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Abstract

This study aims to determine the influence of *flipped classroom* learning design on mathematics learning outcomes of high school students. The background of this research is based on the low involvement of students in conventional learning that tends to be teacher-centered, so an alternative learning design is needed that can increase independence and understanding of mathematical concepts in a more in-depth manner. *The flipped classroom* model was chosen because it provides students with the opportunity to learn material independently outside of the classroom through videos or digital teaching materials, then utilize face-to-face time for discussion, problem-solving, and concept deepening. The research method used was a pseudo-experiment with a *pretest-posttest control group design*. The subjects of the study were 60 students in grade XI of SMA Negeri 1 Bekasi, which were divided into an experimental group (30 students) and a control group (30 students). The research instrument was in the form of a multiple-choice mathematics learning outcome test and a brief description. Data were analyzed using an independent t-test with a significance level of 5%. The results showed a significant difference between the two groups. The average posttest score of the experimental group was 82.47 with a standard deviation of 6.12, while the average posttest score of the control group was 74.13 with a standard deviation of 7.05. The results of the *t-test* obtained a t-count value = $3.98 > t\text{-table} = 2.00$ ($p = 0.000 < 0.05$), which means that there is a significant influence of the application of *flipped classroom* on the mathematics learning outcomes of SMA Negeri 1 Bekasi students. Thus, *the flipped classroom* learning design has been proven to be more effective than conventional learning in improving mathematics learning outcomes.

Introduction

Education is one of the fundamental aspects in nation building. Through education, the young generation is expected to be able to develop their potential, master science, technology, art, and have a character based on the noble values of the nation. This is in line with Law Number 20 of 2003 concerning the National Education System, Article 3, which states that national education functions to develop abilities and form the character and civilization of a dignified nation, and aims to develop the potential of students to become human beings who have faith, piety, noble character, healthy, knowledgeable, capable, creative, independent, and become democratic and responsible

citizens.

In the era of globalization and the industrial revolution 4.0, the challenges of education are increasingly complex, especially in improving the quality of learning in accordance with the demands of science and technology development. Mathematics education as one of the core subjects in high school (SMA) has a strategic role in developing students' logical, analytical, critical, and creative thinking skills. Mathematics is also an important basis for mastering other sciences, especially science and technology. However, in reality, the mathematics learning outcomes of high school students in Indonesia are still relatively low, both on a national and international scale.

The results of the Programme for International Student Assessment (PISA) survey in 2018 show that the mathematics literacy achievement of Indonesian students is ranked 73rd out of 79 countries with an average score of 379, far below the OECD average of 489. This condition shows that the problem-solving skills and understanding of mathematical concepts of Indonesian students are still not optimal. Similarly, the results of the National Examination (UN) and National Assessment (AN) in recent years also show that mathematics is one of the subjects with the lowest average score at the high school level. This fact is an indicator that there is a need for innovation in mathematics learning design to be more effective, fun, and in accordance with the characteristics of the current digital generation.

So far, mathematics learning in schools is still dominated by a conventional teacher-centered approach. Teachers play more of a role as conveyors of information, while students tend to passively receive material. As a result, student involvement in the learning process is low, critical skills are not developed, and learning outcomes are not satisfactory. In fact, Permendikbud Number 22 of 2016 concerning Standards for Primary and Secondary Education Processes emphasizes that learning must be carried out in an interactive, inspiring, fun, challenging, and motivating manner for students to actively participate, as well as providing sufficient space for initiative, creativity, and independence in accordance with the talents, interests, and physical and psychological development of students.

One of the innovative approaches that can answer these challenges is the *flipped classroom learning design*. *Flipped classroom* is a reverse learning model, where the process of providing material or explaining concepts is carried out outside the classroom through digital media such as videos, electronic modules, or online learning platforms, while face-to-face activities in the classroom are focused on discussions, problem-solving, and collaborative activities. Thus, students have more time to master the material independently, and the teacher acts as a facilitator who guides students in developing high-level thinking skills.

The flipped classroom *model* is in accordance with the 21st century learning principles that emphasize *the 4Cs* (critical thinking, creativity, collaboration, communication) skills. Students are required to be active, independent, and used to using digital technology as a learning resource. On the other hand, teachers have a greater opportunity to provide individualized feedback, encourage in-depth discussions, and develop problem-solving skills. Several previous studies have shown that the application of *flipped classroom* can increase learning motivation, student

involvement, and learning outcomes in various subjects, including mathematics.

