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Effect of Blended Learning Models and Self-Efficacy on Mathematical Problem-Solving Ability

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Abstract. The purpose of this research was to determine the effect of the flipped-classroom and flex blended learning models in enhancing the mathematical problem-solving ability of junior high school students. The quasi-experimental pre- and post-test method was used to carry out this research. The sample consisted of 128 students divided into two equal groups (n_1 = n_2 = 64). Self-efficacy data were collected through a questionnaire, while problem-solving ability was evaluated using validated mathematics problem test-sets. Analysis of covariance (ANCOVA) was used to analyze the data, with the independent variables comprising the learning model (flipped and flex) and self-efficacy (low and high). The dependent was the post-problem-solving ability score, and the pre-test was the covariate. The test results showed that participants in the flipped class group obtained a final problem-solving ability score greater than those in the flex group after the initial score was controlled ($p < 0.001$), with a large effect size of $\omega^2 = 0.382$. Although self-efficacy was a significant factor in the final test score ($p = 0.001$, $\omega^2 = 0.134$), the interaction with learning models was insignificant ($p = 0.226$). This shows that students will increase their math problem-solving ability test scores in flipped and flex classes regardless of their self-efficacy level. In conclusion, the flipped classroom technique can be implemented to enhance mathematical problem-solving abilities among Grade 8 students with low or high self-efficacy. To ensure a successful learning process, variances in cognitive capacity, learning medium, objectives, and students' emotional qualities also need to be considered.

Keywords: blended learning; flex model; flipped classroom; problem-solving; self-efficacy

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1. Introduction

The current digital technology development is bound to affect the rate of learning mathematics (Borba et al., 2016). This is evident in its increasing use in schools during the academic process (Lin et al., 2017). Its utilization n the implementation of learning provides new variations on how to deliver teaching materials, interact during the process, as well as carry out evaluations (Stein & Graham, 2014). However, digital technology still has to be adjusted to suit students' needs to achieve learning objectives (Carreira et al., 2016).

According to the National Council of Teachers of Mathematics (NCTM, 2000), five skill objectives need to be achieved by students, namely representation, reasoning, proof, communication, problem-solving, as well as connection. One of the main goals of learning mathematics is acquiring problem-solving skill or ability (Santos-Trigo, 2014). It is an important part of the curriculum, because when students understand mathematical material, the next step is its application (Roehl et al., 2013). Problem-solving ability becomes essential when applied in everyday life (Jazuli et al., 2017). Therefore, it needs to be prioritized in mathematics learning (NCTM, 2000).

Schunk (2020) stated that a problem is a circumstance when an individual tries to achieve some goal and needs to determine or decipher ways to ensure its realization. Problem-solving can occur when new students are asked to solve a particular question and try to find a solution (Sengul & Katranci, 2012). Similarly, Carreira et al. (2016) argued that it requires trial, discussion, and reflection. Based on this description, problem-solving is a thinking activity perceived as an effort to solve questions or issues that are considered difficult and need to be resolved to achieve certain goals.

According to preliminary research, students still face certain difficulties in solving math problems, such as understanding the question and using critical thinking (Purwoko et al., 2019; Setiana et al., 2021; Triana et al., 2021). This makes it difficult for them to transform a problem into a mathematical sentence. Sari et al. (2021) furthermore explained that errors have been found through analysis of students' answers, as it was discovered that they were unable to connect the problem-solving process with known data and facts. This was due to didactic learning, which is usually centered on the teacher (Mulyono & Hadiyanti, 2018). These problems can be managed by using interactive learning designs that construct knowledge and provide opportunities for students to solve questions.

A suitable learning model is blended learning based on cognitive and constructivist theories (Tynan et al., 2013). It combines the conventional face-to-face and online methods to promote more active, interactive, and collaborative learning (Awosdeyi et al., 2014), thereby creating an effective, efficient, and flexible environment (Stein & Graham, 2014). Blended learning combines various activities, namely face-to-face with synchronous and asynchronous e-learning and independent studying (Mundt & Hartmann, 2018). Furthermore, it has the potential to improve teaching quality and ensure the flexibility of students by diversifying instructional delivery and exploring the benefits of information technology in mathematics learning (Lin et al., 2017). Through this model, students are to flexibly interact with the learning materials and media, as well as provide feedback. The use of online media affords students more time to study the material, considering the speed of their understanding (Goos et al., 2020).

