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EFFECT OF PBL WITH YOUTUBE AND AI ON STUDENT ACTIVITY AND MATHEMATICAL CONCEPT UNDERSTANDING

Mey Ria Yulfa[1*], Baiduri[2], Agung Deddiliawan Ismail[3]

[1,2,3]University of Muhammadiyah Malang, Malang, Indonesia

*Correspondingauthor: devenizan18@gmail.com

Abstract: This study aims to analyze the influence of the application of Problem Based Learning (PBL) integrated with YouTube media and the use of Artificial Intelligence (AI) on students' activeness and understanding of mathematical concepts. The study used a quantitative approach with a quasi-experimental design involving 60 students in class X of Maarif Pandaan High School Pasuruan. Data was collected through activity observation sheets, concept comprehension tests, and student perception questionnaires. The results of the descriptive analysis showed a significant increase in student activity (range 74–97) and understanding of mathematical concepts (76–88) in the experimental class compared to the control class. Statistical tests showed an R^2 value of 0.650 for activeness and 0.601 for concept comprehension, with t-calculated values of 2.430 and 2.332 respectively which were greater than the t-table of 1.9876. It was concluded that the integration of PBL with YouTube and AI media had a significant effect on increasing students' activeness and understanding of mathematical concepts

Keywords: *Problem Based Learning; YouTube; Artificial Intelligence; Student Activity; Understanding of Mathematical Concepts*

Abstrak: *Penelitian ini bertujuan untuk menganalisis pengaruh penerapan Problem Based Learning (PBL) yang diintegrasikan dengan media YouTube dan pemanfaatan Artificial Intelligence (AI) terhadap keaktifan dan pemahaman konsep matematika siswa. Penelitian menggunakan pendekatan kuantitatif dengan desain quasi-experimental yang melibatkan 60 siswa kelas X SMA Maarif Pandaan Pasuruan. Data dikumpulkan melalui lembar observasi keaktifan, tes pemahaman konsep, dan angket persepsi siswa. Hasil analisis deskriptif menunjukkan peningkatan signifikan pada keaktifan siswa (rentang 74–97) dan pemahaman konsep matematika (76–88) pada kelas eksperimen dibandingkan kelas kontrol. Uji statistik menunjukkan nilai R^2 sebesar 0,650 untuk keaktifan dan 0,601 untuk pemahaman konsep, dengan nilai t-hitung masing-masing 2,430 dan 2,332 yang lebih besar dari t-tabel 1,9876. Disimpulkan bahwa integrasi PBL dengan media YouTube dan AI berpengaruh signifikan terhadap peningkatan keaktifan dan pemahaman konsep matematika siswa.*

Kata kunci: *Problem Based Learning; YouTube; Artificial Intelligence; Keaktifan Siswa; Pemahaman Konsep Matematika.*

First author et al.
Email: xxx@yyy.ac.id

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▪ INTRODUCTION

The development of digital technology has brought significant transformations in the world of education, including in mathematics learning (Engelbrecht & Borba, 2024). Interactive learning media such as YouTube and Artificial Intelligence (AI) offer great potential to increase students' interest, participation, and understanding in learning (Yulistian et al., 2023). Data shows that Indonesia is the fourth country with the most YouTube users in the world, which is 143 million users or around 5.65% of the total global users, with an average access duration of 1,744 minutes per month (Ryan et al., 2026). This fact makes YouTube a strategic platform for exciting and accessible learning innovations.

On the other hand, the integration of AI in education is growing as a technological breakthrough that is able to create a flexible, adaptive, and personalized learning experience according to individual student needs (Kim & Wargo, 2025; Shi et al., 2024). Surveys Ipsos (2023) showed that 54% of Indonesian respondents believe AI will have more positive than negative impacts in education, the highest figure among the countries surveyed. This indicates public optimism about the role of technology in improving the quality of learning.

