Unraveling Algebraic Understanding: A Comprehensive Analysis of Secondary School Students' Performance

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ABSTRACT

Algebraic expressions are a foundational component of the secondary mathematics curriculum, yet many students struggle to master the topic, especially with tasks involving symbol manipulation, equation solving, and translating real-world problems. This study investigates the specific difficulties faced by Form Two students, a group at a critical stage in early algebra instruction, in understanding and applying algebraic expressions. A diagnostic test comprising 15 questions was administered to 55 students from a suburban school in Perak, all of whom were taught by the same mathematics teacher to ensure instructional consistency. Using a quantitative approach, the study employed descriptive statistics, correlation analysis, and the Revised Bloom's Taxonomy to evaluate performance across cognitive levels. The findings revealed significant deficiencies in students' conceptual understanding and procedural fluency, as evidenced by recurring errors and misconceptions in their responses. The most common mistakes included misinterpreting algebraic symbols, incorrectly applying arithmetic operations, and failing to translate word problems into mathematical expressions. Notably, there were gender-based differences in performance and variations in students' reported weekly study hours. These insights underscore the need for differentiated instructional strategies and targeted interventions to strengthen algebraic thinking. The study contributes to the broader discourse on mathematics education by identifying specific areas for pedagogical improvement at the lower secondary level.

Keywords: Algebraic expression, Bloom's Taxonomy, Secondary School Students' Performance.

INTRODUCTION

Algebraic expression is a key topic in secondary mathematics that forms the foundation for more advanced mathematical concepts. Students are expected to develop the ability to interpret, manipulate, and solve expressions involving variables. However, despite its central role in the curriculum, many students struggle to grasp the abstract nature of algebraic expressions, leading to low achievement and increased mathematics anxiety (Ziyyara, 2019). Even with the integration of innovative teaching strategies, a substantial proportion of students struggle to grasp basic algebraic concepts (Aziz et al., 2024). These difficulties are especially apparent in students' handling of algebraic expressions—an area where understanding is both fundamental and often fragile.

In Malaysia, Form Two students in secondary schools are introduced to algebraic expressions as part of the standard national curriculum. They are required to develop skills in expressing equations in terms of variables, determining unknown values, constructing formulas from real-life contexts, and solving basic algebraic problems. However, previous studies (Nasir et al., 2013; Aziz et al., 2024) revealed that many students continue to struggle with symbolic representation and equation solving due to shallow conceptual understanding. As algebra is a major focus in the mathematics curriculum, fostering a deeper conceptual understanding has become the main goal in mathematics education (Sugiarti & Retnawati, 2019). Misconceptions in algebra often arise from inadequate conceptual understanding. Frameworks such as Bloom's Taxonomy help educators categorize learning objectives and cognitive skills, guiding curriculum design and instruction. Recent studies have applied

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this model to analyze students' problem-solving abilities (Orhani, 2024; Samsudi et al., 2024), emphasizing the need to align algebra instruction with students' stages of cognitive development (Kuloglu et al., 2024).

This study investigates the performance and understanding of Form Two students in algebraic expressions. Using a quantitative approach and a diagnostic test based on Revised Bloom's Taxonomy, the research examines students' achievement across cognitive levels ranging from basic recall to application. The study also examines demographic factors such as gender and weekly study hours to identify patterns and correlations that may affect student performance. The findings offer valuable insights into common misconceptions, error patterns, and weaknesses in understanding algebraic expressions. These insights can help develop targeted instructional strategies and interventions to improve teaching and student learning in mathematics classrooms. While many studies highlight challenges with algebra, few provide a diagnostic breakdown of specific misconceptions among Form Two students in Malaysian classrooms. This study addresses this gap by analyzing performance across subtopics and cognitive levels using Bloom's Taxonomy.

RESEARCH METHODOLOGY

This study adopted a quantitative research design to assess Form Two students' understanding of algebraic expressions. Data were collected through a structured test designed to measure students' achievement, conceptual understanding, and common errors, and a brief questionnaire to collect demographic information. The sample consisted of 55 Form Two students from three intact classes in a suburban secondary school in Perak. The classification of the school as suburban is important for contextualizing the findings and understanding their potential generalizability. All students were taught by the same mathematics teacher, ensuring consistency in instructional delivery. Cluster sampling was employed for its cost-effectiveness and practicality in selecting classroom-based groups.

The primary assessment tool was a structured test developed by the researchers, with items adapted from the Form Two Mathematics textbook. The test consisted of 15 subjective questions. Student performance was interpreted using the following grading scale: A (13–15 marks), B (10–12 marks), C (7–9 marks), D (4–6 marks), and E (0–3 marks). The test was divided into two sections: Section A focused on demographic information (gender, weekly mathematics study hours, and midterm mathematics grade), while Section B comprised 15 questions addressing various subtopics within algebraic expressions.

