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The Differences in Enhancing Students' Mathematical Communication Skills and Learning Independence Between CTL and STAD Models on Polynomial Material

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Abstrak

Penelitian ini bertujuan untuk mengetahui pengaruh Kemampuan Awal Matematik (KAM) dengan kemampuan komunikasi matematis siswa dan kemandirian belajar siswa; mengetahui apakah terdapat interaksi antara model pembelajaran dengan KAM terhadap peningkatan kemampuan komunikasi matematis siswa dan kemandirian belajar siswa. Metode penelitian ini merupakan quasi eksperimen. Populasi penelitian ini seluruh siswa kelas XI MAN 2 Deli Serdang Tahun Ajaran 2024/2025 yang berjumlah 432 terdiri dari empat jurusan medis, tiga Saintek, tiga Soshum dan dua Islamik, sedangkan sampel penelitian adalah kelas XI Medis 3 (Eksperimen 1) dan XI Saintek 3 (Eksperimen 2). Hasil penelitian diperoleh bahwa terdapat pengaruh KAM terhadap kemampuan komunikasi matematis siswa dan kemandirian belajar; terdapat perbedaan peningkatan kemampuan komunikasi matematis dan kemandirian belajar; dan terdapat interaksi kemampuan awal matematika terhadap kemampuan komunikasi matematis dan kemandirian belajar.

Kata Kunci : *CTL, Komunikasi Matematis, Kemandirian Belajar, STAD.*

Abstract

This study aims to determine the effect of Initial Mathematical Ability (KAM) on students' mathematical communication skills and student learning independence; to determine whether there is an interaction between the learning model and KAM on improving students' mathematical communication skills and student learning independence. This research method is a quasi-experimental one. The population of this study was all students of class XI MAN 2 Deli Serdang in the 2024/2025 Academic Year totaling 432 consisting of four medical majors, three Science and Technology, three Social Sciences and two Islamic majors, while the research sample was class XI Medical 3 (Experiment 1) and XI Science and Technology 3 (Experiment 2). The results of the study showed that there was an effect of KAM on students' mathematical communication skills and learning independence; there was a difference in improving mathematical communication skills and learning independence; and there was an interaction between initial mathematical abilities and mathematical communication skills and learning independence.

Keywords: *CTL, Mathematical Communication, Learning Independence, STAD.*

A. Introduction

Mathematics is a graduation requirement at all levels, and some schools evaluate math results to admit new pupils (Swasti, M., Maimunah, M., & Roza, 2020). The queen of science is math. Mathematics is considered the wellspring of all disciplines and the key to knowledge (Rachmawati, N. Y., & Rosy, 2021). Math is also included in all college entrance exams. Math affects many other areas of life. Due to mathematics' importance in life, kids are encouraged to do well in math. Mathematics is a graduation requirement at all levels, and some schools evaluate math results to admit new pupils (Hasratuddin, 2018). The queen of science is math. Mathematics is considered the wellspring of all disciplines and the key to knowledge ((Islahiyah et al., 2021) Math is also included in all college entrance exams. Math affects many other areas of life. Students are expected to do well in math due to its importance in life.

Students' mathematical communication contributes to the unsatisfying reality above. (Baroody, 2017) suggests two reasons to emphasize mathematical communication. Besides thinking, discovering formulas, solving problems, and concluding, mathematics is a fundamental language. Mathematics can convey thoughts clearly, correctly, and exactly; hence, its utility is limitless. Second, mathematics and studying mathematics are fundamental to human social interactions, including instructors and students (Hendriana, 2018). The author interviewed many MAN 2 Deli Serdang instructors, one of whom mentioned pupils' mathematics communication abilities. The instructor said pupils struggle to express themselves. To fully express their opinions, students must first read the text. Students can write down their responses to activities, but they struggle to explain them when asked why. This is consistent with early findings from daily examinations done by researchers at MAN 2 Deli Serdang class XI, revealing that pupils' responses to the following issues exhibit insufficient mathematical communication abilities.

