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Implementation of flipped learning to increase student learning activeness in the combustion engine lecture

Ranto *, Antika Wulandari, Ngatou Rohman
Universitas Sebelas Maret, Indonesia.
* Corresponding Author. Email: rantoptm@fkip.uns.ac.id

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ABSTRACT

This study aims to determine the increase in learning activeness of Sebelas Maret University students in the mechanical engineering education study program through the implementation of a flipped learning model in the combustion engine lecture. This research is classroom action research. The action taken is to apply the flipped learning model in the combustion engine lecture. The subjects of this study were 42 students in the second semester of the mechanical engineering education study program. This classroom action research design refers to the Kemmis and Taggart model. The research was conducted in three cycles, each consisting of planning, implementation, observation, and reflection. Data collection was done through observation, interviews, and documentation. The instrument validity test was carried out with construct validity using expert opinions. Data analysis was carried out in a comparative-descriptive way. The results of this classroom action research show that implementing the flipped learning model can increase the learning activeness of students in the combustion engine lecture. In the pre-cycle stage, student learning activeness only reached 45.24% of active learning students. In cycle 1, by implementing a flipped learning model, students learning activeness reached 81.99%, cycle 2 increased to 87.43%, and cycle 3 increased to 91.74%. The conclusion of this research is that the implementation of the flipped learning model can increase the learning activeness of the mechanical engineering education study program Sebelas Maret University students in the combustion engine lecture. Based on the results of this research, it is highly recommended to use the flipped learning model in lectures, especially in vocational education, increasing student learning activeness will have an impact on increasing student learning achievement.

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INTRODUCTION

The rapid development of communication and information technology affects its wider utilization in all aspects of life. Technological changes are needed to improve the quality of education and meet global needs in education, especially in learning. The use of advanced technology in learning is one of its most prominent impacts. In addition, the education system has also changed with the times. With system changes and the application of advanced technology, it is hoped that students can be more active, creative, and innovative in learning (Respati, 2019).

The success of education is determined by the learning process. Educators, as a key component of learning, have a crucial role in delivering material and motivating learners. The current advances in information technology encourage educators, teachers, and lecturers to adapt and innovate using various digital learning models and methods (Collins, 2025). One of the factors that significantly influences the success of learning is the use of effective learning models (Bali, 2020). Therefore, educators must be adept at creating active, creative, effective, and fun learning models. These models are essential for students to achieve success in the learning process.

According to Mardian and Sylvia (2020), a learning model is a pattern or plan used as a reference for organizing learning activities in the classroom. The accuracy with which educators choose learning models according to relevant material impacts the attractiveness and activeness of student learning (Rizki et al., 2019). By prioritizing students as the center of learning, learning does not become boring because students must be active to produce productive, creative, and innovative students. However, the learning process is still not perfect due to lecturer-centered learning. Teaching and learning activities become boring and will not leave meaningful memories for students.

The teaching and learning process is only successful when students actively participate. Student activeness is a fundamental element for the success of learning. It is the high level of interaction between educators and students, or among the students themselves, that fosters this activeness (Effendi, 2013). Active learning creates a conducive classroom atmosphere and encourages each student to fully develop their skills.

The Mechanical Engineering Education study program at the Faculty of Teacher Training and Education, Universitas Sebelas Maret, has compulsory courses that must be completed by each student, both in theory and practice. Combustion Engine is one of the compulsory courses students must take in the second semester of the study program. This theoretical course studies the basics of gasoline engines, the main and supporting systems of combustion engines, the Engine Management System (EMS) on Electronic Fuel Injection (EFI) gasoline engines, conventional diesel engines, common rail diesel engines, and combustion engine performance tests. After attending this combustion engine theory lecture, students can increase their knowledge of combustion engine theory, which can then be used as a basis for implementing their practicum courses.

Based on information from lecturers and the author's experience during the practical lecture on combustion engines, students still lack an understanding of the theoretical knowledge of combustion engines that should be a provision for practicum implementation. At the time of practicum, many students did not understand the knowledge supporting the implementation of practice, so they had difficulty carrying out combustion engine practice. This happens because, in the process of learning combustion engine theory, a learning model has not been implemented that can condition students to be active in the classroom, so there is very little interaction between lecturers and students. There is no interaction between students, such as discussions, presentations, questions, and answers, so students are less involved in understanding the material being taught. A less interactive learning approach can lead to less student learning activeness. Lecturers can involve active student participation during learning to increase learning activeness and help students understand the theory better.

Researchers also made initial observations on March 8, 2023, in the class of 2nd-semester students in the combustion engine lecture; it was found that students' activeness in the learning was still not optimal due to learning that was still conventional or lecture. The observation results show that student learning activeness during the learning process only reaches 45.24% of active learning students. Observations were carried out based on an observation sheet consisting of 8 indicators of student activity, namely visual activities, listening activities, oral activities, writing activities, drawing activities, motor activities, mental activities, and emotional activities.