The questions, organized according to Revised Bloom's Taxonomy, encompass formulating formulas, expressing equations in terms of variables, determining variable values, and solving problems. Table 1 provides a breakdown of subtopics and item distribution in the test, aligned with cognitive levels based on the Revised Bloom's Taxonomy, as shown in Table 2.

Table 1: Algebraic Expression Subtopics and Test Items Distribution

Subtopics	Question Number	Total Questions	Sample Question
Express variable equation	Q1-Q4	4	Express m as variable equation. z=m-qp
Determine the value of variable	Q5-Q8	4	Find the value of x if 3a=9b-4, when b=1.
Form a formula based on situation	Q9-Q14	6	Create a formula for the area of a rectangle using length and width.
Solve problems involving equation	Q15	1	Solve: 3x-5=2x+7

Table 2: Revised Bloom's Taxonomy Levels and Test Items Distribution

Level	Question Number	Total Questions
Remembering	Q1-Q8	8
Understanding	Q9-Q11	3
Application	Q12-Q15	4

The test was conducted separately for all three classes on the same day, in accordance with the teacher's schedule. Students were allowed to use calculators and seek assistance from the invigilators. The test duration was 60 minutes, and all answer scripts were collected at the end of the test. The test was validated by researchers to ensure that the content aligns with the national curriculum. The validity of the instrument was assessed using Cronbach's alpha, yielding a reliability coefficient of 0.920 for the entire scale or construct, indicating high reliability.

To ensure the architectural integrity of the Test of Students' Understanding Algebraic Expression (SUAET), the 15 subjective items were strictly aligned with the Form Two Mathematics curriculum standards outlined by the Malaysian Ministry of Education. Content validity was established via an expert mapping panel consisting of the researchers and secondary mathematics educators, cross-referring each test item against the targeted algebraic subtopics and cognitive demands. Items Q1 to Q8 were engineered to map exclusively onto the remembering cognitive domain by requiring direct factual recall of operational rules and variable definitions. Items Q9 to Q11 advanced to the Understanding level, requiring students to interpret word problems into standalone algebraic concepts. Finally, items Q12 to Q15 targeted the application phase, challenging students to manipulate multi-step equations to solve situational mathematical problems. This systematic matrix ensured that the instrument possessed high content-to-curriculum alignment alongside its high internal consistency reliability.

This study had several limitations. First, the findings are based on a relatively small sample from a single suburban school, which may limit generalizability to urban or rural contexts. Second, as the test was not part of a formal examination, some students may have lacked motivation or seriousness, potentially impacting their performance. Third, the study relied solely on a single test instrument, which may restrict the depth of analysis regarding students' algebraic comprehension. Finally, while students reported the number of study hours per week, this does not account for the quality or strategy of their study behaviors. Future studies may benefit from incorporating qualitative methods to explore learning behaviors in greater depth.

FINDINGS AND DISCUSSIONS

This section presents an in-depth analysis of the collected data to investigate students' performance with algebraic expressions. Data were analyzed using the Statistical Package for the Social Sciences (SPSS), employing descriptive statistics, correlation analyses, and independent-samples t-tests.

Section A: Student Background and Academic Information

This section presents background information about the 55 participating Form Two students, including how often they study mathematics each week and their recent midterm grades.

Table 3: Gender of the Respondents

Gender	Frequency	Percentage (%)
Male	29	52.7

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Female	26	47.3
Total	55	100.0

Table 3 displays the gender distribution of the 55 respondents, comprising 52.7% male and 47.3% female students.

Table 4 summarizes the time students devoted to studying mathematics per week. More than half of the respondents (54.5%) reported studying 2–3 hours per week. Meanwhile, 21.8% studied for 1–2 hours, 12.7% for 4–5 hours, 3.6% reported daily study, and 7.3% stated that they never studied mathematics outside of class time.

As the data were collected using categorical time intervals, mean values for each group are not reported. Future research is encouraged to collect actual numerical data on study hours to enable more precise quantitative analysis.

Table 4: Reported Study Hours per Week in Mathematics

	Frequency	**Percentage (%)**	**Estimated Midpoint (Hours)**
Everyday	2	3.6	6.0 (approximate)
4-5 hours	7	12.7	4.5
2-3 hours	30	54.5	2.5
1-2 hours	12	21.8	1.5
Never	4	7.3	0
Total	55	100.0	-

Table 5: Mathematics Grade in Midterm Examination

Grade	**Frequency or Observed N**	**Percentage**
A	1	1.8
B	1	1.8
C	1	1.8
D	9	16.4
E	43	78.2
Total	55	100.0

Table 5 presents the grades obtained in Mathematics on the midterm examination, including observed frequencies, percentages, expected frequencies, and residuals for each grade category. The data show that the majority (78.2%) received a Grade E, indicating widespread performance issues. Only one student earned grades A, B, and C, respectively. In contrast, Grade D is at 16.4%.