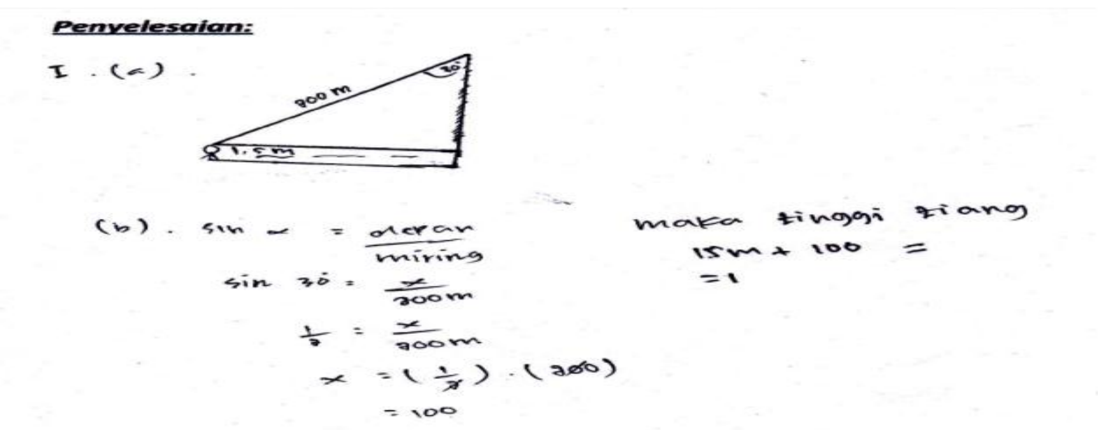

Figure 1. Students' Mathematical Communication Answer Sheet

Because pupils are not engaged in studying, they have poor mathematics communication abilities (Febriyanti, F., & Imami, 2021). Low learning activity reduces student capacity to build new information and abilities. It also hinders students' capacity to connect ideas, materials, and real life, demotivating them to study for the future (Aditya, R. S., & Sukestiyarno, 2019). (Pratama, S., Minarni, A., Saragih, 2017) noted that pupils' limited mathematical communication in math learning activities makes it hard for them to explain their results. The boring learning process seldom excites pupils, according to some.

Mathematical communication helps students formulate mathematical concepts and techniques, participate in mathematical discovery and study, and communicate to learn, share, and discover. (Swasti, M., Maimunah, M., & Roza, 2020) showed that junior high school grade VIII pupils still have inadequate mathematics communication abilities and impediments to mathematical communication. According to ((Nurhasanah, R. A., Waluya, & Kharisudin, 2019) , kids struggle to understand and lack instructor attention. Interviews with MAN 2 Deli Serdang instructors revealed that the MGMPS (School Subject Teacher Deliberation) committee devised the RPP and LKPD. With learning independence, students set objectives, evaluate themselves, examine learning progress, have high views and beliefs about their skills, assess learning, identify elements that affect learning, and anticipate effects (self-efficacy) throughout the learning process (Sriwahyuni, T., Amelia, R., & Maya, 2019). The huge Indonesian dictionary defines independence as "standing alone." Learning independence means students must take charge of their learning, behaviour, and country or state (Muslihah, N. N., dan Suryaningrat, 2021). Learning independence, according to Stephen (Lina, 2020), is self-awareness, motivated by oneself, and the capacity to fulfill objectives.

(Arifin, 2016) also said that the CTL approach may excite pupils and make them want to study more. CTL links material and ideas to life. It may be linked directly to genuine situations or overcome by using pictures and real instances. Since what is learnt is useful, it will be more engaging (Sabariah, 2019). Presenting data rather than theory makes this learning a contextual model. Other learning models, such as STAD-type cooperative learning, may promote students' communication and learning independence (Munawwarah, 2018). The cooperative learning technique is thought to help pupils enhance their mathematical communication abilities. Students must be comfortable conveying their thoughts vocally and in writing according to their own interpretations so others may evaluate and reply. Student learning outcomes must be improved to meet learning goals (Dina, Z. H., Ikhsan, M., 2019). A learning approach that demands student participation is required to solve these issues (Muslihah, 2018). Cooperative learning lets all students participate and be innovative. Study groups that work together to attain objectives are cooperative learning. Students must be physically, cognitively, and emotionally engaged to learn (Dimayati & Mujiono, 2009).