The eight activity indicators are broken down into 14 aspects of student activity in the classroom. This observation guide will also be used to observe student activity when implementing the Flipp Learning model intervention. In its implementation, the researcher was assisted by two observers. Active students are given the number 1 for each aspect of activeness, and those who are not active are given the number 0. The total activeness percentage is 16.15%, obtained by dividing the activeness score obtained by 95 by the activeness score of 100% or 588, which is obtained from the product of 42 students with 14 aspects. Suppose students' active learning is calculated based on indicators and aspects that may appear in learning before implementing flipped learning. In that case, the percentage of student activeness is the average of the active indicators that may appear. With this principle, student learning activity is obtained at 45.24%. This very low student learning activeness is caused by the learning approach used by lecturers, which is classified as a teacher center, not a student center. Efforts or actions are needed to overcome the problem based on the factors that cause the problem.

The shift in the focus of learning from educators to learners emerged as a response to the lack of student activeness in the learning process. The role of educators in student-centered learning is no longer as teachers but as facilitators and motivators, empowering them to take a more active role in their students' learning experiences (Serin, 2018). Educators must find and adapt the latest learning models to the curriculum to encourage students to actively participate in learning (student center). One of the learning models that can be used to make learning interesting and make students more active is the flipped learning model (Arlinah et al., 2020). Flipped learning is a form of learner-centered teaching consisting of two parts: learning outside and inside the classroom (Fahmy et al., 2022). Learning outside the classroom uses learning materials or videos prepared by lecturers, and learning in the classroom is done with interactive groups (Bishop & Verleger, 2013).

According to previous research, the flipped learning model can increase interaction between students, teachers, and teaching materials and generate positive perceptions in its application (Nizhomi et al., 2022). Another study that supports this research is a case study conducted by Farida et al. (2019), which shows that the innovative flipped learning model has the potential to be applied in teaching and learning activities in higher education because it can build active and interactive teaching and learning activities through individual and group activities.

Based on these conditions, students' learning activeness remains very low, making it necessary to take measures to enhance engagement in the internal combustion engine course by implementing the flipped learning model. By applying this learning model, this study aims to obtain results regarding the effectiveness of flipped learning in increasing the learning activeness of students in the Mechanical Engineering Education Study Program at Universitas Sebelas Maret in the internal combustion engine course.

The objective of this research is to analyze the impact of implementing the flipped learning model on students' learning activeness and to assess the effectiveness of this approach in addressing challenges related to theoretical learning in internal combustion engines. This study seeks to provide empirical evidence on the role of flipped learning in enhancing student engagement, deepening conceptual understanding, and creating a more interactive and student-centered learning environment. The findings of this study are expected to be applied more broadly in technical education within vocational training and the general education system, thereby contributing significantly to the development of innovative learning models in engineering education and shaping its future.

METHOD

This study is a Classroom Action Research (CAR) that refers to the Kemmis et al. (2014) model and was conducted in three cycles. Each cycle consists of four main stages: planning, implementation, observation, and reflection. This structure allows for continuous improvement at each stage, demonstrating our dedication to refining the flipped learning strategy to better meet students' needs. The research aims to enhance students' learning activeness in the Internal Combustion Engine course by implementing the flipped learning model. The research subjects were students of the Mechanical Engineering Education Study Program at Universitas Sebelas Maret in the second semester of the 2022/2023 academic year, consisting of 42 Class A students randomly selected from the two available classes. Class A was selected as the research subject to maintain the balance of population characteristics and ensure active student engagement in the learning process. This research was conducted from January to July 2023, with a design aimed at providing effective solutions to improve student participation and understanding of internal combustion engine material.

The planning stage, based on initial observations, indicated that students' learning activeness was still low, impacting their understanding of theoretical concepts before laboratory practice. To address this, a series of actions were designed, with a key focus on developing e-modules. These e-modules, along with other actions such as lesson plan design, instrument validation, and preparation of tools and documentation, were instrumental in implementing the flipped learning model. The e-modules were designed to give students access to materials before class sessions, enabling them to focus more on discussions, case analyses, and problem-solving during face-to-face sessions.

Additionally, research instruments were validated to ensure reliability and validity in measuring students' learning activeness.

The research implementation involved presenting materials before class through videos, readings, or presentations accessible to students, empowering them to take charge of their learning. This approach allowed classroom time for interactive activities such as group discussions, problem-solving, and guidance by the lecturer as a facilitator. Furthermore, students were given opportunities to complete assignments or quizzes to ensure their understanding of the materials they had studied independently before face-to-face sessions.

