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Increasing Students' Mathematical Problem-Solving Abilities and Attitudes Towards Mathematics Through Cups Learning Model

Syaiful[1]*, Puspayanti[2], Khairul Anwar[3]
Universitas Jambi
Corresponding Author: Syaiful pak_bakri@unja.ac.id

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A B S T R A C T

The study investigated the effectiveness of the Conceptual Understanding Procedures (CUPs) learning paradigm in enhancing seventh-graders' mathematical problem-solving skills and attitudes toward mathematics. Conducted with 69 students in Jambi, Indonesia, the quasi-experimental design involved a control group receiving traditional training and an experimental group utilizing CUPs. Data gathered through attitude surveys and mathematics tests revealed that the experimental group had a greater mean gain score (M = 7.69, SD = 2.52) compared to the control group (M = 5.56, SD = 2.96). Most students also expressed positive attitudes toward learning mathematics with the CUPs model, particularly in terms of involvement and teamwork. The findings suggest that CUPs can effectively enhance mathematical problem-solving skills and foster positive attitudes in secondary education.

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INTRODUCTION

It is well acknowledged that one of the most crucial skills in education in the twenty-first century is the ability to solve mathematical problems (Singh & Rai, 2026; Syaiful, Muslim, Huda, Mukminin, & Habibi, 2019; Tan & Kidman, 2025). Students can analyse circumstances, develop strategies, assess solutions, and apply mathematical principles to real-life scenarios through problem-solving, which goes beyond procedural calculation (Nilimaa, 2023; Qiao & Cao, 2026; Torres-Peña, Peña-González, Lara-Orozco, Ariza, & Vergara, 2025). As a result, the development of higher-order thinking abilities through student-centered and constructivist learning methodologies is emphasised in modern mathematics education (Arega & Hunde, 2025; Meiliati, Djodding, Salido, Husain, & Hidayati, 2026; Syaiful et al., 2019). Many secondary school pupils still struggle with answering mathematical problems in spite of this emphasis, especially when it comes to contextual and non-routine situations (Basyal, Nepal, Pokharel, & Lamichhane, 2026; Choi, Mun, & Hand, 2026; Cumhur, 2026).

According to earlier research, students frequently have trouble deciphering mathematical word problems, finding pertinent information, and choosing the best approaches for solving them (Huang, Cai, Lv, Huang, & Zheng, 2024; Vicente, Verschaffel, Sánchez, & Múñez, 2022). These challenges are often linked to teacher-centered teaching methods that prioritise procedural exercises and memorisation over conceptual comprehension and active student participation (Sasson & Tifferet, 2026; Wawire, Kiambati, Muhia, Gathoni, & Abuya, 2026). Students may consequently form unfavourable opinions about mathematics and believe it to be a challenging and abstract subject (Weber, Breuer, & Lindmeier, 2025). Students' desire and confidence in their ability to solve mathematical problems on their own may be hampered by such circumstances (C. Wang, Yang, Cui, Ming, & Sun, 2025).

Educational academics have increasingly looked at constructivist and cooperative learning methods that actively involve students in the learning process in order to address these issues (Asad, Qureshi, & Almusharraf, 2026; P. Chen, Liang, Bao, & Zeng, 2026). Constructivist theory contends that rather than being passively absorbed from educators, knowledge is actively created by social interaction, debate, and introspection (Flavian, 2026; Ghanizadeh, n.d.). According to this viewpoint, cooperative learning gives students the chance to discuss ideas, negotiate meaning, and work together to solve issues (Davidsen & Bernhard, 2026; Gürbüz, Özkul, & Şen, 2025; Soh, 2025). Cooperative learning settings can improve students' mathematical comprehension, engagement, and problem-solving skills, according to research (Aposika, 2026)(Larico, Gutierrez, Talavera-Mendoza, & Paucar, 2026).

