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Cooperative Learning Methods and Algebraic Proficiency: Insights from Secondary School Education

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ABSTRACT

Cooperative learning, a collaborative approach where students work together in small groups to comprehend academic content, has gained recognition as an effective pedagogical method. Algebra, a mathematical discipline employing letters and symbols to represent quantities and figures, often poses challenges for secondary school students. Despite advancements in teaching strategies, Mathematics achievement among students remains a concern. Existing literature suggests that cooperative learning may offer superior results in enhancing students' mathematical performance compared to traditional methods. This study aims to assess the influence of cooperative learning on students' proficiency in comprehending algebraic expressions. Employing a quantitative approach, data was gathered through a questionnaire. 68 samples of secondary students in Kelantan, Malaysia were obtained and analysed using SPSS. The results demonstrate a positive impact of cooperative learning on the secondary students' achievement in understanding algebraic expressions.

Keywords: *algebraic expression, cooperative learning, mathematics achievement, secondary school students*

INTRODUCTION

Mathematics education is a cornerstone of academic development, playing a pivotal role in shaping a student's cognitive abilities and problem-solving skills. Within this sphere, the efficacy of instructional methods, particularly in comprehending complex algebraic expressions, has garnered significant attention. Among these methods, cooperative learning has emerged as a dynamic pedagogical approach, harnessing the power of collaborative efforts among students.

Cooperative learning transcends conventional teaching paradigms by fostering an interactive environment where students actively engage with their peers. It encourages them to seek mutual understanding and collectively tackle mathematical challenges. This approach reinforces comprehension and stimulates a deeper appreciation for the subject matter.
The investigation delved into the multifaceted impact of cooperative learning on students' achievement in understanding algebraic expressions. Through an in-depth exploration of pertinent studies and

empirical evidence, the researchers endeavoured to elucidate the manifold implications and benefits of cooperative learning for Mathematics education.

The inquiry encompassed diverse dimensions, ranging from students' perceptions of the cooperative learning effectiveness to its tangible influence on academic performance, particularly in the algebraic expression domain. Additionally, the researchers scrutinised the role of gender in cooperative learning, discerning whether it influenced the method's efficacy.

By unpacking those critical aspects, the study sought to provide an understanding of the dynamic interplay between cooperative learning and the mastery of algebraic concepts. The exploration did not only amplify the theoretical underpinnings of Mathematics education but also furnished practical insights for educators and policymakers striving to optimise pedagogical approaches.

The study aimed to contribute to the ongoing discourse surrounding effective teaching strategies in Mathematics education via the investigation. By shedding light on the potential of cooperative learning, the study attempted to equip educators with valuable tools to cultivate a more inclusive, interactive, and intellectually stimulating learning environment. In doing so, the researchers aspire to empower students of mathematical proficiency and academic excellence.

LITERATURE REVIEW

Cooperative learning involves a collaborative technique within small groups of students working together to enhance mutual understanding. Sharan (1980) advocated it as a more effective educational approach than traditional methods, emphasising positive peer relationships and attitudes towards learning. This method is particularly beneficial for comprehending algebraic expressions and utilising variables, constants and operational symbols (Daud et al., 2019). It is applied not only in elementary and secondary schools, but also in colleges (Turgut & Turgut, 2018). By forming diverse and cohesive groups, cooperative learning aligns with cognitive theories, emphasising active information process and peer interaction (Yassin et al., 2018). It supports the constructivist perspective that knowledge is constructed via active engagement with others and the environment, reinforcing the idea that cooperative learning aids in meaning construction.

Previous research consistently demonstrates cooperative learning's positive impact on students' mathematical achievement. For instance, Yaduvanshi and Singh (2019) study shows that students utilising the structured cooperative learning strategy (STAD) technique in cooperative learning achieve higher mean scores compared to conventional methods. This approach, involving group discussions, fosters active engagement and improves information processing. Moreover, students actively participating in cooperative groups tend to be more motivated and achieve higher academic performance, underscoring the benefits of this method.

Cooperative learning also encourages competitiveness and collaboration, leading to increased activity and creativity in the learning process, ultimately influencing students' academic performance in Mathematics. A study by Abd Algani and Abu Alhaija (2021) highlights that cooperative learning significantly contributes to enhanced understanding of mathematical concepts, leading to improved problem-solving fluency, flexibility, and creative thinking skills. The findings by Yemi et al. (2018) echoed these results, indicating that cooperative learning strategies instigate heightened Mathematics achievement, interest in the subject, understanding, and self-confidence. Collectively, these outcomes affirm the positive effects of cooperative learning on students' academic performance in Mathematics.