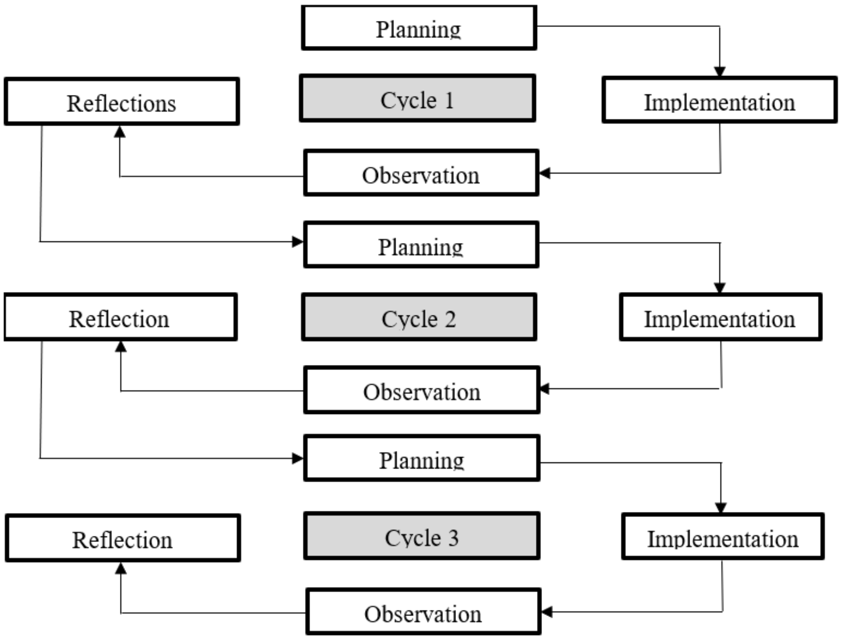

Figure 1. Classroom Action Research Model by Kemmis and McTaggart

The research data were collected through observation, interviews, and documentation. Observations were conducted using an observation sheet that measured students' learning activeness based on 13 indicators, including paying attention to the lecturer's explanation, participating in discussions, answering questions, taking notes, and completing assignments. Interviews were conducted randomly with a significant number of students (specify the number) to explore their experiences attending lectures using the flipped learning model. Documentation included supporting documents such as the syllabus, lesson plans, student attendance lists, and teaching materials used in the study. In addition, visual documentation in the form of photos or video recordings of the learning process was also used to enrich the research data. The use of multiple data collection techniques aimed to enhance the validity of the research results and provide a more comprehensive understanding of the effectiveness of the flipped learning model in increasing student engagement.

Data analysis was conducted using a comparative descriptive technique by comparing students' learning activeness before and after implementing flipped learning. The percentage of student activeness was calculated using a formula comparing the number of active students to the total number of students in the class. The analysis results were interpreted based on the activeness categories proposed by Brookhart (2013) and Masyhud and Tasnim (2012), in which student engagement levels were classified into five categories: very active, active, moderately active, less active, or very less active. This study was successful if at least 80% of students demonstrated active involvement in learning, as supported by Freeman et al. (2014) and Prince (2004), which indicated that increased engagement in class significantly impacts students' academic performance. Furthermore, the analysis was conducted quantitatively through percentage calculations and qualitatively by interpreting students' interview responses and reflections on their learning experiences.

Reflection was conducted at the end of each cycle to identify the strengths and weaknesses of the flipped learning implementation in the course. The findings from these reflections served as the basis for refining actions in the next cycle. This process of refining actions involved (describe the process) to ensure the effectiveness of the learning model applied. With this systematic and cyclical approach, this study is expected to improve the quality of learning in the Internal Combustion Engine course, particularly in enhancing students' learning engagement. Additionally, the study's findings may serve as a reference for developing more innovative learning strategies tailored to students' needs in the digital era. The conclusions drawn from this research are also expected to provide insights for lecturers and educational administrators in designing more effective teaching methods for practice-based courses.

RESULTS AND DISCUSSION

Results

Pre-cycle

The researchers made a startling initial observation on Wednesday, March 8, 2023, regarding students' learning activeness in the combustion engine lecture. The data revealed that student engagement is still heavily reliant on conventional models, with learning activities predominantly lecturer-centered. Shockingly, only 45.24% of students were actively involved in the learning process in class. None of the 13 observed indicators met the predetermined research target of 80% student activeness. This situation demands immediate attention, as illustrated in the diagram of student learning activeness at the pre-cycle stage, as shown in Figure 2.