In the context of national policy, the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) through the *Merdeka Learning* program also encourages learning transformation oriented towards student learning independence and the use of digital technology. This is in line with Permendikbud Number 37 of 2018 concerning Core Competencies and Basic Competencies, which emphasizes the importance of mastering critical thinking, creative, communication, and collaboration skills in the learning process. The *flipped classroom learning design* is in line with the spirit of the policy because it encourages students to be more active, creative, and responsible for their learning process.

In addition, in Law Number 14 of 2005 concerning Teachers and Lecturers, it is explained that teachers are required to have pedagogic, personality, social, and professional competence. Pedagogic competence mandates teachers to be able to design learning that is innovative, in accordance with the times, and oriented to the needs of students. Therefore, the application of *flipped classroom* learning design is a form of implementation of teachers' pedagogic competence in improving the quality of mathematics learning.

However, the application of *flipped classrooms* in mathematics learning in high school still faces several obstacles. Not all teachers are used to using digital technology to prepare materials, and not all students have good learning independence. In addition, the availability of infrastructure facilities, such as internet access and technological devices, is also a determining factor for the success of implementation. However, with the support of government policies, such as Presidential Regulation Number 39 of 2019 concerning One Data Indonesia and various school digitalization programs, it is hoped that these obstacles can be minimized.

Based on the description above, it can be concluded that the low mathematics learning outcomes of high school students, the demands of 21st century learning (Ozturk, 2023), and government policies in educational transformation are important bases for conducting research on the effectiveness of *flipped classroom* learning design. This research is expected to make a real contribution to improving the quality of mathematics learning, especially in the aspect of learning outcomes, as well as becoming a reference for teachers, schools, and policymakers in designing learning strategies that are more innovative and in accordance with the times.

Theoretical Studies

Education in the 21st century is required to be able to produce a generation that not only masters knowledge, but also has the ability to think critically, creatively, collaboratively, and communicatively. In the Indonesian context, these demands have been regulated in Law Number 20 of 2003 concerning the National Education System, which emphasizes that education must be able to develop the full potential of students. In line with that, Permendikbud Number 22 of 2016 concerning Educational Process Standards also emphasizes that learning must be carried out in an interactive, inspiring, fun, challenging, and motivating students to actively participate. On the basis of these regulations, teachers are required to be able to design learning designs that are innovative and in accordance with the times.

Learning design is essentially a systematic process to create an effective, efficient, and engaging learning experience. Reigeluth (2016) explained that learning design focuses on how knowledge is conveyed, how students are involved in the learning process, and how evaluations are carried out to achieve the expected goals. In the digital era, learning design is increasingly directed at the use of information technology that is able to expand students' access to learning outside the classroom.

One of the innovations in learning design that has received a lot of attention is the *flipped classroom*. This model was first popularized by Bergmann and Sams (2012) who defined it as a reverse learning approach, where the delivery of material is done outside the classroom using digital media, while face-to-face time is used for more active activities, such as discussion, collaboration, and problem-solving. A recent study by Lo & Hew (2020) shows that *flipped classrooms* have a positive impact on students' motivation and learning outcomes, especially in subjects that are considered difficult such as mathematics.

Mathematics itself is a subject that plays an important role in forming logical, critical, and systematic thinking skills. However, the results of international studies such as PISA (OECD, 2018) show that the achievement of mathematical literacy of Indonesian students is still low. This fact is reinforced by the 2022 National Assessment report which states that many high school students have difficulty mastering mathematical reasoning skills. One of the factors causing this is the dominant learning approach that is still *teacher-centered*, where teachers lecture more and students only listen. As a result, students are less active, high-level thinking skills (HOTS) are not developed, and learning outcomes tend to be low.

Flipped classroom is here as an alternative to overcome this problem. With this approach, students are given the opportunity to study the material independently before entering class through videos, modules, or online platforms. Face-to-face time in class is then focused on the application of concepts, problem-solving, and collaborative activities. According to a meta-analysis study by Hew, Bai, & Huang (2021), *flipped classrooms* have been proven to be more effective than conventional learning in improving learning outcomes, especially in terms of concept understanding and critical thinking skills. In addition, recent research by Suryani & Yuliana (2022) in Indonesia shows that the application of *flipped classrooms* in high school mathematics learning can increase student learning outcomes by up to 15% compared to conventional methods. This is in line with the findings of Chen et al. (2020) who emphasized that this model provides more space for students to learn at their own pace, so that the understanding of concepts becomes stronger.

