RESEARCH ARTICLE

Flipped classroom based on Khan Academy as a student's problem-solving abilities and cognitive learning outcomes booster

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Abstract: The 21st century learning demanded students to master the 4C competencies: critical thinking and problem-solving, communication, collaboration, and creativity and innovation, with problem-solving skills significantly influencing students' cognitive learning outcomes. This study utilized the Flipped Classroom instructional model, assisted by the Khan Academy application, as a key factor in educational change. This research aimed to determine the effects related to the implementation of the Flipped Classroom instructional model with the assistance of the Khan Academy application on students' problem-solving abilities and cognitive learning outcomes. The research design employed was quasi-experimental with data collection through observation, interviews, tests, and documentation. The results obtained through Independent Sample t-Test in measuring problem-solving abilities indicated that the Sig. value (2-tailed) was 0.028 for the first indicator (understanding the problem); 0.028 for the second indicator (planning the solution); 0.000 for the third indicator (implementing the solution plan); and 0.001 for the last indicator (checking back). This meant that the results were < 0.05 for each indicator. Another result, namely the Analysis of Covariance (ANCOVA) for cognitive learning outcomes was 0.000. This result showed that the Sig. value was < 0.05. Both results indicated that there was an influence of implementing the Flipped Classroom instructional model with the assistance of the Khan Academy application on student's problem-solving abilities and cognitive learning outcomes of class X students at SMAN 1 Kutorejo regarding the topic of viruses and their roles.
Keywords: cognitive learning; flipped classroom; Khan academy; problem-solving; viruses

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Introduction

Learning activities in the 21st century is inseparable from the necessity for students to master the 4C competencies, which include critical thinking and problem-solving, communication, collaboration, as well as innovation and creativity (Aripin et al., 2020). Various competencies in 21st-century learning must be mastered as an effort to prepare students to face the world of work and survival (Saputra et al., 2023). With this in mind, students are required to master various aspects, including problem-solving skills. Problem-solving can be the basis of learning, especially in science classes (Azrai et al., 2022). Problem-solving skills are described as an effort undertaken by students to obtain solutions or answers to problems, thus obtaining final results or answers to presented issues. Problem-solving skills can also be defined as the capability to carry out a process to understand and eliminate the gap between reality and its ideal condition of a phenomenon or several aspects related to the biology subject matter (Meika et al., 2021). Problem-solving directly fosters students' creativity through the development of ideas within themselves. When viewed through its process, problem-solving skills are classified as higher-order thinking skills that focus on the cognitive domain and encompass mental activities (Zahra et al., 2021). The beginning of improving students' problem-solving skills is by presenting a few common problems encountered in daily life so that students feel familiar and gradually find solutions (Azrai et al., 2022).

In the process, student's problem-solving doesn't just demand them to solve problems using methods presented by teachers but also to articulate their own versions of solutions by involving knowledge from topics or materials previously learned (Tendrita et al., 2022). The ability to solve problems can shape students into meticulous individuals because they possess brain activities or thoughts that tend to be creative. All activities related to problem-solving are associated with students' learning outcomes, including cognitive learning outcomes as one measure of achieving learning goals. Students' cognitive abilities are also fundamental needs for them to face various competitions and challenges in daily life

(Ilma et al., 2020). The cognitive domain is a sub-taxonomy that states that mental activities range from the level of knowledge to the highest level, which is evaluation. Cognitive learning outcomes are considered important as they help students develop good character and thinking skills (Ariyanti et al., 2024). In the arrangement of learning outcomes that measure cognitive abilities, the taxonomy used as a guide is the six levels of competency in Bloom's Taxonomy of the cognitive domain.

These levels include the aspects of remembering, understanding, applying, analyzing, evaluating, and creating (Zakiah & Khairi, 2019). These various aspects make problem-solving skills a vital aspect that students should already possess, continuously developing and applying them so that students become accustomed to facing various situations that require high-level thinking skills. Therefore, a learning model is needed that can stimulate students' problem-solving abilities, which will also determine the cognitive learning outcomes obtained. The selection of a good learning model is generally tailored or based on the students' learning environment in order to maximize students' learning outcomes (Siswati et al., 2020).

