**Formative Assessment on The Flipped Classroom Model in theMathematics Learning**

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**Abstract.** The first purpose of this article is to describe what is the benefits of the formative assessment in learning mathematics. Secondly the purpose of this article is to describe how the formative assessment is applied in learning mathematics with the flipped classroom model. The learning stages or syntax of the flipped classroom model in mathematics learning are carried out online and face-to-face. In the online stage, formative assessment can be carried out by giving homework or assignments, quizzes, and assessments through e-learning before the implementation of face-to-face learning. In the face-to-face stage, formative assessment can be carried out with discussions, learning presentations, and peer assessments.

**Keywords:** formative assessment, flipped classroom, mathematics learning

1. ***Introduction***

Globalization brings changes in the world of education. Technology is one of the important to develop the quality of learning in education. Teachers can use technology by planning, designing, and implementing material in the learning process. [1]. The student-centered learning process makes students active in developing their knowledge by asking or working on the questions given. The role of the teacher as a facilitator brings changes in guiding, motivating, and providing feedback to students.

Mathematics is an important subject for students. Learning mathematics requires understanding concepts from students who emphasize understanding symbols and problem-solving rules. Research conducted by Zaini & Retnawati stated that students had difficulty making conclusions or the results of a mathematical calculation because students could not interpret the answers to the questions given [2]. Difficulty in making conclusions is an error in the construction of students' concepts. In this problem, the role of the teacher is needed to update the learning information that takes place in constructing concepts during the mathematics learning process [3]. One of the learning models that can be used for students to construct concepts in mathematics learning is the flipped classroom.

Flipped classroom is a learning model that can encourage learning and student-centered [4]. In traditional learning, mathematical theory is taught in the classroom, and homework is carried out at home. However, in a flipped classroom, mathematical theory is studied at home through online activities or videos and discussions, projects, presentations in the classroom.

Assessment is part of the learning process used to see the achievement of students using the flipped classroom model. Before learning begins, students must make questions in the form of what, why, where, and how the learning/material is being studied. So, students can instill a sense of confidence, responsibility, and self-esteem in learning. One of the assessments that can be carried out in the learning process using the flipped classroom model is formative assessment. Formative assessment or assessment for learning is the provision of information on the progress of students to improve the learning process [5].

Research conducted by DeLuca states that the success criteria and teacher feedback help in the process of improving student learning [6]. The feedback received by students can help reduce problems found, for example, the answers of students who are incomplete in answering math problems using the flipped classroom model. Students who can provide feedback in mathematics learning are students who get specific feedback from the teacher [7]. As a result, the formative assessment in mathematics learning using the flipped classroom model is needed.

1. ***Assessment Formative in Mathematics***

In learning mathematics, an assessment is needed to measure the achievement of students. Assessment measurement in mathematics learning can use summative assessment (assessment of learning) and formative assessment (assessment for learning) [8]. Summative assessment or assessment of learning is an assessment carried out at the end of learning in the form of daily tests, midterm exams, final semester exams, and national exams. Meanwhile, formative assessment or assessment for learning is the giving of feedback by the teacher by looking at the condition of students who still have the opportunity to be improved [9].

Small weights or grades of completeness standards in mathematics subjects depend on the assessment as a learning revision aid. Some assessments are usually carried out at the end of the learning period, but we think that these factors do not join a summative assessment. Sadler stated that the main difference between formative and summative assessment relates to goals than timing [10]. In the basic to high education levels, student-centered learning requires students to learn independently. Thus, it is still possible that the learning assessment carried out is formative.

There are four reasons for using formative assessment in learning mathematics. First, students can focus on learning and teachers can focus on the various learning methods used. Second, direct assessment can give meaning to the feedback provided by the teacher. Third, students have better ideas for improving learning achievement because of specific assessments. Fourth, consistent with the constructivist theory in learning [11]. Although formative assessment seems to spend time learning, formative assessment should be carried out in the learning process not to add to the already busy lesson hours [12].

In formative assessment in mathematics, the role of feedback is very important. The role of feedback for students is to help and determine problems in the learning process by strengthening success in learning. The role of feedback for the teacher is to show the success of the learning strategy and to identify the learning process that should be improved or modified [13]. Providing feedback by involving large numbers of students exploring challenges in several researchers and providing suggestions for applying peer feedback to students, increasing the ability of students to self-assess their work and utilizing technology to improve feedback [14].

1. ***Assessment in Flipped Classroom***

The flipped classroom is a learning model that is implemented in reverse. In traditional learning, the teacher usually explains the material in the learning process in class and gives homework to do at home, while in a flipped classroom learning the teacher explains learning material online and does homework in school [15]. Learning with the flipped classroom model is carried out to minimize the number of direct interactions in teaching material and maximize interaction time in discussing related problems that are carried out by teachers and students [16].

The learning stages or syntax used in learning with the flipped classroom model do not have a standard format. The flipped classroom model is based on Bloom's taxonomic theory in the cognitive domain. Table 1 is presented in the following to see a comparison of the traditional model and the flipped classroom in Bloom's taxonomy: [17]

|  |  |  |
| --- | --- | --- |
| **Table 1.** Comparison of the traditional model and flipped classroom in Bloom's Taxonomy | | |
| ***Level of Learning*** | ***Traditional Classroom*** | ***Flipped Classroom*** |
| Remembering | Face-to-face lecture | Pre-recorded lecture, reading material and watching video lectures independently |
| Understanding | Q & A | Reflection, peer-to-peer discussion and collaboration |
| Analyzing | Homework | Classroom activities such as a group discussion |
| Applying, Evaluating, Creating | Homework or nothing | Student projects, presentations, peer-evaluation and instructor evaluation |