The Conceptual Understanding Procedures (CUPs) learning model is one teaching strategy that incorporates constructivist and cooperative learning elements (Cheng & Chen, 2026; Pallavicini & Anesa, 2026; Tanner, 2013). In order to motivate students to actively create mathematical understanding, the CUPs model places a strong emphasis on small-group interaction, conceptual discussion, and cooperative problem-solving exercises (Danzglock & Hänze, 2026; Miller Marsh, Turner Lindsey, & Raimbekova, 2026; Son & Albert, 2026).

Under this approach, students analyse issues, talk about potential solutions, and explain their thinking to peers in diverse groupings (Soh, 2025; Zhan, He, & Zhong, 2024). It is anticipated that these learning exercises would enhance students' conceptual comprehension and mathematical problem-solving skills while also cultivating more favourable attitudes toward learning mathematics (Aposika, 2026; Hakmi, 2026).

There is still little empirical data on the efficacy of the CUPs learning model, especially in secondary mathematics education environments in developing nations, despite earlier research showing beneficial impacts of cooperative learning approaches on mathematics achievement (Rodrigues et al., 2026; M.-T. Wang, Scanlon, Yamada, & Qin, 2026; Zhao, Liu, Zuo, Qi, & Hu, 2026). Furthermore, very few research have simultaneously looked at affective outcomes like attitudes toward mathematics and cognitive outcomes like the capacity to solve mathematical problems (Aaviste, Löchner, Laas, & Täht, 2026; Goos, Carreira, & Namukasa, 2023; Uğraş, 2025). Therefore, more research is required to assess how well the CUPs learning approach enhances students' mathematics learning outcomes.

The purpose of this study is to evaluate how well junior high school students' mathematical problem-solving skills and attitudes are enhanced by the CUPs learning paradigm. In particular, this study looks into: (1) whether students who learn using the CUPs learning model show a significant improvement in their ability to solve mathematical problems; (2) whether students taught using the CUPs learning model differ significantly from those taught using traditional discussion methods; and (3) how students react to learning mathematics using the CUPs learning model.

The results of this study are anticipated to add to the expanding corpus of research on cooperative constructivist learning in mathematics education and offer useful recommendations for maths teachers looking to improve their students' problem-solving skills and engagement.

LITERATURE REVIEW

Mathematical Problem-Solving in Mathematics Education

Because it allows students to apply mathematical ideas, reasoning, and techniques to novel situations, mathematical problem-solving is regarded as one of the core competences in mathematics education (Ersoy & Kara, 2026; Hošpesová, Hrubešová, & Pártlová, 2026; Syaiful, Mukminin, & Puspayanti, 2025). Problem-solving is emphasised in modern educational systems as a crucial higher-order thinking ability needed for both academic success and practical decision-making (Erdem, Kaya, Tunç Toptaş, & Altunbaşak, 2026; Meiliati et al., 2026; Motukeeva, Azhibaeva, Kazieva, Zainiev, & Tokonbekova, 2026). Despite its significance, many students still struggle to solve mathematical problems, especially non-routine and contextual ones that call for conceptual knowledge and analytical reasoning (Hadi, Hendriana, Noviana, & Csíkos, 2026; Mafarja, Rahim, & Zulnaidi, 2026; Refvik, 2026; Santosa, Setyaningsih, & Kholid, 2026). According to recent research, secondary school pupils often have trouble understanding mathematical concepts, coming up with solutions, and assessing how accurate their answers are (Burgos & Godino, 2022; Jonsson, Granberg, & Lithner, 2020; Monarrez & Tchoshanov, 2022; Ssali et al., 2025; Weber et al., 2025). The methods of instruction used in the classroom have a direct impact on the growth of mathematical problem-solving skills (Montoya, Castro-Gómez, & Zapata-Molina, 2026). Conventional teacher-centered instruction frequently prioritises repetitious exercises and procedural memorisation above conceptual comprehension and active student participation (Bogale, 2026; Klette, Tengberg, Magnusson, Sigurjónsson, & Selling, 2026; Lin & Hung, 2026). Students may have fewer opportunity to investigate mathematical concepts both independently and in groups in such learning contexts (Al Alawi, Gningue, Jarrah, & Almarashdi, 2026; Muhaimin, Dasari, Hendriyanto, Andriatna, & Sahara, 2026; Radišić, Schukajlow, Rach, & Eccles, 2026). As a result, scholars are pushing more and more for student-centered teaching strategies that encourage engagement, dialogue, and group inquiry (Ghanizadeh, 2026; Ogisu, 2022; S. C. Yang, Hsueh, & Hung, 2026).