One of the most popular blended learning models is the flipped classroom. The learning material or content is studied at home through activities using various media. Meanwhile, in the class or face-to-face setting, students have ample time to discuss, ask some questions, or engage in other exercises related to the practical ones (Cronin & Coakley, 2018; Fernández-Martín et al., 2020). This enables them to develop concepts, participate in collaborative learning, and solve problems (Roehl et al., 2013). The flipped classroom minimizes the amount of direct instruction from teachers during meetings, thereby maximizing interactions among students. With respect to mathematics learning, this method is considered more effective than the traditional format for students of various educational levels, ranging from K-12 (Chen et al., 2015; Clark & Falls, 2015; Razm et al., 2021) to university (Chen et al., 2016; Park & Han, 2018).

In addition to the flipped method, another blended learning approach is the flex model, which focuses on directing students' activities to independent online-based learning. The teacher's role is to develop materials and provide students assignments accessed by using the internet. Although the basis of this method is online learning, occasionally, it also directs students to engage in offline exercises. Learning activities with the flex model allow real-time schedules which can be changed to meet students' needs (Beaver et al., 2015; Christensen et al., 2013). The flex model is less popular and has not been widely studied, specifically in relation to learning mathematics compared to the flipped classroom. Salleh et al. (2017) carried out a comparative study involving comparing the flipped and flex models in learning English as a second language (ESL). They reported that the flipped model is more suitable for ESL learning because students do not need to go to the physical English language classroom. All they need to do is watch the video before the lesson and discuss the material or do the exercises related to the topics given in the classroom. Meanwhile, Aboraya (2021) discovered that the flex model, with the help of a web-based virtual laboratory, was more effective in helping Grade 5 students understand abstract mathematical concepts than the conventional methods. The effectiveness of both methods is less known in improving students' problem-solving abilities in mathematics.

Besides these models, another factor that affects learning objectives is self-efficacy (Çikrıkci, 2017). This concept relates to a person's belief in evaluating their abilities while performing a given task (Doménech-Betoret et al., 2017). Generally, the positive relationship between self-efficacy and problem-solving ability can be extended to mathematics learning (Amri & Widada, 2019; Sun et al., 2018). Students who believe in their own capability tend to be able to use various cognitive strategies to learn and complete mathematical tasks (Pajares & Graham, 1999). Research has reported a positive relationship between self-efficacy and blended models both at the university level (Sun et al., 2018) and among high school students (Lai & Hwang, 2016). The evidence mentioned in this research suggested an interaction effect between students' self-efficacy and blended learning which has been less studied, particularly among junior high school students.

This research addresses the gap in the literature about the effect of flipped and flex blended learning models on the mathematical problem-solving abilities of junior high school students. It also examines whether the effect of the learning models on problem-solving ability depends on their self-efficacy level.

2. Literature Review

2.1 The Flipped Classroom

The flipped classroom is quite a popular blended learning model, with a general principle described as follows. In a traditional setting, teachers use some lesson periods to present the material. The remaining periods are used for extracurricular activities, such as practice and exercises. However, in the flipped classroom, the material is studied at home using various media, while the class or face-to-face setting is devoted to discussions, asking questions, or practicing activities and exercises (Cronin & Coakley, 2018). This type of learning is student-centered, with the teacher acting as a facilitator. Students become more active during face-to-face meetings because the material has been previously studied (Cronin & Coakley, 2018; Fernández-Martín et al., 2020). The flipped classroom comprises four pillars, namely flexible environment, learning culture, intentional content, and professional educator (Ayob et al., 2020). Its characteristics are shown in Table 1.

Table 1: Flipped classroom characteristics

Characteristic	Explanation
Rotation	Students switch schedules between offline and online learning activities during and after school, respectively. Class or lesson periods are used to discuss learned concepts and practice assignments.
Learning methods	Teaching materials and directives are delivered during online learning, which occurs outside the school premises.
Activities	Students need to study the teaching materials at home.
Setting	Students can study the materials online and ask questions via the learning management system (LMS) used.
Location	Students practice and engage in discussions during offline learning held at school.

