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The Influence of Collaborative Learning on Students' Misconceptions about Polynomials

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ABSTRACT. Misconceptions in polynomial material pose a significant issue in mathematics education, hindering students' conceptual understanding. This study aims to examine the effect of collaborative learning on students' misconceptions regarding polynomials in Grade XI at SMA Negeri 14 Kota Jambi. The research employed a quasi-experimental nonequivalent control-group design involving 57 students: 28 in the experimental group and 29 in the control group. The research instrument was a diagnostic test in the form of essay items, validated by subject matter experts, and administered as both a pretest and a posttest to measure misconceptions in polynomial operations, polynomial division, and the factors and roots of polynomial equations. Data were analyzed using descriptive statistics, gain scores, and an independent sample t-test. The results indicated that collaborative learning was highly effective in reducing student misconceptions. The experimental group showed a 42.3% reduction in misconception scores (from 71.29 to 41.14), while the control group experienced only a 12.2% decrease (from 70.93 to 62.24). Hypothesis testing revealed a highly significant difference ($p < 0.001$) with a very large effect size (Cohen's $d = 8.848$). All students in the experimental group reached the low misconception category, whereas all students in the control group remained in the moderate category. Therefore, collaborative learning was proven to be more effective than conventional instruction in addressing students' misconceptions.

Keywords: collaborative learning; high school students; mathematics education; misconceptions; polynomial

ABSTRAK. Miskonsepsi pada materi polinomial merupakan permasalahan signifikan dalam pembelajaran matematika yang dapat menghambat pemahaman konseptual siswa. Penelitian ini bertujuan untuk mengetahui pengaruh pembelajaran kolaboratif terhadap miskonsepsi siswa pada materi polinomial di kelas XI SMA Negeri 14 Kota Jambi. Penelitian menggunakan metode kuasi-eksperimen dengan desain *nonequivalent control group* yang melibatkan 57 siswa, terdiri dari 28 siswa kelompok eksperimen dan 29 siswa kelompok kontrol. Instrumen penelitian berupa tes diagnostik berbentuk soal uraian yang telah divalidasi oleh ahli materi dan digunakan sebagai *pre-test* serta *post-test* untuk mengukur tingkat miskonsepsi pada operasi polinomial, pembagian polinomial, serta faktor dan akar persamaan polinomial. Data dianalisis menggunakan statistik deskriptif, *gain score*, dan uji-t sampel independen. Hasil penelitian menunjukkan bahwa pembelajaran kolaboratif sangat efektif dalam mengurangi miskonsepsi siswa. Kelompok eksperimen mengalami penurunan miskonsepsi sebesar 42,3% (dari 71,29 menjadi 41,14), sedangkan kelompok kontrol hanya mengalami penurunan 12,2% (dari 70,93 menjadi 62,24). Uji hipotesis menunjukkan perbedaan signifikan ($p < 0{,}001$) dengan ukuran efek yang sangat besar (Cohen's $d = 8{,}848$). Seluruh siswa pada kelompok eksperimen mencapai kategori miskonsepsi rendah, sedangkan kelompok kontrol tetap pada kategori sedang. Dengan demikian, pembelajaran kolaboratif terbukti secara signifikan lebih efektif dalam mengatasi miskonsepsi dibandingkan pembelajaran konvensional.

Kata kunci: miskonsepsi; pembelajaran kolaboratif; pembelajaran matematika; polinomial; siswa SMA

INTRODUCTION

Mathematics plays an important role in daily life, not only as a tool for calculation but also as a foundation for decision-making and problem-solving. According to Siregar & Dewi (2022) mathematics is used in various social activities, such as buying and selling, financial management, and agriculture, indicating that it makes a significant contribution to the community's social life. Additionally, mathematical logic helps individuals improve their critical and analytical thinking skills, which is very useful for effectively solving everyday problems (Nurhaswinda et al., 2025). In the digital age and knowledge-based economy, students' awareness of the importance of mathematics in their careers influences their interest and motivation to learn mathematics (Sofiyah et al., 2025). Thus, understanding and applying mathematics in daily life is crucial for facing challenges in various aspects of life.

However, despite the subject's crucial role, many students find it difficult to learn mathematics. One of the main challenges in learning mathematics is the emergence of misconceptions, which are errors in understanding mathematical concepts and solving mathematical problems (Putri et al., 2024). According to Rahayu & Yuhana (2023), misconceptions are confusion in using and connecting concepts to solve relevant problems. This is because of an initial concept that students misunderstand, and they have logically built their misunderstandings from their experiences, leading to continuous errors. Furthermore, research by Novianto et al. (2024) indicates that factors such as negative perceptions of mathematics, differences in intelligence levels, and less-than-optimal infrastructure and facilities can lead to difficulties in learning mathematics for students.