The Flipped Classroom model is one of the solutions that can be implemented to maximize students' problem-solving abilities and cognitive learning outcomes. The Flipped Classroom has emerged as a suitable solution to enhance various student competencies, including problem-solving skills and cognitive learning outcomes. This assertion is based on research by Pimdee et al. (2024), which stated that the Flipped Classroom learning model can increase students' motivation in learning activities. This is achieved by utilizing familiar technologies for students and offering flexible learning schedules, allowing students to adjust to their individual needs because with Flipped Classroom, students can spend ample time watching lectures to preparing well before attending the face-to-face session in which they are actively involved in solving problems based on the guiding questions (Thai et al., 2017).

Flipped Classroom requires students to study theory and discover concepts independently and then apply them when in the classroom by applying the theories they learned beforehand. Additionally, the Flipped Classroom is a method where students learn theory freely outside the classroom and then practice their skills with guidance from the teacher in the classroom (Bara et al., 2021). The Flipped Classroom model focuses on the discovery process, where students identify and acquire concepts independently to be discussed during learning activities, while the teacher acts as a facilitator during learning in a blended environment between online and face-to-face classes with a designated platform (Waer & Mawardi, 2021).

The Flipped Classroom can be considered as a solution because it has been proven to enhance students' competencies. According to research conducted by Tan et al. (2017), students in classrooms using the Flipped Classroom model outperformed those in classrooms using conventional or traditional models. The superiority was evident in terms of both knowledge and skills. This advantage may be attributed to students in Flipped Classroom settings having better preparation due to pre-learning stages. The development of students' learning outcomes and problem-solving abilities can be maximized if applied to materials considered difficult by students, such as virus materials. Students perceive virus material as difficult because direct observation cannot be performed during learning activities; thus, the appropriate media to use in this case is the audio-visual media available in the Flipped Classroom model (Dewi, 2020).

Audio-visual media as a supportive tool for implementing the learning model can be found on various platforms, including the use of the Khan Academy application. The Khan Academy app is an internationally renowned learning application that can serve as a practical solution to the weaknesses of the Flipped Classroom model, it’s because Khan Academy can assist students in studying or analyzing advanced material based on what they have previously learned (Ruipérez-Valiente et al., 2015). This application contains various instructional videos and written materials from various subjects that can be accessed or downloaded offline. The download feature for offline access can facilitate students in accessing learning materials when there is insufficient internet connection (Abdillah et al., 2019). Khan Academy is also included in innovative platforms that provide various content from various disciplines that can be accessed anytime and anywhere. In the learning process, Khan Academy plays an important role in self-directed practice by students to enhance the efficiency and effectiveness of learning activities, where teachers provide structured learning (Vidergor & Ben-Amram, 2020).

Khan Academy offers various levels within each subject, allowing students to choose the level that suits their learning abilities (Lee et al., 2023). Furthermore, Khan Academy provides students with a deeper understanding of a topic or material because it contains various explanation videos and practice questions accompanied by solution instructions. Each student is fully responsible for self-directed practice, which includes managing learning pace, study time, study location, and academic needs through the Khan Academy app, thus expanding students' understanding to design solutions to problems presented in active learning (Vidergor & Ben-Amram, 2020). The Khan Academy app categorizes each topic based on its levels, making it a suitable option for implementation in learning because it contains various high-level knowledge that indirectly helps students improve their thinking skills, thus generating various ideas to enhance problem-solving abilities and cognitive learning outcomes that will be achieved later (Li et al., 2024). Therefore, Khan Academy is the right choice as it can help improve students' learning outcomes both at the initial and advanced levels (Rueda-Gómez et

al., 2024).
Based on various previous studies, not much has been revealed about the influence of the Flipped Classroom model with the assistance of the Khan Academy application on Biology learning. This research aimed to determine the effects related to the implementation of the Flipped Classroom instructional model with the assistance of the Khan Academy application on students' problem-solving abilities and cognitive learning outcomes. With this research, various influences resulting from the implementation of the Flipped Classroom learning model with the assistance of the Khan Academy application can be identified. Therefore, the outcomes obtained can be used as a reference in conducting learning activities to enhance various student competencies.

