JPPIPA 11(5) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

The Effectiveness of the Project-Based Learning Model Integrated with Digital Teaching Materials and Computational Thinking to Improve the Habits of Mind of Elementary School Students

Mardhatillah[1*], Ade Eka Anggraini[1], Sri Rahayuningsih[1], Mohammad Yusuf Randy[1]

[1] Primary Education, Universitas Negeri Malang, Malang, Indonesia.

Received: January 19, 2025
Revised: April 24, 2025
Accepted: May 25, 2025
Published: May 31, 2025

Corresponding Author:
mardhatillah
mardhatillah.pasca@um.ac.id

DOI: 10.29303/jppipa.v11i5.11155

Abstract: This study aims to test the effectiveness of the Project-Based Learning (PjBL) learning model that is integrated with digital teaching materials and computational thinking in improving the Habits of Mind of elementary school students in Malang Regency. The research approach used is quantitative with a pre-experiment type experimental design, using a one-group pretest-posttest design. The research instrument is in the form of pretest and posttest questions designed to measure the development of students' Habits of Mind before and after the application of the learning model. The results of data analysis showed a significant increase in posttest scores compared to pretests, with an average difference of 13.28 points and a significance value (Sig. 2-tailed) of 0.000. These findings indicate that *the* Project-Based Learning model that is integrated with digital teaching materials and computational thinking is effective in improving students' Habits of Mind. Thus, this model is recommended as an alternative learning strategy that is innovative and relevant to be applied at the elementary school level, especially in forming a critical, reflective, and adaptive mindset in students.

Keywords: Computational thinking; digital teaching materials; Habits of mind; Project-Based Learning.

Introduction

In the era of Society 5.0, technological advances, especially in the field of digitalization, have a major impact on various aspects of life, including education. This ever-evolving technology offers opportunities to improve the quality and effectiveness of learning (Isti'ana, 2024; Siringoringo & Alfaridzi, 2024). Teachers as educators must be able to show empathy and adapt to the progress of the times by developing relevant learning models so that education remains effective and in accordance with the needs of students (Dewi et al., 2023; Hadar et al., 2020). Transformation in education today requires a paradigm shift from a teacher-centred learning model to a more student-centred approach (Goodwin, 2024; Lembong et al., 2023). Millennials and Generation Z exhibit distinctive characteristics of Habits of Mind, which affect the way they respond to challenges, solve problems, and adapt to a technology-based learning environment. Habits of Mind such as reflective thinking, perseverance, cognitive flexibility, and openness to

The learning process needs to be adapted so that students learn actively and independently, utilizing digital tools and resources to deepen students' understanding (McKnight et al., 2016; Sari et al., 2024). In this case, the project-based learning model integrated with digital teaching materials and computational

How to Cite:
Mardhatillah, Anggraini, A. E., Rahayuningsih, S., & Randy, M. Y. The Effectiveness of the Project-Based Learning Model Integrated with Digital Teaching Materials and Computational Thinking to Improve the Habits of Mind of Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 370-379. https://doi.org/10.29303/jppipa.v11i5.11155

thinking becomes an innovative solution. Project-based learning is a project-based learning model that emphasizes contextual practice and helps students understand learning material through hands-on experience (Akirav, 2023; Fasya & Wiranti, 2024; Mulyani et al., 2023). Using Digital Teaching Materials, this model integrates technology-based learning content into the learning process, allowing students to access information in interactive formats such as videos, animations, simulations, or multimedia presentations through digital devices (Haleem et al., 2022; Pavlásek, 2010). This not only enriches the learning experience, but also supports students' active involvement in understanding the material in a more in-depth and contextual way.

At SD Negeri Dadaprejo 2 and SD Negeri Girimoyo 2, the application of a project-based learning model integrated with digital teaching materials and computational thinking has been carried out to improve students' habbits of mind. Early observations show that students in both schools show high enthusiasm and engagement in learning. At SD Negeri Dadaprejo 2, grade V students experienced significant progress in their understanding of the material, which reflects the improvement of students' habbits of mind. However, at SD Negeri Girimoyo 2, despite the improvement in the quality of learning, students faced technical obstacles and difficulties in adapting to digital teaching materials, which had an impact on the process of improving students' habbits of minds. The following is a table of the results of the observation recap in class V that has been carried out.

Based on the recap observations that have been carried out, the results of the implementation of the project-based learning model integrated with digital teaching materials and computational thinking at SD Negeri Dadaprejo 2 and SD Negeri Girimoyo 2 show significant findings. At SD Negeri Dadaprejo 2, out of 33 students in grade V, around 85% of students showed high enthusiasm for learning. Student involvement in learning activities is also excellent, with 80% of students actively participating. Progress in material comprehension has been very positive, with 90% of students making significant progress. In addition, students' digital skills are improving well, with 88% of students showing improved skills. No obstacles or difficulties were reported in the implementation of digital teaching materials in this school.