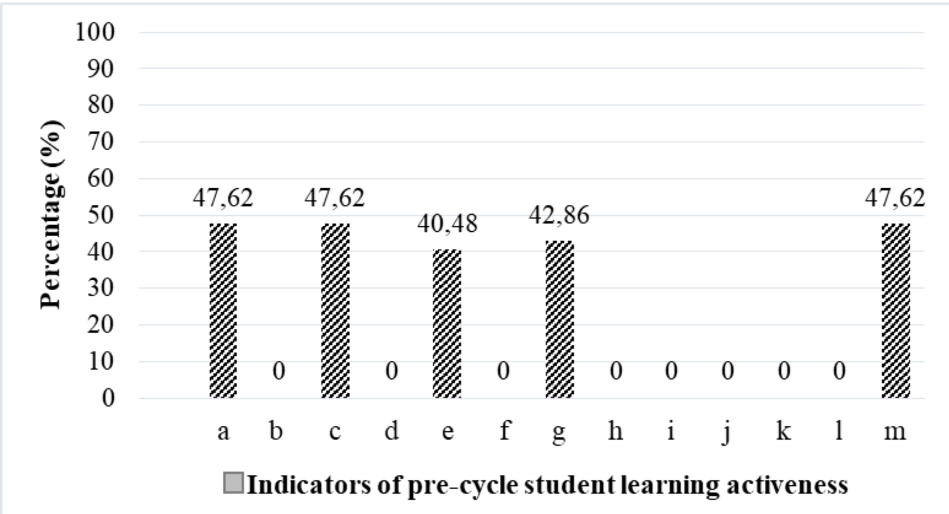

Figure 2. Percentage Diagram of Pre-cycle Student Learning Activeness

It's clear that the current learning model, which heavily relies on lecture-based methods, is not producing the desired results. Students are disengaged and tend to be passive in their learning. The lack of interaction between students and lecturers, as well as among students themselves, is particularly striking. Group discussions are rare, and only a few students are brave enough to ask questions. This lack of interaction is a key factor contributing to the low student engagement. Additionally, students are seen merely taking notes passively without further exploration, which results in a weak understanding of theoretical concepts before laboratory practice.

Several factors contributing to the low student engagement were identified from the observations. One of the primary causes is the lack of an active learning model that encourages students to be actively involved in the learning process. As a result, students receive information passively rather than processing it independently. Furthermore, time constraints in lectures hinder the implementation of more interactive learning methods, as most of the class time is spent on the lecturer delivering materials. Therefore, the need for a new learning model that can effectively enhance student engagement in the learning process is not just important, it's crucial.

This study proposes the implementation of the flipped learning model in the combustion engine lecture. This model, which allows students to study the material before class through instructional videos or digital learning resources, is a promising solution to the current issues. It frees up class time for in-depth discussions, problem-solving, and other interactive activities. With this approach, students are expected to be better prepared for lectures, more actively engaged in discussions, and able to develop a deeper understanding of theoretical concepts before entering the practical stage. Implementing flipped learning is also expected to enhance interaction between students and lecturers, strengthen student participation in learning, and encourage them to become more independent in understanding and applying the concepts they learn.

Cycle 1

Based on the data collected during the implementation of cycle I, it's encouraging to note that some students have begun to take an active role in the learning process. In this first cycle, the average student learning activity reached 81.99%, meeting the research target of 80%. However, five of the 13 observed indicators fell below the predetermined learning activeness target. These indicators include participation in discussions, confidence in asking questions, involvement in problem-solving, presentation skills, and enthusiasm for participating in learning activities. This data suggests that while there's room for improvement, students are showing promising signs of engagement. Therefore, further efforts are needed to increase student learning activeness in the next cycle to ensure all indicators reach the expected targets.

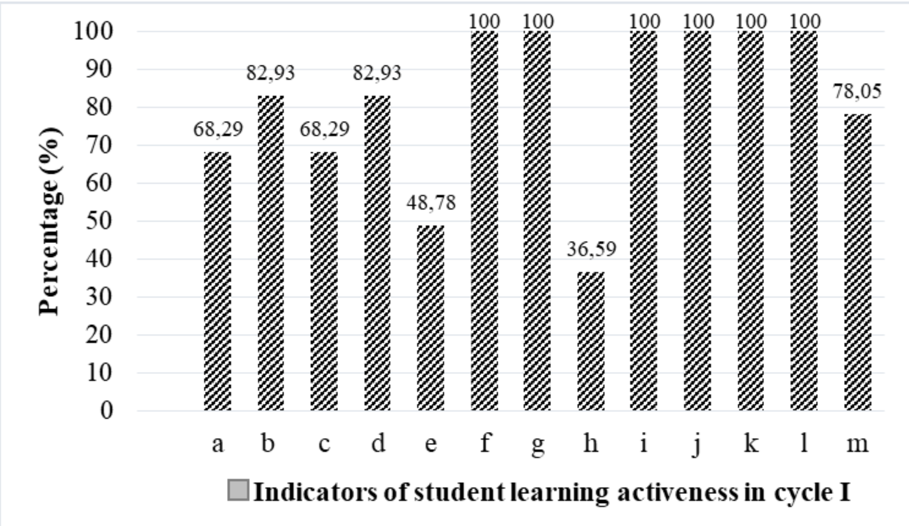

Figure 3. Percentage Diagram of Student Learning Activeness Cycle 1

During the implementation of the first cycle, it became evident that students were facing several challenges that hindered their focus on learning. These challenges included students' reluctance to read the material before class, excessive chatting with peers, lack of attention to the lecturer's explanations and presentations from other groups, and hesitation in asking questions related to the material presented by the lecturer. Additionally, in the presentation session, the discussion results were read aloud in front of the class without any interaction or in-depth analysis from students. The student's attitude in this activity indicated they lacked the initiative to voluntarily present their discussion results, requiring the lecturer to directly appoint each group to come forward and present their findings. The lack of confidence among students in speaking in front of the class suggests that they are still unfamiliar with active learning methods and require further encouragement and guidance.