Source: Ayob et al. (2020)

2.2 The Flex Model

Kennedy (2021) stated that the flex model is a blended learning design where the majority of the activities are carried out online, although with the support of the classroom teacher. According to Christensen et al. (2013), the flex model benefits both face-to-face and online learning, and can also be modified to fulfill students' needs. Some of the characteristics of this model are shown in Table 2.

Table 2: Flex model characteristics

Characteristic	Explanation
Setting	Students study online either individually or in groups, while teachers engage in offline learning when at school, except for homework.
Rotation	Content and instructions are fully delivered online.
Learning methods	Students engage in both online and offline learning individually.
Activities	In the classroom, teachers tend to provide learning activities carried out in small groups and project teams and offer individual guidance. This is carried out either online or offline.

Source: Ayob et al. (2020)

In the flex model, the distribution of teaching materials, discussions, and communication with students, including the collection and assessment of assignments, are carried out using an LMS, for example Google Classroom (Adamu & Hawamdeh, 2020). Teachers can assess students' progress through the online platform used, and then select those who need improvement or to be re-taught (Vanek et al., 2020). These processes are flexibly carried out, and the learning pace can be adjusted based on students' needs and the learning environment (Horn et al., 2014).

2.3 Self-Efficacy

In his book on self-efficacy, Bandura (1997) stated that self-efficacy is an individual's belief in achieving the desired performance level. Someone with a high perception of this attribute hopes to succeed and endeavors to complete any assigned task (Doménech-Betoret et al., 2017). A person with a low perception tends to anticipate failure and is less likely to engage in challenging activities persistently. In the academic field, self-efficacy strengthens motivation in achieving the desired success and determines one's behavior and intellectual capability. This attribute is triggered in students through four sources, namely physiological affective states, verbal persuasion, vicarious experiences, and authentic mastery experiences (Bandura, 1997). Furthermore, there are three dimensions of self-efficacy, namely level, strength, and generality, and these formed the basis for developing the measurement instruments used in this research, as shown in Table 3 below.

2.4 Problem-Solving Ability

Problem-solving ability refers to a person's skill to solve issues encountered in everyday life (Intaros et al., 2014). According to Polya (1973), there are two types of problems in mathematics, namely to find and to prove. The problem to find is any question aimed to determine or obtain the actual value of certain objects that are not known, as well as provide appropriate conditions. Conversely, the problem to prove is resolved with a specific procedure to determine whether or not a statement is true. These problems are further classified into well-structured and ill-structured problems. Well-structured or routine problems create opportunities for the application of procedures obtained from the teaching materials. On the other hand, an ill-structured problem requires collecting information, finding the solution, and clarifying the correct answer (Chiu et al., 2014).

Table 3: Dimensions of self-efficacy

Aspect	Indicator	Statement
Level (confidence level to determine the level of difficulty that is believed to be able to be overcome in completing the task)	Students are optimistic.	I am able to carry out every task based on my ability.
		I will be able to properly complete the given task.
	Students feel that they can confidently complete the task.	I am confident in my ability to complete the task at hand.
		The other students can attest to the fact that I am proficient in completing assignments.
Strength (level of consistency in carrying out the task at hand)	Students are trying their best.	I tend to engage in activities necessary to complete the task.
		When there is a new task given, and I do not know in advance how to solve it, I can complete it well.
	Students are committed to completing assignments.	I usually feel challenged to complete each task.
		I try to complete the task even irrespective of the obstacles.
Generality (the level of belief and ability to generalize previous experiences)	Students are able to properly respond to the various situations and conditions.	I am able to complete new tasks based on previous experiences.
		I am able to perform different tasks.
	Students use their previous experience as a step in determining the success.	I feel confident because previous experience is useful in terms of properly completing the assigned task.
		I believe that experience and achievements serve as a guide to achieving success.