One topic that often leads to misconceptions is polynomials. This topic involves basic algebraic concepts such as adding, subtracting, and multiplying polynomials, which are fundamental to more advanced topics like functions and derivatives. However, the research results indicate that many students make mistakes in understanding and operating with polynomials. Sangaji & Lukmana (2023) found that students made systematic errors in polynomial addition (42.85%), subtraction (50%), and multiplication (21.42%), as well as random errors and omissions in word problems. This indicates a fundamental misconception that hinders students' understanding of the concept. Additionally, Putri et al. (2024) in their literature review state that misconceptions in mathematics learning, including in polynomial material, are a significant problem that can hinder the development of students' logical and conceptual thinking abilities.

To obtain an initial overview of students' misconceptions in polynomial material, observations and diagnostic tests were conducted with students in class XI IPA 1 at SMA Negeri 14 Kota Jambi. The results of the data collection are summarized in Table 1 below, grouped by the identified misconceptions.

Table 1. Percentage of Student Misconceptions on Polynomial Material

Category	N	Percentage
Polynomial Operations	19	65,5%
Polynomial Division	14	48,3%
Factors and Roots of Polynomial Equations	16	55,2%

Based on the data in the table, the most common misconception occurs in polynomial operations, with a percentage of 65.5%, followed by factors and roots of polynomial equations at 55.2% and polynomial division at 48.3%. This data indicates the need for more effective learning strategies to help students correctly understand polynomial concepts and reduce misconceptions. The high rate of misconceptions in polynomial material, as shown in the data above, indicates that most students still struggle to understand this basic mathematical concept. This is also in line with the opinion of Putri et al. (2024), who stated that misconceptions are a major obstacle in learning mathematics because they can disrupt students' thinking processes and lead to incomplete conceptual understanding. This condition certainly has a negative impact on students' learning outcomes, especially for material that requires a strong conceptual understanding, such as polynomials. Therefore, effective learning strategies are needed to help students improve their understanding. One promising approach for addressing misconceptions is collaborative learning. This approach encourages interaction among students in small groups, allowing them to discuss and clarify their understanding and build concepts together.

Collaborative learning, according to Oktafiani et al. (2022), emphasizes the development of students' social and academic skills through group cooperation. This approach combines three important elements: individual responsibility, positive interdependence among group members, and shared success goals. In practice, collaborative learning aims to foster active student interaction to help them collectively understand the material. In mathematics learning, Fatmanissa et al. (2024) found that decision-making activities in a collaborative setting encourage students to articulate their mathematical reasoning, thereby strengthening conceptual understanding and potentially reducing the occurrence of misconceptions. However, studies specifically examining the impact of collaborative learning on students' misconceptions about polynomial material at the high school level remain limited. Most previous research has focused on improving learning outcomes or problem-solving abilities through collaborative learning, but has not directly investigated its impact on mathematical misconceptions. Additionally, research on misconceptions in polynomial material is generally conducted at the junior high school level or is limited to literature reviews, making empirical studies at the high school level in Indonesia using a quasi-experimental design still rare. Therefore, this study fills a gap by investigating the effect of collaborative learning on high school students' misconceptions about polynomial material using a quasi-experimental design. This indicates a need for further research to obtain empirical evidence regarding the effectiveness of this approach in addressing students' misconceptions.

Based on the background and initial observation results explained, the misconception indicators that are the focus of this research include misconceptions in polynomial operations, polynomial division, and the factors and roots of polynomial equations. This indicator serves as a benchmark for identifying students' difficulties and misconceptions in polynomial material, which will be further analyzed through collaborative learning.

This study aims to determine the effect of collaborative learning on students' misconceptions about polynomial material in class XI at SMA Negeri 14 Kota Jambi. The scope of the research is limited to the misconceptions identified through initial observation and focuses on applying collaborative learning methods to reduce them. The novelty of this research lies in its specific focus on examining polynomial misconceptions at the high school level using a non-equivalent control group quasi-experimental design, thereby providing stronger empirical evidence than previous studies that generally examined only overall learning outcomes, were conducted at the middle school level, or were literature reviews. Additionally, this study uses validated diagnostic test instruments to directly measure changes in students' misconceptions. Therefore, the research findings are expected to contribute theoretically to expanding the study of collaborative learning in the context of mathematical misconceptions, as well as practically to teachers in the design of more effective learning strategies.