The teaching of algebra conventionally involves symbolic variables usage such as x and y, integral components of classroom instruction. Adnan et al. (2021) emphasises that algebra employs letters and symbols to represent numerical values and quantities. The algebraic symbolism is a culturally evolved system of representation that facilitates specific cognitive processes (Radford, 2018). The Trends in

International Mathematics and Science Study (TIMSS), administered by the International Association for the Evaluation of Educational Achievement (IEA), accentuates a significant performance gap between Malaysian and Singaporean students, particularly in the domain of algebra (Adnan et al., 2021). Despite some progress since the TIMSS 2011 assessment, Malaysia still trails behind academically, ranking 22nd with 465 points in Mathematics compared to Singapore's more advanced standing. Notably, the 2019 Sijil Pelajaran Malaysia (SPM) examination heavily featured questions centred on algebraic expressions, emphasising the pivotal role of this domain in arriving at accurate final answers. Hence, it is imperative to examine student proficiency and stumbling blocks associated with algebraic concepts via cooperative learning methodology implementation in the classroom. Algebra, being a fundamental component of mathematical learning, retains its crucial position in school curricula (Bal, 2016). However, many students encounter challenges in algebraic concepts, warranting further study and intervention (Adnan et al., 2021). The cooperative learning method emerges as a pivotal strategy to address these difficulties, allowing students to collaborate and develop essential skills collectively (Altun, 2015).

In conclusion, cooperative learning is a valuable tool to enhance students' understanding of algebraic expressions and improve overall mathematical proficiency. This collaborative approach, rooted in cognitive and constructivist theories, fosters active engagement and meaningful learning experiences. It holds immense potential for positively influencing students' academic performance in Mathematics.

RESEARCH OBJECTIVES

The study attempts to achieve the following research objectives:

1. To investigate students' perceptions on the impact of cooperative learning on their achievement in comprehending algebraic expressions (RO1)
2. To determine a significant difference in the mean scores of students' achievement in understanding algebraic expressions between those engaged in cooperative learning versus traditional learning settings (RO2)
3. To ascertain a significant difference in the mean scores of students' achievement in understanding algebraic expressions based on gender (RO3)

RESEARCH METHODOLOGY

This study employs a descriptive survey research design, utilizing a questionnaire as the primary instrument for data collection. This method allows for the efficient gathering of perspectives from students on the study topic due to its ease of administration and widespread applicability characteristics.

Using a simple random sampling technique, a population of approximately 100 Form Two students in Ketereh, Kelantan were identified to participate in the study. However, only 68 samples were eventually selected, due to limitations elaborated later in the study. The samples were evenly divided into two groups: 34 respondents for the cooperative learning group and 34 for the traditional learning group.

The sample size is calculated based on a 95% confidence level with a margin of error set at 5%. Consequently, for a population of 100, the recommended sample size is 80. However, due to the limitations inherent in the study, it is crucial to consider the study insights. Obtaining complete responses from Form Two students posed a primary challenge, as some respondents might not have fully answered the questions on algebraic expressions. Time constraints further complicated data collection across multiple classes, requiring three days to distribute and collect questionnaires. Additionally, the challenges in controlling student access and cheating impact data integrity. Acknowledging these limitations is essential in interpreting the results of the study.

The questionnaire utilised in the study was structured into three sections (A, B, and C). Section A gathered demographic information such as name, gender, and preferred learning method. Section B

consisted of 12 items aiming to gauge students' views on the effects of cooperative learning on their achievement in comprehending algebraic expressions. Responses were recorded on a 5-point Likert scale. Finally, Section C comprised of 10 items requiring students to solve algebraic expression questions. The questionnaire was adopted and adapted from previous research by Valencerina (2014) and Chow (2011).

Reliability and validity are the factors in assessing research quality, signifying how well a method or test captures a phenomenon. Reliability relates to consistency measurement, validity concerns with accuracy. These aspects are vital in designing, executing, and presenting results in quantitative research. The instrument in the study exhibits high internal consistency, with a Cronbach's alpha value of 0.889 (above the 0.70 threshold), affirming their validity in evaluating students' perceptions of cooperative learning impact on understanding algebraic expressions.

RESULTS

The study aims to assess the impact of cooperative learning on the academic performance of Form Two students in understanding algebraic expressions. The results section presents and discusses the results of data analysis in the attempts to achieve research objective 1 to 3. Statistical Package for the Social Sciences (SPSS) was utilised to analyse data. Descriptive statistics particularly frequency, percentages, mean and standard deviation were employed to realize research objective 1 and 2. Meanwhile, independent t-tests were used for data analysis to accomplish research objective 3.

