Does flipped learning method via MOODLE can improve outcomes and motivation of discrete mathematics learning during COVID-19 pandemic?

H Mursyidah, R P Hermoyo, and D Suwaibah
Universitas Muhammadiyah Surabaya, Jl. Sutorejo 59 Surabaya, Indonesia
E-mail: himmatul.pendmat@fkip.um-surabaya.ac.id

Abstract. The purpose of this study is to determine whether the flipped learning method via MOODLE can improve learning outcomes and motivation to learn discrete mathematics during COVID-19 pandemic. This is because discrete mathematics is one of the mathematics subjects that requires a lot of practice and needs direct direction by lecturers or educators. In this study, we used Classroom Action Research that consisted of two cycles. The stages in each cycle were plan, implementation, observation, and reflection. Based on the results of the study, it was found that the flipped learning method via MOODLE can improve the learning outcomes of discrete mathematics from only 30% of students who complete to 100% of students completed. In addition, students' discrete mathematics learning motivation increased from 45% or medium criteria to 79% or high criteria. The stages that can be used are (1) lecturers provide stimulus through questions to students to find references independently of a question, (2) students learn the material independently and make questions about the material which is not yet understood, (3) students and lecturers conduct discussions to correct misconceptions, and (4) students work on questions from lecturers as evaluation.

1. Introduction
Covid-19 in early 2020 has changed the paradigm of education in Indonesia. The Indonesian government's policy that requires learning at home during the Covid-19 pandemic made educators think critically in order to be able to carry out teaching and learning. Studying at home is a must in order to avoid Covid-19, which has not yet been found to have vaccines and medicine [1–3]. Therefore, online distance learning is the only option to do from elementary, secondary, until university levels [4]. At universities, we conduct online lectures during the Covid-19 pandemic by using various platforms that have been determined at each institution, including Google Classroom, Schology, Microsoft 365, Edmodo, Quipper, the Indonesian Online Learning System (SPADA Indonesia), and MOODLE [5].

At Universitas Muhammadiyah Surabaya, one of university in Surabaya Indonesia, we use many varieties of online learning platforms, but the main platform is MOODLE. MOODLE stands for Modular Object-Oriented Dynamic Learning Environment, which is a Learning Management System (LMS) in the form of a software package produced for teaching and learning that utilizes information technology and can be used freely as an open source product under the GNU license [6,7]. MOODLE can be
installed on any computer and operating system that can run PHP and support SQL databases [8]. We have used this platform since before the Covid-19 pandemic, which is 2018 so that lecturers at Universitas Muhammadiyah Surabaya have implemented blended learning since that year. Based on this, both lecturers and students at the Universitas Muhammadiyah Surabaya should be able to adapt quickly when there are government regulations on teaching and learning from home during the Covid-19 pandemic. The reality that occurs, both lecturers and students are still unable to adapt to carry out online learning as a whole. That is because when blended learning, there is face-to-face learning between lecturers and students.

Students of Mathematics Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surabaya also experience the inability to adapt into online learning during the pandemic, especially in learning mathematics courses such as discrete mathematics. This is evidenced by the outcomes and motivation to learn at the beginning of the pandemic in Tables 1 and 2. Learning mathematics requires a lot of practice exercises. The purpose of learning mathematics according to the National Council of Teachers of Mathematics (NCTM) is an activity in improving the ability of problem solving, the ability in argumentation, the ability to communicate, the ability to make connections and the ability to make representations [9]. To achieve this goal, discrete mathematics lecturers at the Department of Mathematics Education at the Universitas Muhammadiyah Surabaya use learning steps i.e. explaining the material and sample questions, followed by questions and answers. After the discussion, students work on questions from the lecturer in front of the class in turn, which can be corrected directly by the lecturer, therefore if there are mistakes or misunderstandings, they can immediately ask. That was a way of teaching and learning before the pandemic. We can't do that during a pandemic. As a result at the beginning of the pandemic i.e. on the 5th until 7th lecture weeks, student learning outcomes are far below the minimum completeness criteria, 70% of students did not complete their studies as in Table 1.