Method

This study was conducted in 2023, at SMA Negeri 1 Kutorejo, located in Mojokerto Regency, East Java. The population in this study comprised all 10th-grade students at SMA Negeri 1 Kutorejo for the 2023/2024 academic year, totaling 5 classes. The sample used consisted of 2 selected classes out of the 5 available classes. Of the 2 selected classes, 1 class served as the experimental group that included 36 students with 13 male and 23 female students. The other class served as the control group that included 34 students with 15 male and 19 female students. The control and experimental classes were determined using purposive random sampling after conducting normality and homogeneity tests, followed by an equivalence test using the ANOVA test on the 5 population classes to identify classes with equal notation. Various instruments in this study utilized tools that had been validated by expert validators. These instruments included case study questions, pre-tests, and post-tests. The case studies were given to assess students' problem-solving abilities, while the pre-tests and post-tests were administered to evaluate students' cognitive learning outcomes. The results obtained from each instrument were evaluated using specific rubrics for problem-solving abilities and cognitive domain rubrics.
The research was conducted in several stages. The first stage involved observing the school chosen as the research site to understand various aspects, including the teaching models typically used and the students' conditions during learning activities. The next stage was to analyze the students' daily test scores on previous material to identify classes with equivalent notations. After obtaining the analysis results, the classes for each experimental group were determined using purposive random sampling.
The next step was to administer a pre-test to the experimental and control classes. After both classes completed the pre-test, the following step involved implementing the Flipped Classroom learning model with the help of the Khan Academy application for the experimental class and applying the conventional learning model to the control class. This conventional learning model is commonly used by the 10th-grade Biology teachers. During the implementation of the learning models, students were also given group case studies to assess their problem-solving abilities. The final step involved administering a post-test to the students in both the experimental and control classes to gather cognitive learning outcome data.
The measurement of problem-solving abilities of students in the experimental and control classes was conducted using the problem-solving ability assessment instrument, and the analysis was performed using the Independent Sample t-Test in the SPSS (Statistical Program for Social Science) software. The students' problem-solving abilities will be calculated according to Endang et al. (2021) as Formula 1.

$$\text{Score} = \frac{Obtained\ score}{Maximum\ score} \times 100\% \quad (1)$$

Based on the provided hypothesis:
H0: There is no influence of the Flipped Classroom learning model with the assistance of Khan Academy application on the cognitive learning outcomes of high school X grade students.
H1: There is an influence of the Flipped Classroom learning model with the assistance of Khan Academy application on the cognitive learning outcomes of high school X grade students.

The measurement of cognitive learning outcomes for the control and experimental classes was conducted by referring to the pre-test and post-test scores obtained. The obtained scores were then analyzed using Analysis of Covariance (ANCOVA) in the SPSS (Statistical Program for Social Science) software.
Research Hypothesis:
H0: There is no influence of the Flipped Classroom learning model with the assistance of the Khan Academy application on the cognitive learning outcomes of 10th-grade high school students.

H1: There is an influence of the Flipped Classroom learning model with the assistance of the Khan Academy application on the cognitive learning outcomes of 10th-grade high school students.

Results and Discussion

Problem-Solving Abilities

Data on problem-solving abilities were obtained through the distribution of case studies to students. The case studies were conducted in groups, with each group receiving a journal to use as a reference in answering various case study questions provided. The case study questions were based on problem-solving ability indicators and consisted of 5 essay questions. The summarized data on problem-solving abilities from the group case studies are presented in Figure 1.