METHOD

This research uses a quantitative method with a quasi-experimental design of the nonequivalent control group type. This design involves two pre-existing groups (not randomly assigned), namely the experimental class and the control class. Each group was given a pretest and a posttest to determine the effect of the treatment, namely the application of collaborative learning, on students' misconceptions about polynomial material. This design is suitable when the researcher does not have full control over assigning students to groups, so the groups are pre-existing, such as school classes, and a pretest is still administered to assess initial equivalence between groups (Fraenkel et al., 1993). The research design can be described in the following Table 2.

Table 2. Research Design

Class	Pretest	Treatment	Posttest
Experimental	O1	Collaborative learning (X)	O2
Control	O3	Conventional learning (-)	O4

The research was conducted at SMA Negeri 14 Kota Jambi during the second semester of the 2024/2025 academic year. The research sample was selected using purposive sampling, a technique based on the researcher's specific considerations or objectives. This technique was used because the researcher chose the class based on the consideration that it had characteristics relevant to the research objectives (Sugiyono, 2013). Two 11th-grade science classes were selected as the sample: one class as the experimental group and one class as the control group, each consisting of approximately 28 and 29 students, respectively.

The research instrument consists of pretest and posttest questions in essay format, which have been validated by subject matter experts. This test is designed to measure students' level of misconceptions about polynomial material. The misconception indicators were developed based on initial observations and theories of misconceptions in mathematics learning. Misconceptions are not simply incorrect knowledge; they are understandings that appear logical and structured in students' minds, making them often persistent and difficult to correct (Nesher, 1987). The compiled instrument is then reviewed by three expert lecturers in mathematics education to assess its content validity and test item clarity. The validation results show that the instrument can be used with minor improvements to its question wording. Subsequently, the instrument was tested with students outside the research sample, and the analysis results showed strong consistency, indicating that it was valid and reliable for use in this study. The misconception indicator used is based on the results of initial observations and related theories, as summarized in the following Table 3.

Table 3. Indicators of Student Misconceptions on Polynomial Material

Number	Misconception Indicator	Description
1.	Errors in the polynomial addition operation	Students make mistakes when adding terms in a polynomial
2.	Errors in the polynomial subtraction operation	Students make mistakes when subtracting terms in a polynomial
3.	Errors in the polynomial multiplication operation	Students make mistakes when multiplying polynomial terms
4.	Errors in polynomial division	Students make mistakes when dividing polynomials, both conceptually and procedurally
5.	Errors in understanding polynomial factors and roots	Students are mistaken in understanding the concepts of factors and roots in polynomial equations

After the research instrument is established, the next step is to implement the learning intervention in the experimental and control groups. The intervention implementation procedure is designed to ensure that collaborative learning is applied in accordance with the research objectives.

The collaborative learning intervention was implemented over four meetings, each lasting 2 x 45 minutes, in accordance with the time allocation for mathematics in 11th-grade high school. Each meeting focused on a different subtopic: (1) polynomial operations, (2) polynomial division, (3) polynomial factors, and (4) roots of polynomial equations. The learning scenario is designed based on the principles of collaborative learning, which emphasize individual responsibility, positive interdependence, and face-to-face interaction. At the beginning of the lesson, the teacher provided a brief explanation of the basic concepts and example questions. Subsequently, students were divided into small groups of 4-5 to discuss collaborative task sheets containing diagnostic questions on the material. In the discussion, students were asked to provide mathematical reasoning, correct each other's understanding, and agree on a joint answer. The teacher serves as a facilitator, guiding group discussions, providing scaffolding, and emphasizing the importance of clarifying concepts. At the end of the lesson, each group presented the results of their discussion, followed by a joint reflection session to reinforce conceptual understanding and identify any remaining misconceptions.

Next, the data analysis used inferential statistical tests, specifically the two-sample t-test (independent-samples t-test), to compare the mean posttest scores for misconceptions between the experimental and control groups. Before the t-test is conducted, the data will first be tested for normality and homogeneity of variance. The t-test formula for two independent samples is as follows (Sugiyono, 2013):

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Explanation:
$\bar{X}_1, \bar{X}_2$ = Average posttest scores of the experimental and control classes
S_1^2, S_2^2 = Variance of each class
n_1, n_2 = Number of students in each class

Hypothesis testing was conducted using a significance level of 0.05. If the calculated t-value is greater than the table t-value, or the p-value is less than 0.05, then there is a significant difference between the two classes, indicating that the collaborative learning treatment is effective in reducing students' misconceptions.