Because all students are directly involved, the Student Team Achievement Divisions (STAD) cooperative learning model encourages students to be active and work together in groups to follow class learning (Sarwono, E.,Yusmin, E., Suratman, 2018). According (Slavin, 2018), Students Teams Achievement Division (STAD) is a cooperative learning strategy that encourages students to assist one other acquire skills. The Contextual Teaching and Learning (CTL) and Student Team Achievement Division (STAD) models are expected to foster mathematical communication competencies and student learning independence in mathematics learning, and provide a positive impact on student learning outcomes, so it is important to take action. That is what prompted the study entitled: Differences in Improving Mathematical Communication Skills and Student Learning Independence Between the Contextual Teaching and Learning (CTL) and Student Team Achievement Division (STAD) Learning Models of Polynomial Material at MAN 2 Deli Serdang.

B. Research Method

This study compares the improvement of mathematical communication skills and independence in learning mathematics of MAN 2 Deli Serdang students using the Contextual Teaching and Learning (CTL) and Student Teams Achievement Divisions (STAD) cooperative learning models. Due of its class setting, this study constituted a quasi-experiment (Sugiyono, 2018). This study was done at MAN 2 Deli Serdang with class XI medicine and science majors in the odd semester of 2024/2025. The mathematics subject instructor at MAN 2 Deli Serdang gave therapy and followed the research timetable. Reasons researchers chose MAN 2 Deli Serdang for research: The school has supporting learning facilities, there has never been a similar research at the school, and the researcher wants to apply a new paradigm of learning. So far, learning has used the lecture method and never used the Contextual Teaching and Learning (CTL) or Students Teams Achievement Division (STAD) cooperative learning models. This study included 432 students from class XI MAN 2 Deli Serdang in the 2024/2025 academic year, divided into 12 classes: 4 medical majors, 3 science and technology, 3 social sciences, and 2 Islamic. Piaget's cognitive development theory indicates that children between 11 and maturity enter the formal operational phase, which is why class XI was chosen. Research sample was randomly chosen from class XI medicine 3 (36 students with Contextual Teaching and Learning (CTL) learning model and class XI science 3 (37 students with cooperative learning type Student Teams Achievement Divisions). This research collected data using communicative skills assessments and student learning independence surveys.

The use of the quasi-experimental method was carried out to explain the effects or effects of the treatment given by comparing one or more groups that received different treatments. The design of this study can be seen in Table 1.

Table 1. Research Design

Group	*Pretest*	Treatment	*Posttest*
CTL (experiment 1)	O_1	X_1	O_2
STAD type cooperative (experiment 2)	O_1	X_2	O_2

Description:

O1: Pretest of experimental group 1 and experiment 2

O2: Posttest of experimental group 1 and experiment 2

X1: Learning with Contextual Teaching and Learning model

X2: Learning with Student Teams Achievement Divisions (STAD) model

C. Result and Discussion

The quantitative research findings were examined using descriptive and inferential statistics. This research uses descriptive statistical analysis to compare students' skills before and after therapy. While inferential statistical analysis seeks to improve students' communication and learning independence. Student interactions in CTL/STAD learning groups

The initial mathematics ability test was given to group students based on high, medium, and low KAM and also to check the equality of the two sample classes, namely experimental class I and experimental class II. To obtain an overview of students' KAM, the average and standard deviation calculations were carried out. The results of the calculation of students' initial mathematics ability are fully seen in the appendix, while the summary results are presented in Table 2 below:

Table 2. Description of Students' Mathematics Ability in Each Sample Class Based on Initial Mathematics Ability Test Scores

Class	x_{min}	x_{maks}	$\bar{x}$	**SD**
CTL Model	46,7	86,7	67,40	12,12
STAD Model	40	73,3	56,67	10,14

Table 2 above provides an illustration that the average KAM score for each class of research samples is relatively the same. Furthermore, it is necessary to conduct an analysis test which includes a normality test, a homogeneity test and a test for the difference in the average of the sample class.

To see the difference in average ability between experimental group I and experimental group II, it was analyzed using a t-test which aims to see whether experimental class I and experimental class II have the same ability. The hypothesis tested is

$H_0 : \mu_1 = \mu_2$

$H_1 : \mu_1 \neq \mu_2$

The test criteria accept H_0 if t_table < t_count and reject H_0 if it is in other cases. The following are the results of the calculation of the difference test on the average value of the initial mathematics ability of students in experimental class I and experimental class II can be seen in Table 3 below

Table 3Analysis of the Difference Test on the Average of Students' Initial Mathematics Ability between Data Groups

Class	Amount	Standard Deviation	t_{hitung}	t_{tabel}	Conclusion
CTL Model	2426,7	12,1213	0,226	1,994	H_0 accepted
STAD Model	2039,99	10,1404			

Based on table 3 above, the calculation results show that the t_count value is between t_table, namely -0.226 and 0.226 (-1.994 ≤ 0.226 ≤ 1.994) so that the null hypothesis stating that there is no difference in the average of students' initial mathematics ability between data groups can be accepted. Thus, experimental class I with the CTL learning model and experimental class II with the STAD learning model have the same initial mathematics ability.