![Table 1. Discrete mathematics learning outcome at beginning of COVID-19 pandemic](image)

| Interval Score | Letter Score | Criteria | Percentage |
|----------------|-------------|----------|------------|
| 80-100         | A           | Complete | 23%        |
| 72-79          | AB          | Complete | 0%         |
| 64-71          | B           | Complete | 0%         |
| 56-63          | BC          | Complete | 7%         |
| 48-55          | C           | Not complete | 36%  |
| 40-47          | D           | Not complete | 17%  |
| 0-39           | E           | Not complete | 17%  |

Whether in a pandemic or not, student learning outcomes can be improved by providing motivation to learn. Motivation possessed by students can encourage themselves to provide solutions to the learning problems they face. Students who have high learning motivation can not only provide solutions but can also see alternatives to the problem solution. This can make them more creative and innovative. If they have high motivation, they can make themselves the best, tough, and different from other students [10]. Learning motivation can arise by giving stimulus by lecturers. Therefore, we as mathematics lecturers should make better learning plans during the pandemic so that students can provide a good learning experience mentally and physically.

Based on the problems in the Mathematics Education Department, students are familiar with the stages of learning; the lecturer explains the material, questions and answers, practice questions and discussion; which is less likely to be done in online learning. Therefore, we changed the learning method by choosing the flipped learning method. Flipped learning is one of the learning methods that we can try to implement it in the COVID-19 pandemic situation. This method differs in conventional learning which is only centred from the lecturer therefore students tend to be passive [11,12]. In the flipped learning method, the teaching and learning process is centred on students by using the reverse concept.
i.e., (1) lecturers provide stimulus through questions to students to find references independently of a question, (2) students learn the material independently and make questions about the material which is not yet understood, (3) students and lecturers conduct discussions to correct misconceptions, (4) students work on questions from lecturers as evaluations. The benefits of using the flipped learning method is students can be independent in learning material at home, students can learn lecture material comfortably, if students have difficulty in doing exercises, they can deliberate with their lecturer. They are advantages that we do not have in conventional mode of schooling [13]. Based on this background, this study aims to determine whether the application of the flipped learning method via MOODLE is able to improve discrete mathematics learning outcomes and motivation during the COVID-19 pandemic.

| Statement                                                                 | Strongly agree | Agree | Disagree | Strongly disagree |
|---------------------------------------------------------------------------|----------------|-------|----------|-------------------|
| 1. Online learning via MOODLE during COVID-19 pandemic kept me motivated to study discrete mathematics | 3%             | 27%   | 67%      | 3%                |
| 2. Online learning via MOODLE during COVID-19 pandemic made discrete mathematics subject interesting | 0%             | 30%   | 67%      | 3%                |
| 3. Online learning via MOODLE during COVID-19 pandemic made it easy for me to understand discrete mathematics subject materials | 0%             | 23%   | 73%      | 3%                |
| 4. Online learning via MOODLE during COVID-19 pandemic made me more productive in learning discrete mathematics | 7%             | 53%   | 73%      | 3%                |
| 5. Online learning via MOODLE during COVID-19 pandemic made discrete mathematics material easy to remember | 10%            | 13%   | 73%      | 3%                |
| 6. I like discrete mathematics online learning via MOODLE during the Covid-19 pandemic because I can discuss with other students and lecturers | 3%             | 30%   | 60%      | 7%                |
| 7. Online learning via MOODLE during COVID-19 pandemic benefited me        | 0%             | 47%   | 53%      | 0%                |
| 8. Online learning via MOODLE during COVID-19 pandemic made it easier to obtain discrete mathematical material and task collection became more flexible | 3%             | 70%   | 27%      | 0%                |
| 9. Online learning via MOODLE during COVID-19 pandemic makes it easy to get real-time announcements | 7%             | 53%   | 40%      | 0%                |
| 10. Online learning via MOODLE during COVID-19 pandemic saves time and money | 7%             | 67%   | 23%      | 3%                |
| Average                                                                   | 4%             | 41%   | 52%      | 3%                |

2. Method
In this study, we used Classroom Action Research (CAR). Classroom action research is a form of research that is reflective and carried out by educators when there are problems in the teaching and learning process, such that improvements and results can be obtained. This was done to make the process and learning outcomes better than before. Classroom action research that had been carried out consists
of two cycles. The stages in each cycle consist of plan, implementation, observation, and reflection as in Figure 1 [14,15].