Section A: Demographic Information

The section commences with an overview of respondents' demographic background. Subsequently, it delves into the analysis of students' perceptions regarding the effects of cooperative learning on their achievement in understanding algebraic expressions. Then, comparisons of mean scores between cooperative and traditional learning methods, including mean scores based on gender are presented.

Table 1: Demographic of Respondent by Gender

Gender	Frequency	Percentages (%)
Male	23	33.8
Female	45	66.2
Total	68	100.0

Table 2: Demographic of Respondent by Method of Learning

Method of Learning	Frequency	Percentages (%)
Cooperative Learning	34	50
Traditional Learning	34	50
Total	68	100.0

Table 1 illustrates gender distribution among the respondents, whereby 23 (33.8%) are male, and 45 (66.2%) are female. Meanwhile, Table 2 depicts the distribution of students' learning methods, whereby 34 (50%) utilized cooperative learning, and 34 (50%) employed traditional learning.

Section B: Results for Research Objective 1

1. **Students' perceptions on the impact of cooperative learning on their achievement in comprehending algebraic expressions (RO1)**

Table 3: Descriptive Analysis in Frequency and Percentages for Items in Section B

No	Items	Scale	Frequency	Percentages (%)
1	Cooperative learning enables me to get good results in Mathematics	Strongly Disagree	2	2.9
		Disagree	2	2.9
		Neutral	15	22.1
		Agree	20	29.4
		Strongly Agree	29	29.4
2	Cooperative learning enables me to get ready to study for a Mathematics test	Strongly Disagree	1	1.5
		Disagree	4	5.9
		Neutral	8	11.8
		Agree	32	47.1
		Strongly Agree	23	33.8
3	Cooperative learning helps me to better understand the topic to be discussed in class	Disagree	2	2.9
		Neutral	14	20.6
		Agree	33	48.5
		Strongly Agree	19	27.9
4	Cooperative learning makes me believe that I can perform well in school	Strongly Disagree	2	2.9
		Disagree	8	8.8
		Neutral	19	27.9
		Agree	28	41.2
		Strongly Agree	13	19.1
5	Cooperative learning helps me to improve the transfer of information from one idea to another	Strongly Disagree	1	1.5
		Disagree	2	2.9
		Neutral	21	30.9
		Agree	26	38.2
		Strongly Agree	18	26.5
6	Cooperative learning enables me to develop skills	Strongly Disagree	1	1.5
		Disagree	4	5.9
		Neutral	11	16.2
		Agree	31	45.6
		Strongly Agree	21	30.9
7	Cooperative learning makes me like working in a group in Mathematics class	Strongly Disagree	2	2.9
		Disagree	2	2.9
		Neutral	10	14.7
		Agree	23	33.8
		Strongly Agree	31	45.6
8	Cooperative learning contributes to spark a solution and an answer without shame	Disagree	5	7.4
		Neutral	20	29.4
		Agree	22	32.4
		Strongly Agree	21	30.9
9	Cooperative learning helps me to finish the task on time	Strongly Disagree	3	4.4
		Disagree	2	2.9
		Neutral	23	33.8
		Agree	28	41.2
		Strongly Agree	12	17.6
10	Cooperative learning makes me confident and know how to handle difficulties in Mathematics	Disagree	3	4.4
		Neutral	13	19.1
		Agree	30	44.1
		Strongly Agree	22	32.4
11	Cooperative learning encourages me to find additional solutions to the same arithmetic problem	Strongly Disagree	2	2.9
		Disagree	1	1.5
		Neutral	22	32.4
		Agree	35	51.5
		Strongly Agree	8	11.8
12	Cooperative learning enables me to ask friends from the group to explain part of the tasks that are unclear	Strongly Disagree	1	1.5
		Neutral	4	5.9
		Agree	26	38.2
		Strongly Agree	37	54.4

The study conducted descriptive analysis to gauge students' perceptions of cooperative learning's impact on their understanding of algebraic expression as research objective 1. The results from twelve items of Section B are tabulated in Table 3.

Overall, the majority of respondents expressed positive views towards cooperative learning.

