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THE EFFECTIVENESS OF THE CIRC LEARNING MODEL ASSISTED BY TPACK-BASED E-LKPD ON THE JUNIOR HIGH SCHOOL STUDENTS' NUMERACY LITERACY SKILLS

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ABSTRACT

Numeracy literacy is one of the important competencies of the 21st century, but the numeracy literacy skills of students in Indonesia are still relatively low. This study aims to analyze the effectiveness of the Cooperative Integrated Reading and Composition (CIRC) learning model assisted by E-LKPD based on Technological Pedagogical Content Knowledge (TPACK) on the numeracy literacy skills of junior high school students. This study uses a quasi-experimental method with a nonequivalent pretest-posttest control group design. The research sample consisted of 28 seventh-grade students from class VII E as the experimental group and 25 seventh-grade students from class VII H as the control group at SMP Negeri 1 Mungkid. Data were collected using numeracy literacy ability tests and analyzed through Paired Sample t-Test, Independent Sample t-Test, N-Gain, and Cohen's d effect size. The research results show that the numeracy literacy skills of students in the experimental class and the control class experienced a significant improvement after the learning process. In addition, there is a significant difference between the numeracy literacy abilities of students in the experimental class and the control class after the treatment was given ($p = 0.021$). Although the N-Gain values of both groups are still in the low category, the experimental class achieved a higher improvement compared to the control class. Cohen's d effect size analysis shows that the CIRC model assisted by TPACK-based E-LKPD has a significant impact on students' numeracy literacy skills. These findings indicate that the integration of the CIRC model with TPACK-based E-LKPD can be an effective learning alternative to support the development of students' numeracy literacy in mathematics education.

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1. INTRODUCTION

Mathematics education has a critical role in educating students for the problems of the 21st century. Mathematics education not only guides students to achieve academic success but also serves as a means to help students build fundamental skills, consisting of competencies or skills, literacy, and character. Literacy becomes a prerequisite component for achieving the 4C life competencies (Critical thinking and problem solving, Creativity, Collaboration, and Communication) that encourage the formation of students' character (Liswati et al., 2021). Basic literacy consists of reading and writing literacy, digital literacy, financial literacy, scientific literacy, cultural and citizenship literacy, and numeracy literacy (Nursyamsudin & Jaelani, 2021). One of the six essential basic literacies that students should possess is numeracy literacy.

Numeracy literacy or mathematical literacy in OECD (2023a) is the ability of an individual to formulate, use, and interpret a problem in various real-world contexts through a mathematical thinking process. Numeracy literacy can be defined as the ability to understand and process information through reading and writing related to basic mathematical knowledge and skills (Salsabilah & Kurniasih, 2022). Numeracy literacy skills that are closely related to real-life contexts are essential for students to face various situations, problems, and difficulties in society (Tyaningsih et al., 2023). In the research by Asri and Maysarah (2024), numeracy literacy skills are beneficial in enhancing thinking skills related to language and mathematics in various situations, not only individually but also within social and professional contexts. Supported by Ammy et al. (2024), numeracy literacy skills form the foundation for individuals to engage in various activities ranging from learning, work, to everyday life. This emphasizes the importance of numeracy literacy skills in everyday life for all individuals.

However, the condition of students' numeracy literacy skills in Indonesia still requires further attention. Based on the results of the PISA or Program for International Student Assessment in 2022 released by the OECD (2023), Indonesia's score was 366. The score indicates that Indonesia lags 106 points behind the OECD average of 472. If we look more closely, Indonesia's score in 2015 was 386 and in 2018 was 379 (OECD, 2016, 2019). The results indicate that over the last three PISA cycles, Indonesia has experienced a significant decline in scores. The low numeracy literacy skills of students in Indonesia are also supported by the research findings of Fitrianingrum and Murtiyasa (2023), which show that 73.08% of students' numeracy literacy skills are still in the low category. In the study by Sundari et al. (2025), the results of the numeracy literacy ability test for students were also low, with an average score of 29.3. Additionally, Rakhmawati and Mustadi (2022) in their research showed that most numeracy literacy indicators have not yet reached the expected standards.

Evidence of low numeracy literacy skills is additionally backed by the findings from the initial ability test on 64 seventh-grade students at SMP Negeri 1 Mungkid. Through the initial ability test, an average numeracy literacy score of 48.49 out of a maximum score of 100 was obtained, which still falls into the poor category according to Putri et al. (2021). The findings indicate that most students are unable to perform the points in the numeracy literacy ability indicators. According to the interview results, the students stated that they still find it difficult to solve numeracy literacy problems. They feel that addressing numeracy literacy problems requires high precision and a considerable amount of time to understand the numeracy literacy questions. In addition, students also face difficulties in remembering formulas, which creates obstacles in the steps to solve problems.

The low literacy skills are due to students not being accustomed to analyzing information and solving problems in real-life situations (Tyaningsih et al., 2023).

Additionally, mathematics learning often focuses solely on mechanical procedures that prioritize memorizing formulas and practicing problems without considering mathematical problems in real-life contexts (Endradewi et al., 2025). This is consistent with the findings of the observation, where students have been given story problems but have not yet included indicators of numeracy literacy skills. It was also discovered through teacher interviews that students are still rarely given questions up to the stage of predicting a decision through the interpretation of analysis results. Therefore, it is necessary to habituate the provision of numeracy literacy questions for students and to implement strategies that can help them enhance their numeracy literacy skills, such as the alternative CIRC (Cooperative Integrated Reading and Composition) learning model.