We carried out research for 4 weeks i.e. the 9th to 12th lecture weeks in the even semester of the 2019-2020 academic years. It took place on April 16 - May 8, 2020. Subjects in this study were all students of 4th semester in Mathematics Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surabaya. The number of 4th semester students in the 2019-2020 academic years was 30 students. They consisted of 4 men and 26 women.

We collected some data in this study to find out both the improvement of student learning outcomes and motivation using the flipped learning method via MOODLE during the COVID-19 pandemic. These data were the activities of students, student learning outcomes, and student motivation. To obtain these data, we used some instruments. They were observation sheets, exercises done by students, and online questionnaires using Google forms. To fill out the observation sheet, we observed the activities of students at MOODLE LMS.

![Figure 1. The stages in each cycle of classroom action research](image)

We also determined indicators of success to know whether the cycle needs to be continued or not. Indicators of success in this study were students included in the category of completion if their learning outcomes score ≥ 56 or minimum in the letter score is BC. This was in accordance with the applicable curriculum of Mathematics Education Department, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surabaya which states that the minimum value of discrete mathematics subjects is BC. Classical completeness was achieved when there were ≥ 80% of students who completed it. The students learning motivation was said to be successful if there were ≥ 80% of students answered agree and strongly agree on the questionnaire that was positive [16]. The criteria of students learning motivation are given in Table 3 [17].

| Percentage interval | Criteria   |
|---------------------|------------|
| 81% - 100%          | Very high  |
| 61% - 80%           | High       |
| 41% - 60%           | Medium     |
| 21% - 40%           | Low        |
| 0% - 20%            | Very Low   |

Table 3. The criteria of students learning motivation
3. Result and Discussion

The first and second patients of COVID-19 in Indonesia are two residents of Depok, West Java. They are the mother and daughter. The daughter was first infected with the COVID-19 virus from her friend, a Japanese citizen who had visited Indonesia. They were eventually isolated and treated at Sulianti Saroso Hospital (RS) which handled the COVID-19 case. President Joko Widodo at the presidential palace announced the first COVID-19 patient in Indonesia on Monday, 2nd March 2020 [18]. The spread of COVID-19 is very fast in various countries such that the World Health Organization (WHO) changes the status of the disease into a global pandemic. This was announced by WHO Director General, Tedros Ghebreyesus in Geneva, Switzerland on March 11, 2020 [1,5]. The COVID-19 pandemic led the Indonesian government to issue a policy regarding the obligation to study at home. On Sunday 15 March 2020, President Joko Widodo instructed regional heads to make policies for the teaching and learning process in schools and universities to be carried out at home [19]. In response to government policy, rector of Universitas Muhammadiyah Surabaya issued a letter number 0290/MLM/II.3.AU/A/2020 on "Increasing Awareness and Prevention of COVID-19 Infection Spread in Universitas Muhammadiyah Surabaya". Therefore, all components of the Universitas Muhammadiyah Surabaya have worked and learned from home since Tuesday, March 17th, 2020 [20].

We implemented the policy in the 5th lecture week, including discrete mathematics subjects. As we explained in the introduction, we have used the MOODLE LMS platform at the web address http://genap2019.um-surabaya.ac.id/ before the pandemic. However, we used this platform only to share learning resources such as books, articles, and slide material. We also used it for online assignment collection. As for discussion forums, we rarely did it via MOODLE. Therefore, discrete mathematics lectures in the early weeks of distance learning i.e. 5th lecture week, we gave assignments as learning evaluation materials in the 4th week. Whereas in the 6th and 7th weeks, we gave a new material about generating function.

