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Research Article

Flipped Classroom Learning Model Assisted by the Experimentation Method: The Impact on Problem-solving Skills and Learning Independence

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Abstract

The issue in the field is that students' problem-solving skills and learning independence could be better. This study aims to analyze students' problem-solving skills and learning independence of students who are influenced by the flipped classroom learning model assisted by the experimentation method. The research employed the quasi-experimentation method with a posttest-only control group design. The data collection techniques employed were a description test to measure problem-solving ability and a questionnaire to measure learning independence that had been tested for validity, reliability, differentiability, and difficulty level. The data analysis technique used was the normality test, homogeneity test, and hypothesis test using the MANOVA test. The MANOVA test has been proven effective in testing hypotheses in several studies. Based on the analysis and discussion, applying the flipped classroom learning model assisted by experimentation affected students' problem-solving ability and learning independence.

Keywords:

Problem-solving skill; Learning independence; Flipped classroom learning model.

INTRODUCTION

Many institutions have declared the necessity of improving problem-solving skills in recent years. According to Holmes [1], individuals need to develop problem-solving abilities in the twenty-first century because people skilled at problem-solving will be able to keep up with the necessities of their lives, become more productive, and understand complicated issues relating to the world. There are at least several reasons why problem-solving ability is critical for every student: (a) problem-solving is a general goal of teaching mathematics [2], [3], (b) problem-solving, which includes methods, procedures, and strategies, is a core and the primary process in the mathematics curriculum [4], [5], and (c) and (c) problem-solving is a basic skill in learning mathematics [6], [7]. However, in developing problem-solving skills in schools, there are frequently unexpected impediments, such as the learning model teachers utilize [8], [9]. To overcome these challenges, teachers must implement learning models that aid in developing students' problem-solving abilities. The above viewpoint emphasizes the significance of selecting the appropriate learning model in learning [10]–[12]. As a result, it is also critical to encourage junior high school pupils to develop quantitative problem-solving skills [13]–[15].

Training in theoretical concepts and practical skills in a student-centered learning environment is an effective teaching technique for students to improve their

mathematical problem-solving skills [16]. Many studies have offered various techniques to create a student-centered learning environment in diverse scenarios [17]–[19]. When students participate in active learning, they are more likely to engage in a more complicated thinking process or to build higher-order thinking skills. This is consistent with one of the learning methods, flipped classroom. The flipped classroom is a student-centered learning strategy to help students enhance their learning abilities and outcomes [20], [21]. Students in the flipped classroom learning model must acquire the learning material in class and at home before the learning begins [22], [23]. In class, learning focuses more on completing assignments and addressing topics and difficulties students do not understand. It is unquestionably linked to student learning independence.

Learning independence is vital in flipped classroom learning because it allows students to choose how and when to study that is most productive for them. According to Miranda et al. [24], the Flipped Classroom learning model significantly impacts students' high learning independence because flipped classroom learning is based on studying not only in class but also at home; students can become more independent [25]. Learning independence is defined as actively participating in the learning environment, successfully organizing, training, and using their abilities, and having positive confidence in their learning ability [26].

Research has been undertaken to investigate problem-solving skills in various domains [27]–[31]. Problem-solving is a fundamental skill in learning mathematics in high school [6], [32]. Thus, problem-solving, particularly in mathematics, is critical for students to understand [33], [34]. Several studies have demonstrated the benefits of the Flipped Classroom learning model in mathematics [35]–[39]. Research [40] shows that the learning model can help students enhance their mathematical problem-solving abilities. Currently, research focuses on establishing new kinds of teaching [41], [42]. The article aims to examine how the flipped classroom learning model affects students' problem-solving skills and learning independence. Since the model incorporates creative learning stages, it will be possible to determine its impact on students' problem-solving skills and learning independence.