In contrast, at SD Negeri Girimoyo 2, out of 30 students in grade V, about 80% of students showed high enthusiasm for this learning model, while 75% of students were actively involved in learning activities. Despite improvements in material comprehension, only 70% of students have made significant progress. Improvements in digital skills were also noted, with 73% of students showing progress. However, in this school there are several technical obstacles and difficulties in adapting digital teaching materials, which affect the process of improving students' habbits of minds. Overall, the project-based learning model integrated with digital teaching materials and computational thinking showed positive results in both schools, despite differences in the level of progress and obstacles faced. These results reflect the great potential of digital teaching materials in improving students' habbits of minds, but also emphasize the need to pay attention to technical challenges and adaptation to ensure optimal effectiveness.

Digital teaching materials serve as interactive learning mediums that combine the real and virtual worlds, creating an instructional environment that supports active student engagement and collaboration (AlGerafi et al., 2023; Jesionkowska et al., 2020; Papanastasiou et al., 2019). Using an app like Assemblr Studio, students can access additional information by scanning an object or QR code (Quick Response), which allows students to obtain more detailed and contextual information. With a project-based learning model integrated with digital teaching materials and computational thinking, students not only learn theory but also engage in relevant and applicable practice processes. This model is designed to improve students' habbits of mind by integrating technology in the daily learning process.

Method

This study uses the Quasi-Experiment Design method, which is a form of experimental design that involves a control group but cannot fully control external variables that affect the implementation of the experiment.

The design of this study uses the Nonequivalent Control Group Design, with the design as follows Table 1.

Table 2. Nonequivalent *Control Group Design Research*

Group	Pre-Test	Treatment	Post-Test
Experiment	O1	x	O2
Control	O3	-	O4

Information:
O1 and O3 = Pre-Test measurements for the experimental and control groups.
X = Learning using a project-based learning model integrated with digital teaching materials and computational thinking.

O2 and O4 = Post-Test measurements for the experimental and control groups.

The variables of this study consist of two variables, namely X and Y. Variable X is an independent variable, namely a project-based learning model integrated with digital teaching materials and computational thinking and Variable Y is a bound variable in this study, namely the habbits of mind.

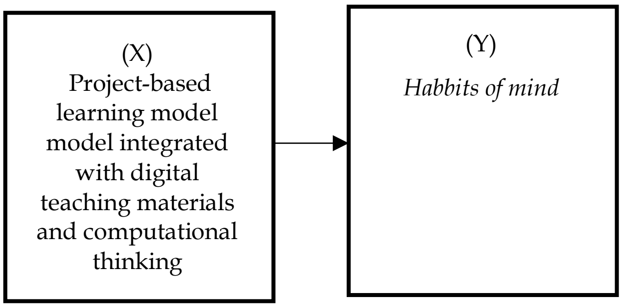

Figure 1. Research Variables

This research was carried out at SD Negeri Dadaprejo 2 and SD Negeri Girimoyo 2. This research was carried out from July 1 to August 12, 2024. The sampling technique in this study used Simple Random Sampling; strata in the population were not taken into account when selecting samples from the population. Each class in the population has an equal chance of being selected as a sample when using this strategy. The two classes that became the selected sample were class V of SD Negeri Dadaprejo 2, which had 33 students as an experimental class, and class V of SD Negeri Girimoyo 2, which had 30 students as a control class, so that the total sample of this study was 63 students.

The data collection techniques in this study involve three main methods of testing, documentation, and observation. The test is used to measure the extent to which a student's habbits of mind is improved, providing a quantitative picture of the student's skills and understanding through Pre-Tests (initial assessment) and Post-Test (final assessment) using practical assessments. Of the 30 assessment indicator points made by the researcher, only 24 points were considered valid and reliable for use in the Pre-Test and Post-Test after the validation process. Documentation is used to collect and store data related to learning processes and outcomes, including records of activities and materials used during experiments. Observations were carried out to obtain qualitative data on student interaction with the learning model, as well as to assess the level of enthusiasm and student involvement. In addition, the assessment also involves questionnaires filled out by observers to gain insight into the effectiveness of the implementation of project-based learning models integrated with digital teaching materials and computational thinking in improving students' habbits of minds.

The data analysis method in this study uses SPSS (Statistical Package for the Social Sciences) software version 21. The analysis was carried out including validity, reliability, and homogeneity tests using the Fisher Test. The normality test was carried out with the Lilliefors test. In addition, the analysis includes calculations of Effect Size and N-Gain, as well as hypothesis testing using t-tests.