1. Cooperative learning was perceived as beneficial to achieve good results in Mathematics by 29.4% of the respondents.
2. 80.9% of the respondents either agreed or strongly agreed that cooperative learning was helpful in their readiness for Mathematics tests.
3. Cooperative learning was considered instrumental to better understand class topics, with 76.4% of respondents expressing agreement.
4. For overall school performance, 60.3% of respondents believed cooperative learning was effective.
5. Cooperative learning was viewed favourably by 64.7% of respondents to improve information transfer between concepts.
6. Skill development was identified as cooperative learning benefit by 76.5% of the respondents.
7. Cooperative learning was positively associated with liking group work in Mathematics class for 79.4% of the respondents.
8. Majority (63.3%) agreed that cooperative learning facilitated solution proposal without hesitation.
9. Cooperative learning was observed to aid in timely task completion by 58.8% of the respondents.
10. It was believed that cooperative learning instilled confidence and problem-solving skills in Mathematics for 76.5% of the respondents.
11. Encouraging alternative solution to arithmetic problems was remarked as cooperative learning strength by 83.0% of the respondents.
12. Cooperative learning was deemed effective in seeking clarification from group members by 92.6% of the respondents.

In summary, the results highlight a positive perception of cooperative learning's impact on various aspects of Mathematics learning and performance among the respondents.

Table 4: Summary of Results for Items in Section B

No	Items	N	Mean	Standard Deviation
1	Cooperative learning enables me to get good results in Mathematics	68	4.06	1.020
2	Cooperative learning enables me to get ready to study for a Mathematics test	68	4.06	.912
3	Cooperative learning helps me to better understand the topic to be discussed in class	68	4.01	.782
4	Cooperative learning makes me believe that I can perform well in school	68	3.65	.989
5	Cooperative learning helps me to improve the transfer of information from one idea to another	68	3.85	.902
6	Cooperative learning enables me to develop skills	68	3.99	.922
7	Cooperative learning makes me like working in a group in Mathematics class	68	4.16	.987
8	Cooperative learning contributes to spark a solution and an answer without shame	68	3.87	.945
9	Cooperative learning helps me to finish the task on time	68	3.65	.958
10	Cooperative learning makes me confident and know how to handle difficulties in Mathematics	68	4.04	.836
11	Cooperative learning encourages me to find additional solutions to the same arithmetic problem	68	3.68	.818

12	Cooperative learning enables me to ask friends from the group to explain part of the tasks that are unclear	68	4.44	.741

Table 4 depicts the summary of results in mean and standard deviation for research question 1 which explores students' perception about the impact of cooperative learning on their achievement in understanding algebraic expressions. The results were obtained from descriptive statistical analysis conducted on students' responses to items 1 until 12 in Section B.

Notably, the highest mean score on students' perception during cooperative learning was observed for item 12 which is the ability to seek clarification from group members with regard unclear tasks at 4.44 (*SD*=0.741). In contrast, the lowest mean is 3.65(*SD*=0.989, SD=0.958 respectively) for item 4 which is students' belief in their ability to perform well in school due to cooperative learning and item 9 which is their confidence in handling difficulties in Mathematics.

2. Mean scores of students' achievement in understanding algebraic expressions between cooperative learning versus traditional learning (RO2)

Table 5: The Results of T-test Analysis on the Methods of Learning from Section C

Method of Learning	N	Mean	Standard Deviation	Standard Error Mean	t	df	Sig (2-tailed)
Cooperative Learning	34	7.65	1.228	0.211	11.946	66	.000
Traditional Learning	34	3.12	1.838	0.315	11.946	57.560	.000

Table 5 illustrates the results obtained from T-test analysis for solving algebraic expressions via cooperative learning and traditional learning methods. It was administered to determine whether there is significance performance differential between the two methods from the respondents' perspective.

On average, the mean score for cooperative learning is 7.655 (*SD* = 1.228), whereas traditional learning is 3.12 (*SD* = 1.838). These results suggest that cooperative learning yields superior results compared to traditional learning in the context of algebraic expression problem-solving. The result of T-test analysis indicates a noteworthy difference with $t(58) = 11.946$, $p<0.05$. Consequently, the null hypothesis is rejected in favour of the alternative hypothesis. Thus, there is significant distinction in the mean scores of cooperative learning and traditional learning pertaining to students' achievement in understanding algebraic expressions among Form Two students.

Table 6: Group Statistics on Gender

Method of Learning	Gender	N	Mean	Standard Deviation	Standard Error Mean
Cooperative Learning	Male	11	7.73	1.104	.333
	Female	23	7.61	1.305	.272
Traditional Learning	Male	12	2.25	1.765	.509
	Female	22	3.59	1.736	.370

Table 6 presents mean perception rating by gender in solving algebraic expressions through cooperative or traditional learning. The mean scores for male and female students in cooperative learning were 7.73 (*SD*=1.104) and 7.61 (*SD*=1.305), respectively. The results indicates that male students believed they performed slightly better in solving algebraic expressions through cooperative learning than the female students. Meanwhile, the mean scores for male and female students in traditional learning were 2.25 (*SD* = 1.765) and 3.59 (*SD* = 1.736), respectively. Hence, the results suggest that female students have higher proficiency than male students in solving algebraic expressions through traditional learning.