Cooperative Learning and Constructivist Approaches

As a teaching strategy that might enhance students' cognitive and affective learning outcomes, cooperative learning has drawn a lot of attention (L. Liu, Alzahrani, Wei, Tavakoli Baghdadabad, & Savita, 2026; Rakha, 2025; Syaiful, Huda, Mukminin, & Kamid, 2022; Yan et al., 2024). In cooperative learning environments, students are encouraged to collaborate in small groups to accomplish common learning objectives through mutual support, interaction, and communication (Bjelobaba, Savić, Tošić, Stefanović, & Kocić, 2023; Chan & Ng, 2024; D'Elia, Stalmach, Di Sano, & Casale, 2025). Constructivist learning theory holds that meaningful engagement with learning tasks and social interaction actively generate knowledge (Kim & Adlof, 2024; Oyewo & Oyewo, 2025; Quoc & Van, 2023). Therefore, by giving students the chance to negotiate meaning, clarify concepts, and work together to solve issues, cooperative learning strongly adheres to constructivist ideals (Kong, Liu, Chen, Zhao, & Chan, 2026; Raymond, Ethridge, & Beisly, 2026; Xu, Gui, & Wu, 2026).

Cooperative learning has been shown to improve students' mathematics achievement and problem-solving skills in a number of recent systematic reviews and meta-analyses (Güngör, Altunbaşak, Aydın, Kaya, & Erdem, 2026). Cooperative learning models considerably enhanced mathematical problem-solving abilities with a strong overall impact size, according to a recent meta-analysis (C.-H. Chen, Kuo, & Chang, 2026; B. Liu, Zhang, & Wang, 2026). According to systematic reviews, students' analytical thinking, peer interaction, and mathematical reasoning skills are improved by cooperative models like Think Pair Share (TPS), Student Teams Achievement Divisions (STAD), Group Investigation (GI), and collaborative problem-solving techniques (Harrell & Capco, 2021).

Cooperative learning environments may improve students' attitudes toward mathematics in addition to providing cognitive advantages (Rakha, 2025). In addition to lowering arithmetic fear, collaborative classroom interactions can boost motivation, confidence, and engagement (Polydoros, Antoniou, & Polydoros, 2026). Compared to pupils using traditional teaching approaches, students engaged in cooperative learning activities frequently exhibit greater classroom participation and more positive impressions of mathematics learning (Al Alawi et al., 2026).

The CUPs Learning Model

The Conceptual Understanding Procedures (CUPs) learning model is one cooperative constructivist method that has gained popularity in maths education (Köroğlu & Yıldız, 2026). Through organised group discussions, cooperative thinking, and engaged student engagement, the CUPs model places a strong emphasis on conceptual knowledge (Garrido & Couso, 2025). Under this methodology, students discuss mathematical ideas, analyse problems, share solutions, and collaborate in diverse small groups (Ssali et al., 2025). The teacher's main role is to facilitate students' autonomous and group knowledge construction (Bhardwaj, Zhang, Tan, & Pandey, 2025).

Constructivist learning theory, which contends that meaningful learning happens when students actively construct knowledge via interaction and reflection, forms the theoretical basis of the CUPs model (Pallavicini & Anesa, 2026). Students are encouraged to express their thought processes and weigh potential answers through group discussions and problem-solving exercises (Karousiou, Evagorou, & Vrikki, 2026). Students' conceptual knowledge and methodical problem-solving skills may both be strengthened by such exercises (Ssali et al., 2025).