On the other hand, there has yet to be any research on the impact of the flipped classroom learning model on students' problem-solving skills and learning independence. Therefore, this research will yield novel results. This study compares the flipped classroom learning model to traditional classrooms to improve students' problem-solving skills and learning independence. Despite extensive research, the flipped classroom learning model has never been applied to students' problem-solving skills or learning independence.

Theoretical Background

Rodríguez et al. [43] believe that junior high school level learning is meant to achieve quality learning of scientific concepts. According to King, D., and Henderson, S. [44], in junior high school, students learn from real-life events so that they are relevant and practical and allow them to position themselves in their performance. Previous research suggests that specialized studies at the junior high level are needed to assess its impact on students' problem-solving skills [34], [45], [46] and students' learning independence [47], [48] in various subjects. This study investigates the impact of a flipped classroom learning model assisted by an experimentation method on junior high school students' problem-solving skills and learning independence.

Furthermore, past research indicates that the flipped classroom learning model is a student-centered learning model that can improve student skills [36], [49], [50]. Learning independence is vital for students since it allows them to achieve their will or desire in real life without relying on others. Students can also learn to study more efficiently, perform learning tasks effectively, and carry out learning activities independently [51]. The flipped classroom learning model involves learning that occurs in class but is completed at home by participants so that students can study more autonomously [21], [52]. As a result, by integrating learning activities at home and school, the flipped classroom learning model enables students to develop various professional competencies. The flipped classroom learning model, aided by experimentation, encourages students to conduct educational programs taught by learning projects based on real-world cases, allowing the application of theory to practice. It results in intellectual and social development, which will develop students' ability to solve problems in everyday life [53].

Sakulviriyakitkul, Sintanakul, and Srisomphan [54] discovered that the flipped classroom learning model stimulates student teamwork and a high level of desire and engagement, encouraging information exchange for project completion. Furthermore, they determined that the experimenting technique helps the efficiency of the Flipped Classroom learning model because it is very advantageous to learning [55]. Kolb, A. Y., & Kolb, D. A. [56] discovered that using the problem-related experimentation technique produced more interest and responsibility in students than was initially envisaged.

METHODS

Type of Research

The research method employed was quasi-experimental. The research samples were the students of class VIII A as the control class and VIII B as the experimental class. In this research, cluster random sampling was utilized as a sampling technique. The research design was the posttest-only control group design. The design of the quasi-experimental research is shown in Table 1.

Table 1. Research Design

Group	Treatment	Post-test
Experimental	X_1	O_1
Control	-	O_2

Description: O_1: Post-test score of the experimental class; O_2: Post-test score of the control class; X_1: The treatment of flipped classroom assisted by experimentation method.

Participants

Students from SMP Negeri 36 Bandar Lampung participated in this research. The research's population consisted of eighth-grade students in the first semester of the 2021/2022 academic year. These students were chosen using convenience sampling. The following are the sample's primary characteristics: The age range is between 13 and 15 years old. Regarding gender, 52.33% were females, and 47.67% were males.

Flipped Classroom Learning Model

The stages of the flipped classroom learning model are presented in Table 2.

Table 2. The Stages of the Flipped Classroom Learning Model

Stage	Activity
Plan	Teachers must first design classroom activities to introduce or create a context for the

	information students learn at home before classroom learning.
Record	Directing students to conduct independent research at home on the material provided by the teacher before class learning. Preparing for practical learning in class by studying the practicum instructions provided by the teacher. Prepare questions concerning poorly comprehended topics. The teacher's material can include videos or pdfs of current learning resources tailored to learning needs and films created by the teacher himself.
Share	In class, the teacher divides students into groups, leads discussions to answer the topics presented, and conducts experiments or practicums as directed by the teacher. The teacher examines the flow of each group's discussion and each member's participation in the group. After the group discussion, the teacher asks students to present the outcomes of the discussion or the practicum to the class and answer questions asked during the presentation.
Change	The teacher gives reviews or feedback to groups that have completed experiments or practicums, and they advise students or groups who still need clarification about the material that has been learned.
Group	After all the tasks have been accomplished, the teacher and students form conclusions from the learning that has taken place.
Regroup	The teacher asks the students questions as an individual assignment.