RESULTS AND DISCUSSION

This study uses a quasi-experimental, nonequivalent control-group design to determine the effect of collaborative learning on students' misconceptions about polynomial material. The pretest and posttest data from both groups showed significant reductions in students' misconceptions. Here are the results of the comprehensive data analysis.

Descriptive Statistics

Descriptive statistical analysis provides an overview of the students' misconception levels in both groups before and after the intervention. In the collaborative learning group, the average pretest misconception score was 71.29 (SD = 2.42), and the posttest showed a significant decrease to 41.14 (SD = 2.55). This decrease indicates that collaborative learning is effective in reducing students' misconceptions about polynomial material.

Table 4. Descriptive Statistics of Students' Misconception Scores

Group	Test	N	Mean	SD	Min	Max	Variance
Experimental	*Pretest*	28	71,29	2,42	67	76	5,84
	Posttest	28	41,14	2,55	37	47	6,50
Control	*Pretest*	29	70,93	2,20	67	75	4,85
	Posttest	29	62,24	2,21	59	66	4,90

Meanwhile, in the control group receiving conventional learning, the average pretest misconception score was 70.93 with a standard deviation of 2.20, which decreased to 62.24 with a standard deviation of 2.21 on the posttest. The decline in the control group was relatively small compared to the experimental group. This data indicates that although conventional learning can also reduce misconceptions, its effectiveness is far lower compared to collaborative learning. The comparison of minimum and maximum values also reveals an interesting pattern. In the experimental group, the posttest score range (37-47) indicates a consistently low level of misconceptions, while in the control group, the posttest score range (59-66) is still in the moderate misconception category. This indicates that collaborative learning is not only effective on average, but also consistent in reducing misconceptions among all students in the group.

Gain Score Analysis

Gain score, or improvement score, is calculated as the difference between the pretest and posttest scores to determine the extent of misconception reduction in each group. The analysis results show that the experimental group had an average gain score of 30.14 with a standard deviation of 2.92, while the control group had an average gain score of 8.69 with a standard deviation of 1.51.

Table 5. Analysis of Gain Score for Misconception Reduction

Group	N	Mean Gain Score	SD	Min	Max	Misconception Reduction
Experiment	28	30,14	2,92	25	35	42,3%
Control	29	8,69	1,51	6	12	12,2%

The significant difference in gain scores between the two groups indicates that collaborative learning has a far greater impact on reducing students' misconceptions. The experimental group experienced a 42.3% decrease in misconceptions, while the control group only experienced a 12.2% decrease. This difference shows that collaborative learning is almost 3.5 times more effective at reducing misconceptions than conventional learning. The consistency of the results is also evident from the relatively small standard deviation of the gain scores in the experimental group (2.92), indicating that almost all students experienced a uniform reduction in misconceptions. This indicates that collaborative learning is effective for students with varying prior abilities.

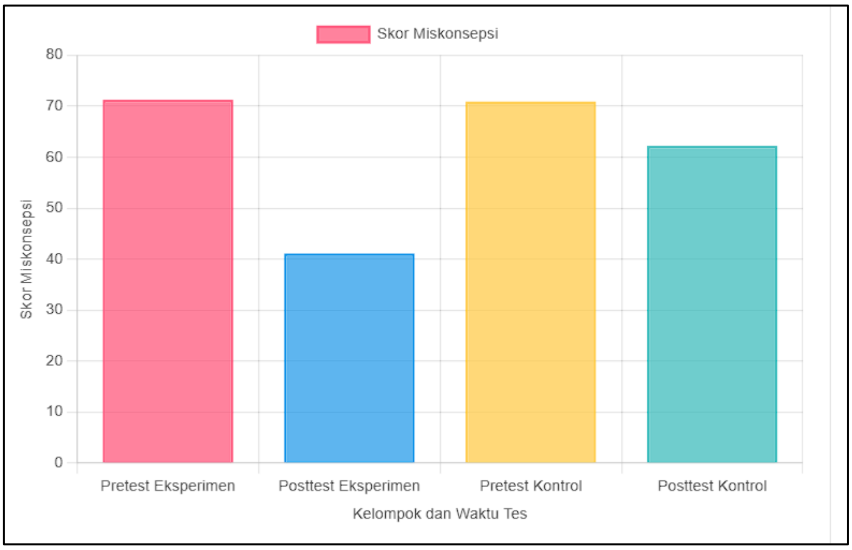

Figure 1. Comparison of Pretest and Posttest Misconception Scores

This graph shows the comparison of misconception scores between the pretest and posttest in both groups. The experimental group (collaborative learning) showed a very significant decrease from 71.29 to 41.14, while the control group (conventional learning) showed only a limited decrease from 70.93 to 62.24.

