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Exploring The Effect of Discussion Based Learning in The Flipped Classroom on Physics Concept Mastery

Mawarni Saputri*, Evendi, & Rouzatul Jannah
Department of Physics Education, Universitas Syiah Kuala, Indonesia

Abstract: This study aims to determine the effect of the Flipped Classroom learning model through the discussion method in improving students' conceptual understanding in physics learning. The population in this study consisted of all 49 eleventh-grade students, divided into a control class and an experimental class. The instruments used in this study were test instrument (two tier test) and non-test instruments (observation sheet and student response questionnaires). Students categorized as having a "known concept" in the control class increased to 67%, while in the experimental class, this increased to 88%. Students categorized as having a "misconception" in the control class decreased to 33%, and in the experimental class, this decreased to 20%. Students categorized as "guessing" in the control class decreased to 4%, while in the experimental class, this decreased to 0%. Students categorized as having an "unknown concept" in the control class decreased to 33%, while in the experimental class, this decreased to 24%. The results of the analysis of the student response questionnaire showed an average score of 72.25, which indicated to "good" category. The hypothesis test results revealed a $tcount$ value of 5.605 > $ttable$ value of 1.67, indicating a significant difference in the improvement of conceptual understanding between students in the experimental and control class. Furthermore, the N-Gain analysis resulted in a score of 0.74, categorized as high. Therefore, it can be concluded that the Flipped classroom learning model through the discussion method positively influences students' conceptual understanding in physics learning.

Keywords: flipped classroom learning model, discussion method, conceptual understanding.

▪ INTRODUCTION

Education is an effort to develop and optimise the potential of learners through the facilitation of teaching and learning activities. As a dynamic form of human culture, education plays an important role in life, especially in the process of learning and transferring knowledge (Yulianti, 2021). Improving the quality of education aims to make it better and able to produce quality future generations. Educational goals can be achieved if the learning process is designed according to the times. One step towards quality education is to improve the quality of learning, for example through the selection of learning models that are relevant to the material (Noviyana, 2018).

Along with the times, teachers are required to continue to improve their competence (Nurgiansah & Pringgowijoyo, 2020). However, in practice, teachers still often use the lecture method, which makes students act more as listeners. Teachers tend to give examples and their solutions without giving students the opportunity to actively participate, so students only take notes and are less involved. This condition makes students less active and creative in the learning process (Utami et al., 2020).

Based on initial observations made during the School Field Practice (PLP) 2 activities in the Merdeka Belajar Kampus Merdeka (MBKM) program at SMAN 1 Baitussalam, Aceh Besar, it was found that physics learning still focuses primarily on reading materials as the main resource. This approach tends to be passive, limiting students' opportunities to actively engage in the learning process, which results in

Mawarni Saputri
*Email: mawarni_saputri@usk.ac.id
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difficulties in understanding abstract and complex physics concepts. According to the 2018 Program for International Student Assessment (PISA) report, Indonesian students' performance in science literacy is still relatively low, with an average score of 396, far below the OECD average of 489. This indicates that Indonesian students face challenges not only in understanding the material but also in applying scientific concepts to real-life situations. Additionally, a study by Kurniawan (2020) shows that traditional teaching methods, which rely solely on text or lectures, are less effective in building deep conceptual understanding and developing students' critical thinking skills.

To address this issue, innovation in learning is needed to optimize students' learning time, both inside and outside the classroom. One approach that is considered effective is the flipped classroom model. This model moves theoretical learning activities outside the classroom through independent learning materials, such as videos, modules, or presentations, so that class time can be used for discussions, collaboration, and concept reinforcement (Fauzan, 2021). With learning media available outside the classroom, class time can be maximized for discussion, providing students with opportunities to develop their understanding of physics concepts. Through this model, students can access material not only in class but also outside the classroom.

In this approach, students study materials at home before class meetings, so that when in class, they can focus on activities such as working on assignments, discussing, or addressing materials or problems they have not understood (Fradila et al., 2015). Students' initial understanding of the material before class starts is very helpful in solving problems given by the teacher in class. Students also become more active in connecting the problems presented by the teacher with the material they have previously learned. A previous study by Zainuddin & Halili (2016) showed that the flipped classroom model can significantly improve students' conceptual understanding, engagement in learning, and critical thinking skills.

According to Patandea and Indrajit (2021), Flipped Classroom is a learning strategy and method that reverses the pattern of teaching in a conventional classroom. In conventional classes, teachers usually deliver material in class and then give assignments to do at home. However, in Flipped Classroom, the teacher asks learners to study the material before the class starts. The teacher provides learning videos, teaching materials, references, and other materials that help students understand the basic concepts before the class meeting. The Flipped Classroom model is also often used in online learning, where learning activities are conducted outside the classroom (online) and then continued in face-to-face sessions (Hadijah & Shalawati, 2021).