Despite the fact that cooperative learning has been extensively researched, there is still a dearth of empirical studies that particularly look at the efficacy of the CUPs learning model in secondary mathematics teaching (Fitzpatrick & Leavy, 2026). Studies that have already been done typically concentrate on more general cooperative learning strategies rather than the particular mechanisms and instructional features of the CUPs model (Visser, Tijsma, & Zweekhorst, 2026). Furthermore, the majority of prior research has focused on cognitive outcomes, with fewer studies concurrently examining affective outcomes like students' attitudes about learning mathematics (B. Liu et al., 2026).

Research Gap and Contribution

According to recent research, cooperative and collaborative learning strategies can greatly enhance students' capacity to solve mathematical problems (Ssali et al., 2025). Nevertheless, there are still a number of gaps in the body of current literature (Widdowson, Rochester, Barbour, & Hullinger, 2020). First, there is still a dearth of empirical data on the application of the CUPs learning paradigm in junior high school math classes, especially in developing nations (da Costa, Picharillo, & Elias, n.d.). Second, very few studies look at students' attitudes toward mathematics and their ability to solve mathematical problems at the same time in a single intervention (Ssali et al., 2025). Third, prior research frequently focuses on broad cooperative learning models without particularly examining how the CUPs framework's organised conceptual discussion aids in students' development of problem-solving skills (Ssali et al., 2025).

Thus, by investigating the efficacy of the CUPs learning model in enhancing junior high school students' mathematical problem-solving skills and attitudes toward mathematics, this study adds to the body of literature. This study offers more empirical data about the potential of the CUPs learning model to enhance mathematics learning in secondary education contexts by including cognitive and affective outcomes within a cooperative constructivist framework (Köroğlu & Yıldız, 2026).

METHODOLOGY

Research Design

This study used a pretest–posttest control group design and a quasi-experimental research design (Asadova, 2026). The purpose of the study was to determine how well the CUPs learning model improved students' attitudes toward mathematics and their capacity to solve mathematical problems (Getenet, 2026). The study included two groups: a control group that received traditional discussion-based education, and an experimental group that received instruction utilising the CUPs learning model (W. Yang, Acuto, Zhou, & Wojtczak, 2026). The research design is presented in Table 1.

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Control	O_1	X_2	O_2

Note: O_1 = Pretest, O_2 = Posttest, X_1 = CUPs model, X_2 = Conventional discussion method.

Since the study was carried out in naturally occurring classroom settings where complete random assignment of individual students was impractical, the use of a quasi-experimental approach was deemed appropriate (Pham Nguyen Hong, Nguyen Thi Ha, Nguyen, Nguyen Thuy Phuong, & Trinh Thi Phuong, 2026).

Participants and the Sampling Procedure

During the first semester of the school year, seventh-grade students from SMP Negeri 11 Kota Jambi participated in the study. Based on school records and math achievement statistics, the group comprised six seventh-grade classes with comparatively similar academic characteristics.

The research sample was chosen using cluster random sampling (Zumitzavan, 2026). Out of the six classes that were offered, two were chosen at random. One class was designated as the control group and the other as the experimental group. A total of 69 students made up the sample, with 35 individuals in the experimental group and 34 in the control group.

Despite the small sample size, it was thought to be sufficient for an initial quasi-experimental classroom study and in line with related studies in mathematics education (K.-M. Chen, Jen, & Shang, 2026). Before the intervention, the researchers made sure that all classrooms had similar learning conditions, curriculum material, instructional duration, and teacher characteristics in order to reduce selection bias (Rojo et al., 2024).

Research Instruments

To conduct this study, the research instruments were required. The mathematical problem-solving test and a student's attitude toward mathematics questionnaire were utilized. For the mathematical problem-solving test, the following indicators were taken from George Pólya's problem-solving framework and used to create the mathematical problem-solving test: first, comprehending the issue; second, formulating a solution; third, putting the strategy into practice (Bereczki, Biró, Szitányi, Turzó-Sovák, & Csíkos, 2026); fourth, double-checking the answer. Six essay questions about fraction themes covered in seventh-grade arithmetic made up the test. The test had a maximum possible score of sixty.

An analytical rubric that was modified from problem-solving assessment criteria suggested in mathematics education literature was used for scoring (Lit, Kool, & Drijvers, 2026). Every item was assessed according to the completeness of the solution procedure, procedural appropriateness, and reasoning accuracy.