The normalized gain formula uses the following methods to determine the improvement of student learning outcomes.

$$\text{Normalized gain (g)} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}} \quad (1)$$

Table 2. Modified Normalized Gain (G) Interpretation

Normalized Gain Values	Interpretation
-1.00≤g>0.00	There is a decline
g = 0.00	There is no improvement
0.00<g<0.30	Low
0.30≤g<0.70	Keep
0.70≤g≤1.00	Tall

The following categories apply to the criteria used to determine the Effect Size:

Table 3. Category Effect Size

Effect Size	Category
d<0.2	Small
0.2<d<0.8	Keep
d>0.8	Tall

Before being used for research, the instrument must be tested for validity and reliability first, so that it is proven to be valid and reliable as a *measuring tool for Habbits of mind*. In this case, an instrument item is said to be valid if the significance value is less than 0.05 (sig<0.05), the instrument item is said to be invalid if the significance value is greater than 0.05 (sig>0.05). The following are the results of the validity test of indicator items:

Table 4. Results of the Validity Test of Assessment Indicators

No Indicator	Significance	Information
1	0.001	Valid
2	0.000	Valid
3	0.001	Valid
4	0.000	Valid
5	0.001	Valid
6	0.000	Valid
7	0.001	Valid
8	0.000	Valid
9	0.000	Valid
10	0.000	Valid
11	0.001	Valid

No Indicator	Significance	Information
12	0.000	Valid
13	0.000	Valid
14	0.000	Valid
15	0.000	Valid
16	0.854	Invalid
17	0.976	Invalid
18	0.883	Invalid
19	0.000	Valid
20	0.000	Valid
21	0.691	Invalid
22	0.000	Valid
23	0.001	Valid
24	0.000	Valid
25	0.0976	Invalid
26	0.000	Valid
27	0.951	Invalid
28	0.000	Valid
29	0.000	Valid
30	0.000	Valid

Twenty-four of the instrument test findings were considered valid, while 6 were considered invalid based on the validity test results listed in the table. As a result, 24 valid indicators can be used as a measuring tool to assess students' Habbits of mind.

For a test to produce reliable results, its level of reliability must be high. A valid test must be reliable, but a test can have reliability without always being valid. To evaluate the consistency of the indicators, the researchers used a reliability test with the Cronbach Alpha formula. Data for the Cronbach alpha reliability test, an instrument is considered reliable if the Cronbach alpha value is more than 0.60 (Sugiyono, 2019). The table below shows the reliability test findings of the instrument.

Tabel 5. Reliability Statistics

Cronbach's Alpha	N of Items
0.983	24

Table 5 shows that the instrument reliability test results in an r11 score of 0.983, which is much greater than 0.60 (0.983 > 0.60). Thus, the indicator instruments for measuring the assessment of Habbits of minds meet the high reliability requirements, as indicated by the high reliability value in Table 6.

The researcher chose to use 24 of the 30 test questions for the hypothesis test, which was the final test, after conducting a validity and reliability test analysis of all 30 Habbits of mind test questions. Of the 30 questions, 6 did not meet the requirements for differentiation. Therefore, this study uses the following series of questions: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 19, 20, 22, 23, 24, 26, 28, 29, and 30. Based on the results of the validity and reliability tests, these 24 questions are considered to meet good standards and are suitable for use as a measure of Habbits of mind.

Result and Discussion

In the application of learning, the project-based learning model integrated with digital teaching materials and computational thinking has been proven to be more effective in improving students' Habbits of mind compared to the use of the conventional Project Citizen model. In the experimental class, student-centered learning with educators acting as facilitators who support and implement all predetermined steps using a project-based learning model integrated with digital teaching materials and computational thinking. The results of each meeting can be seen in the Table 6.

Table 6. Results of Learning Implementation Using Project-Based Learning Model Integrated Digital Teaching Materials and Computational Thinking

Implementation	Percentage (%)
Meeting 1	80
Meeting 2	83
Meeting 3	89
Meeting 4	92
Encounter 5	95
Encounter 6	97
Meeting 7	100

Table 6 presents the results of the analysis regarding the application of the integrated project-based learning model, digital teaching materials and computational thinking in the learning process. This data was obtained from observation sheets filled out by classroom teachers as observers during the research project. Based on these findings, the learning management estimate showed a progressive increase from meeting to meeting: at the first meeting it was recorded at 80%, increasing to 83% at the second meeting, 89% at the third meeting, 92% at the fourth meeting, 95% at the fifth meeting, and reaching 97% at the sixth meeting. At the last meeting, the estimated learning management reached 100%.

Table 7. Pretest and Posstest Scores Recapitulation

Indicator	Experiment		Control	
	Pretest	Posstest	Pretest	Posstest
Total Values	1191	2031	961	1741
Average	49.62	84.62	40.04	71.54

The findings of the pretest and posttest in the control class and the experimental class show the results obtained from the application of the project-based learning model integrated with digital teaching materials and computational thinking. The following is a recapitulation of the pretest and posttest scores of the control class and the experimental class.