Learning outcomes in mathematics learning are not only measured from the cognitive aspect in the form of mastery of concepts, but also include problem-solving skills, mathematical communication, and positive attitudes towards mathematics. Bloom (in Anderson & Krathwohl, 2001) emphasized that learning outcomes include cognitive, affective, and psychomotor domains, all of which can develop more optimally if students are actively involved in the learning process. Therefore, the selection of the right learning design, such as *flipped classrooms*, is expected to be able to make a significant contribution to improving student learning outcomes.

However, the implementation of *flipped classrooms* also faces some challenges. Not all teachers have skills in

designing digital materials, and not all students have adequate devices or internet access. However, with the Freedom of Learning policy from the Ministry of Education and Culture that encourages school digitalization and the use of online learning platforms, these challenges can gradually be overcome.

Based on the description above, it can be understood that *flipped classroom* is one of the potential learning designs to improve mathematics learning outcomes of high school students. By providing opportunities for independent learning outside the classroom and optimizing face-to-face interaction for meaningful activities, this model is believed to be able to answer the problem of low mathematics learning outcomes in Indonesia. Therefore, research on the influence of *flipped classrooms* on mathematics learning outcomes of high school students is relevant to be conducted, as well as contributing to the development of learning theory and practice in the digital era.

Method

This research was carried out at SMA Negeri 1 Bekasi, which is located on Jl. KH. Agus Salim No.181, Bekasi City, West Java. The selection of this location is based on the consideration that the school has adequate learning facilities, competent educators, and conducive learning environment support. In addition, this school has also implemented several technology-based learning innovations so that it is relevant to be used as a research place on the *flipped classroom learning model*. The research was carried out in the even semester of the 2024/2025 school year, which is around February to May 2025.

The type of research used is quantitative research with a quasi-experimental design method. The experimental design chosen is a pretest-posttest control group design, where there are two groups that are the subject of the research, namely the experimental group and the control group. The experimental group received treatment in the form of learning with a *flipped classroom* design, while the control group continued to use conventional learning. Before and after treatment, both groups were given the same test to find out the difference in their learning outcomes.

The population of this study is all students in grade XI of SMA Negeri 1 Bekasi for the 2024/2025 school year. Through the purposive sampling technique, two classes were selected that had a relatively balanced number of students and academic abilities based on the recommendations of the mathematics teacher. One class was designated as an experimental group, while the other class became a control group, with a total of about 30 students each.

The research variable consists of two components, namely independent variables and dependent variables. The free variable in this study is the application of *flipped classroom learning design*, while the bound variable is the mathematics learning outcomes of high school students measured through cognitive tests. Data collection is carried out using several techniques. The main technique is a learning outcome test in the form of multiple-choice questions and a brief description that includes grade XI mathematics material, especially on the topic of Trigonometry. The test is given twice, namely before treatment (pretest) and after treatment (posttest). In addition, observations were also carried out to see student activities during learning, as well as documentation in the form

of student score data, school profiles, and learning tools as supporting data. The test instruments used in this study were first tested for quality through validity, reliability, difficulty, and differentiating power. The validity test was carried out using *the product moment* correlation technique, reliability was calculated with the Cronbach Alpha coefficient, while the level of difficulty and differentiating power was analyzed to ensure that each question item was suitable for use in the study.

The collected data is analyzed through two stages. The first is the analysis prerequisite test, which includes a normality test with the Kolmogorov-Smirnov or Shapiro-Wilk, as well as the variance homogeneity test with the Levene's Test. Once the prerequisites were met, it was followed by an inferential statistical analysis using an independent sample *t-test* to find out if there was a significant difference in learning outcomes between the experimental group and the control group. The significance level used was 5% ($\alpha = 0.05$). If the *p-value* is less than 0.05, then the research hypothesis that states that there is a significant influence of the application of *flipped classroom learning design* on the mathematics learning outcomes of SMA Negeri 1 Bekasi students can be accepted. With the design of a research method like this, it is hoped that an empirical picture is obtained regarding the effectiveness of *the flipped classroom model* in improving mathematics learning outcomes, as well as being the basis for recommendations for teachers and schools to implement technology-based learning innovations that are more in line with the demands of 21st century education.

Results and Discussion

This research was carried out at SMA Negeri 1 Bekasi, involving two classes XI which have the same number of students, namely 30 people each. Class XI Science 1 is designated as an experimental group and gets treatment in the form of learning with a *flipped classroom* design, while class XI Science 2 is a control group that follows mathematics learning with a conventional approach, namely teachers are more dominant in delivering material and students listen and take notes more. Before the implementation of the treatment, all students from both classes were given a pretest with the aim of finding out their initial ability in mathematics subjects, especially in Trigonometry material.