The CIRC learning model is a group learning model that integrates students' reading and writing skills (Hartati & Apriliana, 2021). The CIRC learning model has 5 phases, which include (1) orientation, (2) organization, (3) concept introduction, (4) publication, and (5) reinforcement and reflection (Mailani et al., 2024). The CIRC learning model, when implemented in groups, supports students in understanding, reading, developing skills, and solving problems more easily (Nurainun & Nasution, 2024). Additionally, the CIRC learning model can also increase students' motivation in learning and provide support for students who struggle to understand problems (Hartati & Apriliana, 2021). The implementation of the CIRC learning model has a positive impact on mathematical problem-solving skills, thereby effectively enhancing students' numeracy abilities (Fitriana et al., 2023). In the study by Muntaha et al. (2022), the CIRC learning model with the aid of smart boards has also been proven to improve students' reading, writing, and numeracy skills. The CIRC learning model, which encourages collaboration, group discussions, and a deep understanding of mathematical problems, can support the enhancement of students' numeracy literacy skills.

However, in its implementation, there are several challenges faced in the execution of the CIRC learning model, such as time management, resource availability, and the lack of student motivation in the learning process (Nuryani et al., 2025; Widhiyastuti et al., 2025). Additionally, in the concept introduction phase, students are asked to understand the material, identify, analyze, and solve a problem within a reading (Mailani et al., 2024). This indicates that instructional material that can facilitate students throughout the CIRC learning process is needed. One of the teaching materials that can facilitate that need is E-LKPD (*Lembar Kerja Peserta Didik Elektronik*). E-LKPD, which is packaged in a practical and interactive manner with an attractive appearance, can encourage participation and help students understand the material independently (Kusmayanti & Murtiyasa, 2024; Siregar et al., 2024). Additionally, E-LKPD that is systematically and structurally organized can optimize learning activities, making the learning process more effective and efficient (Sudirman et al., 2024).

This integration can further be linked to the TPACK (Technological, Pedagogical, and Content Knowledge) framework, which aligns three domains of knowledge: technology, pedagogy, and mathematics content. The TPACK framework in this study is realized through the design of mathematics learning that combines the CIRC learning model as the pedagogical aspect (PK), E-LKPD as technology-based teaching materials (TK), and mastery of similarity content (CK) in an integrated manner. With the TPACK framework, richer and more meaningful learning experiences are created for students through the appropriate use of technology, effective pedagogical strategies, and in-depth content knowledge (Melati et al., 2025). In the study by Efendi et al. (2024), the development of E-LKPD using the TPACK approach was able to support students' learning outcomes. Additionally, research by Febrila et al. (2024) found that the integration of TPACK in learning was effective in improving students' numeracy literacy skills. This explains that the

use of the TPACK framework contributes to enhancing numeracy literacy skills as a form of adaptation to technological developments in the 21st century.

Although research on the CIRC learning model, E-LKPD, and TPACK has been extensively conducted, most studies still focus on learning outcomes, learning motivation, or problem-solving abilities. The research specifically examining the effectiveness of integrating the CIRC model, E-LKPD, and TPACK on students' numeracy literacy is still very limited. Thus, there is a research gap in the integration of cooperative learning models, digital teaching materials, the TPACK framework, and numeracy literacy skills.

The novelty of this research lies in the integration of the CIRC model with TPACK-based E-LKPD designed to facilitate reading, analyzing, discussing, and collaboratively solving numeracy literacy problems in the context of junior high school mathematics learning. Based on this description, this research aims to analyze the effectiveness of the CIRC learning model assisted by TPACK-based E-LKPD on junior high school students' numeracy literacy skills. The results of this study are expected to provide empirical contributions to the development of mathematics education that supports the improvement of numeracy literacy in the digital era.

2. METHOD

This study is quantitative and employs a nonequivalent pretest-posttest control group design using a quasi-experimental methodology. This design consists of two groups, namely experimental and control, which are not randomly selected (Sugiyono, 2024). This design was chosen because the researchers were unable to randomize individuals among students who were already part of fixed classes. The procedures applied include administering a pretest to the students, an intervention over 4 sessions, and a posttest followed by data analysis. The research design is illustrated in table 1.

Table 1. Research design

Class	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control	O_3	X_2	O_4

Description:
O_1: Administration of a pretest on numeracy literacy skills to students in the experimental class
O_2: Administration of a posttest on numeracy literacy skills to students in the experimental class
O_3: Administration of a pretest on numeracy literacy skills to students in the control class
O_4: Administration of a posttest on numeracy literacy skills to students in the control class
X_1: Treatment of the experimental class using the CIRC learning model assisted by E-LKPD based on TPACK
X_2: Treatment of the control class using direct instruction

This study was carried out at SMP Negeri 1 Mungkid during the even academic semester of the 2025/2026 school year. The study population comprised 256 seventh-grade students enrolled at SMP Negeri 1 Mungkid. Sample selection was conducted through the cluster random sampling technique. The experimental class, namely Class VII E, consisted of 28 students who received treatment using the CIRC learning model assisted by TPACK-based E-LKPD. Meanwhile, the control class, namely Class VII H, comprised 25 students who underwent direct instruction. The independent variable encompassed the implementation of the CIRC learning model assisted by TPACK-based E-LKPD in the

experimental class and the implementation of direct instruction in the control class, while the dependent variable referred to students' numeracy literacy skills as measured through their test scores.