At the end of the lecture, students were asked to take a post-test as a form of assessment to measure their understanding of the material taught. In completing the post-test, students struggled to understand the questions, as seen in their tendency to collaborate with peers when answering. This occurred because the problem topics assigned to each group were different, leading to limited comprehension of the overall material. Some students also faced difficulties connecting theoretical concepts to their practical applications, indicating that they had not yet fully grasped the relationship between theory and the real-world application of internal combustion engines.

To address various learning challenges, the lecturer implemented several strategic steps to enhance student engagement and the effectiveness of flipped learning. One of the key measures was distributing learning materials one day before the face-to-face lecture, allowing students sufficient time to study the material beforehand. Students were also encouraged to engage in independent learning by being given short assignments or guiding questions that helped them grasp key concepts before the discussion session.

In addition, the lecturer created a learning environment that fostered two-way interaction between students and lecturers and among students themselves. Students who actively asked questions and participated in discussions were given recognition to boost their learning motivation. Discussion topics were also standardized across all groups to broaden students' understanding and minimize knowledge gaps between groups. Lastly, students were encouraged to complete individual questions or tests to enhance critical thinking skills and independent learning. With these steps, implementing flipped learning is expected to be more effective in increasing student engagement and improving their understanding of the material.

Cycle 2

In cycle 1, there were still five indicator aspects where student activity achievements were below the target of 80%, so implementing the flipped learning model needed to be improved (Freeman et al., 2014; Prince, 2004), so it can reach 80%. Improvements to the implementation of the flipped learning model were carried out in cycle 2. On June 8, 2023, cycle II observations were carried out in one meeting with an allocation of 2 x 50 minutes (2 credits). Forty-one students attended the combustion engine lecture in cycle 2. The cycle 2 stage is a follow-up action from cycle 1. The implementation of cycle two is a collaborative effort, with the research team, consisting of 1 lecturer and four observers, working together to fix the obstacles when using the flipped learning model in the combustion engine lecture. The results of discussions with several selected students also contributed to this process.

The improvements made in cycle 2 significantly enhanced the implementation of the flipped learning model. Our observations revealed a notable increase in student engagement compared to the first cycle. This improvement is clearly demonstrated in the diagram of student engagement in the second cycle, as shown in Figure 4.

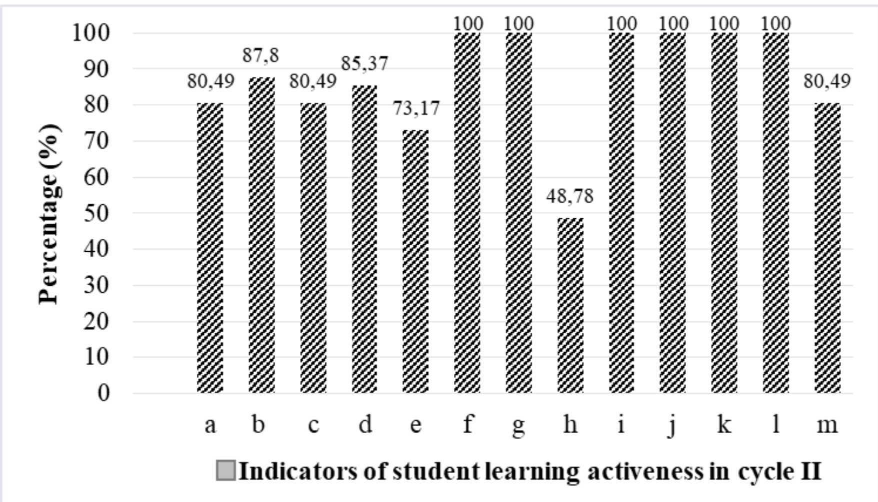

Figure 4. Percentage Diagram of Cycle 2 Student Learning Activeness

Based on the observations, students have begun actively participating in learning in cycle 2. Students are eager to participate in learning and look enthusiastic about attending lessons and responding to their friends' presentations. The percentage of student learning activeness in cycle 2 increased from 81.99% to 87.43%. Overall, the level of student learning activeness has met the research target, but two aspect indicators are still below the target of 80%. Indicators still below the research target in cycle 2 are: (1) answering questions posed by the lecture and (2) making or copying pictures or diagrams related to the subject matter. For this reason, it is necessary to evaluate and improve in the next cycle, including (1) Making the delivery of learning materials as interesting as possible so that students are more focused on participating in learning; (2) Giving motivation to students to be more courageous in asking questions and expressing opinions; and (3) Directing students to add or copy images related to the material in the PowerPoint of their group discussion tasks.