Analysis of Students' Mathematical Communication Ability Improvement Based on Learning

The mathematical communication ability data was collected and analyzed to determine the students' mathematical communication ability before and after the provision of the learning model. This data was obtained from the results of the pretest and posttest of students' mathematical communication ability and their N-Gain.

From the results of the analysis of the calculation of the communication ability test of students in both learning groups are presented in Table 4.

Table 4. Data Description of Mathematical Communication Skills of Both Learning Groups

Aspect	Learning model					
	CTL			STAD		
	Pretest	*Posttest*	*N-Gain*	*Pretest*	*Posttest*	*N-Gain*
Average	63,53	82,97	0,53	52,17	76,11	0,50

In general, the bar chart describing the average score of students' mathematical communication skills in both learning groups in Table 4 can be seen in Figure 2 and Figure 3 below:

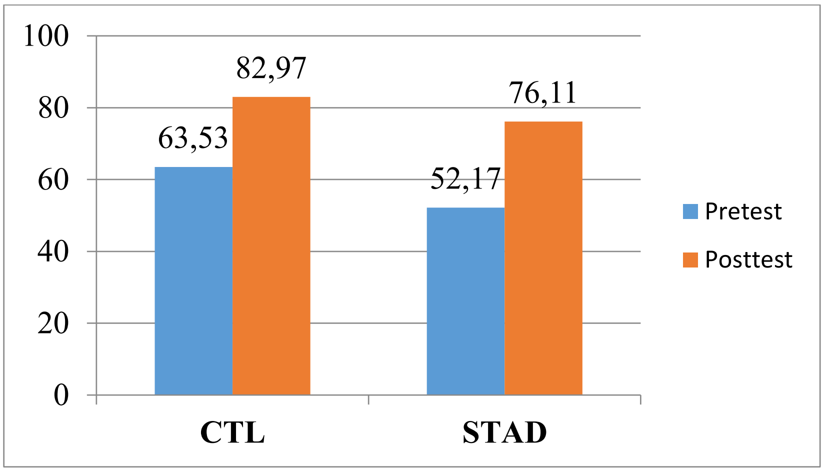

Figure 2. Average Score of Mathematical Communication Ability

Based on Figure 2, it provides an average pretest score of students' mathematical communication skills in CTL learning and STAD information learning, but based on the quality of the posttest score, students' mathematical communication skills in CTL and STAD learning have increased from the pretest results.

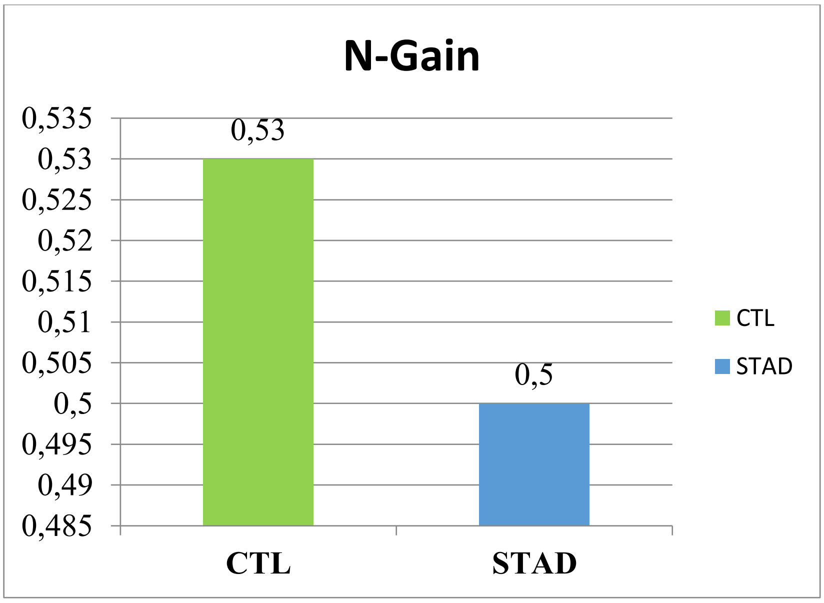

Figure 3. Improving Mathematical Communication Skills

Based on Figure 3, it provides information about the increase between the pretest and posttest scores of students' mathematical communication skills (N-Gain mathematical communication skills) in CTL and STAD learning, there is an increase in the N-Gain data of students' mathematical communication skills.