Distribution of Misconception Category

To provide a more comprehensive overview of students' misconception levels, posttest scores were categorized into three levels: high (≥70), medium (50-69), and low (<50). The categorization results show a very striking difference between the two groups.

Table 6. Distribution of Posttest Misconception Category

Category	Experiment Frequency	%	Control Frequency	%
High(≥70)	0	0,0%	0	0,0%
Moderat (50-69)	0	0,0%	29	100,0%
Low (<50)	28	100,0%	0	0,0%
Total	**28**	**100,0%**	**29**	**100,0%**

The results observed in the experimental group, where all students (100%) were in the low misconception category after receiving collaborative learning. Conversely, in the control group, all students (100%) remained in the moderate misconception category. No students in either group remained in the high misconception category after learning, indicating that both teaching methods had a positive impact, though with different levels of effectiveness. This finding is highly significant because it demonstrates that collaborative learning not only reduces the average misconception scores but also successfully brings all students to a good level of understanding of polynomial concepts. This indicates that collaborative learning has an even and comprehensive impact on all students in the class.

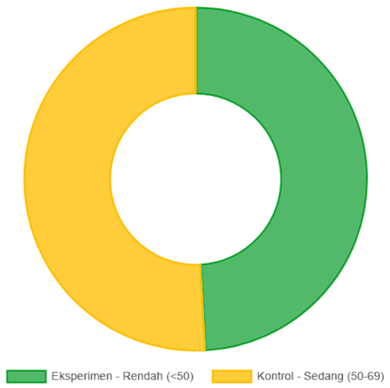

Figure 2. Distribution of Posttest Misconception Categories

Hypothesis Testing

The independent-samples t-test was used to compare the mean posttest scores between the experimental and control groups. Before conducting the t-test, normality and homogeneity tests were performed as prerequisites, indicating that the data met the assumptions for parametric analysis.

Table 7. Independent Samples t-test Results

Statistics	Value
Mean Difference	-21,10
t-value	-33,312
df (degrees of freedom)	55
t-critical (α=0,05, two-tailed)	±2,006
p-value	< 0,001
The decision	H_0 is rejected

The t-test results show a calculated t-value of -33.312 with 55 degrees of freedom (df). This value is much larger than the t-table value (2.006) at the 0.05 significance level, so the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This indicates a significant difference in the average posttest misconception scores between the experimental and control groups. The obtained p-value is very small (< 0.001), indicating that the probability of this difference in results occurring by chance is extremely low. Thus, it can be concluded that collaborative learning is significantly more effective than conventional learning at reducing students' misconceptions about polynomial material.

Effect Size and Practical Significance

In addition to statistical significance, this study also assessed practical significance by calculating effect sizes using Cohen's d. The calculation results showed a Cohen's d value of 8.848, which falls into the very large effect category.

Table 8. Effect Size Analysis

Metric	Value	Interpretation
Cohen's d	8,848	Very high
Pooled Standard Deviation	2,38	-
Experiment variance	6,50	-
Control variance	4,90	-

According to Cohen's (1988) convention, a d-value > 0.8 is considered a large effect, and the value obtained in this study (8.848) exceeds that threshold. This indicates that the differences found are not only statistically significant but also highly practical in the context of mathematics learning. This very large effect size indicates that collaborative learning has a substantial and meaningful impact on reducing students' misconceptions. In a practical context, this means that implementing collaborative learning will make a very real and immediately noticeable difference in the mathematics learning process in the classroom.

Discussion

The results of this study indicate that collaborative learning has a very significant impact on reducing students' misconceptions about polynomial material compared to conventional learning. This finding aligns with Situmorang (2024) research, which found that a collaborative approach to mathematics learning can enhance students' conceptual understanding through social interaction and co-construction of knowledge. The 42.3% decrease in misconception scores in the experimental group demonstrates the remarkable effectiveness of collaborative learning methods, where students can correct each other's misconceptions through discussion and peer feedback. The gain score analysis, which shows a significant difference between the experimental group (30.14) and the control group (8.69), indicates that collaborative learning is not just marginally impactful but transformative in addressing misconceptions. This can be explained by Piaget's cognitive conflict theory, which holds that conflicts arising in group discussions force students to reconstruct their incorrect understandings (Husain, 2020). In the context of polynomial learning, when students interact in collaborative groups, they encounter different perspectives on algebraic operations, polynomial division, and the concepts of factors and roots, which encourage them to evaluate and refine their initial understanding, which may be incorrect. The distribution of posttest misconception categories, which showed that 100% of students in the experimental group were in the low misconception category, is a very practically significant finding. The consistency of these results indicates that collaborative learning is effective for students with varying levels of initial ability, not just for high-achieving students. According to Vygotsky's Zone of Proximal Development, collaborative learning allows students to learn within their zone of proximal development through the assistance of more competent peers (scaffolding), thus facilitating a deeper understanding of complex mathematical concepts (Fitriani & Maemonah, 2022).