The reality on the ground shows that the understanding of mathematics concepts of Indonesian students is still low. The results of the Trends in International Mathematics and Science Study (TIMSS) place Indonesian students below the international average in the domains of knowledge, application, and reasoning (Çiftçi & Yildiz, 2019). This low understanding correlates with a learning approach that is still conventional, teacher-centered, and lacks in-depth exploration of concepts (Hamzah, 2023).

Problem Based Learning (PBL) as an authentic problem-based learning model has been proven to be effective in increasing students' active participation and conceptual understanding (Nguyen et al., 2024; Setiawan, 2021). In PBL, students are encouraged to think critically, collaborate, and construct knowledge through real problem-solving, so that learning becomes more meaningful and student-centered (Suginem, 2021).

Several previous studies have examined the effectiveness of PBL and the integration of digital media in mathematics learning. Rézio et al., (2022) found that the PBL model had a significant effect on improving students' understanding of mathematical concepts compared to conventional learning. Setiawan (2021) reports that PBL can improve high school students' mathematical problem-solving skills. Rahayu et al., (2024) integrate PBL with YouTube media and find improvements in math learning outcomes, while Aminatun et al., (2023) shows that PBL with the help of online media is able to increase students' learning motivation.

In the context of AI utilization, Meiliawati et al., (2024) conduct a literature review and conclude that AI-based media can support the learning process through material personalization and instant feedback. Nujum & Hadi (2025) also reported that AI-media-assisted problem-based learning had a positive effect on the critical thinking skills of elementary school students. Wahyuni et al., (2024) expand the study by integrating PBL and Scratch media to improve mathematical problem-solving skills.

Although previous studies have proven the partial effectiveness of PBL and digital media, there are research gaps that have not been comprehensively addressed. First, most studies examine PBL with only one type of media (YouTube or AI), not integrating the two simultaneously in a single learning design. Second, research that

measures the impact of PBL, YouTube, and AI integration on two bound variables at once, namely activeness and understanding of mathematical concepts, is still very limited. Third, the context of previous research was more often carried out at the junior high or elementary level, while research on high school students with more complex mathematical materials such as three-dimensional and trigonometry was still rare.

Based on these gaps, this study offers novelty in the form of: (1) the integration of the three components of learning PBL models, YouTube media, and the use of AI in one high school mathematics learning design framework; (2) simultaneous measurement of the influence of such integration on student activity and understanding of mathematical concepts; and (3) application in the context of the deep learning curriculum that emphasizes deep, contextual, and developmental learning critical thinking.

Based on the background and gap analysis above, the problems of this study are formulated as follows: (1) Does the application of Problem Based Learning (PBL) integrated with YouTube media and the use of AI have a significant effect on students' activity in mathematics learning?; and (2) Does the approach have a significant effect on students' understanding of mathematical concepts?

▪ METHOD

Research Design and Stages

This study uses a quantitative approach with a quasi-experimental design in the form of a Nonequivalent Control Group Design. The research was carried out in three operational stages as follows: 1) Implementation Stage: Treatment was carried out over six meetings (three cycles, two meetings each). The experimental class applied PBL syntax integrated with YouTube videos for the visualization of abstract concepts and Artificial Intelligence (AI) such as ChatGPT as an interactive companion. The control class applied conventional learning (lectures and practice questions). 2) Data Processing Stage: Data collection is carried out through pre-tests, observations during the learning process, post-tests, and questionnaires, then statistically analyzed. 3) Data Processing Stage: Data collection is carried out through pre-tests, observations during the learning process, post-tests, and questionnaires, then statistically analyzed.