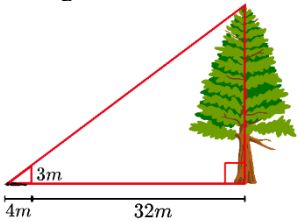
The implementation of the CIRC learning model in the experimental class is carried out through five phases, which include orientation, organization, concept introduction, publication, and reinforcement and reflection (Mailani et al., 2024). In the orientation phase, the teacher conveys the learning objectives and conducts an apperception to check the students' prior knowledge regarding the material to be studied. In the organization phase, the teacher divides the students into several heterogeneous groups and explains the learning process mechanism. The concept introduction phase is carried out through activities such as reading, understanding information, identifying problems, and completing tasks using TPACK-based E-LKPD materials. In the publication stage, students present the results of their discussions, followed by feedback from other groups. Next, in the reinforcement and reflection stage, the teacher reinforces the concepts and facilitates reflection and evaluation of the learning outcomes.

The implementation of the TPACK framework is carried out through the fulfillment of the technological knowledge aspect, which is realized in the use of interactive E-LKPD that can be accessed through digital devices. The aspect of pedagogical knowledge is realized through the application of the CIRC learning model, which emphasizes collaborative activities, reading, and group discussions. The aspect of content knowledge is realized through the presentation of similarity material adjusted to the learning outcomes of phase D in the geometry element. The integration of these three aspects is designed to help students understand mathematical concepts while simultaneously solving numeracy literacy problems in the context of everyday life.

The research instruments used include interview guidelines, observation sheets, and numeracy literacy ability tests in the form of pretests and posttests. The interview guidelines are used to obtain information about the initial learning conditions and the difficulties students face in solving numeracy literacy problems. Observation sheets are used to monitor the implementation of learning during the research period.

The test instrument is structured based on numeracy literacy indicators, which include: (1) using basic mathematical numbers and symbols to solve everyday problems; (2) analyzing information in questions in various forms (graphs, tables, diagrams, etc.); (3) interpreting the results of the analysis to predict, formulate, and make decisions (Asri & Maysarah, 2024; Nuryami, 2024; Putri et al., 2021). The instrument consists of four contextual essay questions, each containing the three indicators of numeracy literacy, thereby capable of comprehensively measuring students' abilities. One of the questions included in the numeracy literacy test instrument is shown in table 2 below.

Table 2. Test question in the numeracy literacy ability test instrument

Test Question	Indicator of Numeracy Literacy Ability	Score
Pay attention to the following illustration!  	Using basic mathematical numbers and symbols to solve everyday problems	4
	Analyzing information in questions in various	3

SMP Cahaya Mentari is currently holding a scout camp for seventh-grade students. During the wide game agenda, each team was asked to find the posts provided by the committee and carry out the tasks given by the post guide. Lily's group, which had reached post 7, was assigned the task of estimating the height of the tree indicated by the post 7 guide. They were given a support stick 3 m tall that stood 32 m away from the tree. One of Lily's group members, Dina, lay on the ground and looked toward the end of the stick and the top of the tree, making them appear as a straight line. Dina's eye position is 4 m away from the support pole. a. What is the estimated height of the tree? b. If there is a coconut tree next to that tree with a height of 30 m, is that tree taller than the coconut tree? Explain the reason!	forms (graphs, tables, diagrams, etc.)	
	Interpreting the results of the analysis to predict, formulate, and make decisions	3

Before use, the pretest and posttest instruments were tested for their feasibility through content validity, construct validity, reliability, discriminating power, and difficulty level tests. Content validity was obtained through scores from validation sheets filled out by three expert validators. After that, the pretest and posttest instruments were revised according to the feedback from the experts before the trials were conducted. Meanwhile, construct validity, reliability, discriminating power, and difficulty level were obtained based on the results of the pretest and posttest trials. Details of the analysis results of the pretest and posttest instruments are listed in table 3.

Table 3. Results of the pretest and posttest instrument analysis

Test	Item	Content Validity		Construct Validity		Reliability		Discrimination Index		Difficulty Index		Decision
		V	Category	t_{obs}	t_{tab}	r_{11}	Category	DP	Category	TK	Category	
Pretest	1	0.785	Medium Validity	6.755	2.042	0.780	High	0.400	Adequate	0.722	Easy	Used
	2			4.771				0.289	Adequate	0.622	Medium	Used
	3			10.331				0.533	Good	0.600	Medium	Used
	4			6.648				0.400	Adequate	0.489	Medium	Used
Posttest	1	0.784	Medium Validity	8.933	2.045	0.743	High	0.367	Adequate	0.550	Medium	Used
	2			3.780				0.211	Adequate	0.550	Medium	Used
	3			6.681				0.289	Adequate	0.478	Medium	Used
	4			7.540				0.456	Good	0.383	Medium	Used

As shown in table 3, the content validity of both the pretest and posttest was determined through Aiken's V formula as referenced in Retnawati (2016), yielding values that fall within the moderate validity range at an interval of $0.4 < V \leq 0.8$. Construct validity was calculated using the Pearson/Product Moment formula by Sundayana (2018), which was then used to obtain the t_{hit} value. All items received results where $t_{hit} > t_{tab}$, indicating that all items are valid. The reliability testing of both instruments, examined through the Cronbach's Alpha formula, falls within the interval $0.60 \leq r < 0.80$, which is categorized as high (Sundayana, 2018). Then, discrimination power and difficulty level were analyzed using formulas outlined in Sundayana (2018). Based on the overall instrument feasibility assessment, all four items in each of the pretest and posttest instruments were deemed suitable for use as data collection tools to measure students' numeracy literacy skills.