The extremely large effect size (Cohen's d = 8.848) indicates not only statistical significance but also very high practical significance. This value far exceeds the standard considered a large effect in educational research (d > 0.8), indicating that the observed differences have a very substantial impact in the context of real-world learning. From a social constructivist perspective, collaborative learning facilitates the construction of knowledge through the negotiation of meaning and collaborative reasoning, enabling students not only to passively receive information but also to actively build understanding through social interaction (Situmorang, 2024).

The mechanism of collaborative learning for overcoming misconceptions about polynomial material can be explained in several ways. First, verbalizing or articulating thoughts in group discussions forces students to make their reasoning explicit, making conceptual errors more visible and correctable. Second, cognitive elaboration occurs when students explain concepts to their peers, strengthening their own understanding while identifying areas where they are still weak. Third, the multiple perspectives that emerge in group discussions provide students with alternative viewpoints on solving polynomial problems, which helps them develop a more flexible and comprehensive understanding (Husain, 2020).

This finding is also supported by Shimizu & Kang (2025), who, through a scoping review, showed that students' errors and misconceptions in mathematics can be minimized through classroom practices that emphasize collaboration. Abdullah et al. (2018) found that cooperative learning is effective in reducing misconceptions about fractions, findings relevant to this study on polynomials. Additionally, Wei et al. (2024) emphasized that students' metacognitive beliefs about collaborative learning are often inconsistent with their learning preferences, yet group interaction still has a positive impact on correcting misconceptions. Furthermore, Sun (2024) research indicates that collaborative knowledge construction among middle school students can lead to significant differences between high-and low-ability groups, with misconceptions suppressed through more intensive interaction.

Furthermore, the study by Firmansyah et al. (2025) showed that group discussions can strengthen students' social metacognition, which is the process of regulating one's own and group thinking during collaborative learning. Additionally, research by Murni (2019) emphasizes that metacognition in mathematics learning, which includes planning, monitoring, and evaluating thinking, is an important aspect in supporting the success of collaborative learning to reduce misconceptions.

The contribution of this research to the body of knowledge in mathematics education is to provide strong empirical evidence regarding the effectiveness of collaborative learning in the specific context of polynomial material at the high school level. These findings support the theoretical argument that mathematical misconceptions can be effectively addressed through approaches that emphasize social interaction and collaborative knowledge construction. Additionally, the consistency of results across different ability levels indicates that collaborative learning has inclusive effectiveness, where all students in the class can benefit significantly (Rahmawati et al., 2025).

The practical implication of this finding is the importance of reorienting the approach to learning mathematics from a teacher-centered knowledge transmission model toward a student-centered and collaborative knowledge construction model. Teachers need to be provided with adequate training to effectively implement collaborative learning, including understanding group dynamics, scaffolding strategies, and facilitation techniques that support productive discourse in mathematics learning. Furthermore, these findings indicate the need to develop learning materials and assessment tools that align with the characteristics of collaborative learning to optimize learning outcomes (Fitriani & Maemonah, 2022).

Nevertheless, this study has limitations. First, the research was conducted at a single school with relatively homogeneous student characteristics, so generalizing the results to other school contexts needs to be done with caution. Second, the intervention lasted only four meetings, so the long-term effects on misconceptions cannot yet be determined. Third, the success of collaborative learning is highly influenced by the teacher's role in facilitating discussion; without good management, collaboration actually risks reinforcing existing misconceptions. Therefore, further research is needed with a broader contextual scope, longer intervention duration, and different variations of collaborative models to strengthen these findings. As a local comparison, research by Ernawati et al. (2019) found that the PDEODE (Predict-Discuss-Explain-Observe-Discuss-

Explain) learning strategy was more effective than conventional methods at reducing students' misconceptions in mathematics. Another study by Mujib (2017) used the Certainty of Response Index (CRI) to identify the level of student misconceptions in Calculus II. This method can more accurately identify areas of misconception that warrant targeted intervention strategies. Therefore, future research could consider combining collaborative models with approaches such as PDEODE or instruments such as CRI to enrich the diagnosis and intervention of misconceptions.