Adapted from: Bandura (1997)

Polya (1973) described the four stages of problem-solving. In the first stage, namely understanding the problem, students need to identify the known parameters, either in data, quantities, relationships, and related values or the variable being sought. Some suggestions that can help them understand complex problems include asking questions about the known and sought variable, explaining the difficulty in their own words, relating the current problem to other similar ones, focusing on the important part, developing models, and drawing diagrams (Kirisci et al., 2020). In the second stage, namely devising a plan, students must identify the operations involved and the strategies needed to solve the given problem. This is carried out by guessing, developing a model, sketching diagrams, simplifying problems, identifying patterns, making tables, conducting experiments and simulations, working in reverse, testing all possibilities, identifying sub-goals, making analogies, and sorting data or information (Kirisci et al., 2020). As for the third stage, a plan is carried out where the information provided is interpreted in mathematical form and strategies are implemented during the calculation process. At this stage, students need to maintain the plan that has been selected. Unfortunately, assuming such a plan cannot be implemented, students are free to select another method (Kirisci et al., 2020). In the final stage, it is necessary to re-check all important information that has been identified and the calculations, consider whether the solution is logical, analyze other alternatives, read the question again, and ask oneself whether it has been properly answered (Kirisci et al., 2020).

2.5 The Relationship Between Blended Learning, Self-Efficacy, and Mathematical Problem-Solving Ability

Several studies have reported that both flipped and flex models of blended learning have a positive effect on mathematical problem-solving skills compared to conventional or face-to-face learning (Aboraya, 2021; Awosdeyi et al., 2014; Clark & Falls, 2015; Fazal & Bryant, 2019; Lopes & Soares, 2018; Razm et al., 2021; Wiginton, 2013). Students are usually less interested and motivated during face-to-face learning; therefore, they find it difficult trying to understand the learning material (Bringula et al., 2021). The application of active blended learning triggers interactivity among students and teachers. Constructive knowledge is imbibed in students; therefore, they are made to memorize and understand the teaching material. They are also facilitated to discuss the lesson delivered and apply it as a starting point to be used in problem-solving. Students have more time to study the material and assignments at their own pace independently. It has been shown that blended learning has many variations in teaching mathematics (Awosdeyi et al., 2014). Its application is considered appropriate for improving mathematical problem-solving ability, specifically at the secondary level.

According to Loch and Borland (2014), successful blended learning improves students' performance and aids them to develop self-regulation skills and become aware of their lack of understanding related to complex conceptual tasks. The success of its implementation is affected by both cognitive and affective abilities (Çikrıkci, 2017). Self-efficacy is one of the main factors that can affect the success of blended learning. It also has an impact on students' choices, level of motivation, and resistance to adversity (Chytrý et al., 2020). Those with high self-efficacy generally tend to have certain beliefs, accurately perform assigned tasks, are determined, and tend to think clearly, and are therefore highly confident when solving a problem (Wiginton, 2013). Conversely, students with low self-efficacy have low self-regulation, motivation, and self-awareness. They are generally not confident in their ability to solve problems, tend to be unwary, and are not careful in writing their answers (Wiginton, 2013). Prior studies have shown that self-efficacy is closely related to learning achievement in mathematics (Amri & Widada, 2019; Arifin et al., 2021). It is also one of the main factors that determines the success of blended learning implementation (Rafiola et al., 2020; Sun et al., 2018). We attempt to explore whether students in the flipped classroom will obtain different problem-solving results than those in the flex classroom, depending on their levels of self-efficacy.

3. Method

3.1 Participants

The participants in this research were Grade 8 students of a junior high school in Gresik, East Java, Indonesia. The sample selection was carried out using a purposive sampling technique based on prior knowledge of the population and the specific study objectives (Fraenkel et al., 2012). The District Education Office selected a school with low mathematics achievement. In general, Grade 8 Indonesian students scored below the "*low*" level in the 2013 mathematics testing for international benchmarking (OECD/ADB, 2015). Data were obtained from four out of eight classes of Grade 8 students at the selected school based on their similar composition of self-efficacy levels (low and high). The four classes consisted of 128 students, which were divided into two groups, namely flipped and flex. Each group comprised 64 students within the age range of 13 to 14 years.