Previous research (Aprianah et al., 2018) showed that the Flipped Classroom model was effective in increasing students' self-efficacy. Meanwhile, another study by Widodo et al. (2021) revealed that the Flipped Classroom model supports the independence of 6th grade students of SD Negeri 1 Trucuk in understanding mathematical concepts and working on problems well, where students look more prepared in online learning. Fauzi et al. (2022) and Fikri (2019) also found that although the use of Flipped Classroom with the help of learning videos can improve students' understanding of mathematical concepts, its effectiveness has not been proven better than conventional methods, as the results of the n-gain average test showed no significant difference between the experimental and control classes. Another study by Juniantari et al. (2018) found that students who learned with the Flipped Classroom approach had a higher understanding of mathematical concepts than those who learned with conventional methods, indicating a positive influence of this approach on student understanding.

This study is different from the four previous studies because previous studies generally highlighted the effectiveness of Flipped Classroom in improving self-efficacy and concept understanding in mathematics learning. However, this study focuses on the application of the Flipped Classroom model with discussion methods in physics learning to strengthen concept understanding. This is based on the finding that the use of Flipped Classroom which is only assisted by video is not fully effective in improving students' concept understanding.

This research has significance because conventional learning models often do not provide enough time and opportunities for students to understand concepts deeply, especially in physics learning which requires a high level of understanding. The Flipped Classroom model combined with the discussion method has the potential to overcome these obstacles by allowing students to study basic materials independently outside the classroom, so that time in class can be optimally used for discussion and deepening concepts.

▪ METHOD

Participants

The participants in this study consisted of 11th-grade students from a senior high school who had previously studied specific physics concepts.. The samples were selected using purposive sampling technique based on certain considerations relevant to the research objectives (Maharani, 2018). The research sample comprised two classes selected using purposive sampling, with a total of 49 students divided into 25 in the experimental group and 24 in the control group. The sample selection was based on the equivalence of academic characteristics and readiness to participate in the intervention.

Research Design and Procedures

This type of research is quantitative research with experimental methods. The experimental method is a method used to determine the effect of independent variables (treatment) on the dependent variable (outcome) under controlled conditions. Conditions are controlled so that there are no other variables (other than treatment variables) that affect the dependent variable (Sugiono, 2018).

This study uses a quasi-experimental design with a pretest-post test control group design. The selection of this design is based on the research conditions where random assignment of subjects (Randomized Control Trials/RCTs) is not feasible due to administrative and ethical limitations in the context of formal education. According to Creswell (2014), quasi-experimental designs are often used in educational research when interventions need to be implemented in existing classrooms without disrupting the established learning structure. Additionally, this design still allows for comparison of treatment effects, even though control over external variables is not as strict as in Randomized Control Trials/RCTs.

The steps of the research include: 1) Development of research instruments and validation by experts, 2) Conducting a pretest to measure students' initial understanding, 3) Implementing the treatment for the experimental group using a discussion-based method, while the control group uses a lecture method, 4) Monitoring and observing student discussions in the experimental class, 5) Conducting a post test to measure improvements in understanding, and 6) Data analysis to determine the effectiveness of the treatment.

Instruments

The research instruments consisted of tests and non-tests. The test instrument given was a concept understanding test during the pre-test and post-test. Multiple choice questions with the Two-Tier Test model were used to measure students' understanding concept of the material. The Two-Tier Test instrument is adapted from previous research that has been tested for its validity. The content validity of the instrument was examined by three experts in the field of physics education. The test instrument used was the Two-Tier Test, with the scoring guidelines presented in table 1 below. The criteria for answers to measure students' conceptual understanding are presented in table 2.

Tabel 1. Two-Tier test scoring guidelines

Criteria	Score
No answer	0
Answers more than one option	0
One correct answer in the second tier	0
One correct answer pada first tier	1
Two correct answer	2

Table 2. Student answer criteria and categories

Types of Student Answer	Explanation	Category
C-C (Correct-Correct)	The student answers both questions correctly.	Known concept
C-I (Correct-Incorrect)	The student answers correctly at the first tier and incorrectly at the second tier.	Misconception
I-C (Incorrect-correct)	The student answers incorrectly at the first tier but correctly at the second tier.	Guessing
I-I (Incorrect-Incorrect)	The student answers both questions incorrectly.	Unknown concept

This test instrument measures students' conceptual understanding through three aspects: translation, interpretation, and exploration (Anderson & Krathwohl, 2015). In the translation aspect, the indicators used are interpreting and exemplifying. In the interpretation aspect, the indicators measured include students' ability to classify, explain, and conclude. Meanwhile, in the exploration aspect, the indicators measured are students' ability to compare and summarize the concepts that have been learned.