CONCLUSION

Based on the research findings and data analysis, it can be concluded that collaborative learning has a very significant influence on reducing students' misconceptions about polynomial material in class XI at SMA Negeri 14 Kota Jambi. A quasi-experimental study with a nonequivalent control group design involving 57 students (28 in the experimental group and 29 in the control group) showed very encouraging results. The experimental group receiving collaborative learning treatment experienced a highly significant decrease in misconception scores from an average of 71.29 on the pretest to 41.14 on the posttest, representing a 42.3% reduction. Meanwhile, the control group receiving conventional learning only experienced a decrease from 70.93 to 62.24, or 12.2%. The striking difference in gain scores between the experimental group (30.14) and the control group (8.69) indicates that collaborative learning is nearly 3.5 times more effective than conventional learning.

The most significant finding is the distribution of posttest misconception categories, which shows that all students (100%) in the experimental group successfully achieved the low misconception category, while all students in the control group remained in the moderate misconception category. The results of the independent-samples t-test showed a t-value of -33.312 and a p-value < 0.001, indicating a highly significant difference. The effect size analysis, using Cohen's d, indicates that collaborative learning is not only statistically significant but also has very high practical significance in the context of mathematics learning. The consistency of results across different ability levels indicates that collaborative learning is effective for all students with varying levels of prior knowledge. The collaborative learning mechanism involving verbalization, cognitive elaboration, and multiple perspectives has proven capable of comprehensively addressing misconceptions in polynomial operations, polynomial division, and polynomial equation factors and roots, making it a recommended alternative, effective learning strategy for overcoming mathematical misconceptions at the high school level.

REFERENCES

Abdullah, A. H., Julius, E., Mokhtar, M., & Abd Rahman, S. N. S. (2018). Using Cooperative Learning to Overcome Students' Misconceptions about Fractions. *NeuroQuantology*, *16*(11). https://doi.org/10.14704/nq.2018.16.11.1699

Ernawati, E., Farida, F., & Anggoro, B. S. (2019). Analisis Miskonsepsi Matematis: Dampak Strategi Pembelajaran Predict Discuss Explain Observe Discuss Explain. *Desimal: Jurnal Matematika*, *2*(3), 259–269. https://doi.org/https://doi.org/10.24042/djm.v2i3.4862

Fatmanissa, N., Siswono, E., Yuli, T., & Lukito, A. (2024). Utilizing Decision-making Task: Students' Mathematical Justification in Collaborative Problem Solving. *Avances de Investigación En Educación Matemática*, *26*.

Firmansyah, F. F., Yudianto, E., Febriyanto, E. Y., Sulihah, N. T., & Budianto, T. R. (2025). Proses Metakognisi dalam Interaksi Siswa pada Diskusi Kelompok. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *9*(2). https://doi.org/https://doi.org/10.31004/cendekia.v9i2.3964

Fitriani, F., & Maemonah, M. (2022). Perkembangan Teori Vygotsky dan Implikasi dalam Pembelajaran Matematika di MIS Rajadesa Ciamis. *Primary: Jurnal Pendidikan Guru Sekolah*

Dasar, *11*(1), 35. https://doi.org/10.33578/jpfkip.v11i1.8398

Fraenkel, J., Wallen, N., & Hyun, H. (1993). *How to Design and Evaluate Research in Education 10th ed.* McGraw-Hill Education.

Husain, R. (2020). Penerapan Model Kolaboratif dalam Pembelajaran di Sekolah Dasar. *E-Prosiding Pascasarjana Universitas Negeri Gorontalo*, *1*(2012), 12–21.

Mujib, A. (2017). Identifikasi Miskonsepsi Mahasiswa menggunakan CRI pada Mata Kuliah Kalkulus II. *Mosharafa: Jurnal Pendidikan Matematika*, *6*(2), 181–192.

Murni, A. (2019). Metakognisi dalam Pembelajaran Matematika. *Jurnal Prinsip Pendidikan Matematika*, *1*(2), 1–14. https://doi.org/10.33578/prinsip.v1i2.23

Nesher, P. (1987). Towards an Instructional Theory: The Role of Student's Misconceptions. *For the Learning of Mathematics*, *7*(3), 33–40.