Validity and Reliability

Two specialists in mathematics education and one seasoned maths instructor evaluated the instruments to determine their content validity. The instruments were assessed by the experts based on: content relevance, instruction clarity, language suitability, and conformity to curriculum requirements and research objectives (Sathya & Alamelu, 2026). Before the instruments were used, changes were made in response to expert input.

Cronbach's alpha coefficient was used to assess the reliability of the attitude questionnaire and mathematics problem-solving test (Hakmi, 2026). An appropriate level of internal consistency dependability was demonstrated by the mathematical problem-solving test's Cronbach's alpha coefficient, which was above 0.70. In a similar vein, the attitude questionnaire showed adequate reliability for gauging students' attitudes toward learning mathematics. These findings show that the instruments were trustworthy enough to be used in the research.

To assess item clarity and instrument quality before the main study, a pilot test was carried out with students who were not part of the research sample (Guinovart-Pedescoll & Palau, 2025). To find unclear items and assess if the exam difficulty level was adequate, item analysis was done.

Research Procedure

During the fractions unit in mathematics education, the research was carried out over a number of instructional meetings.

The CUPs learning model was used to implement learning activities in the experimental group. Students with different levels of mathematical proficiency were divided into small, diverse groups of three. Students worked together to analyse issues, discuss mathematical ideas, suggest solutions, and explain their thinking to classmates during class activities (Ssali et al., 2025). By directing conversations and promoting active engagement, the instructor mostly served as a facilitator.

Conventional discussion-based instruction, which is frequently used in schools, was used to teach mathematics to the control group (Adawiah, Arsyad, Dassa, & Djam’an, 2026). After guiding class discussions and offering examples, the instructor led individual exercises.

Both groups took a pretest before to the intervention to gauge their baseline proficiency in solving mathematical puzzles. A posttest was given to the students to gauge their progress following the intervention session. To assess their opinions on the CUPs learning paradigm, students in the experimental group also filled out an attitude questionnaire.

Ethical Considerations

The ethical guidelines for educational research were followed in the conduct of this study. Before gathering data, the school administration granted permission to carry out the study. Students and their parents or guardians gave their informed consent, and participation in the study was entirely voluntary. Participants were told that their names would be kept private and anonymous and that the information gathered would only be utilised for the study. The study did not reveal any personally identifiable information.

Data Analysis

With the aid of SPSS software, descriptive and inferential statistical methods were used to analyse the gathered data (Barrett, Leech, Gloeckner, & Morgan, 2025). In this study, the descriptive statistics included: analysis of the mean, standard deviation, minimum, maximum, and gain scores. Assumption testing was done before hypothesis testing: The Kolmogorov–Smirnov test was used to determine normality, and Levene's test was used to determine homogeneity of variance (Montero, 2026).

An independent-samples t-test was used on the gain scores to compare the experimental and control groups. At the 0.05 threshold, statistical significance was established.

To assess the practical impact of the CUPs learning model on students' mathematical problem-solving skills, effect size analysis using Cohen's d was advised in addition to statistical significance testing (Karakuyu & Karafil, 2026).

RESULTS AND DISCUSSION

The analysis of the test results data was conducted to test the hypothesis that the mathematical problem-solving ability of junior high school students who used the CUPs learning model was better than that of those who used the discussion method. Before conducting the hypothesis testing, the normality and homogeneity of the data were analyzed, both from the control group and the experimental group (Hadi et al., 2026). The data analyzed were the results of the problem-solving test (score), namely the pretest, posttest, and Gain.