The components in the learning phase or syntax with the flipped classroom model according to Muyzka & Luker are pre-class instructions, pre-class assessments, in-class discussions, active learning activities in class, and in-class assessments [18]. According to Bergmann & Sams, the learning stages or syntax comparing traditional models and flipped classrooms are presented in table 2 below: [15]

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 2.** Comparison of traditional models and flipped classroom according to Bergmann & Sams | | | |
| **Traditional Classroom** | | **Flipped Classroom** | |
| ***Activity*** | ***Time***  ***(min)*** | ***Activity*** | ***Time***  ***(min)*** |
| Apperception | 5 | Apperception | 5 |
| Repeat the previous lesson | 20 | Q&A time on video | 10 |
| New material content | 30-45 | Assignments or exercises facilitated by the teacher | 75 |
| Assignments or exercises facilitated by the teacher | 20-35 |  |  |

The learning stages in the flipped classroom model consist of online and direct learning. Online learning is carried out by providing video material explanations, homework or assignments, quizzes, and assessments via e-learning. Learning that is carried out directly after online learning is a question and answer about videos that have been watched, discussions, learning presentations, and assessments [18]. Formative assessment with online learning stages in the flipped classroom model is homework or assignments, quizzes, and assessments via e-learning. Formative assessment with face-to-face learning stages is a discussion, presentation, and peer assessment.

1. ***Formative Assessment on The Flipped Classroom Model in the Mathematics Learning***

The formative assessment process in the online flipped classroom learning model is homework/assignments, online quizzes, and e-learning assessments. Homework is a type of formative assessment that is often done in mathematics learning. Homework or in online learning is given after students watch the learning video. The assignments given by the teacher online come from several materials related to manuals and learning videos that have been studied without informing students beforehand. Formative assessment that can be done in giving assignments or homework is the completeness of students in answering math problems and presentations of face-to-face assignments [19]. Online quizzes on mathematics lessons carried out by students can be given every week to see students' understanding of concepts in that week [18]. Formative assessment using e-learning has benefits in knowing the conceptual understanding of students in mathematics lessons. The teacher can provide questions from previous materials through e-learning. The results of the formative assessment that students have can provide input in the revision of the module that will be used. In doing assignments or homework and quizzes, the teacher can arrange the assessments given. Students can do assignments or homework and quizzes several times or only once [20] [21]. From doing assignments or homework and quizzes, teachers can provide feedback to students on the e-learning platform used.

The formative assessment process carried out face-to-face is discussion, presentation, and peer assessment. Discussions that are carried out are related to assignments or homework given to online learning. Students work in small groups to answer questions. In this small group, students who do not understand the questions can discuss with their peers. Group members take turns providing solutions, strategies, and proper approaches to questions on assignments or homework and providing feedback on errors that may be made. The discussions carried out provided benefits in interactive explanations, motivation and self-confidence carried out by students and peers. In group discussions, no score was given [22].

The presentation carried out was related to assignments or homework that had been discussed in the group to the whole class with a duration of about five to ten minutes of presentation [23]. The presentation made by students provides motivation and confidence in mathematical skills because students realize that the mistakes made are not only from themselves. Mathematical presentation assessments carried out by students orally provide opportunities for students to correct mistakes in reading math sentences. By doing the presentation, students can listen to the explanation of the material apart from the teacher and it is easier to understand [24].

Assessments conducted by peers provide an assessment of one student to other students. Thus, the role of students is not only as learners but also as teachers to assess peers [25]. The teacher must provide criteria and training in peer assessment to students. To be able to do peer assessment, students must have a good understanding of mathematical concepts. Peer assessment can improve students' ability to think, present, and foster cooperation. Students have different abilities (high, medium, and low), so this peer assessment must be carried out with the same abilities of students.

Research has shown the benefits of formative assessment are improving learners' learning achievement and increasing teacher content knowledge [26]. Johnson's research on the flipped classroom learning model focuses on the mastery of learning. Students who have not reached more than 70% on the formative assessment quiz cannot continue the material. These learners receive a remedy for their repetition. The benefit of applying formative assessment in mathematics learning using the flipped classroom model is that the teacher can ensure that students have a stronger basic understanding [27].

The use of formative assessment in teaching can provide benefits to increasing students' mathematics learning and developing positive beliefs [28]. Formative assessment by providing feedback can help students to conclude learning activities [29]. This is in line with research conducted by Rakocyz et al which states that teacher feedback is useful when teachers use diagnostic tools and feedback according to the provision of material during learning activities in formative assessment. Students feel confident about learning achievement on upcoming tests or quizzes and tend to have an interest in taking tests or quizzes [30].

Lai & Hwang's research entitled "A Self-Regulated Flipped Classroom Approach to Improving Students' Learning Performance in a Mathematics Course". Among the research results, the post-test score of the experimental group was significantly higher than the control group. From this study, it was also found that the integration between self-regulated and flipped learning can improve the abilities of students. Where students can learn to improve the abilities of students through planning activities and efficient use of time [31].

The results of Muir & Geiger's research shows that students and teachers get positive experiences from learning using a flipped classroom and students are motivated to follow online mathematics learning resources designed by the teacher [32]. Ogen's research results show that students can carry out learning with many questions and teachers can control students in learning so that students can be facilitated if they do not understand the subject matter [33].

1. ***Concluding Remarks***

In this article, we have detailed the types of formative assessment used in the flipped classroom learning model and their benefits. The learning stages or syntax of the flipped classroom model in mathematics learning are carried out online and face-to-face. In online learning, formative assessments can be carried out by giving homework or assignments, quizzes, and assessments via e-learning before face-to-face or direct learning. In face-to-face or direct learning, formative assessment can be carried out by discussion, learning presentations, and peer assessments.

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