3.2 Experimental Design

This research employed a quasi-experimental design consisting of two groups, subject to pre- and post-tests. The independent variables were blended learning (flipped classroom and flex model) and self-efficacy (high and low). The covariate was the initial problem-solving score (pre-test), while the dependent variable was the final problem-solving score (post-test). This research was based on experimental and control classes as well as pre- and post-tests, as shown in Table 4.

Table 4: Quasi-experimental design

Group	Pre-test	Experimental treatments	Post-test
Experimental group	O_1	X_1	O_2
Control group	O_3	X_2	O_4

X_i : Experimental treatments at i = 1, 2
O_i : Problem-solving ability test at i = 1, 2, 3, 4

As seen in Table 4, self-efficacy questionnaires and pre-tests were initially administered and performed before the learning process (pre-test). The treatment for the experimental and control groups involved using the flipped and flex classroom models. After the learning procedure, both groups were given a problem-solving ability test (post-test).

3.3 Instrument and Data Analysis

In this research, self-efficacy was measured with a questionnaire adapted from the indicators designed by Bandura (1997). The participants were asked to answer 12 statement items on a 4-point Likert scale (1 = *strongly disagree* to 4 = *very appropriate*). An example of an item is: "I can engage in every task based on my ability." The content validity test was evaluated by experts, with good assessment results. The item validity evaluation was also carried out using the Pearson product-moment correlation, based on the criterion that the value of r_{count} has to be > r_{table} (Aspelmeier, 2005). A total of 62 students who were not included in the intervention were involved to evaluate the self-efficacy questionnaire. The correlation test results for each question item at the level $\alpha = 5\%$ and the value of r_{table} = 0.25 for df = 60 are shown in Table 5.

Table 5: Pearson correlation values of self-efficacy questionnaire

Number	Correlation	Criterion	Number	Correlation	Criterion
1	0.626	Valid	7	0.357	Valid
2	0.589		8	0.518	
3	0.380		9	0.577	
4	0.494		10	0.324	
5	0.485		11	0.543	
6	0.635		12	0.605	

Based on the validity of the test results, it was discovered that all statement items were valid. Moreover, a reliability test that aims to determine the internal consistency of the instrument questions was carried out using Cronbach's alpha criteria. In the social science field, a coefficient value > 0.6 is acceptable (Field, 2017). The reliability test result of the self-efficacy questionnaire was 0.747, which is presumed to be good.

Furthermore, a test instrument that consisted of four essay questions on Pythagorean theorem was used to measure students' problem-solving ability. This test was developed following the four stages by Polya (1973). The problem-solving test is performed within 60 minutes, and the score for each question ranges from 1 to 8. Mathematics education experts conducted content validity testing, with the results of this instrument category being very good. The item validity test was performed using the Pearson product-moment correlation based on the criterion that $r_{count} > 0.25$ for $df = 60$, $\alpha = 5\%$. Table 6 shows that all items were declared valid. The Cronbach alpha coefficient value of 0.686 implies that the test instrument for problem-solving ability was reliable.

Table 6: Pearson correlation value of problem-solving test instrument

Number	Correlation	Criterion
1	0.682	Valid
2	0.657	
3	0.757	
4	0.783	

The data were gathered after the research instrument was proven valid and reliable. The total score of the self-efficacy questionnaire was obtained by adding up the scores for each item, which were further classified under low and high categories. This division was used to obtain the median, and the results are taken into consideration while grouping the participants into two classes. After acquiring all the relevant data, statistical inference testing was carried out using the analysis of covariance (ANCOVA) performed with SPSS 23. During the evaluation, the dependent variable was the post-test value of problem-solving ability, the independent one was the value of model and self-efficacy, while the results of the pre-test acted as a covariate.

3.4 Procedure

This research was carried out for six weeks by implementing two blended learning models: flipped and flex models. The first step was to determine the participants for the flipped and flex classes. Before assigning any work, all of them were asked to fill out a self-efficacy questionnaire to group each participant into the appropriate category. They were also expected to engage in a pre-test to determine their initial problem-solving ability. The subject matter of the Pythagorean theorem was adapted to the Grade 8 junior high school mathematics curriculum. The lessons were delivered by the same teacher twice a week, with a duration of 30 minutes for each group. The learning media used were videos, textbooks, and the internet, for example Google Sites. Google Classroom was used for the interactive sessions outside of the school, using electronic devices such as smartphones and computers to access learning resources.