Descriptively, there are several conclusions regarding students' mathematical communication skills based on high, medium and low abilities that can be revealed from Table 4. Figure 2 and Figure 3, namely:

Before learning, the average mathematical communication skills of students from CTL learning were 63.53 while the average value of mathematical communication skills of students who received STAD learning was 52.17. After learning, there was an increase in the average mathematical communication skills of the two groups of students. The average mathematical communication skills of students from CTL learning were 82.97 (N-Gain of 0.53). Based on Hake's category (1998), the increase in students' mathematical communication skills obtained from CTL learning is included in the moderate category (0.3<g≤0.7). Meanwhile, students who were taught with the STAD learning model got an average mathematical communication skills of 76.11 (N-Gain of 0.50). Based on Hake's (1998) category, the increase in students' mathematical communication skills taught using the STAD model is included in the moderate category (0.3<g≤0.7).

The results of the descriptive analysis of the mathematical communication skills of students in both learning groups based on the grouping of students' initial mathematical ability (KAM) categories are presented in Table 5 below:

Table 5 Description of Data on Students' Mathematical Communication Skills in Both Groups for the KAM Category

KAM Category Low	Learning model					
	CTL			STAD		
	Pretest	*Posttest*	*N-Gain*	*Pretest*	*Posttest*	*N-Gain*
Low	43,00	67,22	0,42	37,20	62,40	0,78
Medium	64,06	83,65	0,55	51,30	76,56	0,56
High	81,1	95	0,8	67,93	91,86	0,78

Table 5 shows that CTL and STAD learning improves students' mathematics communication skills. High KAM students gain more mathematical communication ability (N-Gain) via CTL learning than medium and low KAM students. In the STAD learning paradigm, high KAM students gain more mathematical communication ability (N-Gain) than medium and low KAM students. CTL learners also improve mathematical communication ability (N-Gain) more than STAD learners for each pair of KAM categories. According to Hake's (1998) classification of students' mathematical communication abilities using the CTL learning model, strong KAM falls under the high N-Gain group (g≥0.7), whereas medium and low KAM fall under the medium N-Gain category (0.3

Linear Regression Model of Mathematical Communication Ability

Based on the results of the student communication ability test, the regression equation for experimental class I is Y_E=37.578+ 0.715X_E and the regression equation for experimental class II is Y_K=25.992+ 0.961X_K. The calculation of the regression equation coefficient is carried out using the SPSS program and can be seen in Table 6 and Table 7 as follows:

Table 6. Results of Calculation of the Regression Equation Coefficient for Experimental I

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
1 (*Constant*)	37.578	1.537		24.446	.000
Pretest	.715	.023	.982	30.409	.000

Table 7. Results of Calculation of the Regression Equation Coefficient for Experimental II

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
1 (*Constant*)	25.992	3.211		8.096	.000
Pretest	.961	.059	.941	16.176	.000

Results of Student Learning Independence

The results of the descriptive analysis of the data on the learning independence of students in both learning groups based on the grouping of students' initial mathematics ability (KAM) categories are presented in Table 8.

Table 8. Description of Data on Learning Independence of Students in Both Learning Groups for each KAM Category

KAM Category Low	Learning model					
	CTL			STAD		
	Pretest	*Posttest*	*N-Gain*	*Pretest*	*Posttest*	*N-Gain*
Low	61,58	74,72	0,34	42,66	64,00	0,37
Medium	69,85	82,30	0,42	60,43	78,30	0,45
High	77,42	92,17	0,66	69,79	84,17	0,48

According to Table 8, CTL and STAD learners have more learning freedom. High KAM students gain more learning independence (N-Gain) for CTL and STAD learning than medium and low KAM students. CTL learning also increases learning independence (N-Gain) more than

STAD learning for each pair of KAM categories. Hake (1998) classifies the average improvement in learning independence of CTL-taught students at high, medium, and low KAM as medium N-Gain $(0{,}3 < g \leq 0{,}7)$.