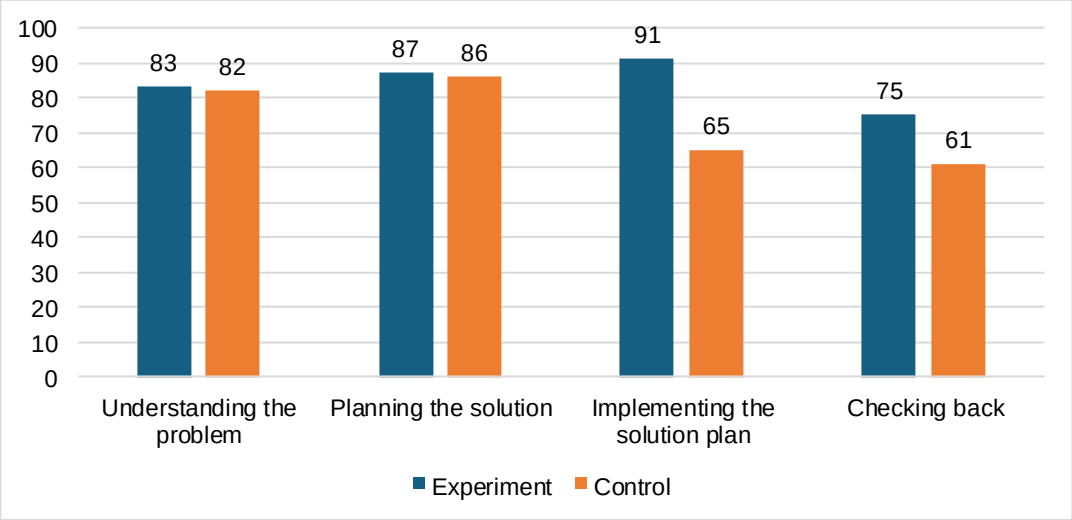

Figure 1. Average Scores of Problem-Solving Abilities for Each Indicator

Figure 1 above shows the average scores of problem-solving abilities for the experimental and control classes on each evaluated indicator. There is a significant difference in the third and fourth indicators, namely executing the solution plan and re-evaluating. For the third indicator, the experimental class scored 91, while the control class scored only 65, indicating a considerable difference of 26 points. For the fourth indicator, the experimental class scored 75, while the control class scored only 61, which means there is a difference of 14 points on the fourth indicator.
The student's problem-solving ability scores were then tested using the Independent Sample t-Test analysis, with the results presented in Table 1.

Table 1. Results of Independent Sample t-Test on Problem-Solving Abilities

Problem Solving Indicator	Class				t	Sig. (2-tailed)
	Experiment		Control			
	Mean	SD	Mean	SD		
Understanding the problem	83	9.460	82	9.600	0.881	0.028
Planning the solution	87	12.670	86	19.640	0.002	0.028
Implementing the solution plan	91	18.890	65	12.330	0.351	0.000
Checking back	75	20.700	61	12.590	0.039	0.001
Total	84	15.430	73.500	13.540	0.318	0.014

First table shows the results of the Independent Sample t-Test on students' problem-solving abilities. Based on the data obtained, it is known that each indicator has a sig. value >0.05, with the following details: the first indicator, understanding the problem, has a sig. value of 0.028; the second indicator, devising a plan, has a sig. value of 0.028; the third indicator, executing the plan, has a sig. value of 0.000; and the final indicator, re-evaluating, has a sig. value of 0.001. This data indicates that the results obtained by students in the two experimental classes in terms of problem-solving abilities show significant differences. The experimental class consisted of 36 students and the control class consisted of 34 students, with the average scores obtained in the two experimental classes differing from each

other. The average score for the experimental class was 84, while the average score for the control class was 73.5 in the aspect of problem-solving ability. These scores were then tested using the Independent Sample t-Test analysis, which resulted in a Sig (2-tailed) value of 0.014, indicating a result less than 0.05. Based on these findings, it is concluded that H0 is rejected and H1 is accepted.

The hypothesis testing results on problem-solving abilities indicate an influence due to the treatment. The treatment involved applying the Flipped Classroom learning model to the experimental class. The data obtained from the overall group case study scores for both the control and experimental classes were analyzed using the Independent Sample t-Test, which showed a Sig (2-tailed) value of 0.014, indicating a result less than 0.05. The results indicate that students in the experimental class have problem-solving abilities that surpass those of the control class. The impact of implementing the Flipped Classroom learning model with the assistance of the Khan Academy application on problem-solving abilities is attributed to various stages that encourage students to think more broadly.

As explained by Nurtamam et al. (2023), student creativity can be increasingly stimulated due to the implementation of the Flipped Classroom learning model. Additionally, students become more innovative in their learning activities, which supports the maximization of their problem-solving abilities. The increase in problem-solving abilities with the Flipped Classroom learning model is also due to the intensity of discussions among students. The interaction among students allows each student to gain new insights on a particular topic (Kang & Kim, 2021). The findings were in line with research conducted by Hwang and Chen (2019) which stated that the flipped classroom learning model can help students improve their problem-solving abilities. This is because in its implementation, this learning model provides more flexible time for teachers to guide students in class based on discussions that students have had beforehand.

There are also results showing the scores obtained for each indicator by each class. There are 4 problem-solving indicators, including understanding or identifying the problem, planning the solution or formulating a strategy, executing the solution plan or implementing the strategy, and reviewing or verifying the solution (Chabibah et al., 2019). Each problem-solving indicator shows varying scores between the experimental and control classes. Reviewing the scores for all indicators, the largest difference is 26 points in the third indicator, which is executing the solution plan. This difference aligns with the statement by Fathi and Rahimi (2020) that students with more intensive practice and a practical understanding of concepts will be able to generate more complex and accurate ideas in both oral and written forms. This relates to the pre-learning activities conducted by the experimental class students as an initial step before formulating solutions to the presented problems.