Through the Table 7, a graph can be produced to find out a broader histogram picture of the results of the pretest and posstest, the following pretest and posttest graphs.

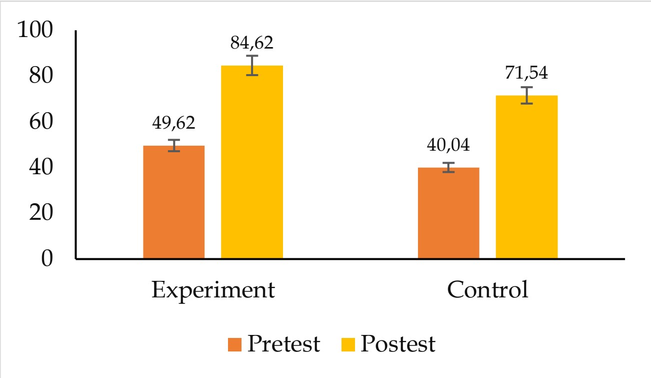

Figure 2. Pretest and Posstest Average Score Chart

The results showed that the experimental class had a higher average score of pretest and posttest than the control group, as seen in the graph above. In the experimental class, the average pretest score was 49.62, while in the control group it was 40.04. After the posttest, the average score of the experimental class rose to 84.62, while the average score of the control class was 71.54.

It can be seen from the results of the pretest and posttest of the experimental class that have increased significantly, that the use of the project-based learning model integrated with digital teaching materials and computational thinking can improve students' Habbits of mind (Chen et al., 2022; Nurhayati et al., 2020).

Normality Test (Liliefors Test)

The Liliefors test, especially with a significance threshold of α = 0.05, is a normative test used in this study. The sample is normally distributed if Lcal < Ltable Ha is accepted, and not normally distributed if Lcal > Ltable Ha is rejected. The calculation of the normality test is based on criteria to determine whether the data is normally distributed or not. Table 8. Below shows the results of the pre-test and post-test normality tests.

Table 8. Results of Pretest and Posstest Normality Test for Experiment and Control Class

Statistics	Experiment		Control	
	Pretest	Posstest	Pretest	Posstest
N	33	33	30	30
$\bar{x}$	49	84	40	71
SD	18,83	83,91	16,39	76,45
Count	0,138	0,146	0,152	0,159
Tables	0,154	0,154	0,161	0,161
Conclusion	Normal	Normal	Normal	Normal

Table 8 shows that the number of experimental class calculations is distributed regularly, with pretest results of 0.138 and postes findings of 0.146. The number of control class counts was also distributed normally, although the pre-test and post-test scores of the control class were 0.152 and 0.159, respectively. Similarly, the results of both classes can meet the requirement that Lcal < Ltab, which indicates that the distribution of both classes in *the pre-test* and *post-test* is normally distributed.

Normality Test (One-Sample Kolmogorov-Smirnov Test)

Requirements tests or traditional assumptions tests for data analysis include normality tests. This means that the normality of the distribution of research data must be checked before conducting statistical analysis to test the hypothesis, i.e. regression analysis. Regularly dispersed data is considered good data. The Kolmogorov-Smirnov normality test relies on the following principles to draw conclusions: If the significance value (Sig.) of a study is greater than 0.05 then the data is considered to be evenly distributed; and if the Sig value is less than 0.05, then the research data is not normally distributed.

Table 9. Normality test (One-Sample Kolmogorov-Smirnov Test)

Parameters		Unstandardized Residual
Normal Parameters[a,b]	N	63
	Mean	0.0000000
	Std. Deviation	2.92713942
Most Extreme Differences	Absolute	0.199
	Positive	0.076
	Negative	-0.188
Test Statistic		0.188
Asymp. Sig. (2-tailed)		0.188[c]

The value of the significance of Asymp is a variable of product quality. The sig (2-tailed) is higher than 0.05 which is 0.188, according to the SPSS output table generated. The data is distributed normally, according to the conclusions drawn from the Kolmogorov-Smirnov normality test described.

Multicollinelarity Test

It is a common fact that all statistical tests must have a foundation for making conclusions. The following is the basis for the inferences made in the multicollineaity test that uses tolerance and VIF: If the regression model's VIF value is less than 0.10, this indicates that multicollinearity does not exist; If the value is more than 0.10, multicollinearity occurs.

Table 10. Multicollinearity Test

Model	Collinearity Statistics	
	Tolerance	Bright
(Constant)		
Project-based learning model integrated with digital teaching materials and computational thinking (X)	0.684	0.068
a. Dependent Variable: Habbits of mind		

By looking at the Tolerance and VIF values, multicollinearity test decisions can be made. The coefficient for variable (X) is less than 0.10, according to the output table 'Coefficients' in the 'Collinearity Statistics' section. The VIF value for variable (X) is less than 0.10, which is 0.068 with a tolerance of 0.684. It can be said that there are no signs of multicollinearity in this regression model based on the decision making criteria of the multicollinearity test.