Pretest Data Analysis

The result of the pretest data analysis can be seen in Tables 2 and 3 as follows:

Table 2. The Pretest Score of the Control Group

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Pretest	34	21.00	13.00	34.00	21.5000	5.24693	27.530
Valid N (listwise)	34						

Table 3. The Pretest Score of the Experimental Group

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Pretest	35	16.00	20.00	36.00	26.6000	3.85166	14.835
Valid N (listwise)	35						

As shown in Tables 2 and 3, the mean for the control group was 21.5000 with a standard deviation of 5.24693, and the mean for the experimental group was 26.6000 with a standard deviation of 3.852. While the variance for the control group is 27.530 and the standard deviation (square root of the variance) is 5.247, for the experimental group, the variance is 14.835, and the standard deviation (square root of the variance) is 3.852. The maximum and minimum pretest scores for the control group were 34 and 13, respectively, while for the experimental group, they were 36 and 20, respectively. In addition, the pretest score range for the control group was 21.00, and for the experimental group, 16.

Posttest Data Analysis

The following tables, Table 4 and 5, are the result of posttest data analysis.

Table 4. The Posttest Score of the Control Group

	N	Range	Minimum	Maximum	Sum	Mean		Standard Deviation	Variance
	Statistics						Std. Error	Statistics	
Posttest	34	26	15	41	920	27.06	1.112	6.485	42.057
Valid N (listwise)	34								

Table 5. The Posttest Score of the Experimental Group

	N	Range	Minimum	Maximum	Sum	Mean		Standard Deviation	Variance
	Statistics						Std. Error	Statistics	
Posttest	35	35	27	42	1200	34.29	.599	7.250	52.563
Valid N (listwise)	35								

Based on Tables 4 and 5, the mean score for the control group is 27.06 with a standard error of 1.112, and the mean for the experimental group is 34.29 with a standard error of 0.599. The variance for the control group is 42.057 and the standard deviation is 6.485, while for the experimental group, the variance is 52.563 and the standard deviation is 7.250. While the maximum and minimum post-test scores for the control group were 41 and 15, respectively, for the experimental group, they were 42 and 27. The post-test score range of the control group was 26, and the experimental group was 35.

Gain Analysis

Data was obtained from the difference between the pretest and posttest, test scores for the control and experimental groups. This gain data was analyzed using a two-sample difference test, after first conducting normality and homogeneity tests.

Table 6. Statistical Description of Control Group Gain Score and Experimental Group

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Gain (control)	34	13	0	12	5.56	2.956	8.739
Gain (experiment)	35	11	3	16	7.69	2.518	6.339

Table 6 shows that the mean for the control group was 5.56 with a standard deviation of 2.956, and the mean for the experimental group was 7.69 with a standard deviation of 2.518. The variance for the control group is 8.739, and the standard deviation is 2.956, while for the experimental group, the variance is 6.339 and the standard deviation is 2.518. The maximum and minimum gain scores for the control group were 12 and 0, respectively, while for the experimental group, they were 16 and 3 respectively. While the gain score range for the control group was 13, and for the experimental group was 11.

Table 7. Normality Test of the Gain Score of the Control Group

		Gain (Control)
N		34
Normal Parameters[a,b]	Mean	5.56
	Std. Deviation	2.956
Most Extreme Differences	Absolute	.166
	Positive	.166
	Negative	-.123
Kolmogorov-Smirnov Z		.967
Asymp. Sig. (2-tailed)		.307

Based on Table 7, it can be seen that by taking a significance level (α) of 0.05, the value of sig. 0.307. Thus, Ho is accepted, and it can be concluded that the control group sample comes from a normally distributed population.

Table 8. Normality Test of the Gain Score of the Experimental Group

		Gain (Experiment)
N		35
Normal Parameters[a,b]	Mean	7.69
	Std. Deviation	2.518
Most Extreme Differences	Absolute	.158

	Positive	.158
	Negative	-.086
Kolmogorov-Smirnov Z		.935
Asymp. Sig. (2-tailed)		.347

As shown in Table 8, it can be seen that by taking the significance level (α) of 0.05, the value of sig. 0.347. is with acceptance. It can be concluded that the sample of the experimental group came from a normally distributed population.

Table 9. Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
.260	5	23	.930

Table 9 shows that based on the Levene test, the value of sig. by 0.260. Because 0.260 < 0.05, H_0 was rejected, so that H_1 was accepted. It can be concluded that there is a difference in the variance of the population of the gain score data of the control group and the variance of the population of the gain score data of the experimental group, meaning that the population of the control group and the experimental group come from a population that is not homogeneous.