In addition, non-test instruments used in this study was observation and student response questionnaires. The questionnaire was used to measure student responses to the application of the Flipped Classroom learning model on optical equipment material. This questionnaire consists of 20 statements, consisting of 15 positive statements and 5 negative statements, and then its result was analyzed by percentage formula.

Data Analysis

Data analysis in this study was carried out through several stages of statistical testing. The first stage begins with the prerequisite test of analysis which consists of normality test and homogeneity test. In addition, the data also analyzed by hypothesis test (t test) to explore the effect discussion based learning in the flip classroom and N-gain test to know the improvement of conceptual understanding of students.The N-gain calculation uses the formula (posttest score - pretest score)/(100 - pretest score). The results of the N-gain calculation were then categorised into three levels: low if N-gain < 0.3, medium if 0.3 ≤ N-gain < 0.7, and high if N-gain > 0.7. This analysis provides an overview of the extent of the increase in students' concept understanding after participating in learning (Lestari, 2017). N-Gain is chosen because it provides a more objective picture of the intervention's effectiveness compared to just using the difference between pretest and posttest scores. Compared to merely using the difference between pretest and posttest scores, N-Gain provides a more proportional measure of the difficulty level of the concepts being studied and allows for a fairer comparison between groups.

▪ RESULT AND DISSCUSSION

The instruments have been validated in this study are the lesson plan (RPP), student worksheets (LKPD), concept understanding test, observation sheet for learning implementation, and student response questionnaire. The results of the instrument validation are briefly presented in the table 3.

Table 3. The results of the instrument validation

No	Instruments Type	Average	Category
1	Validation sheet of lesson plan	3.6	Valid
2	Validation sheet of students' worksheet	3.0	Valid
3	Validation sheet of concept understanding test	3.5	Valid
4	Validation sheet for the learning implementation observation sheet	4.0	Very valid
5	Validation sheet for the student response questionnaire	4.0	Very valid
	Average	3.62	Valid

Based on the table 3, the validation results of both non-test and test instruments show an average validity score of 3.62, categorized as valid. This indicates that the instruments are suitable for measuring the research variables.

In addition from the research findings, the conceptual understanding of students in physics learning is still relatively low. This low level of understanding can be seen from the results of the pre-test. Before the intervention was applied, the average student was still categorized under misconceptions, guessing, and unknown concepts. However, after the intervention, the misconceptions, guessing, and unknown concepts shifted to known concepts. The data from the concept understanding tests in the pre-test and post-test are described in several categories, including known concept, unknown concept, misconception, and guessing. To observe the differences in each category, refer to Figures 1 and 2.

Students categorized under "known concept" in the experimental class were 48%, and in the control class, 29%. After the intervention, the experimental class increased to 88%, and the control class increased to 67%. Students categorized under "misconception" in the experimental class were 48%, and in the control class, 42%. After the intervention, the experimental class decreased to 20%, and the control class decreased to 33%.