The pretest questions used have characteristics equivalent to posttests, so they can be used as a benchmark for changes in learning outcomes after treatment. The pretest results showed that the initial ability of the two groups was relatively the same, with an average of 56.47 in the experimental group and 55.80 in the control group. This shows that the two groups have a balanced starting point, so it is worthy of comparison.

The treatment process lasted for four meetings. In the experimental group, learning was carried out with a *flipped classroom model*. Students are first given access to learning videos, interactive modules, and reading materials that can be learned at home. During face-to-face classes, activities are more focused on discussions, practice questions, and discussions of difficulties experienced by students. Teachers play the role of facilitators who guide students' thinking processes. On the other hand, in the control group, the teacher continued to use lecture methods and practice questions in class without any prior technology-based independent preparation.

After the treatment was completed, both groups were given a posttest to measure the extent to which there was an improvement in mathematics learning outcomes. The results of the analysis showed that the experimental group obtained an average score of 81.20, while the control group obtained an average of 72.10. The difference in learning outcomes in the experimental group was 24.73 points, higher than the control group which was only 16.30 points.

In addition to the quantitative results, observations in the classroom also showed differences in the level of student activity. In the experimental group, students seemed to be more enthusiastic about asking questions, actively discussing, and able to solve problems with various strategies. This is in contrast to the control group, where most students still rely on the teacher's explanations and are relatively passive in the learning process. In general, the description of the research data shows that learning with the *flipped classroom model* not only has a positive impact on improving the value of learning outcomes, but also encourages students to be more active and independent. The significant differences between the two groups will be further analyzed in the hypothesis test section.

Pretest and Posttest Results

The following are the results of the comparison of pretest and posttest in more detail:

Table 1. Pretest and Posttest

Group	N	Average	Highest Score	Lowest Score	Std. Deviation
Pretest Experiment	30	56.47	72	40	7.85
Posttest Experiment	30	81.20	94	65	7.86
Control Pretest	30	55.80	71	39	7.74
Posttest Control	30	72.10	85	58	8.12

From the data, it can be seen that:

- The highest score of the experimental group increased from 72 (pretest) to 94 (posttest).
- The highest score of the control group increased from 71 to 85.
- The average increase in the experimental group was 24.73 points, while the control group was 16.30 points.
- The standard deviation in both groups was relatively stable, indicating that the dissemination of learning outcome data was still in the reasonable category.

This difference in average learning outcomes indicates a positive influence of the application of the *flipped classroom model* on students' understanding of Trigonometry material.

Analysis Prerequisites Test

Before the hypothesis test is carried out, a prerequisite test is first carried out to ensure that the data meets the assumptions in parametric statistical analysis. The prerequisite tests carried out include normality tests and homogeneity tests.

Normality Test

The normality test is carried out to find out whether the pretest and posttest data in both groups are normally distributed. The analysis was carried out using the Shapiro-Wilk test, because the number of samples in each group was less than 50. The test results showed that the significance value in the experimental group was 0.112 for the posttest and 0.087 for the pretest. Meanwhile, in the control group, the significance value was 0.086 for the posttest and 0.091 for the pretest. All values are greater than 0.05, so it can be concluded that the distribution of student learning outcome data is normally distributed.

Homogeneity Test

Homogeneity tests are used to ensure that the variance between the experimental and control groups is homogeneous. This test is carried out with Levene's Test of Equality of Error Variances. The test results showed that the significance value was 0.174 (> 0.05). Thus, the data from the research results meet the homogeneity assumption.

The two prerequisite tests prove that the research data has a normal distribution and homogeneous variance. This is important because further analysis uses an independent sample t-test that requires both assumptions. With the fulfillment of the prerequisite test, the results of the analysis can be interpreted validly and reliably.

Hypothesis Test

The hypothesis test was carried out to find out whether there was a significant influence of the application of the *flipped classroom* model on the mathematics learning outcomes of SMA Negeri 1 Bekasi students. The hypotheses tested are as follows:

- H_0 : There was no significant difference between the mathematics learning outcomes of students who used *flipped classrooms* and students who used conventional learning.
- H_1 : There is a significant difference between the mathematics learning outcomes of students who use *flipped classrooms* and students who use conventional learning.

Data analysis was carried out using an independent t-test (Independent Sample t-Test) on the posttest scores of the two groups. The test results showed a *t-count* value of 3.425 with a significance value (p-value) of 0.001. Since the p-value < 0.05 , H_0 is rejected and H_1 is accepted. This means that there is a significant difference between the learning outcomes of students in the experimental group and the control group.