Table 10. Test of the similarity of the Mean Gain of the Control Group and Experimental Group

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Gain	Equal variances assumed	2.181	.144	-3.886	66	.000	-5.55882	1.43062	-8.41516	-2.70249
	Equal variances not assumed			-3.886	63.244	.000	-5.55882	1.43062	-8.41748	-2.70016

Based on table 10, it can be seen that by taking a significance level () of 0.05, a Sig. (2-tailed) The value of 0.000 is obtained. Because 0.000 > 0.05, H_0 is rejected, so that H_1 is accepted. It can be concluded that there is a difference in the average gain score of the control group and the gain score of the experimental group.

Table 11. Results Test One- Way ANOVA Group Gain Coordination Control and Experimental Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	113.466	10	11.347	1.492	.205
Within Groups	174.917	23	7.605		
Total	288.383	33			

In Table 11 above, the calculated F value is 1.492 with a Sig. = 0.205. This means that H_0 is rejected. So, there is an influence of the CUPs Learning Model on Mathematical Problem-Solving Ability.

Moreover, the results of the student questionnaire show that, in general, students have a positive attitude towards learning activities using the CUPs learning model. Thus, it can be seen from the results of the percentage of student questionnaire results that show a higher positive attitude compared to a negative attitude towards the CUPs learning model, or most students stated that they agreed and strongly agreed with positive statements and disagreed with negative statements; these results are in line with the findings.

Findings indicate that students who learned through the CUPs (Conceptual Understanding Procedures) learning model demonstrated significantly higher mathematical problem-solving ability than those who learned through the conventional discussion method. Although the experimental group had a higher mean pretest score than the control group, the posttest and gain analyses consistently showed greater improvement in students' mathematical problem-solving performance after the implementation of the CUPs learning model. The independent-samples t-test confirmed that the difference in gain scores between the two groups was statistically significant ($p < .001$), suggesting that the learning model contributed positively to students' mathematical problem-solving development.

These findings support the constructivist perspective, which argues that knowledge is actively constructed through learners' interactions with ideas, peers, and learning environments rather than transmitted directly by teachers. According to Jean Piaget, learning occurs through cognitive restructuring when learners experience cognitive conflict and assimilate new knowledge into existing cognitive schemas. Likewise, Lev Vygotsky emphasized that social interaction plays a fundamental role in cognitive development through collaborative learning and scaffolding. The CUPs learning model facilitates these principles by encouraging students to discuss, negotiate, and justify mathematical ideas collaboratively, thereby promoting deeper conceptual understanding and problem-solving competence. This interpretation is consistent with recent reviews emphasizing that collaborative constructivist learning environments significantly improve higher-order mathematical thinking and conceptual understanding (Hiebert, 2007; Hmelo-Silver, Duncan, & Chin, 2007).

The improvement observed in students' mathematical problem-solving ability is also consistent with the theoretical framework proposed by George Pólya, who suggested that effective problem solving requires students to understand problems, devise plans, execute strategies, and evaluate solutions. The CUPs learning process naturally guides students through these stages because learners are encouraged to identify mathematical relationships, discuss alternative strategies, evaluate peers' reasoning, and reflect on the validity of solutions. Such learning activities develop metacognitive awareness, which has been widely recognized as one of the strongest predictors of mathematical problem-solving success (Kholid et al., 2025; Owusu, Arthur, Banson, & Ackon, n.d.; Schoenfeld, 2016).