Additionally, Lin et al. (2021) state that the implementation of the Flipped Classroom learning model encourages direct student involvement in active learning, including discussions and sharing notes among students. This allows students to execute the solution plan systematically, based on resources and aligned with the plan structure in the previous indicator. The research findings also align with Lin's (2019) study, which suggests that the Flipped Classroom learning model enhances students' competencies across various aspects, including problem-solving skills and cognitive learning outcomes. This is supported by higher scores among students in the experimental group compared to the control group. The implementation of the Flipped Classroom model leads to significant improvements for students, facilitated by the use of tools that are familiar in students' daily lives.

The differences in scores between the two experimental classes are due to the more thorough preparation of the experimental class for learning activities, as they had studied the material to be discussed in class during pre-learning activities. In these pre-learning activities, students were directed to independently access the material to be discussed in class. This provided students with a more flexible space to learn the concepts at their own pace (Sinatrya & Aji, 2020). Flexible time and space can help students develop independent learning skills in understanding the material concepts, thus providing them with sufficient preparation for in-class discussions, including problem-solving activities (Sari et al., 2020). In the indicator of strategy implementation or executing the solution plan, the experimental class outperformed the control class by 26 points. This difference is because the students in the experimental class were better prepared due to pre-learning stages and independent concept understanding, allowing them to grasp concepts and theories optimally according to their learning styles (Annajmi & Kuswadi, 2024). Additionally, students had more flexible time to study the theories related to the material to be learned, not being constrained by a fixed study schedule, thus enabling them to delve into theories and concepts according to their own effective times (Muller & Mildenberger, 2021).

Cognitive Learning Outcomes

The test was conducted to obtain data on cognitive learning outcomes through the distribution of pre-test and post-test questions. The questions provided consisted of 3 essay questions and 12 multiple-choice questions. Table 2 contains the summarized data on cognitive learning outcomes of students by working on the given test for the experimental and control classes.

Table 2. Student's Cognitive Learning Outcomes

Class	Test	Component		
		Minimum Score	Maximum Score	Averange ± SD
Experiment	Pre-test	16	75	39.97 ± 13.31
	Post-test	65	90	77.36 ± 7.51
Control	Pre-test	16	57	34.85 ± 12.25
	Post-test	10	80	49.67 ± 23.70

Table 2 displays the average post-test scores of cognitive learning outcomes for the control class, which amounted to 49.67, and the experimental class, which amounted to 77.36. Based on the data obtained, it can be indicated that the cognitive learning outcomes of the control class are smaller than those obtained in the experimental class. One of the reasons for this difference in outcomes is the different treatment in terms of the learning model applied to the two experimental classes. The cognitive learning outcomes data were further tested using Levene's Test, with significance values of 0.96 for the pre-test and 0.26 for the post-test. Both significance values indicate that the obtained data are homogeneous because they are >0.05. After conducting homogeneity and normality tests, the cognitive learning outcomes of the students were tested using Analysis of Covariance (ANCOVA), with the results shown in Table 3.

Table 3. Ancova Test of Pre-test and Post-test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	17673.262	2	8836.631	34.652	0.000
Intercept	11667.903	1	11667.903	45.753	0.000
Pretest	4271.523	1	4271.523	16.750	0.000
Class	10096.414	1	10096.414	39.591	0.000
Error	17086.224	67	255.018		
Total	320712.000	70			
Corrected Total	34759.486	69			

a. Coefficient of Determination = 0.508 (Adjust R Squared = 0.494)

Based on the results of the Analysis of Covariance (ANCOVA) test conducted on the pre-test and post-test results of the students, a significance value of 0.000 was obtained. This data indicates that H0 is rejected and H1 is accepted because it has a value <0.05. The rejection of H0 and acceptance of H1 indicate that there is an influence of the treatment given to the students, in the form of the Flipped Classroom learning model with the assistance of the Khan Academy application, on the cognitive learning outcomes of the students. The data on students' cognitive learning outcomes indicate that there is an influence of the treatment given. The treatment given is the implementation of the Flipped Classroom learning model in the experimental class. The data obtained from the testing of pre-test and post-test scores overall, including both the experimental and control classes, using Analysis of Covariance (ANCOVA) show a significance value of 0.000. The significance value obtained is less than 0.05, indicating a significant difference between the two experimental classes. It means, the implementation of the Flipped Classroom learning model with the assistance of the Khan Academy application has an effect on the cognitive learning outcomes produced by the students.