Heteroscedasticity Test

The heteroscedasticity test was used to find out whether the residual variance of the regression model was different or similar between the data. This test is called homocedasticity if the residual variance between observations is constant; It is called heteroscedasticity if it varies. Regression models that meet the conditions of homokedasticity are considered good. The presence or absence of a particular pattern on the scatter chart can be used to determine whether heteroscedasticity is present. When a particular pattern appears, heteroscedasticity has occurred. However, heteroscedasticity does not exist if there is no visible pattern and the points stretch above and below the zero value of the Y-axis.

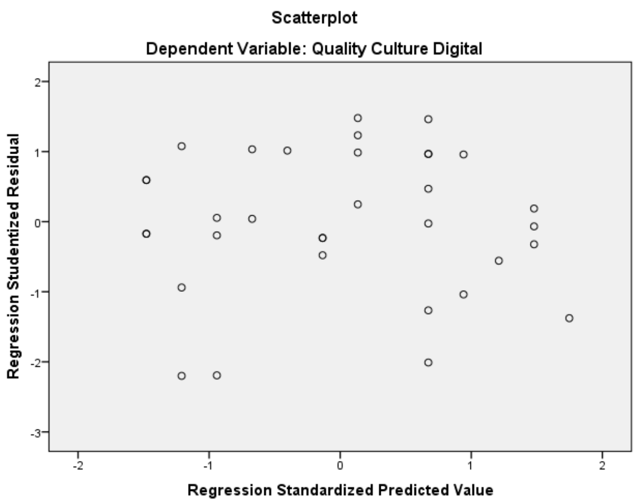

Figure 3. Sacatterplot Heteroscedasticity Test

It can be seen from the image above that the findings of the scatter plot of the heteroscedasticity test meet the heteroscedasticity requirements. This can be seen from the scatter plot above, where the dots are erratic and do not follow a certain pattern. Therefore, it can be said that the data are heteroscedasticity free or do not show heteroscedasticity.

Homogeneity Test

After the data is distributed normally, a homogeneity test is performed. The Fisher test is used as a homogeneity test. The appendix displays the results of the data homogeneity test calculation. A homogeneous sample if Fcal < Ftabel Ha is declared acceptable; the sample is not homogeneous if the Fcal > Ftabel Ha is declared to be rejected. This criterion is used to determine whether the data is homogeneous or not. Table 11. Below shows the homogeneity test results for the pretest and posttest

Table 11. Homogeneity Test Results Pretest and Posstest Experiment and Control Class

Statistics	Pretest	Posttest
Calculation	2.1846	1.8376
Table	3.9984	3.9984
Conclusion	Homogeneous	Homogeneous

The results of the homogeneity test for *the pretest* and *posttest* in the control and experimental classes are shown in Table 11 above. *The* experimental and control class pretest resulted in a Fcal value of 2.1846, while the experimental and control *class posttest* resulted in a Fcal of 1.8376. Since Fcal < Ftabel was found for data from both classes, it can be said that both samples have the same and homogeneous variance.

Hypothesis Test (t-Test)

It has been determined through the necessary data analysis test that the test results of each class are homogeneous and distributed regularly. Thus, the data analysis can be proceeded to the next stage, namely hypothesis testing, to confirm whether or not there is an influence. With the following conditions, the t-test is used to test this hypothesis: Ha is accepted if the tcount is > ttable and rejected if the tcount is < ttable. Table 13. Below shows the hypothesis test results for the experimental and control classes.

The Table 12 shows that the results of the hypothesis test show that the value of the tcal is greater than the ttabul, namely (2.439 > 1.670). So Ha was accepted and Ho was rejected, meaning that based on the results of the hypothesis test, the use of a project-based learning model integrated with digital teaching materials and computational thinking had a significant effect on students' Habbits of mind.

Table 12. Hypothesis Test Results

Model	Unstandardized Coeff.		Standardized Coeff.	t	Sig
	B	Std. Err	Beta		
Constant	49.348	11.343		1.988	0.005
Project-based learning model integrated with digital teaching materials and computational thinking	0.087	0.186	0.058	2.439	0.000

Determination Coefficient Analysis (R2)

The value of the determination coefficient can be seen as the degree of contribution of an independent variable to a dependent variable or as the amount that an independent variable can explain to the variance of the dependent variable. The percentage of variance described by the independent variable (X) relative to the dependent variable (Y) is known as the coefficient of determination (R squared or R-squared), denoted by "R^2". In other words, the coefficient of determination, also known as R squared, can be used to predict and determine the extent to which variable X contributes to variable Y simultaneously or collectively.