Initial data were obtained through the pretest results of students in both the experimental and control classes, which were subsequently subjected to prerequisite analyses comprising normality tests, homogeneity tests, and mean equality tests. The final data were collected through the pretest and posttest scores of students and analyzed through prerequisite tests such as normality tests and homogeneity tests. The pretest and posttest outcomes for both classes were then compared using a Paired Sample t-Test, and the effectiveness of the CIRC learning model assisted by TPACK-based E-LKPD was assessed using an Independent Sample t-Test.

Next, N-Gain and Cohen's d effect sizes were calculated. Using the formula found in Sundayana (2018), the N-Gain calculation is utilized to provide an overview of how much students' numeracy literacy skills have improved.

$$g = \frac{posttest\ score - pretest\ score}{Ideal\ score - pretest\ score}$$

Table 4 includes the N-Gain categories from Sundayana (2018) as follows.

Table 4. N-Gain category

N-Gain	Interpretation
$-1.00 \leq g < 0.00$	Decrease
$g = 0.00$	Stable
$0.00 < g < 0.30$	Low
$0.30 \leq g < 0.70$	Medium
$0.70 \leq g \leq 1.00$	High

The influence of an intervention is indicated by Cohen's d effect size, which is divided into three categories: an effect size of around 0.2 as a small category, around 0.5 as a medium category, and around 0.8 as a large category (Cohen, 1988).

3. RESULTS AND DISCUSSION

3.1. Results

The pretest and posttest findings of the experimental and control classes are used in this study to compare students' numeracy literacy skills. The results of the pretest are used to measure the initial numeracy literacy skills of students in the experimental and control groups. After obtaining the pretest scores, both classes were given treatment over 4 sessions with the established learning model. Posttest data were collected to assess the students' numeracy literacy skills after the intervention. To analyze the effectiveness of the applied learning model on students' numeracy literacy skills, the pretest and posttest results were tested with a significance level of 0.05.

Initial Data Analysis

A pretest was used to obtain the initial numeracy literacy skills of the students. The findings from the pretest for students in both the experimental class and the control class are listed in table 5.

Table 5. Descriptive statistics pretest

Class	N	Mean	Std. Deviation	Variance	Maximum	Minimum
Experimental	28	38.13	12.22	149.36	55	7.5
Control	25	31.40	13.66	186.50	60	10

Table 5 demonstrates that the average pretest score of the experimental class reached 38.13, while the control class attained an average of 31.40. The relatively higher standard deviation and variance observed in the control class indicate a wider distribution of numeracy literacy skills among its students, implying more pronounced variation in learning outcomes in comparison to the experimental class.

The two classes exhibited a pretest score difference of 6.73 points, in which the experimental class outperformed the control class. To investigate further whether this gap signified a meaningful difference in students' baseline numeracy literacy skills, an Independent Sample t-Test was conducted. As a preliminary step, prerequisite tests were performed, including a normality test through the Shapiro-Wilk test and a homogeneity test

via the Levene test. The results of the pretest data analysis obtained with the help of SPSS version 27 are presented in table 6.

Table 6. Pretest data analysis

Class	Normality Test			Homogeneity Test		Independent Sample t-Test			Decision
	Shapiro-Wilk			Levene					
	Statistic	df	Sig.	Statistic	Sig.	t	df	Sig. (2-tailed)	
Experimental	0.935	28	0.081	0.387	0.536	1.892	51	0.64	H_0 accepted
Control	0.969	25	0.629						

The Shapiro-Wilk normality test revealed significant values of 0.081 for the experimental class and 0.629 for the control class, as shown in table 6. The H_0 test decision is accepted because both values are higher than 0.05 ($p > 0.05$). This indicates that both classes' pretest data are normally distributed. Furthermore, the pretest data variances in both classes are homogeneous, as indicated by the Levene homogeneity test's significance value of $p = 0.536$ (> 0.05), which also results in the acceptance of the H_0 test decision.

Following the confirmation that the pretest data satisfied the assumptions of normal distribution and homogeneity variance the Independent Sample t-Test was subsequently applied. The pretest data for the experimental class and the control class were not significantly different, as indicated by the significance value of $p = 0.64$ (> 0.05). This leads to the conclusion that the initial numeracy literacy abilities of the students from both classes are equivalent.

Final Data Analysis

The final numeracy literacy ability of the students after the treatment was obtained through a posttest. The posttest results of the students belonging to both the experimental class and the control class are displayed in table 7.

Table 7. Descriptive statistics posttest

Class	N	Mean	Std. Deviation	Variance	Maximum	Minimum
Experimental	28	47.68	14.62	213.86	72.5	12.5
Control	25	38.60	12.89	166.19	72.5	15

Table 7 shows that the experimental class recorded a mean posttest score of 47.68, surpassing the control class, which attained a mean score of 38.60. The experimental class scored 9.08 points higher than the control class. This gap in posttest scores is similar to the discrepancy observed in the pretest results. Nonetheless, the posttest variance of the experimental class was found to be higher, implying a wider range of variability in learning outcomes. In addition, the standard deviation values also indicate that the distribution of numeracy literacy abilities among the experimental class is wider than in the control class.