The Flipped Classroom can enhance cognitive learning outcomes across various competencies because, with its implementation, students become the focal point of learning activities and take on an active role. This approach trains students from understanding to analyzing concepts (Bozdağ et al., 2021). This model also can drive improvement in students' cognitive learning outcomes because before participating in class discussions, students have already studied the material to be discussed in class. Similarly, in test-taking, students already have an understanding of concepts and theories in phase 1 or pre-learning (Efendi & Maskar, 2020). The implementation of the Flipped Classroom learning model can help boost students' cognitive learning outcomes because students have more effective and conditional learning time according to their individual circumstances, thus not being bound by specific times to understand the material. Flexible time allows students to understand concepts and theories according to their capacity (Bara et al., 2021).

The students' results in both experimental classes show differences in the average scores between classes. The results reveal that the average post-test score in the experimental class far surpasses that of the control class after the treatment, which involved implementing the Flipped Classroom learning model with the assistance of the Khan Academy application in the experimental class. The average post-test score in the experimental class is 77.36, while the control class has an average post-test score of 49.67. Based on the obtained average post-test scores, it can be observed that there

is a difference of 27.69 points between the experimental and control classes. There has been an improvement in students' cognitive learning outcomes in both the experimental and control classes, with the results in the experimental class tending to be more significant than those in the control class. This is attributed to the implementation of the Flipped Classroom learning model with the assistance of the Khan Academy application in the experimental class, especially with the pre-learning phase and discussions, which lead students to have a broader initial perspective on the topics to be studied (Novitri et al., 2022).

The experimental class experienced a significant improvement in cognitive learning outcomes due to differences in the effectiveness of the time used by students in the two experimental classes. In the experimental class, the active learning phase or phase 2 in the classroom involves building understanding by exchanging opinions on the previously learned material, while in the control class, active learning is done for information transfer. The difference in the allocation of time used can affect the insights and understanding of students, where active learning as a means of building understanding is more important than mere information transfer (Rusnawati, 2020).

Cognitive learning outcomes for students can improve with the implementation of the Flipped Classroom model because during learning activities, students focus on applying previously studied material with the guidance of teachers. This is consistent with research by Van Alten et al., (2019), which indicates that, cognitively, lack of direct guidance during learning activities can overload students and hinder their ability to store knowledge in long-term memory. Therefore, pre-learning activities in the Flipped Classroom help students understand the material to be covered in face-to-face sessions with teacher instructions. Therefore, the Flipped Classroom model enhances face-to-face learning time and promotes active learning settings that focus on exploring student engagement as an intermediary for measuring learning outcomes (Murillo-Zamorano et al., 2019).

Conclusion

Based on this research, there's some conclusion that there is an influence of implementing the Flipped Classroom learning model based on the Khan Academy application on the problem-solving skills of 10th-grade students at SMA Negeri 1 Kutorejo. The analysis of the Independent Sample t-Test shows a Sig. (2-tailed) value of 0.014 or <0.05, indicating a significant difference between the experimental and control classes due to the treatment provided. Besides, there is also an influence of implementing the Flipped Classroom learning model based on the Khan Academy application on the cognitive learning outcomes of 10th-grade students at SMA Negeri 1 Kutorejo. The analysis of covariance (ANCOVA) shows a Sig. (2-tailed) value of 0.000 or <0.05, indicating a significant difference between the experimental and control classes due to the treatment provided.

Based on this research, it was suggested to introduce a trial period or pilot phase for the implementation of new learning models such as the Flipped Classroom in schools. This allowed teachers to assess students' ability to adapt to the new learning model. The research findings on the Flipped Classroom learning model with the assistance of the Khan Academy application regarding students' problem-solving abilities and learning outcomes served as a basis for consideration in schools. Given that studies applying this learning model showed positive outcomes in students' learning processes, both in problem-solving skills and cognitive learning outcomes, it provided compelling evidence for adoption.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

A. L. Qomara: writing original draft preparation. **B. H. Siswati:** review and editing. **B. Wahono:** review and editing.

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