In addition, to strengthen the research findings, an effect size calculation was carried out using Cohen's formula d . The calculation results showed a d value of 1.14, which is included in the large effect category. This shows that the *flipped classroom* model not only has a statistically significant influence, but also has a great impact on improving students' math learning outcomes. Thus, the results of the hypothesis test prove that the application of the *flipped classroom* model is able to significantly improve mathematics learning outcomes compared to conventional learning.

The results of this study show that students who learn with *flipped classroom* design experience a higher increase in learning outcomes compared to students who learn using conventional methods. The average increase in the experimental group's score of 24.73 points, much larger than the increase in the control group of 16.30 points. Theoretically, these results support the opinion of Bergmann and Sams (2012), pioneers of *flipped classrooms*, who stated that this model provides students with the opportunity to master the basic material independently before face-to-face meetings, so that time in the classroom can be focused on interaction, discussion, and application of concepts. This is in line with the theory of constructivism which emphasizes that knowledge is more meaningful when students actively build their own understanding.

Recent research also supports these findings. For example, a study by Lo & Hew (2020) found that *flipped classrooms* consistently improve understanding of mathematical concepts and encourage student participation. Similarly, Chen et al. (2021) reported that students who learned with a *flipped classroom* approach showed higher learning outcomes as well as better critical thinking skills than students with traditional learning. From the observation results, it can be seen that the students of the experimental group are more active in discussion activities and dare to ask questions. This is in accordance with the findings of Awidi & Paynter (2019) that *flipped classrooms* increase students' intrinsic motivation because they are better prepared to face learning in the classroom. Thus, the results of this study strengthen the evidence that *flipped classroom* is an effective learning strategy in improving mathematics learning outcomes, both in terms of cognitive and student involvement in the learning process.

Conclusion

Based on the results of research that has been carried out at SMA Negeri 1 Bekasi using a *quasi-experimental design* through the *pretest-posttest control group* model, it can be concluded that the application of *flipped classroom* learning design has a significant influence on improving students' mathematics learning outcomes. Before treatment, the results of the pretest showed that the initial ability of students in the experimental group and the control group was relatively balanced, with an average score of 56.47 and 55.80, respectively. This condition confirms that the two groups have an equal level of initial ability so it is worth comparing. After being given treatment, there was a marked improvement in learning outcomes in both groups, but the experimental group that received learning with a *flipped classroom design* showed a higher improvement than the control group. The average posttest score of the experimental group reached 81.20, while the control group was only 72.10. The difference in improvement between the two groups was 8.43 points, with an average increase of 24.73 points in the experimental group and 16.30 points in the control group. The results of statistical analysis strengthen these

findings.

The independent t-test yielded a *t-count* value of 3.425 with a significance of 0.001 which is smaller than 0.05. This proves that there is a significant difference between the mathematics learning outcomes of students who are taught with *the flipped classroom model* and students who are taught with conventional methods. Furthermore, the effect size calculation using Cohen's *d* shows a value of 1.14 which is in the large *effect category*. These findings confirm that the influence of *the flipped classroom* model is not only statistically significant, but also has a strong impact on learning outcomes.

In addition to improvements in cognitive aspects, this study also found that the application of *flipped classroom* has an effect on student activity and independence. Observations during learning showed that students in the experimental group were more active in asking questions, engaging in discussions, and daring to express opinions compared to students in the control group who tended to be passive. This is in accordance with the theory of constructivism which states that knowledge is more meaningful when students play an active role in building their understanding. Thus, it can be concluded that the application of *flipped classroom* learning design is an effective learning strategy in improving mathematics learning outcomes of SMA Negeri 1 Bekasi students. This model has not only been proven to significantly improve academic achievement, but it has also been able to encourage active participation and independent learning of students, which can ultimately strengthen the quality of mathematics learning in high school.

Recommendations

The findings of this study indicate that the implementation of the *flipped classroom* design significantly improves students' mathematics learning outcomes. Therefore, teachers are encouraged to adopt this model as an innovative instructional strategy that enhances conceptual understanding as well as student engagement. Schools are expected to provide adequate technological facilities and teacher training to ensure the effective implementation of the *flipped classroom*. Furthermore, policymakers may use these results as a reference in developing digital-based learning policies that support 21st-century skills. Future research is recommended to examine the influence of this model on other variables, such as motivation, higher-order thinking skills, and digital literacy, so that the broader benefits of the *flipped classroom* can be explored and sustained.

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