Cycle 3

Two indicator aspects still need to be improved because they have not yet reached the target of 80% of active students (Freeman et al., 2014; Prince, 2004). The third cycle stage was carried out to improve the implementation of actions in cycle two based on the results and the reflection. Learning activities in cycle 3 still use the flipped learning model in the combustion engine lecture. Observations in cycle 3 were carried out on June 15, 2023, in one meeting with an allocation of 2 x 50 minutes (2 credits). Forty-one students attended the combustion engine lecture in cycle 3. In implementing this cycle 3 action, the activities of the combustion engine lecture with the flipped learning model went well. They were in accordance with the lesson plan that had been designed. Based on the observation of cycle 3, there was an increase in the number of active students in each indicator observed. This can be clarified through the diagram of student learning activeness at the third cycle stage, as shown in Figure 5.

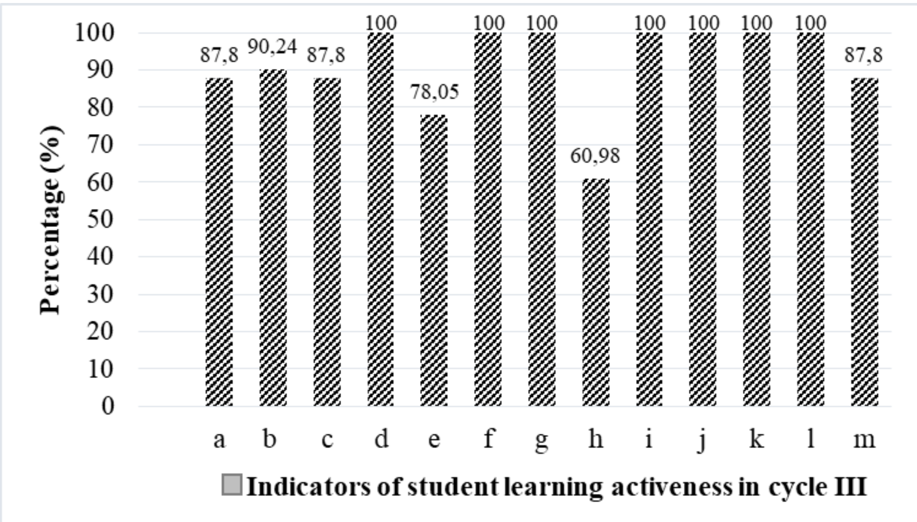

Figure 5. Percentage Diagram of Student Learning Activeness Cycle 3

Based on the observation results of cycle 3, it is evident that the flipped learning model has significantly increased student learning activeness. Of the 13 indicators observed, an impressive 11 met the set research target of 80%. While there are still two indicators below the research target, the overall increase in student engagement is a promising sign. In cycle 3, the percentage of students actively involved in learning increased from 87.43% to 91.74%. This consistent increase in student learning activeness over the three cycles of action is a testament to the potential of the flipped learning model.

At the end of cycle 3, interviews were conducted with several second-semester students of the PTM Study Program at FKIP UNS to determine the students learning activeness after implementing the flipped learning model in the combustion engine lecture. From the interview results, it is known that the use of the flipped learning model in the combustion engine lecture makes learning more varied and students more active. Students prefer learning through discussion rather than only theory. With the flipped learning model, students can think actively because they have to discuss the tasks given and increase their responsibility for them. The flipped learning model is also suitable because the lecture or conventional model makes students bored and sleepy.

Based on student learning activeness data obtained through observations, interviews, and documentation, student learning activeness increased after implementing the flipped learning model in the combustion engine lecture. Students become more active and involved in the classroom than conventional models that tend to make students passive. In other words, applying the flipped learning model can change teacher-centered learning to student-centered learning (Magdalena et al., 2023). The flipped learning model also trains students' activeness in solving problems by discussing, interacting, and collaborating between students and lecturers.

This aligns with research conducted by Luo et al. (2019), which found that the flipped learning model teaches students to build good interactions with their peers and trains them to solve group problems by exchanging thoughts or ideas. Similar research conducted by Dewi (2022) stated that the use of the flipped learning model requires students to engage in question-and-answer activities and class discussions to create an active and student-focused learning environment so that the implementation of the flipped learning model can increase student activity from 72.22% to 91.67%. Cheng et al. (2018) concluded that implementing the flipped classroom provides better learning outcomes than traditional learning, especially in the STEM field; student activity increases because this method encourages them to be more independent and actively involved in the learning process.

The same conclusion was expressed by Låg and Sæle (2019) that the flipped classroom improves student learning outcomes and satisfaction, making students feel more active and responsible for their learning process. In research by Fleagle et al. (2018), it was concluded that the flipped classroom significantly improved human anatomy learning outcomes and increased student activity in the laboratory. Hew and Lo (2018) also concluded that the flipped classroom has proven effective in increasing health education student activity and learning outcomes. Based on the discussion of the research results above, the use of a flipped learning model can increase the learning activeness of students. The difference and, at the same time, the novelty of this research is the application of flipped learning in combustion engine lectures, a mechanical engineering field.