Table 13. Coefficient of determination Model Summary

Model	R	R Square	Adjusted R Square	Std. Err Estimate
1	0.413	0.334	0.278	2.199

It is known that the R Square value is 0.334 and the determination coefficient or R is 0.413 based on the SPSS output table "Model Summary" above. The coefficient of determination (R) has a magnitude of 0.413 or 41.3%. This graph shows a partial influence of 41.3% of the project-based learning model of digital teaching materials and computational thinking on the Habbits of mind variables in SD Negeri Dadaprejo 2 Malang Regency and SD Negeri Girimoyo 2 Malang Regency. Meanwhile, variables that are not included in this regression equation or variables that are not studied affect the rest by 100% - 41.3% = 58.7%.

N-Gain

Habbits of students' minds are marked by a gain value, gain is the difference between posttest and pretest scores, gain shows an increase in students' abilities after the learning process. The normalized NGain test was carried out to show how much the Habbits of mind of students improved after participating in learning with a project-based learning model integrated with digital teaching materials and computational thinking. The calculation of N-Gain is the difference between the posttest and pretest scores divided by the difference between the highest score and the pretest score. The following are the results of the N Gain score in the experimental class.

Table 14. N-gain experiment class

Parameters	N	Min	Max	Mean	Std. Dev
N-gain Score	33	0.30	0.100	0.8462	0.24902
N-Percentage	33	30.00	100.00	84.6286	24.90274
Valid N (listwise)	33				

The table 14 is known as the result of the N-Gain Score with a mean value of 0.8462, the value is greater than 0.3 (0.84>0.3) then the category obtained is high/high effectiveness. N-Gain Percent of the mean value is 84.6286, this value is greater than 76% (84%>76%), so it is considered effective. So it can be concluded that the use of the integrated project-based learning model of digital teaching materials and computational thinking to improve students' Habbits of mind has proven to be effective in experimental and high-category classes.

The results of the N Gain test in the control class are presented in the Table 15.

Table 15. N-gain control class

Parameters	N	Min	Max	Mean	Std. Dev
N-gain Score	30	0.30	0.100	0.7154	0.23522
N-Percentage	30	30.00	100.00	71.5444	23.52174
Valid N (listwise)	30				

The Table 15 is known as the result of the N-Gain Score with a mean value of 0.7154, the value is greater than 0.3 (0.71>0.3), then the category obtained is high/high effectiveness. N-Gain Percent has a mean value of 71.5444, and is in the medium category.

Effect Size

In this study, effect measures were used to measure how well one variable affected another. The efficacy of the project-based learning model integrated with digital teaching materials and computational thinking in *Habbits of mind* was assessed using the Effect Size test. The following table shows the results of the Effect Size calculation.

Table 16. Effect Size Results

Class	Average Gain	SD	Effect Size	Category
Experiment	84.6286	24.9027	0.2	Keep
Control	71.5444	23.5217		

The results of the effect size calculation showed that the use of the project-based learning model integrated with digital teaching materials and computational thinking could be used to improve *students*' *Habbits of mind*, with a value of 0.2 indicating the effectiveness of this model had a moderate effect on *students*' Habbits of mind.

Discussion

Based on the results of the analysis and research that has been carried out, it can be proven that the project-based learning model integrated with digital teaching materials and computational thinking is effective in improving the Habbits of mind of elementary school students in Malang Regency. This is supported by an effect size value of 0.2, which indicates a medium category. This proves that the application of the model has a significant impact on improving students' Habbits of mind, even though it does not fall into the large category. The success of the project-based learning model integrated with digital teaching materials and computational thinking in improving the Habbits of mind needs to be seen from the perspective of practical implementation in the field. This approach is adopted by educators by tailoring learning content according to the local context and the needs of students. In the process, students respond well to the use of digital teaching materials, which makes students more engaged and motivated in learning.

The project-based learning model integrated with digital teaching materials and computational thinking is designed so that students not only understand digital concepts, but also be able to apply them in real-life contexts that are relevant to students. As in learning about environmental issues, students can use digital teaching materials to simulate the impact of students' actions on the surrounding environment, which helps students understand and appreciate the importance of their role as responsible citizens. The application of teaching materials in the project-based learning model integrated with digital teaching materials and computational thinking not only helps students understand the material better, but also fosters an appreciation for digital technology and its responsible use. Students' responses to this model are an important indicator of its success. Based on observations and assessments conducted during the study, students showed a significant increase in learning motivation. Students become more active in class discussions, more enthusiastic in completing given projects, and more critical in providing solutions to the problems at hand.

This improvement shows that the Project-Based Learning Model integrated with digital teaching materials and computational thinking not only improves Habits of Mind, but also creates a more dynamic and interactive learning environment. Institutional support and school culture also play an important role in the successful implementation of this model. The elementary school that is the location of the study has a commitment to integrating technology in every aspect of learning, from curriculum to teaching methods. This support ensures that the implementation of the Project-Based Learning Model integrated with digital teaching materials and computational thinking is carried out consistently and sustainably, allowing students to feel the full benefits of this approach in the long term.