The average posttest scores of both classes are still far below the school's minimum completeness score of 80. However, there is an observable increase in scores from the previous pretest results. In order to confirm whether the improvement between pretest and posttest scores in the experimental and control classes was significant, a Paired Sample t-Test was conducted for each respective class. An Independent Sample t-Test was also employed to investigate whether a significant disparity existed between the posttest scores of the two classes. Prior to these analyses, normality and homogeneity tests were administered to ensure that the data were drawn from a normally distributed population with

homogeneous variances. The results of the prerequisite test data posttest analysis obtained with the help of SPSS version 27 are presented in table 8.

Table 8. Posttest prerequisite test

Class	Normality Test			Homogeneity Test		Decision
	Shapiro-Wilk			Levene		
	Statistic	df	Sig.	Statistic	Sig.	
Experimental	0.978	28	0.789	0.534	0.468	H_0 accepted
Control	0.925	25	0.067			

As presented in table 8, the Shapiro-Wilk test produced significance values exceeding 0.05 for both classes, with the experimental class recording $p = 0.789$ and the control class obtaining $p = 0.067$. These results lead to the acceptance of the null hypothesis, confirming that both classes originated from a normally distributed population. In addition, the H_0 is accepted due to the Levene test's significance value of $p = 0.468$ (> 0.05), which shows that the variances of the two data sets are homogeneous.

1) Hypothesis Test 1

The improvement in numeracy literacy skills among students in the experimental class, which applied the CIRC learning model assisted by TPACK-based E-LKPD, was conducted using the Paired Sample t-Test. The Paired Sample t-Test was performed to examine whether there was a significant progression in students' numeracy literacy skills from pretest to posttest. The hypothesis in this test is formulated as follows.

- $H_0: \mu_1 \leq \mu_2$ (There is no increase in the numeracy literacy skills of the experimental class students after the implementation of the CIRC learning model assisted by TPACK-based E-LKPD)
- $H_1: \mu_1 > \mu_2$ (There is an increase in the numeracy literacy skills of the experimental class students after the implementation of the CIRC learning model assisted by TPACK-based E-LKPD)

The results of the analysis from the Paired Sample t-Test on the experimental class were obtained with the help of Minitab, as shown in table 9 below.

Table 9. Paired Sample t-Test for the experimental class

Class	Estimated for Paired Differences				Test		
	Mean	StDev	SE Mean	95% Lower Bound for μ_difference	T-Value	P-Value	Decision
Experimental	9,55	11,61	2,19	5,82	4,35	0,000	H_0 rejected

Based on the results of the Paired Sample t-Test for the experimental class in table 9, a value of $t = 4.35$ was obtained with a mean difference of 9.55, indicating that the posttest scores were higher than the pretest scores. With a significance value of $p = 0.000$, it can be concluded that there is an improvement in students' numeracy literacy skills after the implementation of the CIRC learning model assisted by TPACK-based E-LKPD.

2) Hypothesis Test 2

The improvement in students' numeracy literacy skills based on pretest and posttest scores in the control class taught with direct instruction was also conducted through the Paired Sample t-Test. The hypothesis used is formulated as follows.

- $H_0: \mu_1 \leq \mu_2$ (There is no increase in the numeracy literacy skills of the control class students after the implementation of direct instruction)

- $H_1: \mu_1 > \mu_2$ (There is an increase in the numeracy literacy skills of the control class students after the implementation of direct instruction)

The results of the Paired Sample t-Test analysis for the control class were obtained using Minitab, as shown in table 10 below.

Table 10. Paired Sample t-Test for the control class

	Estimated for Paired Differences				Test		
Class	**Mean**	**StDev**	**SE Mean**	**95% Lower Bound for μ_difference**	**T-Value**	**P-Value**	**Decision**
Control	7,20	16,60	3,32	1,52	2,17	0,020	H_0 rejected

As presented in table 10, the results of the Paired Sample t-Test in the control class obtained a value of $t = 2.17$ with an average difference of 7.20, which also shows that the posttest score is higher than the pretest score. With a significance value of $p = 0.020$, it proves that the application of the direct learning model also improves students' numeracy literacy skills.

3) Hypothesis Test 3

An Independent Sample t-Test was carried out to examine whether a significant difference existed in posttest scores between the experimental and control classes. The hypothesis of the posttest score difference is formulated as follows.

- $H_0: \mu_1 = \mu_2$ (There is no significant difference between the final numeracy literacy abilities of students in the experimental class and the control class)
- $H_1: \mu_1 \neq \mu_2$ (There is a significant difference between the final numeracy literacy abilities of students in the experimental class and the control class.)

The results of the Independent Sample t-Test analysis using SPSS version 27 are shown in table 11 as follows.

Table 11. Independent Sample t-Test

				t-test for Equality of Means				
Class	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**		**Decision**
						Lower	**Upper**	
Experimental Control	2.385	51	0.021	9.079	3.807	1.436	16.722	H_0 rejected

While the Independent Sample t-Test on the pretest data showed no significant disparity in students' initial abilities, the posttest results in table 11 produced a significance value of $p = 0.021$ (< 0.05), suggesting a substantial difference between the posttest scores of the experimental and control classes. The mean difference of 9.079 reflects that the average posttest score of the experimental class (47.68) surpassed that of the control class (38.60). Accordingly, it can be inferred that the CIRC learning model assisted by TPACK-based E-LKPD demonstrated greater effectiveness than direct instruction in improving students' numeracy literacy competencies.