This classroom action research regarding the application of the flipped learning model in combustion engine lectures has several limitations, namely: (1) its specific nature, combustion engine are included in engineering subjects with special content and problem, this will have implications when applied to lecture and research in other subjects, namely that teaching materials and problems that will be used must be good prepared and adapted for discussion in class, (2) requires sufficient observer personnel, when implementing flipped learning as classroom action research, sufficient observer staff are required, around 3-4 people, so that they can observe student activities in class well, (3) not being able to monitor students' learning activities outside the classroom before learning in the classroom, observations of students' learning activities are only carried out in class, for further research to be more perfect, an instrument needs to be created that can monitor students' learning activities outside the classroom.

Comparison of Interaction Results

Implementing flipped learning, a pedagogical approach where students study the material before class and use face-to-face sessions for discussions and problem-solving, in the combustion engine lecture has significantly increased student learning activeness in each cycle. Before implementing this model, the percentage of student activeness at the pre-cycle stage was only 45.24%, which falls into the category of inactive or passive. After applying flipped learning, there was a gradual increase, reaching 81.99% in cycle 1, 87.43% in cycle 2, and 91.74% in cycle 3, demonstrating that this method can create a more interactive and participatory learning environment. This improvement indicates that students are becoming more accustomed to the flipped learning model and are actively engaging in learning activities. These findings align with the study conducted by Freeman et al. (2014), which states that active learning methods, such as flipped learning, can increase student engagement by up to 80% of class time, positively impacting their academic performance.

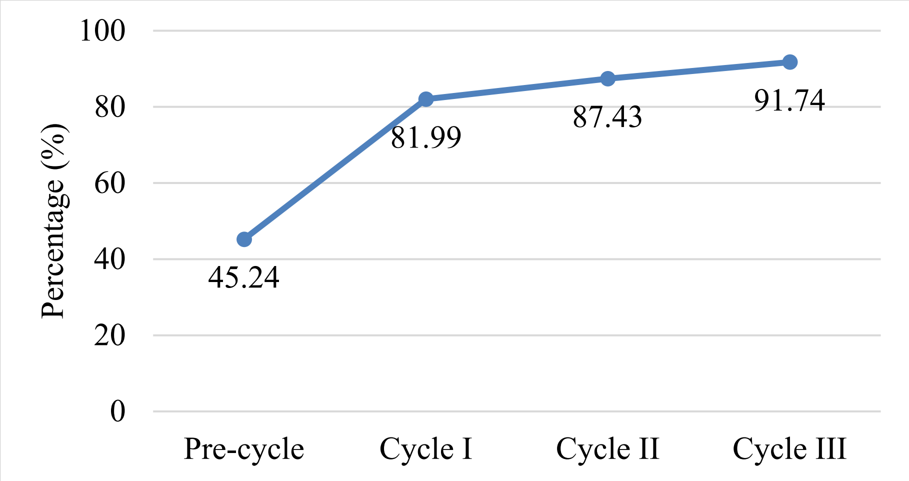

Figure 6. Comparison Chart of Students Learning Activeness in Each Cycle

The implementation of flipped learning in this study has demonstrated a significant and positive impact on student engagement. This model not only encourages students to study the material before class, but also allows face-to-face sessions to be utilized for more in-depth discussions, collaboration, and problem-solving. These findings, supported by Bahadur and Akhtar (2021), suggest that flipped learning improves students' academic performance and contributes to developing their social and emotional skills in an active learning environment. Furthermore, Agyeman and Aphane (2024) emphasize that providing access to learning materials before class enables students to be better prepared for classroom discussions, ultimately fostering a deeper understanding of the concepts taught.

However, the implementation of the flipped learning model also presents challenges. One of the primary obstacles is the varying levels of student motivation in independently studying the material before class. Some students still struggle to manage their time and comprehend the material without direct guidance from the lecturer. Additionally, the lecturer's readiness to design engaging and interactive learning materials is a crucial factor in the success of this model (Bahadur & Akhtar, 2021). To address these challenges, educators play a pivotal role in implementing strategies, such as providing learning materials before class, guiding students in preparing the material to be discussed, and creating a learning environment that fosters active interaction. Educators can significantly increase students' motivation to engage in self-directed learning before the face-to-face session by giving clear instructions and encouraging participation.

Based on the findings of this study, flipped learning has been proven effective in increasing student learning activeness in the combustion engine lecture. With consistent improvements from the first to the third cycle, this model has created a more dynamic learning process and provided students with greater independence in understanding the material. The successful implementation of flipped learning not only demonstrates its effectiveness but also its potential to significantly improve the quality of education, especially in theoretical and practical courses like combustion engines. If implemented with the right strategies, flipped learning can be expanded as a broader approach in technical education, producing students who are more active, independent, and well-prepared to face challenges in the professional world.