Instrument

Tests and questionnaires were employed to collect data. The test instrument was used to determine the profile of students' problem-solving skills. In this research, the test was descriptive questions about plant structure and function. Indicators of problem-solving skills were adopted from [57], shown in Table 3.

Table 3. Problem-solving Indicators

Problem-solving Indicators	Operational Forms
Understanding the problem	- Writing the information in the problem. - Writing the question statement based on the problem
Devising a plan	Devising and writing the mathematical models (or equations) for solving the problem
Carrying out the plan	- Carrying out the procedure for solving the problems. - Doing the calculation correctly.
Looking back	Writing the conclusion correctly

A questionnaire distributed to students served to assess learning independence. The questionnaire was organized around the following themes: planning, responsibility, initiative, confidence, discipline, and self-evaluation. The questionnaire was a statement with response alternatives on a Likert scale. The Likert scale range was 1-5, with two categories of statements: negative and positive.

Procedure and Data Analysis

After the lesson, the instruments were distributed by referring to the participants and the importance of the research

and assuring confidentiality of information for students who freely chose to participate. The instrument was distributed offline by the researcher. Statistical tests were performed using the SPSS version 25 application, which permits data organization through descriptive statistics such as mean (M) and standard deviation (SD).

RESULTS AND DISCUSSIONS

Results

The results of the MANOVA test to analyze problem-solving ability and learning independence influenced by the flipped classroom learning model simultaneously are shown in Table 4.

Table 4. MANOVA Test Result

Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.989	2799.920[b]	2.000	61.000	.000
	Wilks' Lambda	.011	2799.920[b]	2.000	61.000	.000
	Hotelling's Trace	91.801	2799.920[b]	2.000	61.000	.000
	Roy's Largest Root	91.801	2799.920[b]	2.000	61.000	.000
Class	Pillai's Trace	.468	26.850[b]	2.000	61.000	.000
	Wilks' Lambda	.532	26.850[b]	2.000	61.000	.000
	Hotelling's Trace	.880	26.850[b]	2.000	61.000	.000
	Roy's Largest Root	.880	26.850[b]	2.000	61.000	.000

The Manova test contains several tests: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root.

Table 4 demonstrates the mean differences in test results from the average component of problem-solving skills and learning independence with treatment (experimental and control). The treatment outcomes obtained a Sig value of 0.00. Therefore, H_1 was accepted. Thus, the independent variables jointly show the difference between the two dependent variables. Thus, the independent variables jointly show the difference between the two dependent variables following the requirements that H_1 is acceptable. Furthermore, the Test of Subject Effects was performed to determine whether the dependent variable (problem-solving skills and learning independence) was influenced individually by the independent variable (flipped classroom learning model assisted by experimentation method). Table 5 shows the results of the MANOVA test.

Table 5. The result of the Tests of Between-Subjects Effects

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Problem-solving skills	3073.316[a]	1	3073.316	34.812	.000
	Learning independence	1782.317[b]	1	1782.317	25.204	.000
Intercept	Problem-solving skills	257137.733	1	257137.733	2912.657	.000
	Learning independence	237112.998	1	237112.998	3353.091	.000
Class	Problem-solving skills	3073.316	1	3073.316	34.812	.000
	Learning independence	1782.317	1	1782.317	25.204	.000
Error	Problem-solving skills	5473.539	62	88.283		
	Learning independence	4384.315	62	70.715		
Total	Problem-solving skills	265684.588	64			
	Learning independence	243279.630	64			
Corrected Total	Problem-solving skills	8546.855	63			
	Learning independence	6166.632	63			

Table 5 shows the conclusions of the Tests of Between-Subjects Effects acquired by problem-solving skills and learning independence with a Significance value of 0.000, which is lower than 0 05. Therefore, students using the flipped classroom learning model assisted by the experimentation method outperformed those who learned using other learning models in average problem-solving skills. Furthermore, the average learning independence score demonstrates a difference between students who use the flipped classroom learning model assisted by the experimentation method and those who utilize alternative learning models. As a result, the flipped classroom learning model assisted by the experimentation method affected students' problem-solving abilities and learning independence.