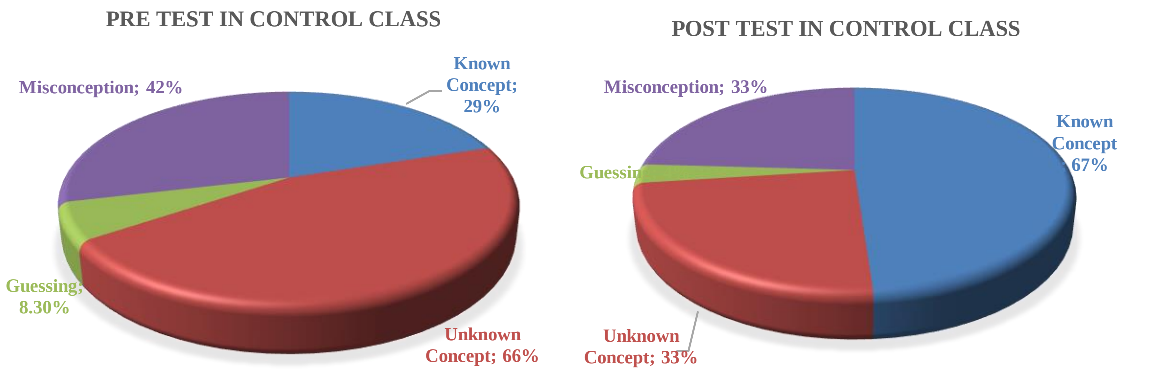

Figure 1. Data on pretest and post test results by categoty in the control class

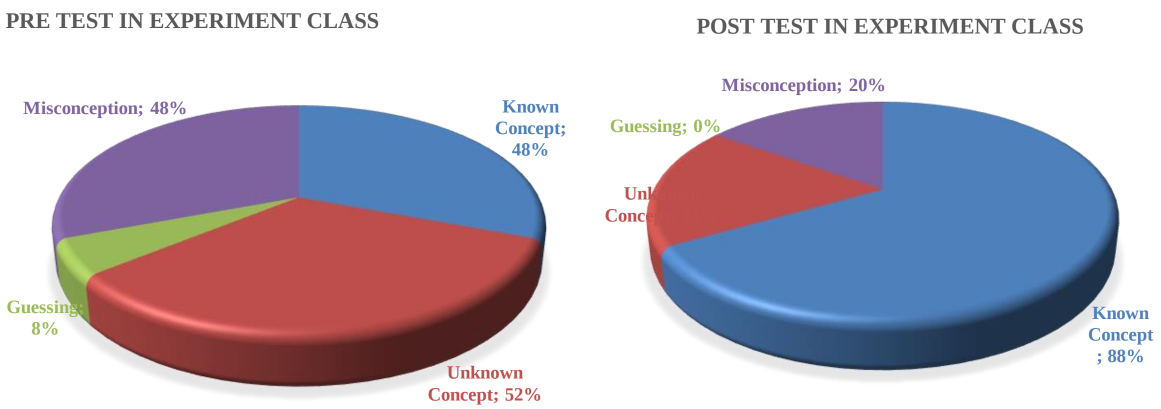

Figure 2. Data on pretest and post test results by categoty in the experiment class

Misconceptions that frequently occur among students, such as difficulties in memorizing and understanding the material being taught (Jusniar et al., 2020), can be addressed through the application of more interactive and in-depth learning models, one of which is the flipped classroom combined with discussion methods. A study by Amdani et al. (2022) shows that low student interest in learning can cause difficulty in understanding types and functions of human senses, while Suryawan et al. (2020) emphasize that a lack of understanding in memorizing material often leads to misconceptions that impact learning outcomes.

Students categorized under "guessing" in the experimental class were 8%, and in the control class, 8%. After the intervention, the experimental class decreased to 0%, and the control class decreased to 4%. Students categorized under "unknown concept" in the experimental class were 52%, and in the control class, 67%. After the intervention, the experimental class decreased to 24%, and the control class decreased to 33%. From these four categories, it is evident that there was an improvement in conceptual understanding (known concept) in both classes. Students who understand a concept demonstrate that they can process the concepts learned during the learning process (Pradina, 2020).

Flipped classroom offers an advantage by shifting basic learning activities, such as memorizing and reading materials, outside the classroom through videos or independent learning resources. This approach provides more in-class time for active activities, such as group discussions or collaborative problem-solving. During discussions, students not only act as receivers of information but also as active participants who can express opinions, ask questions, and share knowledge with one another. The discussion method also helps students explore concepts more deeply than just relying on memorization. In line with Haerunnisa et al. (2022), students who understand concepts through discussions tend to retain the material better and solve problems more accurately compared to students who only rely on memorization. The flipped classroom, complemented by discussions, allows students to directly address and correct misconceptions, as discussions provide opportunities to explore concepts in depth, engage with peers, and receive clarifications from the teacher.

Meanwhile, the overall results of students' conceptual understanding in the pre-test and post-test, without categorizing, can be seen in Figure 3.

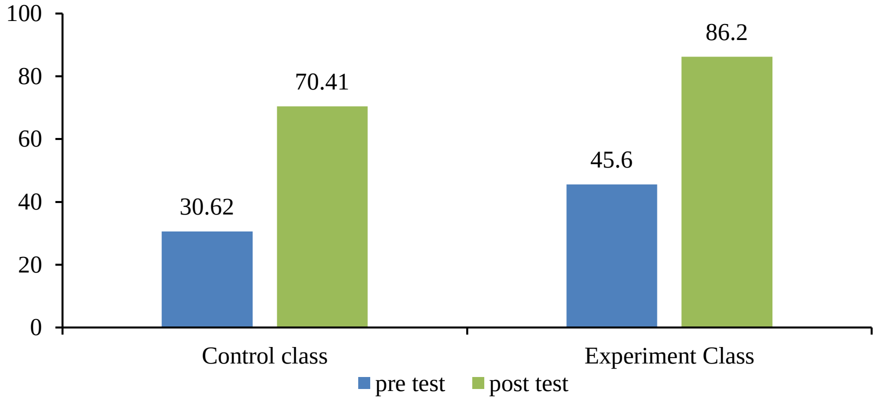

Figure 3. The improvement of students' conceptual understanding based on the average pre-test and post-test scores