Discussion

The results of this study reveal a promising trend in student activeness when the flipped learning model is applied to the combustion engine lecture. At the pre-cycle stage, student activeness was at a modest 45.24%, indicating room for improvement in engagement. However, after three cycles of implementing flipped learning, a consistent and significant increase was observed. Student activeness rose to 81.99% in cycle 1, 87.43% in cycle 2, and peaked at 91.74% in cycle 3, demonstrating the model's effectiveness in enhancing student engagement.

The findings of this study are in line with previous research, which has consistently shown the effectiveness of flipped learning in boosting student interaction and participation in the learning process. Freeman et al. (2014) found that active learning methods, including flipped learning, can occupy up to 80% of class time, leading to improved academic performance. Similarly, Cheng et al. (2018) demonstrated that flipped classrooms in STEM fields outperformed traditional methods, fostering student independence and activity in their learning process.

Additionally, Hew and Lo (2018) study revealed that the flipped classroom model not only enhances student activeness and learning outcomes in health education, but also fosters better student interaction and problem-solving skills. Students, being better prepared before entering face-to-face sessions, were able to participate more actively in discussions and develop a better understanding of concepts. This is relevant to the present study, where students who reviewed the material before class were able to participate more actively in discussions and develop a better understanding of concepts. Furthermore, a study by Luo et al. (2019) supports these findings, stating that flipped learning fosters better student interaction and enhances problem-solving skills through collaborative group work, inspiring a new way of learning.

However, this study also revealed several challenges in implementing flipped learning. One of the main obstacles is students' motivation to prepare before class, as some students were less disciplined in studying the material before face-to-face sessions. This finding is consistent with Bahadur and Akhtar (2021), who highlighted that one of the barriers to flipped learning is the variation in students' readiness to access and comprehend the material before class. Additionally, the readiness of lecturers to design engaging and interactive learning materials is a crucial factor in the success of this model. As emphasized in the study by Låg and Sæle (2019), the flipped classroom approach is only effective if lecturers can provide relevant and easily accessible materials for students, underscoring the pivotal role of educators in the success of flipped learning.

The findings of this study have several important implications for the field of education, particularly in technical learning and vocational education. First, this study demonstrates that flipped learning can effectively enhance student learning activeness in courses that integrate theory and practice, such as internal combustion engines. With increased learning activeness, students are better prepared to understand theoretical concepts and find it easier to apply these concepts during practical sessions.

Second, this study provides a foundation for developing more interactive and technology-based learning strategies, particularly in engineering education. By utilizing digital learning resources, such as instructional videos and online modules, flipped learning enables students to study the material flexibly before class sessions, which can improve their understanding of complex concepts. Third, this study offers educators and educational institutions insights into designing a more student-centered curriculum. By encouraging students to take greater responsibility for their learning, flipped learning helps develop critical thinking skills, collaboration, and problem-solving abilities, which are essential in today's workforce.

Although this study has demonstrated the effectiveness of flipped learning in increasing student learning activeness, several research opportunities remain to be explored. Future studies can investigate the application of flipped learning in other disciplines, such as medicine, science, or economics, to determine whether this model yields similar results in enhancing student engagement. Additionally, further research could assess the impact of flipped learning on academic achievement, including exam scores, conceptual understanding, and analytical skills. With the advancement of technology, studies may also explore how artificial intelligence (AI), augmented reality (AR), and gamification can further enhance the effectiveness of flipped learning, particularly in technical and vocational education. A deeper analysis is needed to identify factors influencing the successful implementation of flipped learning, such as student readiness, instructor skills, and the availability of institutional infrastructure and resources, to ensure a more optimal and sustainable application.

CONCLUSION

The results of this study unequivocally demonstrate the effectiveness of the flipped learning model in increasing the learning activeness of Mechanical Engineering Education students at Universitas Sebelas Maret in the combustion engine lecture. This learning model, based on the concept of active student learning, has been proven to encourage students to engage in the learning process actively. The increase in student learning activeness, from 45.24% in the pre-cycle stage to 91.74% in cycle 3, is a testament to its effectiveness. These findings reassure educators of the model's success, categorizing it as highly active and instilling confidence in its application.

For instance, students were required to [specific task or activity] before each class, and the in-class time was dedicated to [specific in-class activity]. Based on these findings, the results of this study can serve as a guideline for lecturers in implementing flipped learning as an alternative learning model that is more effective and interactive. Flipped learning increases student engagement and trains them to be more active in group discussions, confident in expressing opinions, and accustomed to asking questions. By adopting this model, students become more independent and responsible for their learning, making learning more meaningful and effective.

Furthermore, this study underscores the potential for applying flipped learning to other technical courses and broader academic disciplines. This model can be adapted and further developed across various fields of study by adjusting teaching materials and discussion topics to align with specific course requirements. The potential for future research to explore the implementation of flipped learning in other courses is vast, and it promises to provide a deeper understanding of the most effective learning syntax across different educational contexts, sparking curiosity and eagerness for more knowledge among educators.

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