Regarding the flipped model, the learning materials were delivered online through Google Sites and Google Classroom before in-class meetings. Furthermore, during in-class or face-to-face sessions, participants were invited to discuss the material they had studied independently. They were also asked to evaluate the worksheets that had been provided. In contrast to the flex model, teachers encouraged participants to study the online materials by accessing them using a computer or smartphone. The teacher's role was to assist participants in studying independently. At the end of the meeting, participants were given a worksheet to be evaluated at home. The answers were collected through Google Classroom. After each flipped and flex class, a formative assessment was carried out to evaluate the learning process during each meeting. At the end of the entire procedure, participants were asked to work on their problem-solving ability post-test.

4. Results

4.1 Descriptive Statistics

Descriptive statistics for math problem-solving scores based on the main effects of each factor and the interactions between them are shown in Figure 1 and Table 7.

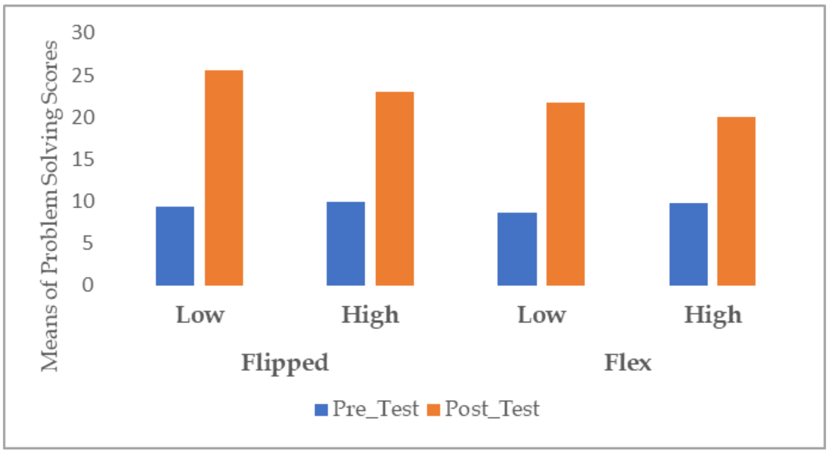

Figure 1. Comparison of problem-solving ability between blended learning model and self-efficacy before and after intervention

Table 7: Descriptive statistics of all variables

Variable		n	Pre-test		Post-test	
			Mean	**SD**	**Mean**	**SD**
Model	Flipped	64	9.73	2.807	24.75	3.537
	Flex	64	9.38	2.682	21.11	2.955
Efficacy	Low	43	8.93	2.649	21.42	3.6
	High	85	9.87	2.746	23.69	3.569
Cross-tabulation of the model vs efficacy vs test score						
Model	**Efficacy**	**n**	**Pre-test**		**Post-test**	
			Mean	**SD**	**Mean**	**SD**
Flipped	Low	21	9.29	2.723	22.95	3.309
	High	43	9.95	2.853	25.63	3.338
Flex	Low	22	8.59	2.594	19.95	3.302
	High	42	9.79	2.664	21.71	2.597

In general, the problem-solving test scores between participants in the flipped (M = 9.73; SD = 2.807) and flex classes (M = 9.38; SD = 2.682) before the intervention were relatively similar. Those with low (M = 8.93; SD = 2.649) and high (M = 9.87; SD = 2.746) levels of self-efficacy did not show significant differences on their pre-test scores. Similar observations were also noted in the respective cross-tabulation, as shown in Table 7.

4.2 Evaluation of the Blended Models

Before the ANCOVA analysis, Levene's test was carried out, and the following results were obtained: $F(3,124) = 2.372$, $p = 0.0735$ ($p > 0.05$). This indicates that the assumption of variance homogeneity is fulfilled. A summary of the ANCOVA test results is shown in Table 8.