N-Gain

The calculation of the N-Gain score was conducted to review the level of enhancement in numeracy literacy skills within the experimental and control classes. The findings of the N-Gain results for both classes are listed in Table 12.

Table 12. N-Gain result

Class	N	Minimum	Maximum	Mean	Std. Deviation	*N-Gain* Percent
Experimental	28	-0.290	0.570	0.151	0.184	15.08%
Control	25	-0.400	0.590	0.075	0.246	7.47%

Table 12 indicates that the experimental class experienced an increase of 0.151, which is categorized as low. Meanwhile, the control class recorded a score of 0.075, which also belongs to the low category. Although the degree of improvement in both classes remains within the low range, the experimental class evidently outperformed the control class in terms of N-Gain, with a mean difference of 7.61% between the two groups.

Effect Sizes

To determine the magnitude of the effectiveness of the applied learning model, a statistical test of Cohen's d effect sizes was conducted. The results of Cohen's d effect sizes for the experimental class and the control class are listed in table 13.

Table 13. Effect Sizes

Class	Std. Deviation	Cohen's d
Experimental	11.608	0.823
Control	16.604	0.434

As presented in table 13, the Cohen's d effect size for the experimental class, which implemented the CIRC learning model assisted by TPACK-based E-LKPD, yielded a score of 0.823, placing it within the large category. This indicates that the CIRC learning model assisted by TPACK-based E-LKPD exerted a considerable effect on students' numeracy literacy skills. In contrast, the control class, which employed direct instruction, obtained a Cohen's d score of 0.434, classified under the small category, suggesting that direct instruction had only a minor influence on students' numeracy literacy abilities.

3.2. Discussion

Improvement of Numeracy Literacy Skills in the Experimental Class

The results of the Paired Sample t-Test show that the numeracy literacy skills of students in the experimental class significantly improved after the treatment was given. This indicates that students' numeracy literacy skills can be improved through the CIRC learning model assisted by TPACK-based E-LKPD. Based on the pretest and posttest results, there was an improvement in two indicators of numeracy literacy skills, namely the indicator of using numbers and basic mathematical symbols to solve everyday problems and the indicator of analyzing information in questions in various forms (graphs, tables, diagrams, etc.). However, students still struggle to interpret the results of the analysis to predict, formulate, and make decisions. This is because the students have difficulty understanding the connections and how to apply their findings to formulate a decision.

The CIRC learning model's characteristics as a student-centered cooperative learning paradigm that integrates writing and reading skills impact this improvement. This model is then enriched with the help of E-LKPD and the integration of TPACK, allowing for the creation of more effective and efficient learning. The implementation of the CIRC learning model assisted by E-LKPD based on TPACK follows the syntax of the CIRC learning model, which consists of the orientation, organization, concept introduction, publication, and reinforcement and reflection phases.

The activities of students and the role of the teacher at each phase play an important part in enhancing students' numeracy literacy skills. In the orientation phase, the teacher presents the title of the material and the learning objectives to the students. Additionally, an

apperception is conducted to review the students' initial understanding of the material to be studied. In the organizational phase, the teacher delivers learning activity instructions and divides the students into several heterogeneous groups. In the concept introduction phase, students then build knowledge together with their group members through discussion activities. This phase encourages students to actively read and understand the material, as well as identify and solve problems that contain numeracy literacy contexts within the E-LKPD. This aligns with Vygotsky (1978) constructivist theory, which states that learning can be effective when students interact and collaborate with their peers to build knowledge.

In the publication phase, student representatives along with their groups move to the front of the class to present the findings of their discussion and then receive feedback from other groups. Feedback is provided to help students identify and correct mistakes (Nainggolan & Listiani, 2024). In the reinforcement and reflection phase, the teacher guides students to summarize the learning outcomes and provides individual exercises to strengthen students' numeracy literacy skills. At the end of the process, the teacher conducts a learning reflection as a reference to improve the learning process in the next meeting. The activities of students in the experimental class are presented in Figure 1.

Figure 1. Activities of students in the experimental class

The findings of this study are in line with the research by Fitriana et al. (2023), which shows that the CIRC learning model has a positive impact on solving mathematical problems, thereby enhancing students' numeracy skills. The results of this study also support the findings of Nurainun and Nasution (2024), which state that the application of the CIRC learning model can improve students' reading comprehension skills. However, this research expands on previous findings because it not only examines the CIRC learning model in general but specifically investigates the CIRC model's impact on numeracy literacy through the integration of TPACK-based E-LKPD in junior high school mathematics education.

The integration of TPACK in the research is demonstrated by the implementation of three aspects consisting of Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). Through a deep mastery of similarity material in the Content Knowledge (CK) aspect, teachers are able to present accurate and meaningful similarity content. The questions formulated include numeracy literacy problems in real-life situations. With the availability of access to contextual information for students, the ability to interpret mathematical analysis results into real-life situations to make decisions is enhanced.

In the Pedagogical Knowledge (PK) aspect, teachers choose appropriate teaching strategies according to needs, which include group discussion methods, question and answer sessions, and presentations that have been incorporated into a CIRC learning model. Through the CIRC learning model, students are encouraged to read and understand problems together, which trains their ability to analyze and formulate issues. Next, through group discussions, students are directed to re-present a problem in the form of symbols, numbers, equations, or other mathematical expressions that can train their mathematical representation skills.