Based on Figure 3, the understanding of concepts by students, as seen in the final test (post-test) results, showed an improvement in both the experimental and control classes. The average post-test score in the experimental class was 86.2, while the control class had an average post-test score of 70.41. This indicates that students in the experimental class, which used the Flipped Classroom model, had a higher level of concept understanding compared to the control class, which used conventional teaching methods. This difference is likely due to the Flipped Classroom approach, which allows students to learn the material at home first, so that class time can be focused on deeper discussions and the application of concepts. The comparison of pretest and posttest data shows a significant improvement in conceptual understanding in the experimental class. However, some students still experience misconceptions despite using the Flipped Classroom approach. This may be due to several factors, such as difficulties in independently understanding video materials, lack of interaction with the teacher during online learning sessions, or deeply rooted initial misconceptions that are difficult to change in a short period. According to Taber (2009), misconceptions in physics are often persistent and require deeper interventions to be corrected.

According to Namaziandost & Cakmak (2020), Flipped Classroom enhances students' self-efficacy because they come to class with a foundational understanding already formed, making them more confident and actively engaged in class.

In line with the research by Nurma'ardi et al. (2022), initial understanding plays a crucial role in determining learning outcomes. Misconceptions at the beginning can make it difficult for students to answer questions correctly. As explained by Pratiwi et al. (2022), a lack of understanding of concepts at the early stages of learning can lead to repeated mistakes in subsequent lessons, as reflected in incorrect student responses. These errors are often exacerbated by students' lack of attention to detail, such as not carefully reading the wording of a question (Ramadhini & Kowiyah, 2022). Precision and the ability to comprehend material are critical internal factors that greatly influence students' success in answering questions (Rosdianah et al., 2019). With the Flipped Classroom model, students not only improve their initial understanding but also develop analytical skills that help them become more attentive when reading and understanding questions, thus increasing their chances of achieving better learning outcomes.

The data from the pre-test and post-test were processed using prerequisite tests (normality and homogeneity tests). After the data showed a normal distribution and homogeneity, a t-test was conducted. Based on the t-test results, the calculated t-value for the post-test was 5.605, which is greater than the table t-value of 1.67. Therefore, in line with the hypothesis, it can be concluded that there is a significant difference in the effectiveness of the Flipped Classroom model with the discussion method in improving students' conceptual understanding in physics education.

The data between the experimental and control classes also showed an improvement, supported by the N-gain test results. In the experimental class, the average N-Gain score was 0.74, which falls into the high gain index category indicating the effectiveness of the Flipped Classroom method in improving students' understanding. This result aligns with the study conducted by Lo et al. (2017), which also found a significant improvement in physics conceptual understanding through a similar instructional model. However, another study by Chen et al. (2020) suggests that the effectiveness of the Flipped Classroom depends on students' readiness for independent learning and the quality of the provided materials. In contrast, the control class had an average N-Gain score of 0.57, placing it in the medium gain index category. Both classes experienced an improvement in conceptual understanding, but the experimental class showed a higher increase due to the difference in the teaching model applied. According to Sin & Siahpoosh (2020), the Flipped Classroom model creates more interactions, which help improve conceptual understanding, particularly in the context of a more active and collaborative classroom.

The implementation of the Flipped Classroom model in the experimental class was also reflected in the observation of the lesson's implementation. The average implementation rate during the first meeting was 88.8%, and the second meeting had an average of 87.5%, with an overall average of 88.15%, indicating a "very good" implementation. This shows that the Flipped Classroom model with the discussion method was applied effectively. This success is attributed to the fact that Flipped Classroom allows students to study the material first, making them more prepared for in-class learning. Moreover, the Flipped Classroom model provides teachers with more time in class to focus on deeper activities such as discussions, practices, or projects, while students learn basic theory outside the classroom through independent learning materials. In addition, the study by Bergmann & Sams (2012) shows that the success of the Flipped Classroom heavily depends on students' active engagement in learning. In this context, the improvement in understanding observed in the experimental class can be attributed to the higher level of interaction during face-to-face learning sessions after watching the instructional videos.