Table 8: ANCOVA results

Source	F	p	η^2	ω^2
Problem-solving_Pre	43.156	< 0.001	0.260	
Model	40.639	< 0.001	0.248	0.382
Efficacy	10.906	0.001	0.081	0.134
Model * Efficacy	1.479	0.226	0.012	0.007

Based on the results displayed in Table 8, the learning model was a significant factor after the initial problem-solving score was controlled, with $F(1,123) = 40.639$, $p < 0.001$. Although the SPSS output yielded an effect size value of η^2, in this research, we manually calculated the value of ω^2 for bias correction (Lakens, 2013). The value of ω^2 relating to the difference in the learning model of 0.382 indicates that the blended model had a large effect, where participants in the flipped class obtained a higher problem-solving score than those in the flex class (Table 7). Problem-solving scores also differed between participants with high and low self-efficacy, with $F(1,123) = 10.906$, $p < 0.001$, with a medium effect size ($\omega^2 = 0.134$). However, no interaction was detected between the learning model and self-efficacy in the final problem-solving score, with a value of $F(1,123) = 1.479$, $p = 0.226$, $\omega^2 = 0.007$. This shows that both variables are able to individually explain the ability to solve mathematical problems. Regardless of the level of self-efficacy, participants' problem-solving abilities increased after they had attended the flipped and flex classes, with those in the flipped class scoring higher (see Figure 2).

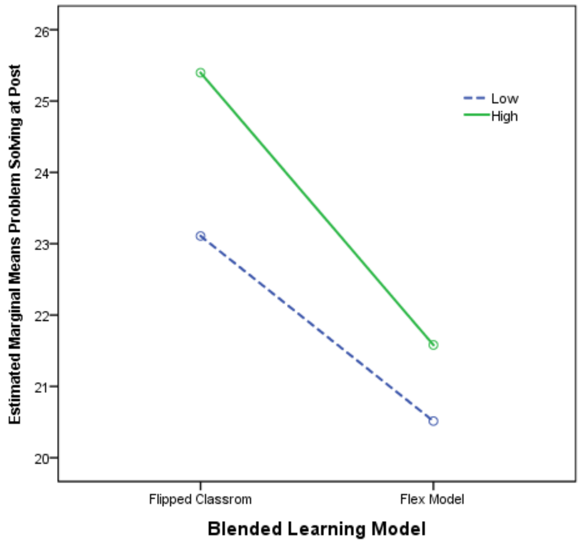

Figure 2: Interaction between learning model and self-efficacy

5. Discussion

In general, we found that the blended learning model was able to increase the final scores awarded to the mathematical problem-solving abilities of the participating junior high school students. This is in line with previous research, which showed the positive impact of blended learning, specifically the flipped classroom method, compared to the conventional approach adopted in learning mathematics in both K-12 (Clark & Falls, 2015; Fazal & Bryant, 2019; Razm et al., 2021; Wiginton, 2013) and higher education (Awosdeyi et al., 2014; Chen et al., 2016).

5.1 Main Effects of Blended Models and Self-Efficacy

Lin et al. (2017) demonstrated that blended learning effectively improves academic achievement. This model allows students to use their digital devices to access teaching resources, thereby enabling them to control their entire progress and study without being distracted. They can browse the learning materials as many times as possible, and repeat the explanations and exercises for them to understand the content (Tynan et al., 2013).

Specifically, the flipped classroom also boosts interaction among peers, students, and teachers. Students benefit from group discussions and collaborative learning helps them increase their understanding of previous self-studies (Guo et al., 2016; Roehl et al., 2013). Furthermore, they actively use online resources rather than passively receive information from teachers to acquire and learn mathematical concepts. In the face-to-face part, students are aided with their assignments and encouraged to get involved. This process improves students' mathematical problem-solving ability. They exhibit more positive attitudes, enjoy the lessons delivered, and are more motivated to practice mathematics (Razm et al., 2021). Good interaction between the main components tends to impact learning efficiency.

Meanwhile, compared to the flex model, participants in the flipped class achieved higher scores. Unfortunately, no research has compared these two methods in learning mathematics and other subjects at the secondary school level. The flex model allows students to move according to a more fluid schedule between learning activities and modalities according to their needs.