These findings are in line with various relevant studies that have been conducted previously, showing that the application of technology-based learning models can significantly improve *students*' Habbits of mind (Alakrash & Abdul Razak, 2021; Nurunisa & Shodiq, 2024; Rasdiana et al., 2024). The research reveals that integrating technology with real-world contexts helps strengthen students' understanding and critical skills. Technology-based approaches such as AR can increase students' motivation and engagement in the learning process, as well as improve students' digital skills and creativity (Wang, 2020). Technology-based learning models assist students in connecting various concepts, which contributes to the improvement of critical thinking and problem-solving skills (Dominggus et al., 2021; Simanjuntak et al., 2021). The integration of technology in the curriculum not only improves students' understanding of the material, but also strengthens students' analytical and critical thinking skills (Murillo-Zamorano et al., 2019).

Conclusion

Based on the results of research and data analysis, it can be concluded that students' *Habbits of mind* (QCD) can be improved through the application of a project-based learning model integrated with digital teaching materials and computational thinking (AR). This can be seen from the comparison of *pretest* and *posttest* scores in the experimental class, where *the pretest* score of 49.63 increased significantly to 84.63 in *the posttest*. In comparison, *the pretest* and *posttest scores* in the control class remained at a lower level compared to the experimental class, with a pretest score of 40.04 and a posttest score of 71.54. The results of the hypothesis test showed that the tcal value was greater than the table, namely (2.439 > 1.670). So Ha is accepted and Ho is rejected, with an effect size of 0.2 which falls into the medium category, at a significance level of α = 0.05. Therefore, it can be concluded that the project-based learning model integrated with digital teaching materials and computational thinking is effective in improving *the Habbits of mind* of students in elementary schools in Malang Regency.

Acknowledgments
The author expresses his deepest gratitude to the Directorate of Research and Community Service (DPPM) for the support and funding that has been provided in the implementation of this research through the 2024 funding scheme. This support is very meaningful in supporting the smooth research process to the preparation of this article.

Authors Contributions
This article was written by three authors, namely A. S., J. S., and W. F. S. All authors worked together at every stage of the preparation of this article.

Funding
This research received funding from Directorate of Research and Community Service Universitas Negeri Malang.

Conflicts of Interest
The authors declare no conflict of interest.

References

Akirav, O. (2023). Active Civic Education Using Project-Based Learning: Israeli College Students' Attitudes towards Civic Engagement. *Interdisciplinary Journal of Problem-Based Learning*, *17*(1). Retrieved from https://eric.ed.gov/?id=EJ1411048

Alakrash, H. M., & Abdul Razak, N. (2021). Technology-based language learning: Investigation of digital technology and digital literacy. *Sustainability*, *13*(21), 12304. https://doi.org/10.3390/su132112304

AlGerafi, M. A. M., Zhou, Y., Oubibi, M., & Wijaya, T. T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics (Switzerland)*, *12*(18). https://doi.org/10.3390/electronics12183953

Chen, S.-Y., Lai, C.-F., Lai, Y.-H., & Su, Y.-S. (2022). Effect of project-based learning on development of students' creative thinking. *The International Journal of Electrical Engineering & Education*, *59*(3), 232–250. https://doi.org/10.1177/0020720919846808

Dewi, A. C., Salsabila, Jannah, M., Cantika, A. Z., Aurora, F., & Amirah, A. (2023). Menelusuri Jejak Guru Ideal di Era Digital. *PENDIRI: Jurnal Riset Pendidikan*, *1*(1), 1–8. https://doi.org/10.63866/pendiri.v1i1.11

Dominggus, R., Kristin, S., Martha M, B., Since Y, K., Vera V, K., & CorneliLatu, P. (2021). Resource based learning design thinking (RBLDT): A model to improve students' creative thinking skills, concept gaining, and digital literacy. *Cypriot Journal of Educational Sciences*, *16*(1), 288–302. Retrieved from https://eric.ed.gov/?id=EJ1288557

Fasya, N. A., & Wiranti, D. A. (2024). Efektivitas Model Project Citizen untuk Meningkatkan Kemampuan Literasi Budaya Peserta Didik pada Pembelajaran Pendidikan Pancasila Kelas 5 SDN 2 Tahunan. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *4*(3), 930–942. https://doi.org/10.53299/jppi.v4i3.667

Goodwin, J. R. (2024). What's the Difference? A Comparison of Student-Centered Teaching Methods. *Education Sciences*, *14*(7), 736. https://doi.org/10.3390/educsci14070736