By utilizing the advantages of Flipped Classroom and discussion methods, students are expected not only to memorize the material but also to understand it in a broader context, thereby enhancing their critical thinking, problem-solving skills, and avoiding misconceptions that can hinder their learning process. A high level of implementation of this model results in better learning outcomes, as it supports students' creativity during the learning process (Trisnowali & Aswina, 2019).

Next, based on the analysis of the student response questionnaire, which covers four indicators, the average score obtained was 72.25, falling into the "good" category. The detailed breakdown can be seen in Table 3.

Table 4. Analysis result of student response questionnaire

Indicator	Statement	%	Average	Category
I. Engagement with the Flipped Classroom learning model	7	74	77.5	Good
	10	74		
	11	81		
	13	80		
II. Benefits of the Flipped Classroom model	1	69	77.4	Good
	4	80		
	5	74		
	8	77		
	14	76		
	15	80		
	17	74		
	19	85		
	20	82		
III. Challenges of using the Flipped Classroom model	3	53	57	Enough
	6	57		
	9	63		
	12	57		
	18	55		
IV. Students' expectations of the Flipped Classroom model	2	78	77	Good
	16	76		
Average			**72.25**	**Good**

Based on the four indicators, the average score of the student response questionnaire was 72.25, which falls into the "good" category. This is because more students answered positively than negatively. The Flipped Classroom model increases student engagement and learning outcomes by utilizing class time for active learning activities, while learning materials are accessed independently outside of class (Zainuddin & Attaran, 2016). By using the discussion method within the Flipped Classroom model, students are given the opportunity to exchange ideas and clarify their understanding of the physics material. This not only enhances conceptual understanding but also encourages students to be more active and collaborative in the learning process. Overall, from the previous data analysis, it can be concluded that the Flipped Classroom model through the discussion method effectively improves students' conceptual understanding of physics, particularly in optics.

The challenges of implementing the Flipped Classroom also need further discussion. One of the main obstacles is the teachers' preparedness in designing engaging and easily understandable video materials. Additionally, students' accessibility to video content is a crucial factor, especially for those with limited internet access or inadequate technological devices. Several studies (e.g., Hew & Lo, 2018) indicate that students who are not accustomed to self-directed learning may struggle to grasp the material before face-to-face sessions. Therefore, additional support, such as mentoring sessions or online discussion forums, is needed to assist students facing difficulties.

▪ CONCLUSION

Based on the results of the research and data analysis, it can be concluded that the Flipped Classroom learning model has a significant impact on students' conceptual understanding of optical equipment material. The hypothesis test revealed a t-value of 5.605, which is greater than the table value of 1.67, leading to the acceptance of Ha and confirming a difference between the experimental and control classes in the post-test. The experimental class showed a significant improvement in conceptual understanding, with an average post-test score of 86.2%, compared to the control class, which had a post-test average of 70.41%. These results, supported by the students' response criteria, demonstrate that the Flipped Classroom model, when combined with the discussion method, effectively enhances students' understanding of physics concepts. However, some students still experience misconceptions, indicating the need for additional mentoring strategies.

Teachers can implement the Flipped Classroom approach with limited resources by using simple video materials or available digital sources. Schools should ensure students' access to devices and the internet while providing teacher training to optimize this method. Future studies could explore the effectiveness of the Flipped Classroom in other subjects and educational levels, as well as integrate it with other methods such as project-based learning. This study provides empirical evidence on the effectiveness of the Flipped Classroom in enhancing students' understanding of physics concepts, complementing previous studies that focused more on students' perceptions. These findings can serve as a reference for educators and policymakers in designing innovative learning strategies.

▪ REFERENCES

Amdani, R, N., & Irma Purnamasari, A. (2022). *Pengembangan media belajar menggunakan augmented reallity berbasis android pada konsep panca indera*. JATI (Jurnal Mahasiswa Teknik Informatika), 6(1), 399–407. https://doi.org/10.36040/jati.v6i1.4719

Anderson, L. W., & Krathwohl, D. R. (2015). *Kerangka landasan untuk pembelajaran, pengajaran, dan asesmen.* Yogyakarta: Pustaka Pelajar.

Apriyanah, P. (2018). *Efektivitas model flipped classroom pada pembelajaran fisika ditinjau dari self efficacy dan penguasaan konsep siswa.* Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah, Vol. 2 No. 2

Bergmann, J., & Sams, A. (2012). Flip your classroom: reach every student in every class every day. washington: international society for technology in education.