At first, we used the learning method as usual. At the first meeting, (a) the lecturer gives the material and explains in the discussion forum about important points that students must understand, (b) students ask questions they don't understand. At the second meeting, (c) students work on an assignment as an evaluation. Apparently, this makes 70% of students' learning outcomes incomplete as in Table 1. Therefore, we designed learning using the flipped learning method via MOODLE to be implemented starting 9th week. For each cycle consists of two meetings that discuss a material, and we use the stages as in the introduction. We conducted stages (1) and (2) at the first meeting. While stages (3) and (4), we did at the second meeting.

![Figure 2](https://genap2019.um-surabaya.ac.id/course/view.php?id=101)

**Figure 2.** Discrete mathematics learning using flipped learning method via MOODLE in cycle 1
We did cycle 1 on Thursday, 23rd and 29th April 2020. The material discussed was generating function application to solve the recurrence relation, see Figure 2. In stage (1), lecturer gave a stimulus in the form of an order to complete the mathematical completion steps. For example, at the stage of forming a general Maclaurin series with the partial fraction method from generating function which has been simplified in the solving recursive sequence problem. The instruction given was “Describe how to get A and B as exercise 1”, see Figure 3. Based on the lecturer stimulus, students did stage (2). They tried to complete the steps by guidance references from the lecturer and looking for other references. Students also noted things that were not understood to be discussed in the discussion forum at stage (3) in the next meeting.

![Figure 3. Lecturer stimulus in cycle 1](image)

In stages (1) to (3), we observe student activities. Student activities with the highest score are students study slide material given by lecturers and doing assignments, they are equal to 100%, so it can be said that all students actively participate in these two points. Then the student activity with the lowest score is students give opinions in an online discussion forum that is equal to 23.33%. The overall results can be seen in Table 4.

| Indicators                                      | Percentages |
|------------------------------------------------|-------------|
| 1. Study material slide provided by the lecturer | 100%        |
| 2. Look for other references related to the material being studied | 80%        |
| 3. Ask questions in the discussion forum        | 37.68%      |
| 4. Give opinions in the discussion forum        | 23.33%      |
| 5. Work on assignment                           | 100%        |

The last stage, we evaluated the learning process by giving exercises to students. This also determines the sustainability of the cycle. Evaluation results show that classical completeness is 93%, this means that the results of cycle 1 have met the indicators of success. However, there are still two students who are incomplete. Furthermore, the average value of student learning outcomes is 60.67 with a maximum value equals to 75, and a minimum value equals to 55. It can be seen in Table 5. Because of that, we continued on cycle 2.
Table 5. Discrete mathematics learning outcome

| Interval Score | Letter Score | Criteria | Percentage | Cycle 1 | Cycle 2 |
|----------------|-------------|----------|------------|--------|--------|
| 80-100         | A           | Complete | 0%         | 0%     | 20%    |
| 72-79          | AB          | Complete | 7%         | 37%    |        |
| 64-71          | B           | Complete | 0%         | 43%    |        |
| 56-63          | BC          | Complete | 86%        | 0%     |        |
| 48-55          | C           | Not complete | 7%     | 0%     |        |
| 40-47          | D           | Not complete | 0%     | 0%     |        |
| 0-39           | E           | Not complete | 0%     | 0%     |        |

For cycle II, we did it on 11th and 12th weeks i.e. on April 30, 2020 and May 8, 2020. The material being studied was the generating function application to solve combination problems, see Figure 4.

**Figure 4.** Discrete mathematics learning using flipped learning method via MOODLE in cycle 2

Similar to cycle 1, the lecturer provided a stimulus by instructions to solve a problem. One of the problems is “Then, what if the problem is modified? Young brother wants to take out plastic balls 3 times out of 3 blue balls (B) and 3 yellow balls (K) in the box. How many ways young brother can take out at most 2 blue balls and 3 yellow balls? Explain your answer as Exercise 1!” see Figure 5.