Here is a picture of the design and procedure of the research:

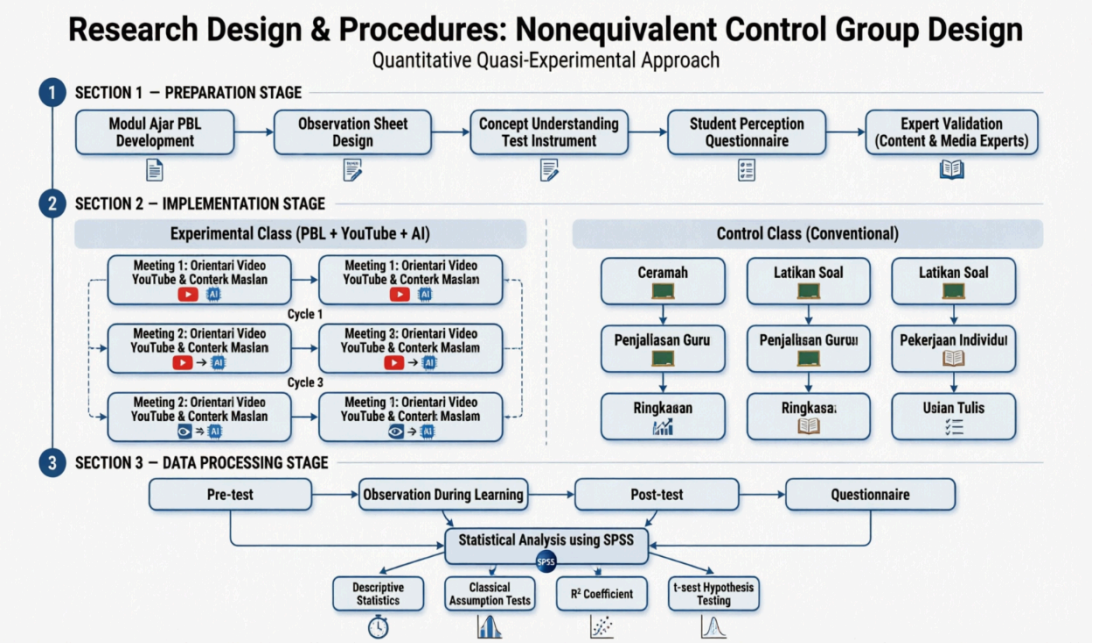


Figure 1. Research Design and Procedure

The subjects of the study were 60 students in class X of Maarif Pandaan High School, Pasuruan, who were selected using purposive sampling techniques with the following criteria: (1) the school implements a learning policy that is open to digital innovation, (2) there is supporting infrastructure (internet access and multimedia devices), and (3) students have never received the PBL model integrated with YouTube and AI before. The sample was divided into two groups: class X-A as a control class (30 students) and class X-B as an experimental class (30 students). The research was carried out in December 2024 January 2025 with the subject matter of trigonometric comparison on right triangles.

Data were collected using three main instruments adjusted to the research variables: 1) Student Activeness Observation Sheet: Used to measure students' physical and cognitive engagement during learning based on indicators of discussion participation, frequency of questioning, and contribution to group work. Observations were made by two independent observers using a Likert scale of 1–4. The final score was obtained from the average of the two observers. 2) Mathematical Concept Comprehension Test: In the form of pre-test and post-test description questions that measure three indicators: understanding the meaning of mathematical symbols, mastering prerequisite concepts, and connecting previous concepts with new concepts. The score of each item is converted to a scale of 0–100. 3) Student Perception Questionnaire: Measures students' responses to the integration of YouTube and AI in PBL, covering 10 aspects (accessibility, attractiveness, concept comprehension, activeness, interactivity, independence, relevance, motivation, effectiveness, and general expectations) on a Likert scale of 1–4.

The validity test of the instrument construct was carried out using Pearson Product Moment correlation. Next, the reliability test was carried out using Cronbach's Alpha coefficient. Then the results of the analysis were categorized and continued into quantitative analysis using IBM SPSS Statistics 25 software.

▪ RESULT AND DISCUSSION

Research Results

This study examines the effect of the application of Problem Based Learning (PBL) integrated with YouTube media and the use of Artificial Intelligence (AI) on the activeness and understanding of mathematical concepts of grade X students of Maarif Pandaan High School Pasuruan. The following are presented the results of data analysis based on the instruments used.