Next, in the aspect of Technological Knowledge, teachers utilize E-LKPD as a technological medium accessed by students through smartphones. Through the E-LKPD

learning materials, similarity problems are presented through image visualizations that can help students understand spatial concepts in the similarity material. Additionally, the E-LKPD presents information in a structured manner, which can assist students in understanding, reading, and solving problems related to the context of numeracy literacy. By utilizing the features provided by Liveworksheet, teachers can present material interactively, which can provide immediate feedback on answers, allowing students to detect their mistakes. The TPACK framework ensures that the three components work in an integrated manner. This is in line with the research by Melati et al. (2025), which states that a good integration of pedagogical knowledge, content, and technology can enhance the effectiveness of learning.

These findings support the research by Syafrudin et al. (2025), which shows that TPACK-based E-LKPD effectively enhances students' conceptual understanding. The results of this study are also in line with the research by Febrila et al. (2024), which found that the integration of TPACK in learning contributes to the improvement of numeracy literacy skills. However, unlike previous research that focused more on the development of learning tools or general learning outcomes, this study shows that the integration of TPACK-based E-LKPD can support the process of numeracy literacy through activities such as reading information, analyzing data, and systematically interpreting problem-solving results.

In each meeting, the CIRC learning model assisted by E-LKPD based on TPACK has been consistently implemented according to the prepared teaching module. The implementation of the learning process was fully achieved, as evidenced by the observation sheets filled out by two individual observers. This reinforces the interpretation that the quality of implementation and the support of appropriate teaching materials are also factors in improving students' numeracy literacy skills. Good classroom management encourages learning to be more effective and efficient (Fitriana et al., 2023). Overall, the findings in the experimental class indicate that the CIRC learning model assisted by TPACK-based E-LKPD is effective in improving students' numeracy literacy skills.

Improvement of Numeracy Literacy Skills in the Control Class

In the control class, the numeracy literacy skills of the students after the implementation of the direct learning model also showed an improvement. This improvement occurs because the direct instruction continues to provide concept explanations, practice questions, and feedback to the students. Unlike the CIRC learning model assisted by TPACK-based E-LKPD, which uses a cooperative approach, the direct instruction is more teacher-centered with a syntax consisting of 5 phases: (1) communicating objectives and preparing students, (2) demonstrating knowledge and skills, (3) guided practice, (4) checking understanding and providing feedback, and (5) providing opportunities for further practice and implementation (Wulandari et al., 2024). The activities of students in the control class are presented in Figure 2.

Figure 2. Activities of students in the control class

Based on the results of the observation sheet, the implementation of learning in the control class is also in the very high category. This indicates that the learning is proceeding according to the prepared teaching module. This shows that the teacher is able to consistently

implement the direct instruction syntax through systematic explanation of the material, providing example questions, and guiding students in solving practice questions. The structured learning process and the presence of practice questions contribute to improving students' numeracy literacy skills. This is in accordance with the statement by Lindström-Sandahl et al. (2024) that a structured direct learning model with clear material delivery procedures and concept modeling ensures the development of students' skills in a sequential, repetitive, and varied manner.

The improvement in numeracy literacy skills of the control class students, which is lower than that of the experimental class, is due to the limitations of direct instruction in developing numeracy literacy skills. In direct instruction, the teacher plays a dominant role in every phase of learning, from explaining the material, providing example problems, to directing students to work on practice problems individually. Meanwhile, students tend to receive information through the process of seeing and listening. This causes students to not have enough space to actively engage in constructing their own knowledge. Additionally, students also do not have the opportunity to discuss, which leads to a lack of activities that promote their understanding. Une et al. (2023) mention that teacher-dominated direct instruction makes students feel bored and hinders the development of their abilities.

Findings in the control class indicate that the direct instruction remains effective in improving students' numeracy literacy skills. However, the increase observed is not as significant as that of the learning model that encourages student activity.

Differences in Numeracy Literacy Skills between the Experimental Class and the Control Class

The results of the Independent Sample t-Test show a significant difference in numeracy literacy skills between the experimental class and the control class after the treatment was given. The improvement in numeracy literacy skills of students in the experimental class after using the CIRC learning model assisted by TPACK-based E-LKPD was better compared to the control class students who received direct learning models. This is reinforced by the N-Gain results of the experimental class, which were higher than those of the control class, although both were still in the low category. Furthermore, Cohen's d effect sizes in the experimental class reached the large effect category, while the control class was in the small effect category. This indicates that the CIRC learning model assisted by TPACK-based E-LKPD is more effective than the direct learning model.

The enhanced performance of the experimental class can be attributed to the distinctive characteristics of the CIRC learning model assisted by TPACK-based E-LKPD, which fosters a more profound and meaningful learning experience. The CIRC learning model promotes greater collaboration, engagement, and understanding among students compared to direct teacher-centered learning (Illaningtyas & Syahri, 2025). Additionally, the integration of the TPACK approach and E-LKPD teaching materials allows students to better understand and visualize mathematical concepts related to real-world contexts, thereby supporting the improvement of numeracy literacy skills.

Statistically, the CIRC learning model assisted by E-LKPD based on TPACK shows a significant improvement and is superior compared to the direct learning model. However, the N-Gain analysis indicates that the increase in numeracy literacy skills is still relatively low and has not been able to raise the average student achievement to meet the minimum completeness criteria. This shows that the CIRC learning model assisted by E-LKPD based on TPACK is relatively effective, as it is able to improve students' numeracy literacy skills and is better than the direct learning model. The condition is influenced by the limitations faced during the ongoing research.