Anthony (2019) examined best teacher practices in blended elementary classrooms through observations of and interviews with six teachers and found that flex model learning requires more drastic changes in instructional design than other station rotation models. This explains why it is less effective than the flipped classroom in enhancing mathematical problem-solving skills. Students in a flipped class are exposed to more opportunities in terms of discussing the material while in class because it was studied beforehand. Comparative research has also supported that the flipped model is more suitably applied in the ESL classroom than the flex one (Salleh et al., 2017).

This study also discovered that self-efficacy has a significant effect on problem-solving ability. The findings are in line with previous research showing that self-efficacy has a positive effect on the general academic scores and mathematical problem-solving ability (Amri & Widada, 2019; Sun et al., 2018). This implies that in circumstances where students are faced with a particular problem, the higher their self-efficacy, the more positive their attitude. Conversely, it implies that the lower their self-efficacy, the higher the feeling of being threatened and the more negative the attitude. Students need to be able to overcome obstacles and not give up quickly on these online subjects. Self-efficacy is needed for students to develop their thinking processes (Chen et al., 2015; Lai & Hwang, 2016). It helps them to predict their problem-solving abilities in a controlled model as well as to detect the effects of anxiety, cognitive competence, math achievement, and self-efficacy on independent learning (Pajares & Graham, 1999).

5.2 Interaction Effect Between Blended Models and Self-Efficacy

We found an insignificant interaction between learning model and self-efficacy, which indicates that the two variables (learning model and self-efficacy) had no simultaneous effect on mathematical problem-solving ability. It is presumed that the effect of the learning model on this variable does not depend on self-efficacy. Participants in both the low and high self-efficacy groups tended to experience an increase in problem-solving ability in both the blended flipped and flex classes (see cross-tabulation section in Table 7). Moreover, their problem-solving abilities were affected by independent variables that had a separate impact (Kerlinger, 2006). This is because this study only evaluated self-efficacy before blended learning was applied, thereby probably boosting those with low self-efficacy.

Action research conducted on students in Grade 9 relating to their learning of algebra showed that students in the flipped mastery learning method class had higher scores in the Mathematics Self-Efficacy Scale-Revised (MSES-R) test than those in the traditional classes (Wiginton, 2013). This is also in line with a systematic review of the flipped classroom, which showed that the level of self-efficacy in collaborative learning positively impacts strategies employed during the learning sessions (Rasheed et al., 2020). Therefore, it has potential to obtain different outcomes, assuming self-efficacy is also re-measured after the intervention.

6. Limitations

This research had several limitations. First, it was limited to the use of junior high school students from a particular institution, and as such the results cannot be generalized to other populations and disciplines. Second, the learning outcomes measured were limited to problem-solving ability. Therefore, further research needs to be conducted to determine the effectiveness of blended and other models, such as the rotation and dependent variables. According to preliminary research, these academic outcomes are related to understanding mathematical concepts (Arifin et al., 2021; NCTM, 2000) and students' attitudes or perceptions after the intervention (Chen et al., 2016; Clark & Falls, 2015).

7. Implications

This is the first research to compare the effect of two blended methods in mathematics learning in secondary schools. According to the findings, the blended method offers many combinations of various learning models, such as the flipped and flex models. The flipped model was suggested because it is more suitable to improve certain mathematical abilities in secondary school students. Furthermore, cognitive ability, learning media, objectives, and students' affective characteristics need to be considered in order to ensure its effectiveness (Setiana et al., 2021). Educators must be able to combine certain learning approaches with environmental conditions and facilities that allow students to achieve their objectives optimally (Purwoko et al., 2019).

8. Conclusion

The main objective of this research was to examine the effect of blended learning with flipped and flex models and self-efficacy, respectively, on the mathematical problem-solving abilities of Grade 8 students and the interaction between these two factors. In summary, participants in the flipped class obtained higher problem-solving ability than those in the flex class. Furthermore, those who had high self-efficacy performed better than those with low self-efficacy. There was no interaction between the learning models and self-efficacy. This indicates that its effect on the mathematical problem-solving ability does not depend on the level of self-efficacy.

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