1. Description of Student Activity and Concept Understanding Data

Based on the results of the comparison between the control class (conventional learning) and the experimental class (PBL, YouTube and AI), the following findings were obtained:

Table 1. Comparison of Student Activeness and Concept Comprehension Scores

Variable	Control Class (n=30)	Experimental Class (n=30)
Uptime (Min–Max)	72–95	74–97
Activity (Mean ± SD)	85.20 ± 6.84	87.93 ± 7.12
Concept Comprehension (Min–Max)	74–87	76–88
Concept Understanding (Mean ± Elementary)	80.27 ± 3.91	82.33 ± 3.76

The data in Table 1 shows that the experimental class obtained a higher average score of activeness and concept understanding than the control class. The highest improvement was seen in indicators of discussion participation and the ability to solve contextual problems.

2. Instrument Validity and Reliability Test

All instrument items were declared valid with the r-count value > r-table (0.254) at α=0.05. A reliability test using Cronbach's Alpha showed a score of 0.443 for PBL, 0.539 for student activeness, and 0.636 for understanding mathematical concepts. The three values are categorized as questionable/acceptable and are eligible for quantitative analysis.

3. Classic Assumption Test

The results of the classical assumption test show that the regression model meets the parametric requirements: (1) the Kolmogorov-Smirnov normality test yields Asymp. Sig. = 0.057 > 0.05, so that the data is distributed normally; (2) the multicollinearity test showed VIF<10 values and a tolerance of > 0.10 for all independent variables; (3) The heteroscedasticity test produced a significance value of 0.337 > 0.05, indicating the absence of heteroscedasticity.

4. Coefficient of Determination (R^2)

Table 2. Determination Coefficient Results

Variable Relationships	R^2	Interpretation
PBL and Student Activity	0,650	65% of activeness variations are explained by PBL
PBL and Concept Understanding	0,601	60.1% variation in concept understanding explained by PBL

Based on Table 2, the R^2 value shows that the application of YouTube-based PBL and AI has contributed significantly to increasing students' activeness and understanding of mathematical concepts.

5. Hypothesis Testing (Independent Sample t-test)

Table 3. Hypothesis Test Results

Variable Relationships	t-count	t-table (α=0.05)	Conclusion
PBL and Student Activity	2,430	19,876	Significant Impact
PBL and Concept Understanding	2,332	19,876	Significant Impact

Based on Table 3, Since the t-calculated > t-table value on both variables is bound, H_0 is rejected and H_1 is accepted. Thus, the application of PBL integrated with YouTube media and the use of AI has a significant effect on increasing students' activeness and understanding of mathematical concepts.

Discussion

1. The Influence of YouTube-Based PBL and AI on Student Activity

The results of the study show that the integration of PBL with YouTube media and AI has a significant influence on students' activeness in mathematics learning. These findings are in line with the characteristics of PBL that place students as active subjects in the process of authentic problem-solving (Suginem, 2021). Through the syntax of problem-oriented PBL, self-investigation/group, presentation of results, and reflection, students are encouraged to participate physically, cognitively, and emotionally.

YouTube media reinforces the visualization dimension of abstract mathematical concepts, such as trigonometric comparisons on right triangles, through animations and contextual examples that are relevant to everyday life. This increases student interest and engagement, as shown by the increase in activeness scores on the "discussion participation" and "questioning" indicators. Meanwhile, the use of AI (such as ChatGPT) provides instant feedback and adaptive exercises that allow students to learn at an individual pace, thus fostering independence and confidence in exploring the material.

These findings are consistent with research Boncukçu & Gök (2023) which states that the activeness of students is not only reflected in physical actions, but also intellectual involvement in analyzing information and constructing knowledge. In the context of the deep learning curriculum, the integration of digital technologies in PBL creates a dynamic, collaborative, and developmentally oriented learning environment for critical thinking essential characteristics for 21st-century learning.