Novianto, A., Fitriani, N., Deniswa, A. S., Izzati, M. H., Firdaus, F., Ningrum, N., & Dewi, R. C. (2024). Analisis Kesulitan Belajar Matematika dalam Penerapan Kurikulum Merdeka di Sekolah Dasar. *Jurnal Ilmiah Kependidikan*, *12*(2), 946–960. https://doi.org/10.20961/jkc.v12i2.88914

Nurhaswinda, N., Rahman, A., Mahdi, M., Zahara, J., & Isamadola, I. (2025). Peran Logika Matematika dalam Pemecahan Masalah Sehari-hari. *Cahaya Pelita: Jurnal Pendidikan Dan Kebudayaan*, *1*(2), 56–60. https://jurnal.cahayapublikasi.com/index.php/cp/article/view/31/27

Oktafiani, I. S., Muhtarom, Y., & Ahdad, M. M. (2022). Pembelajaran Kolaboratif dalam Meningkatkan Kemampuan Belajar Matematika di Madrasah Aliyah Miftahul Jannah Selatbaru Kabupaten Bengkalis. *Annual Conference on Islamic Early Childhood Education (ACIECE)*, *6*, 227–234. https://conference.uin-suka.ac.id/index.php/aciece/article/view/916

Putri, J. H., Diva, D. F., Dalimunthe, N. F., Melani Prasiska, & Irani, A. R. (2024). Miskonsepsi dalam Pembelajaran Matematika : Sebuah Tinjauan Literatur terhadap Penelitian-Penelitian Terbaru. *JagoMIPA: Jurnal Pendidikan Matematika Dan IPA*, *4*, 580–589. https://doi.org/https://doi.org/10.53299/jagomipa.v4i3.749

Rahayu, W. I., & Yuhana, Y. (2023). Miskonsepsi dalam Pelajaran Matematika Materi FPB dan KPK pada Siswa Kelas IV Sekolah Dasar. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *08*, 5926–5936. https://journal.unpas.ac.id/index.php/pendas/article/view/11988

Rahmawati, S., Aini, L. N., Junaedi, I., & Kurniasih, A. W. (2025). Systematic Literature Review: Implementasi Pembelajaran Kolaboratif terhadap Pemecahan. *PRISMA, Prosiding Seminar Nasional Matematika*. *8*(5), 338–345. https://journal.unnes.ac.id/sju/index.php/prisma/

Sangaji, J., & Lukmana, D. A. (2023). Analisis Kesalahan Siswa dalam Menyelesaikan Masalah Polinomial di SMP Negeri 10 Kota Ternate. *Jurnal Ilmiah Wahana Pendidikan*, *9*(3), 265–280. https://doi.org/10.5281/zenodo.7625113

Shimizu, Y., & Kang, H. (2025). Research on Classroom Practice and Students' Errors in Mathematics Education: A Scoping Review of Recent Developments for 2018-2023. *ZDM – Mathematics Education*, *57*(4), 695–710. https://doi.org/10.1007/s11858-025-01704-0

Siregar, R. M. R., & Dewi, I. (2022). Peran Matematika dalam Kehidupan Sosial Masyarakat. *Scaffolding: Jurnal Pendidikan Islam Dan Multikulturalisme*, *4*(3), 77–89. https://doi.org/https://doi.org/10.37680/scaffolding.v4i3.1888

Situmorang, D. Y. (2024). Efektivitas pembelajaran kolaboratif berbasis teknologi dalam meningkatkan hasil belajar siswa. *Jurnal Teknologi Pendidikan*, *3*(1), 146-151. https://doi.org/10.56854/tp.v3i1.231

Sofiyah, K., Nasution, N. E., Amelia, A., & Hutagalung, L. A. (2025). Pengaruh Kesadaran Siswa terhadap Pentingnya Matematika dalam Karir di Era Digital dan Ekonomi Berbasis Pengetahuan. *Aliansi: Jurnal Hukum, Pendidikan Dan Sosial Humaniora*, *2*(1), 111–118.

https://doi.org/https://doi.org/10.62383/aliansi.v2i1.673

Sugiyono, D. (2013). *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif dan R&D*. Alfabeta.

Sun, B. (2024). Examining Junior High School Students' Collaborative Knowledge Building: Based on the Comparison of High-Low Performance Groups' Mathematical Problem-Solving. In Y. Cao (Ed.), *Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study* (pp. 19–51). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-7386-6_2

Wei, Y., Soderstrom, N. C., Meade, M. L., & Scott, B. G. (2024). Metacognition About Collaborative Learning: Students' Beliefs Are Inconsistent with Their Learning Preferences. *Behavioral Sciences*, *14*(11). https://doi.org/10.3390/bs14111104