Linear Regression Model of Student Learning Independence

Hypothesis testing that has been formulated using covariance analysis using F statistics with the established formula and criteria. The results of the calculation of the hypothesis test analysis with the help of the SPSS program can be seen in the following table 9:

Table 9. Results of Regression Analysis between KAM and Student Learning Independence

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	44.387	1.363		32.572	.000
KAM	.575	.022	.954	26.682	.000

Based on Table 9, the results of the regression analysis obtained a significance value (sig) of 0.000, which is smaller than the probability value (sig) of 0.05. Because the probability value (sig) is smaller than 0.05, H_0 is rejected. So it can be concluded that there is an influence of KAM on student learning independence.

Discussion

The hypothesis statistical test findings are known from ANACOVA results with a probability value (sig) of 0.000, which is less than 0.05. This research found that CTL-taught students improved their mathematics communication abilities more than STAD-taught students. It's logical that CTL learners improve mathematical communication skills more than STAD learners. CTL students are given LKPD that contains real or real problem demands from children's daily lives, making it easier for them to understand because it is real, accessible to their imagination, and imaginable (Darmiati, 2021). This allows them to use their communication skills to find the meaning of the material they are studying.

STAD learners are given LKPD and told to discover themselves and utilize many sources of knowledge and ideas to study. STAD learning also uses a structured group or team work approach to empower, refine, assess, and grow students' communicative thinking abilities. In truth, group learning does not inspire kids to discover. Study groups and real-life situations make active students more active and less active students more interested in studying. According to this argument, CTL learners have better mathematical communication abilities than STAD learners. (Danoebroto., 2020) found that CTL learning is more successful in

"Problem-Based Learning to Mathematics". (Efendi, Nofriza, 2020) also found that CTL students had superior communication abilities than STAD pupils.

The pretest and posttest independence of student learning in experimental class I had an average N-Gain of 0.44 and experimental class II 0.44. The difference between the average posttest and pretest with the desired score shows the growth. Experimental class I increases student learning freedom. The hypothesis statistical test findings are known from the ANACOVA calculated from 0.000, which is less than 0.05. Thus, CTL learning increased student independence more than STAD learning in this research.

The calculations show that CTL learning increases student independence more than STAD learning. CTL learning engages students in active learning with daily ideas, principles, and issues. The instructor encourages them to solve issues and concepts for themselves to acquire experience. CTL learning promotes student engagement, independence, and deep learning, according to (Rusman, 2018). High learning independence means pupils want to study on their own and will learn without being instructed. Thus, student mathematics interest and independence indicate learning independence. This learning will increase student drive and curiosity, increasing learning independence. This shows that CTL learners are more independent than STAD learners. STAD learning is inferior than CTL learning. This matches research findings.

D. Conclusion

This study's research data and conversations yielded numerous insights. Here are some findings: KAM affects students' mathematics communication abilities when they get Contextual Teaching and Learning (CTL), which is greater than STAD. KAM affects the learning independence of students who get Contextual Teaching and Learning (CTL), which is greater than STAD. Students who get Contextual Teaching and Learning (CTL)-based mathematics learning have better mathematical communication skills than those who receive STAD cooperative learning. Students that get Contextual Teaching and Learning (CTL)-based learning learn more than those who receive STAD-based cooperative learning. The learning method and Initial Mathematical Ability (KAM) interact to improve students' mathematical communication. The learning strategy and beginning mathematical ability (KAM) interact to increase student learning independence. Implementing the learning process using Contextual Teaching and Learning (CTL) and Student Teams Achievement Division (STAD) requires teachers to build interactive learning, build students' enthusiasm and learning independence, and develop mathematical communication skills. Discussion in Contextual Teaching and Learning (CTL) and Student Teams Achievement Division (STAD) learning helps students strengthen their mathematical communication skills and learning independence, which can make the classroom more comfortable and motivate students to learn math. Teachers' roles as learning partners, mediators, and facilitators deepen teacher-student relationships. This type of discussion helps instructors identify open material strengths and limitations and student skills.

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