The relatively higher gain score of the experimental group further indicates that collaborative conceptual learning provides richer opportunities for students to construct mathematical meaning than conventional classroom discussions (Funa, 2026). Unlike teacher-centered discussion methods, the CUPs model requires every student to participate actively in explaining ideas, defending arguments, and evaluating different solution strategies (Xenofontos & Andrews, 2023). This finding aligns with recent meta-analyses demonstrating that collaborative learning significantly improves mathematics achievement and problem-solving performance because students become cognitively engaged in explaining and refining mathematical reasoning rather than merely receiving procedural information (Hattie & Zierer, 2024; Kyndt et al., 2013). Another important finding concerns the positive responses obtained from the student questionnaires. Most students expressed positive attitudes toward learning mathematics through the CUPs learning model (Fitzpatrick & Leavy, 2026). Positive attitudes toward mathematics have consistently been associated with increased motivation, persistence, and willingness to engage in complex mathematical tasks. According to educational psychology research, positive emotions during learning facilitate cognitive engagement, reduce mathematics anxiety, and improve students' self-efficacy, ultimately enhancing mathematical achievement (Z. Zhang, Gao, Wu, & Ren, 2026). The collaborative nature of the CUPs learning model appears to create a supportive learning environment where students feel more confident expressing ideas and making mistakes during problem solving .

The findings are also consistent with recent international studies reporting that student-centered instructional approaches improve mathematical problem-solving ability more effectively than traditional instructional methods (Y. Zhang & Star, 2026). For example, a systematic review conducted by Jo Boaler concluded that classrooms emphasizing collaborative inquiry, conceptual understanding, and mathematical discussion consistently produce higher levels of reasoning and problem-solving ability than classrooms emphasizing procedural practice alone (Boaler & Dieckmann, 2026). Similarly, recent meta-analytic evidence has shown that inquiry-oriented and collaborative mathematics instruction positively affects students' conceptual understanding, mathematical communication, and higher-order thinking skills (Capar & Tarim, 2015).

Nevertheless, one aspect of the statistical analysis deserves careful consideration. The pretest means of the experimental and control groups differed considerably before the intervention (Bauer et al., 2025). This suggests that the two groups were not entirely equivalent at baseline. Consequently, although the gain-score analysis indicates that students receiving the CUPs learning model improved significantly more than those in the control group, future studies should consider applying covariance analysis (ANCOVA) using pretest scores as covariates. ANCOVA is generally recommended because it controls for initial differences between groups and provides a more accurate estimate of the instructional effect (Tabachnick, Fidell, & Ullman, 2007)(Field, 2024) Field. Such an approach would strengthen the internal validity of future investigations.

Overall, the present study provides empirical evidence that the CUPs learning model effectively enhances junior high school students' mathematical problem-solving ability while simultaneously fostering positive learning attitudes (Aregahegn, Atnafu, & Abate, 2026). These findings reinforce the growing international evidence that mathematics instruction emphasizing conceptual understanding, collaboration, and active knowledge construction is more effective than conventional discussion-based instruction in developing higher-order mathematical competencies required in twenty-first-century education.

CONCLUSIONS AND RECOMMENDATIONS

This study demonstrated that the Conceptual Understanding Procedures (CUPs) learning model significantly enhanced students' mathematical problem-solving abilities and fostered positive attitudes toward mathematics. Participants showed improved performance compared to their initial skills, engaging in structured learning stages that promoted conceptual understanding, collaboration, and systematic application of mathematical concepts to real-world problems. The model also increased students' confidence and motivation, creating a supportive environment that reduced anxiety and encouraged meaningful learning. Overall, CUPs proved to be an effective instructional strategy for both cognitive and affective outcomes in mathematics education.

Based on the study's findings, several recommendations are made: Mathematics teachers should integrate the CUPs learning model into their instruction to enhance students' conceptual understanding and problem-solving skills, as well as their confidence in mathematics. Schools are urged to offer continuous professional development for teachers to effectively implement student-centered models like CUPs. Additionally, policymakers should consider incorporating learning models that focus on conceptual understanding and active participation into the curriculum to improve mathematics education quality.

FURTHER STUDY

While the study demonstrates the effectiveness of the CUPs learning model, it has limitations such as a small and specific sample that may limit the generalizability of the findings. Future research should include larger, more diverse samples across various educational contexts and examine the long-term impacts of the model on students' mathematical achievement and critical thinking. Additionally, comparative studies with other instructional methods like Problem-Based Learning and the integration of digital technologies and AI are recommended to enhance students' learning outcomes and engagement.

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