, *7*(1), 2548–4419.

Haryadi, Rudi, & Pujiastuti, H. (2015). Pengaruh Kemampuan Matematis Terhadap Hasil Belajar Fisika. *Prosiding Seminar Kontribusi Fisika*, 174–177.

Levitt, G., & Grubaugh, S. (2023). Teacher-centered or Student-centered Teaching Methods and Stu-dent Outcomes in Secondary Schools: Lecture/Discussion and Pro-ject-based

Learning/Inquiry Pros and Cons. *EIKI Journal of Effective Teaching Methods*, *1*(2), 36–38. https://doi.org/10.59652/jetm.v1i2.16

Lu, C., Xu, J., Cao, Y., Zhang, Y., Liu, X., Wen, H., … Zhu, H. (2023). Examining the effects of student-centered flipped classroom in physiology education. *BMC Medical Education*, *23*(1). https://doi.org/10.1186/s12909-023-04166-8

Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. (2022). Dimensi, Elemen, dan Subelemen Profil Pelajar Pancasila pada Kurikulum Merdeka. Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia

Naing, C., Whittaker, M. A., Aung, H. H., Chellappan, D. K., & Riegelman, A. (2023, September 1). The effects of flipped classrooms to improve learning outcomes in undergraduate health professional education: A systematic review. *Campbell Systematic Reviews*, Vol. 19. John Wiley and Sons Inc. https://doi.org/10.1002/cl2.1339

Peng, W., Xiong, Y., Wei, J., Chen, X., Huai, W., He, S., … Chen, Y. (2022, August 30). Flipped classroom improves student learning outcome in Chinese pharmacy education: A systematic review and meta-analysis. *Frontiers in Pharmacology*, Vol. 13. Frontiers Media S.A. https://doi.org/10.3389/fphar.2022.936899

Phanphech, P., Tanitteerapan, T., & Murphy, E. (2019). Explaining and enacting for conceptual understanding in secondary school physics. *Issues in Educational Research*, *29*(1), 180–204.

Shikino, K., Ide, N., Kubota, Y., Ishii, I., Ito, S., Ikusaka, M., & Sakai, I. (2022). Effective situation-based delirium simulation training using flipped classroom approach to improve interprofessional collaborative practice competency: a mixed-methods study. *BMC Medical Education*, *22*(1). https://doi.org/10.1186/s12909-022-03484-7

Subagia, I. W. (2020). Roles Model of Teachers in Facilitating Students Learning Viewed from Constructivist Theories of Learning. *Journal of Physics: Conference Series*, *1503*(1). https://doi.org/10.1088/1742-6596/1503/1/012051