Hadar, L. L., Ergas, O., Alpert, B., & Ariav, T. (2020). Rethinking teacher education in a VUCA world: student teachers' social-emotional competencies during the Covid-19 crisis. *European Journal of Teacher Education*, *43*(4), 573–586. https://doi.org/10.1080/02619768.2020.1807513

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, *3*, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

Isti'ana, A. (2024). Integrasi Teknologi dalam Pembelajaran Pendidikan Islam. *Indonesian Research Journal on Education*, *4*(1), 302 – 310. https://doi.org/10.31004/irje.v4i1.493

Jesionkowska, J., Wild, F., & Deval, Y. (2020). education sciences Active Learning Augmented Reality for STEAM Education — A Case Study. *Education Sciences*, *10*(8). https://doi.org/10.3390/educsci10080198

Lembong, J. M., Lumapow, H. R., & Rotty, V. N. J. (2023). Implementasi Merdeka Belajar Sebagai Transformasi Kebijakan Pendidikan. *Jurnal Educatio FKIP UNMA*, *9*(2), 765–777. https://doi.org/10.31949/educatio.v9i2.4620

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education*, *48*(3), 194–211.

https://doi.org/10.1080/15391523.2016.1175856

Mulyani, S., Yogiarni, T., & Caturiasari, J. (2023). Pelatihan Model Pembelajaran Project Citizen Bagi Guru-Guru di Sekolah Indonesia Johor Bahru, Malaysia Untuk Meningkatkan Civic Literacy. *Indonesian Journal of Community Services in Engineering & Education (IJOCSEE)*, *3*(2), 84–92. https://doi.org/10.17509/ijocsee.v3i2.63251

Murillo-Zamorano, L. R., López Sánchez, J. Á., & Godoy-Caballero, A. L. (2019). How the flipped classroom affects knowledge, skills, and engagement in higher education: Effects on students' satisfaction. *Computers and Education*, *141*(October 2018). https://doi.org/10.1016/j.compedu.2019.103608

Nurhayati, E., Rizaldi, D. R., & Fatimah, Z. (2020). The effectiveness of project-based learning with the blended learning system to improve 21st century skills during the COVID-19 pandemic. *Journal Scientia*, *9*(2), 46–52. https://doi.org/https://shorturl.asia/qI4Nx

Nurunisa, F. A., & Shodiq, S. F. (2024). Developing Quality Social Relationships : Technology-Based Learning Model to Enhance Social Skills in Boarding Schools. *Journal of Innovation in Educational and Cultural Research*, *5*(3), 364–372. https://doi.org/10.46843/jiecr.v5i3.1537

Papanastasiou, G., Drigas, A., Skianis, C., Lytras, M., & Papanastasiou, E. (2019). Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills. *Virtual Reality*, *23*(4), 425–436. https://doi.org/10.1007/s10055-018-0363-2

Pavlásek, P. (2010). Digital Teaching and Learning Environment in Student-Focused Teaching Concept: Making it Work in the Technology Oriented Content. *INTED2010 Proceedings*, 2768–2779. Retrieved from https://library.iated.org/view/PAVLASEK2010DIG

Rasdiana, Wiyono, B. B., Imron, A., Rahma, L., Arifah, N., Azhari, R., Elfira, Sibula, I., & Maharmawan, M. A. (2024). Elevating Teachers' Professional Digital Competence: Synergies of Principals' Instructional E-Supervision, Technology Leadership and Digital Culture for Educational Excellence in Digital-Savvy Era. *Education Sciences*, *14*(3). https://doi.org/10.3390/educsci14030266

Sari, H. D., Riandi, R., & Surtikanti, H. K. (2024). Bahan Ajar Digital Bermuatan Potensi Lokal Untuk Meningkatkan Pemahaman Konsep dan Motivasi Belajar Pada Materi Bioteknologi Konvensional. *Jurnal Basicedu*, *8*(1), 263–276. https://doi.org/10.31004/basicedu.v8i1.6503

Simanjuntak, M. P., Hutahaean, J., Marpaung, N., & Ramadhani, D. (2021). Effectiveness of problem-based learning combined with computer simulation on students' problem-solving and creative thinking skills. *International Journal of Instruction*, *14*(3), 519–534. https://doi.org/10.29333/iji.2021.14330a

Siringoringo, R. G., & Alfaridzi, M. Y. (2024). Pengaruh Integrasi Teknologi Pembelajaran terhadap Efektivitas dan Transformasi Paradigma Pendidikan Era Digital. *Jurnal Yudistira: Publikasi Riset Ilmu Pendidikan Dan Bahasa*, *2*(3), 66. Retrieved from https://shorturl.asia/JTy63

Sugiyono. (2019). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: PT Alfabeta.

Wang, Y. H. (2020). Integrating games, e-books and AR techniques to support project-based science learning. *Educational Technology and Society*, *23*(3), 53–67. Retrieved from https://www.jstor.org/stable/26926426