**Figure 5.** Lecturer stimulus in cycle 2
Based on Table 4, student activities have increased in cycle 2. They are activity of look for other references related to the material being studied increase 20%, ask questions in the discussion forum activity increase 5.65%, and give opinions in the discussion forum activity increase 23.34%. However, still two activities related to discussion forums in real-time are not up to 50% of students doing well. We can find out the cause after giving a motivational questionnaire. 43% of students have difficulty obtaining a signal network. Nevertheless, they still can understand well the material provided. This is proven by Table 5. All students get learning outcomes with complete criteria; it means classical completeness reaches 100%. The highest score is 80 and the lowest score is 70, with an average score equals to 73.93. Therefore, this study stopped until cycle 2.

At the end of the study, we gave motivation questionnaires to students via Google form. The results showed that 79% of students responded agreed and strongly agreed to positive statements about the use of the flipped learning method via MOODLE. We can see this in Table 6. Based on Table 3, students’ learning motivation is included in the high criteria.

**Table 6. Discrete mathematics learning motivation using flipped learning method via MOODLE**

| Statement                                                                                     | Percentage |
|---------------------------------------------------------------------------------------------|------------|
| 1. Learning using the flipped learning method via MOODLE during COVID-19 pandemic kept me motivated to study discrete mathematics | 20% 73% 7% 0% |
| 2. Learning using the flipped learning method via MOODLE during COVID-19 pandemic made discrete mathematics subject interesting      | 10% 70% 20% 0% |
| 3. Learning using the flipped learning method via MOODLE during COVID-19 pandemic made it easy for me to understand discrete mathematics subject materials | 17% 47% 37% 0% |
| 4. Learning using the flipped learning method via MOODLE during COVID-19 pandemic made me more productive in learning discrete mathematics | 7% 67% 27% 0% |
| 5. Learning using the flipped learning method via MOODLE during COVID-19 pandemic made discrete mathematics material easy to remember | 10% 53% 37% 0% |
| 6. I like discrete mathematics learning using the flipped learning method via MOODLE during the Covid-19 pandemic because I can discuss with other students and lecturers | 17% 63% 20% 0% |
| 7. Learning using the flipped learning method via MOODLE during COVID-19 pandemic benefited me | 20% 73% 7% 0% |
| 8. Learning using the flipped learning method via MOODLE during COVID-19 pandemic made it easier to obtain discrete mathematical material and task collection became more flexible | 17% 70% 13% 0% |
| 9. Learning using the flipped learning method via MOODLE during COVID-19 pandemic makes it easy to get real-time announcements | 10% 87% 3% 0% |
| 10. Learning using the flipped learning method via MOODLE during COVID-19 pandemic saves time and money | 10% 50% 33% 7% |
| Statement | Percentage |
|-----------|------------|
|            | Strongly agree | Agree | Disagree | Strongly disagree |
| Average    | 14% | 65% | 20% | 1% |

In addition, we also provide open-ended questions to students regarding the benefits of using the flipped learning method via MOODLE in discrete mathematics learning. They say learning becomes more flexible, acquires a new atmosphere, becomes more motivated to learn independently to find references, can have more discussions with friends and lecturers, makes students trained in critical thinking, learning is more scheduled and productive, and so on. This is consistent with previous studies about the use of flipped learning method [9,11–13]. The difference is that during a pandemic, face-to-face learning cannot be implemented. But, it has a positive effect which is to train students to be more responsible.

4. Conclusion
The flipped learning method can be an option for use in the learning process via MOODLE during the COVID-19 pandemic. Based on the research results obtained that the method can improve student learning outcomes and motivation in learning discrete mathematics. The stages that can be used in learning using the flipped learning method via MOODLE are (1) lecturers provide stimulus through questions to students to find references independently of a question, (2) students learn the material independently and make questions about the material which is not yet understood, (3) students and lecturers conduct discussions to correct misconceptions, (4) students work on questions from lecturers as evaluations. In one material, it takes 2 meetings where the first meeting contains stages (1) and (2), while in the second meeting contains stages (3) and (4). The results of this study indicate that by doing this method, student learning outcomes can increase by 70% while learning motivation increases by 34%. Nevertheless, as lecturers we must also pay attention to the obstacles experienced by students, especially internet network problems in this situation.

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