Chen, Y., Wang, Y., & Chen, N. (2020). Investigating the impact of flipped classroom on students' learning outcomes: A meta-analysis. Educational Technology & Society, 23(2), 1-15.

Creswell, J. W. (2014). Research design: qualitative, quantitative, and mixed methods approaches (4th ed.). SAGE Publications.

Fajri, Z., Baharun, H., Muali, C., Farida, L., & Wahyuningtiyas, Y. (2021). Student's learning motivation and interest; The effectiveness of online learning during COVID-19 pandemic. Journal of Physics: Conference Series, 1899(1), 12178. https://doi.org/10.1088/1742- 6596/1899/1/012178/meta

Fauzan, M., Haryadi, & Haryati, N. (2021). *Penerapan elaborasi model flipped classroom dan media google classroom sebagai solusi pembelajaran bahasa indonesia abad 21.* Jurnal Riset Pedagogik. 5(2).361-371.

Fauzi, Y. N., Irawati, R., & Aeni, A. N. (2022). *Model pembelajaran flipped classroom dengan media video untuk meningkatkan pemahaman konsep matematis siswa.* Jurnal Cakrawala Pendas, 8(4), 1537–1549.

Festiawan, R., Hooi, L. B., Widiawati, P., Yoda, I. K., Adi, S., Antoni, M. S., & Nugroho, A. I.(2021). The problem-based learning : how the effect on student critical thinking ability and learning motivation in COVID-19 pandemic? Journal Sport Area, 6(2), 231–243. https://doi.org/10.25299/sportarea.2021.vol6(2).6393.

Fikri, S. A. (2019). *Flipped classroom terhadap kemampuan pemahaman konsep.* Prosiding Sendika, 5(1), 325–330.

Fradila, Y., Mulyoto, & Sutimin, L. A. (2015). *Model flipped classroom dan discovery learning pengaruhnya terhadap prestasi belajar matematika ditinjau dari kemandirian belajar.* Teknodika, 13(2), 5-17.

Galatea, K, C,. Sari, R, A, N,. (2022) *Kemampuan berpikir analisis siswa dalam menggunakan soal two tier multiple choice.* Jurnal Gammath. 7(2), 76

Giancoli. (2001). Fisika jilid 2 . Jakarta : Erlangga.

Hadijah, S., & Shalawati, S. (2021). Pelaksanaan pembelajaran inovatif melalui metode flipped learning. Community Education Engagement Journal, 2(2), 52-61.

Haerunnisa, H., Prasetyaningsih, P., & Biru, L. T. (2022). *Analisis miskonsepsi siswa smp pada konsep getaran dan gelombang.* PENDIPA Journal of Science Education, 6(2), 428–433. https://doi.org/10.33369/pendipa.6.2.428-433

Hew, K. F., & Lo, C. K. (2018). Flipped classroom improves student learning in health professions education: A meta-analysis. BMC Medical Education, 18(1), 38.

Juniantari, M., Pujawan, I. G. N., & Widhiasih, I. D. A. G. (2018). *Pengaruh pendekatan flipped classroom terhadap pemahaman konsep matematika siswa sma.* Journal of Education Technology, 2(4), 197–204.

Jusniar, J., Effendy, E., Budiasih, E., & Sutrisno, S. (2020). Eliminating misconceptions on reaction rate to enhance conceptual understanding of chemical equilibrium using EMBE-R Strategy. International Journal of Instruction, 14(1), 85–104. https://doi.org/10.29333/IJI.2021.1416A

Kurniawan, D. A. (2020). *Efektivitas model pembelajaran berbasis inkuiri terhadap pemahaman konsep sains siswa.* Jurnal Pendidikan dan Pembelajaran, 27(2), 56-68.

Lestari, Kurnia, E., & Yudhanegara, M. R. (2017). *Penelitian pendidikan matematika.* Bandung: Refika Aditama.

Lo, C. K., Hew, K. F., & Chen, G. (2017). Toward a set of design principles for mathematics flipped classrooms: A synthesis of research in mathematics education. Educational Research Review, 22, 50-73.

Maharani, S., & Bernard, M. (2018). *Analisis hubungan resiliensi matematik terhadap kemampuan pemecahan masalah siswa pada materi lingkaran.* JPMI (Jurnal Pembelajaran Matematika Inovatif), 1(5), 819-826

Namaziandost, E., & Çakmak, F. (2020). An Account of EFL learners' self-efficacy and gender in the flipped classroom model. Education and Information Technologies, 25(5), 4041-4055.

Noviyana, H. (2018). *Pengaruh model open ended terhadap kemampuan pemecahan masalah matematis siswa SMP.* JURNAL e-DuMath, 4(2), 1-10.