Discussion

This discussion aims to examine the impact of the flipped classroom learning model, assisted by the experimentation method, on problem-solving skills and student learning independence. The research was carried out at the eighth-grade level at SMP Negeri 36 Bandar Lampung. Two classes were chosen as research samples in this research: experimental classes (VIII B) with 32 students and control classes (VIII-A) with 32 students. The experimental class employed the flipped classroom learning model assisted by the experimentation method. The control class used a traditional learning model. Because of the Covid-19 pandemic, learning was done online using various applications.

This research aimed to see if using the flipped classroom learning model assisted by the experimentation method affected students' problem-solving skills and learning independence. The flipped classroom learning model is an alternate learning model that combines face-to-face learning with online learning.

The structure and function of plant tissues were taught. The experimental and control classes each had three meetings to complete their learning. Students were given a post-test through description questions to examine problem-solving skills and a questionnaire to gauge learning independence. The questions and questionnaires were based on problem-solving skills and learning independence indicators that had passed the validity, reliability, difficulty, and discriminating index tests.

The study's findings were taken from the post-test questions and questionnaires distributed at the end of the meeting. According to Table 2, there are four indicators of problem-solving skills based on Polya's theory. In the indicator of understanding the problem, the experimental class has a percentage of 70% (moderate), and the control class has a percentage of 45% (low). Delors's [58] states that the indicator of understanding the problem is included in the pillars of education. This aspect is intended to define and understand the elements contained in the subject matter. The devising a plan indicator in the experimental class obtained a percentage of 55% (moderate), and the control class obtained 44% (low). This indicator makes it easy to work on the next indicator. Students are required to determine the strategies needed to solve the problem. The indicator of implementing the plan in the experimental class obtained a percentage of 58% (moderate), and the control class obtained a percentage of 45% (low).

The indicator of implementing the plan, the third indicator, requires students to implement the strategy that has been prepared. The indicator of looking back in the experimental class obtained a percentage of

65% (high), and the control class obtained a percentage of 47% (low). The indicator of looking back means checking or re-checking the results of the solution or problem-solving solution. This indicator is very important to avoid mistakes or mistakes in solving problems. The difference in the achievement of students' problem-solving skills with the flipped classroom learning model shows that the model requires students to improve their problem-solving skills and be better prepared to understand learning materials. The flipped classroom learning model fulfills the criteria of effective learning [59]. In addition, it can make students solve high-level problems such as problem-solving problems because the flipped classroom learning model provides sufficient time for students to work on practice problems independently. So that the flipped classroom learning model is effective in students' problem-solving skills. Students' activities support this finding during learning that can achieve learning objectives so that students' problem-solving skills in learning will increase and be active.

Table 4 reveals that the experimental class received 59% (medium) in the 'not depending on others' indicator, while the control class received 52% (medium). In this indicator, students are expected to study in their unique style and to solve problems creatively. The experimental class received a 69% (high) percentage on the confidence indicator, while the control class received 56% (moderate). The enthusiasm with which students convey the outcomes of their work, ask questions, and answer questions demonstrates their confidence. The experimental class received a percentage of 69% (high) on the indicator of self-control, while the control class received a percentage of 53% (moderate). Students with learning independence must be able to self-control. Students with self-control must manage their learning time, pay attention to developing their learning successes, and strive to enhance their learning outcomes. The experimental group scored 67% (high) on the motivation indicator, while the control group received a 57% (moderate) score. This indicator motivates students to accomplish something, to be motivated to finish their work, to be excited about learning, and to be enthusiastic about learning.