First, the limitation of learning duration. The application of the CIRC learning model assisted by TPACK-based E-LKPD requires a lot of preparation, including the installation of LCDs, conditioning the classroom during discussion sessions, and access to E-LKPD on each student's device. This takes up a considerable amount of time, which affects the effective teaching time. Although the entire learning process has been carried out, there are still aspects that have not been implemented optimally. Limited time causes students to have less freedom in understanding the quite complex material of similarity. Additionally, during the individual practice session, students cannot complete the questions optimally and thoroughly. Widhiyastuti et al. (2025) emphasize that limited time cannot accommodate the differences in students' abilities to understand reading materials.

Secondly, the application of the CIRC learning model assisted by TPACK-based E-LKPD, which was only conducted over four meetings, is not sufficient to assess the long-term effects. This is in line with the statement by Arbadilah et al. (2025) that the limited duration of implementation has not yet been able to measure the long-term impact of the learning model. In addition, this study has limitations in the consistency of data collection timing. The research schedule was interrupted several times due to coinciding with the TKA and ASAT for ninth-grade students. This condition may disrupt the continuity of the learning process and weaken students' retention of the material content. Valderama and Oligo (2021) state that the interval of time causes a person to forget what has been learned.

Thirdly, the limited digital facilities are one of the challenges affecting the learning process. To facilitate learning, accessibility to E-LKPD is contingent upon the use of a smartphone. However, there are some students who do not bring a mobile phone or face network and other technical issues in using personal devices, resulting in limitations in accessing E-LKPD. Nuryani et al. (2025) explain that limited facilities can hinder students' involvement in reading and discussion activities. The lack of roles results in disorganized group dynamics (Juhana, 2025). These limitations explain why the CIRC learning model assisted by TPACK-based E-LKPD has not yet been able to meet the completeness criteria and the improvement that has occurred is still relatively low.

However, there is an interesting finding in the experimental class with a contradiction between the low N-Gain values and the large Cohen's d effect sizes. This is because the two calculations measure different aspects conceptually. The analysis of N-Gain values is conducted to provide an overview of the improvement in learning outcomes between before and after the learning process (Sundayana, 2018). A low N-Gain indicates that the improvement achieved by the students is still limited compared to the maximum improvement that should be attainable. Meanwhile, Cohen's d effect sizes are used to measure the magnitude of the average difference in standard deviation units (Cohen, 1988). A large Cohen's d effect size indicates that the treatment can produce a strong influence on numeracy literacy skills with a relatively consistent improvement among most students. In other words, although the score improvement is not yet optimal, the CIRC learning model assisted by TPACK-based E-LKPD applied is able to provide a better influence compared to direct learning. It can be concluded that the two results do not contradict each other but rather provide complementary information regarding the effectiveness of the learning model.

Based on the overall findings, the CIRC learning model assisted by TPACK-based E-LKPD has proven to make a significant contribution to the improvement of students' abilities. These findings are consistent with Adawiyah (2023) research, which explains that the CIRC learning model, using a cooperative approach to reading comprehension, has been proven effective in improving learning outcomes. Research by Nuryani et al. (2025) also shows that the CIRC learning model is effective in enhancing students' reading comprehension skills because it trains students to collaborate, think critically, and communicate effectively. Additionally, the CIRC learning model that integrates digital

Flipbook media can create more engaging and interactive learning, thereby supporting active collaboration among students (Widhiyastuti et al., 2025).

This research provides empirical contributions to the development of mathematics learning oriented toward numeracy literacy. The novelty of this research lies in the integration of the CIRC model assisted by TPACK-based E-LKPD, designed to facilitate collaborative activities such as reading, analyzing, discussing, and solving numeracy literacy problems. These findings expand the understanding that the development of numeracy literacy not only requires a learning model that encourages social interaction but also needs systematic support from technology and teaching materials. Therefore, the CIRC model assisted by E-LKPD based on TPACK can be one of the learning alternatives that mathematics teachers can use to support the development of students' numeracy literacy in the digital era.

4. CONCLUSION

The study's findings show that junior high school students' numeracy literacy skills can be effectively improved by using the CIRC learning model in conjunction with TPACK-based E-LKPD. Students in the experimental class and those in the control class had significantly different numeracy literacy skills, according to statistical analysis. Nearly every student in the class who used the CIRC learning model with TPACK-based E-LKPD obtained better and more consistent results. Although the results obtained have not yet reached the expected standards, the CIRC learning model assisted by TPACK-based E-LKPD still reflects that the combination of appropriate media and facilities is capable of positively influencing students' numeracy literacy skills. This research emphasizes the importance of learning innovations that integrate cooperative approaches with technology in meeting the demands of improving students' numeracy literacy skills in the age of digitalization.

This research provides implications for teachers to implement the CIRC learning model assisted by TPACK-based E-LKPD as an alternative active learning that can support the improvement of students' numeracy literacy skills. Teachers are advised to encourage active participation from students in the learning process, which can be supported by the use of digital technology. In addition, school support is needed to ensure the availability of facilities that align with the needs of the CIRC learning model assisted by E-LKPD based on TPACK. In future research, the CIRC learning model assisted by E-LKPD based on TPACK can be explored with different material topics to obtain a more comprehensive picture of the effectiveness of this learning model. In addition, it is recommended to extend the implementation period so that students can assess their abilities in the long term.

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