3. Mean score of students' achievement in understanding algebraic expressions based on gender (RO3)

Table 8: The Results of T-test Analysis on Gender

Gender	N	Mean	Standard Deviation	Standard Error Mean	t	df	Sig (2-tailed)
Male	23	4.87	3.152	.657	-1.097	66	.276
Female	45	5.64	2.533	.378	-1.022	36.907	.313

Table 8 displays the results from T-test analysis on gender in solving algebraic expressions among Form Two students. Overall, mean scores attained by male and female students are 4.87 (*SD* = 3.152) and 5.64 (*SD* = 2.533), respectively. The results indicate no significant difference in the mean scores of students' achievement in comprehending algebraic expressions between male and female students with $t(66) = -1.097$, $p > 0.05$. Consequently, the null hypothesis is accepted. It implies that both groups experience similar effects of cooperative learning on their achievement in understanding algebraic expressions.

DISCUSSION

The questionnaire, which includes 12 statements measured on a Likert scale ranging from "strongly disagree" to "strongly agree," was utilized to gauge students' perceptions regarding the impact of cooperative learning on their achievement in understanding algebraic expressions. The results highlight a noteworthy result, particularly on item 12, "students able to ask friends from the group to explain part of the tasks that are unclear." It indicates that students seek clarification from their peers during cooperative learning, contributing to a more comprehensive learning experience.

Apart from that, the results demonstrate a significant difference in the mean scores of students' achievement in understanding algebraic expressions between those engaged in cooperative versus traditional learning settings. It suggests that consistent participation in cooperative learning enhances students' proficiency in the subject compared to traditional methods, particularly in solving algebraic expression questions. The outcome aligns with Valencerina (2014) that there is a significant impact of cooperative learning methods on students' achievements in Mathematics than traditional methods.

The results also reveal a significant distinction in the mean scores of gender-based perception on achievement in understanding algebraic expressions. The data signifies a reversal in performance, with female students demonstrate a superior understanding of algebraic expressions in the traditional learning setting than their male counterparts. The result resonates with Ercikan et al. (2005)'s findings, who conducted research across Canada, the United States, and Norway. It was discovered that the prediction accuracies for Mathematics participation were higher for females than males, similar with the outcomes observed in the present study.

CONCLUSION

In conclusion, current study supports the notion that cooperative learning in Mathematics education is crucial in enhancing students' understanding of algebraic expressions. It demonstrates that cooperative learning is a valuable platform for students to seek clarification from peers, leading to heightened comprehension and increased engagement in the classroom. Furthermore, cooperative learning is superior to traditional methods for students comprehending algebraic expressions, especially during examinations, emphasising its significance in achieving higher Mathematics proficiency.

Moreover, the study indicates that gender does not significantly influence the effectiveness of cooperative learning, affirming its universal applicability. Henceforth, it is imperative to prioritise comprehensive training programmes for educators, equipping them with the necessary skills to

implement cooperative teaching strategies. It will ensure a seamless integration of cooperative learning in biology classes, ultimately resulting in more effective Mathematics education.

Exposing students to diverse student-centred approaches, including cooperative problem-solving and real-life problem-solving activities, has shown promise in enhancing interest and achievement in Mathematics. Tailoring instructional methods to accommodate different topics, individual interests, and learning preferences is a promising avenue for further exploration.

In moving forward, it is paramount to delve into students' motivation in various subjects and develop strategies to alleviate test anxiety. Future studies can pave the way to create a more conducive learning environment in Mathematics and other critical subjects such as physics, biology, chemistry, and social sciences.

In summary, cooperative learning is a powerful tool in Mathematics education, holding immense potential for enriching students' comprehension and proficiency in algebraic expressions. The insights from these studies provide a robust foundation for furthering the effectiveness and application of cooperative learning strategies in the classroom, ultimately benefiting educators and students alike.

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Che Aziz, N. and Mohamed Nadzri, A. Z. conceived and planned the experiments and also carried out the experiments and carried out the simulations. Othman, Z. S. contributed to the interpretation of the results and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

CONFLICT OF INTEREST DECLARATION

I/We certify that the article is the Authors' and Co-Authors' original work. The article has not received prior publication and is not under consideration for publication elsewhere. This research/manuscript has not been submitted for publication nor has it been published in whole or in part elsewhere. We testify to the fact that all Authors have contributed significantly to the work, validity and legitimacy of the data and its interpretation for submission to Jurnal Intelek.

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