The experimental class received a percentage of 64% (high) on the responsibility indicator, while the control class received 54% (moderate). This indicator is assessed as an instance by examining students' attitudes toward receiving feedback and criticism on their work, delivering assignments on time, and avoiding cheating on tests. The difference in student learning independence achievement with the flipped classroom learning model demonstrates that it requires students to increase their learning independence.

The flipped classroom learning model's attainment of high learning independence in learning demonstrates that the model can boost student learning independence in all indicators. Ananda, R., & Hayati, F. [60] discover that learning independence influences student learning outcomes because they attempt to examine learning information from diverse sources freely. Independence is required so that students can feel responsible for planning and disciplining themselves. According to O'Shea, E. [61], the key aspect of learning independence is the growth of students' ability to learn without relying on teachers, friends, classes, or others. As a result, students' participation in numerous learning activities suggests that they have high learning independence. According to Suryawan et al. [62], the flipped classroom learning model substantially enhances student learning independence.

The next test was the normality test using the Liliefors formula on the problem-solving skills test. The significant level of the

experimental class was 0.200, which was greater than α (0.05). The control class obtained a value of 0.141, greater than α(0,005). In the learning independence questionnaire, the average significance level of the experimental class was 0.200, which was greater than α (0.05). The significance level of the control class was 0.200, which was greater than α (0.05).

The homogeneity test in this study used Fisher's test to determine whether the data on the results of students' problem-solving skills and learning independence had homogeneous characteristics or not. After the homogeneity test, the significant level of the problem-solving ability test is 0.928, which is greater than 0.05, and the significant level of learning independence is 0.143, which is also greater than 0.05. Therefore, it can be concluded that the data is homogeneous.

According to the MANOVA test analysis findings in Table 9, the value of problem-solving skills is 0.000, or less than 0.05. As a result, H_0 is rejected. Learning independence has a value of 0.000, which is less than 0.05. As a result, H_0 is rejected. Because problem-solving skills and learning independence are interrelated, students can learn independently and solve problems while learning. In support of the study's influence of the two dependent variables, the researcher indicated that the flipped classroom learning model assisted by the experimentation method could be employed since it helps enhance problem-solving skills and learning independence. Based on the research findings, the researcher concludes that the flipped classroom learning model can promote problem-solving skills and learning independence when combined with the experimentation method.

Previous relevant studies support the findings of this research. One of them is the research by Putri et al. [63], which demonstrates that the flipped classroom learning model can increase students' critical thinking skills. Furthermore, Miranda et al. [24] found that the growth in students' learning independence in the flipped classroom class was greater than in the scientific class. Rahmawati, A., and Nuraeni, Z. [64] discovered a favorable and significant effect of the flipped classroom learning model assisted by animated films on student learning independence. Based on the findings and discussions, it is possible to conclude that the research hypothesis is accepted, which means that the flipped classroom learning model assisted by the experimentation method has a significant effect on the problem-solving skills and learning independence of the eighth-grade students at SMP Negeri 36 Bandar Lampung.

CONCLUSIONS

The analysis and discussion reveal that using the flipped classroom learning model with the experimentation method influences problem-solving skills and learning independence. The objectivity of the results obtained in this research is somewhat distorted because the material of plant form and function as a stimulus is only assessed using a limited number of objective assessment criteria. Given the uncertain nature of uniqueness as an assessment criterion, the teacher's perspective and awareness of the subject matter is the only basis for this research method.

Future lesson models will explore students' problem-solving skills and learning independence. It is envisaged, in particular, that objective criteria that indicate the amount of originality of the work will be discovered and validated. The sample size and number of participants will be increased to achieve more reliable results.

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Conflicts of Interest

The authors declare no conflict of interest.

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