2. The Influence of YouTube-Based PBL and AI on the Understanding of Mathematical Concepts

The application of YouTube-based PBL and AI also has a significant effect on students' understanding of mathematical concepts. The value of $R^2 = 0.601$ shows that 60.1% variation in concept understanding can be explained through this learning model. This improvement can be understood through the cognitive mechanisms activated in PBL: students do not simply memorize formulas, but build understanding through exploration of real problems, collaborative discussions, and metacognitive reflection.

YouTube media facilitates multimodal representations (visual, verbal, symbolic) that enrich students' learning experience in understanding abstract concepts such as sin, cos, and tan. This dual representation favors a deeper internalization of concepts, as theorized by (Mulyono & Hapizah, 2018). On the other hand, AI acts as a digital

scaffolding that helps students clarify misconceptions, test solutions, and accept alternative explanations according to individual levels of understanding.

These results reinforce the findings Yanti et al., (2019) that the PBL model is more effective than conventional learning in improving the conceptual understanding of mathematics. The advantage of PBL lies in its ability to relate material to an authentic context, so that concepts are not seen as isolated entities, but rather as thinking tools to solve problems. In this study, the integration of YouTube and AI strengthens the contextual and personalization dimensions, so that the positive impact of PBL on concept understanding becomes more optimal.

▪ CONCLUSION

Based on the results of the study, it can be concluded that: (1) the application of PBL integrated with YouTube media and the use of AI have a significant effect on increasing student activity in mathematics learning; and (2) the approach also has a significant effect on improving students' understanding of mathematical concepts. The integration of digital technology in the PBL model creates more interactive, adaptive, and student-centered learning. adaptive learning companions who provide formative feedback; and (3) facilitate metacognitive reflection so that students are not only procedurally active, but also conceptually profound. For schools, these findings encourage investment in digital infrastructure and teacher training in the use of innovative learning media.

The results of the study provide recommendations for mathematics teachers to: (1) design PBL scenarios that utilize YouTube videos for visualization of abstract concepts; (2) integrate AI as a

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ATTACHMENT

Table 8. Problem Based Learning (PBL) Validity Test

Statement Items	r count	r table	Conclusion
I felt interested in solving math problems shown through YouTube videos.	0,628	0,254	Valid
The problems presented in learning encourage me to think critically.	0,645	0,254	Valid
Teachers provide clear directions in using AI-based teaching materials.	0,457	0,254	Valid
I feel that group study activities help me understand math concepts better.	0,468	0,254	Valid
The teacher guided me in solving math problems independently and in groups.	0,448	0,254	Valid
I find it helpful when discussing with friends to understand problems in mathematics.	0,471	0,254	Valid
I was able to present the results of solving math problems with the help of video and AI.	0,592	0,254	Valid
I am confident when I deliver the results of the group discussion on mathematical concepts.	0,508	0,254	Valid

Statement Items	**r count**	**r table**	**Conclusion**
I can judge whether the solution I made to the math problem is correct.	0,554	0,254	Valid
I am able to reflect on mistakes and correct them in the process of learning mathematics.	0,464	0,254	Valid

Source : Data Processed, 2025.

Table 9. Test the validity of student activity

Statement Items	r count	r table	Conclusion
I actively look for my own solutions when given math problems through learning YouTube videos.	0,36	0,254	Valid
I discuss more with friends when learning math materials through AI-based teaching materials.	0,361	0,254	Valid
The teacher guided me when I had difficulty understanding the math concepts from the learning videos.	0,358	0,254	Valid
The teacher encouraged me to express my opinion when discussing math problems.	0,331	0,254	Valid
I was able to solve math problems according to learning objectives after using YouTube media.	0,761	0,254	Valid
I understand math material well even with AI-based teaching materials.	0,266	0,254	Valid
I was encouraged to create short presentations or videos to explain mathematical concepts.	0,67	0,254	Valid
I was given the freedom to find creative ways to solve problem-based math problems.	0,562	0,254	Valid
I get regular feedback from teachers about my understanding and attitude in learning math.	0,452	0,254	Valid
I am often given project-based assignments to gauge my skills in applying math concepts.	0,482	0,254	Valid

Source : Data Processed, 2025.