Nurgiansah, T. H., & Pringgowijoyo, Y. (2020). *Pelatihan penggunaan model pembelajaran jurisprudensial pada guru Di KB TK Surya Marta Yogyakarta.* KUAT: Keuangan Umum dan Akuntansi Terapan, 2(1), 52-57.

Nurma'ardi, H. D., Oktaviani, A. M., & Rokmanah, S. (2022). *Penerapan model pembelajaran discovery learning terhadap pemahaman konsep ipa siswa sekolah dasae.* Pelita Calistung, 3(2), 45–54. https://jurnal.upg.ac.id/index.php/jpc/article/view/292/201

OECD. (2019). PISA 2018 Results (Volume I): What students know and can do. Paris: OECD Publishing.

Patandean, Y. R., & Indrajit, R. E. (2021). *Flipped Classroom: Membuat peserta didik berpikir kritis, kreatif, mandiri, dan mampu berkolaborasi dalam pembelajaran yang responsif.* Yogyakarta.Penerbit Andi.

Pradina, L. E., & Yuliani, Y. (2020). *Profil miskonsepsi siswa pada materi pertumbuhan dan perkembangan tumbuhan menggunakan three-tier multiple choice test.* BioEdu: Berkala Ilmiah Pendidikan Biologi, 9 (1): 310-318

Pratiwi, E. M., Gunawan, G., & Ermiana, I. (2022). *Pengaruh penggunaan video pembelajaran terhadap pemahaman konsep ipa siswa.* Jurnal Ilmiah Profesi Pendidikan, 7(2), 381–386. https://doi.org/10.29303/jipp.v7i2.466

Ramadhini, D. A., & Kowiyah, K. (2022). *Analisis kesalahan siswa dalam menyelesaikan soal cerita matematika materi kecepatan menggunakan teori kastolan.* Jurnal Cendekia: Jurnal Pendidikan Matematika, 6(3), 2475–2488. https://doi.org/10.31004/cendekia.v6i3.1581

Rosdianah, R., Kartinah, K., & Muhtarom, M. (2019). *Analisis faktor penyebab kesulitan belajar matematika pada materi garis dan sudut kelas vii sekolah menengah pertama.* Imajiner: Jurnal Matematika Dan Pendidikan Matematika, 1(5), 120–132. https://doi.org/10.26877/imajiner.v1i5.4458

Sin, S. L., & Siahpoosh, H. (2020). Looking at the impact of the flipped classroom model on reading comprehension of Iranian EFL learners. Arabic Language, Literature & Culture, 5(2), 14.

Sugiyono (2018). *Metode penelitian kuantitatif.* Bandung: Alfabeta.

Suryawan, I., Santyasa, I., & Sudarma, I. (2020). *Pengaruh metode pembelajaran discovery-inquiry program studi teknologi pembelajaran universitas pendidikan ganesha.* Jurnal Teknologi Pembelajaran Indonesia, 10(1), 25–34

Taber, K. S. (2009). Progressing science education: constructing the scientific research programme into the contingent nature of learning science. Springer.

Trisnowali, A., & Aswina, A. (2019). *Pengaruh model pembelajaran core* (connecting, organizing, reflecting and extending) *terhadap hasil belajar siswa kelas* X. DIDAKTIKA: Jurnal Kependidikan, 13(1), 43-55.

Utami, R. W., Endaryono, B. T., & Djuhartono, T. (2020). *Meningkatkan kemampuan berpikir kreatif matematis siswa melalui pendekatan open-ended.* Faktor: Jurnal Ilmiah Kependidikan, 7(1), 43-48.

Widodo, L. S., Prayitno, H. J., & Widyasari, C. (2021). *Kemandirian belajar matematika siswa sekolah dasar melalui daring dengan model pembelajaran flipped classroom.* Jurnal Basicedu, 5(5), 3902–3911.

Yulianti, Y. A., & Wulandari, D. (2021). *Flipped classroom: model pembelajaran untuk mencapai kecakapan abad 21 sesuai kurikulum 2013.* Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran, 7(2), 372-384.

Zainuddin, Z., & Halili, S. H. (2016). Flipped classroom research and trends from different fields of study. International Review of Research in Open and Distributed Learning, 17(3), 313–340. DOI: 10.19173/irrodl.v17i3.2274

Zainuddin, Z., & Attaran, M. (2016). Malaysian students’ perceptions of the flipped classroom: a case study. Innovations in Education and Teaching International, 53(6), 660–670. DOI: 10.1080/14703297.2015.1102079