The examination of Section A revealed insightful trends and patterns related to students' demographic information, study habits, and midterm examination grades. The gender-based analysis demonstrated a significant difference in mean scores. The results show that females exhibited a higher average performance on the SUAET than males, suggesting a potential gender-related discrepancy in the understanding of algebraic expressions. Meanwhile, study habits, as outlined in Table 4, showcase diverse approaches, emphasizing the need for tailored instructional strategies. The prevalence of Grade E in midterm examination grades in Table 5 indicates challenges in students' academic performance, with notable disparities in Grades A, B, and C.

The collective findings prompt reflections on potential correlations between study habits, gender, and academic performance in algebraic expression. The observed variations underscore the need for targeted interventions and instructional approaches reflecting the demographic and behavioral factors. The insights lay the groundwork for a more in-depth exploration of the themes in subsequent sections.

Section B: Analysis of Student Performance in Understanding Algebraic Expression

Section B assessed students' understanding of algebraic expressions by administering 15 test questions. The questions were designed to gauge their comprehension of the algebraic expression subtopics. SUAET includes tasks such as formulating formulas based on real-world situations, expressing equations in terms of variables, determining variable values, and solving problems centered on equations. The intention is to assess proficiency across diverse dimensions of algebraic expressions. At the same time, it should provide a comprehensive evaluation of their grasp of the key concepts. As students navigated the questions, the section aims to uncover insights into their ability to apply theoretical knowledge to practical problem-solving scenarios. Generally, it comes down to the depth and breadth of their understanding of algebraic expressions.

Table 6: Students' Marks for Algebraic Expression Subtopics

Subtopic	**Minimum Mark**	**Maximum Marks**	**Mean**	**Std. Deviation**
Express variable equation	0	6	1.27	1.870
Determine the value of variable	0	10	1.13	2.082
Form a formula based on situation	0	15	1.78	3.857
Solve problems involving equation	0	4	0.29	1.048

Table 6 presents the marks obtained by students for each algebraic expression subtopic covered in SUAET. The results indicate that the highest mean score is 1.78 for their understanding of how to formulate a formula for a given situation. It suggests that, on average, most students scored 1.78 percent in this aspect of the test. The second-highest mean score is 1.27 for their understanding of how to express equations in terms of variables. The following is the subtopic for determining the value of variables with a mean score of 1.13. The subtopic on problem-solving involving equations has the lowest mean score on the test at 0.29. The findings offer insights into the varying levels of student performance across different subtopics. They aid in identifying specific areas that may necessitate targeted interventions or instructional enhancements.

The detailed analysis of student performance at SUAET reveals significant variation in mean scores across subtopics. The highest mean score in formulating formulas based on situations suggests relative strength in this area, while challenges are evident in problem-solving involving equations. The findings offer crucial guidance for educators, highlighting specific areas that may require focused instructional strategies and interventions. Students performed slightly better when asked to form formulas from given situations, but struggled the most with solving equations.

These findings echo Marpa (2019), who observed similar issues with students' inability to carry out multi-step problem-solving in algebra due to weak foundational skills. This pattern also aligns with Subramaniam and

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Banerjee (2004), who found that students often lack procedural fluency when manipulating symbols, even after direct instruction.

Table 7: Correlation between Subtopics in SUAET

Subtopic		**Express Variable Equation**	**Determine the Value of Variable**	**Form a Formula based on Situation**	**Solve Problems Involving Equation**
Express Variable Equation	Pearson Correlation Sig. (2-tailed)	1	.600** .000	.542** .000	.337* .012
Determine the Value of Variable	Pearson Correlation Sig. (2-tailed)	.600** .000	1	.771** .000	.560** .000
Form a Formula based on Situation	Pearson Correlation Sig. (2-tailed)	.542** .000	.771** .000	1	.694** .000
Solve Problems Involving Equation	Pearson Correlation Sig. (2-tailed)	.337* .012	.560** .000	.694** .000	1

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Table 7 reveals several significant relationships within algebraic expression subtopics. First, a strong significant relationship exists between expressing equations in terms of variables and determining variable values ($r = 0.600$, $p < 0.01$). Next, a significant and moderate relationship emerges between expressing variable equations and formulating formulas based on situations ($r = 0.542$, $p < 0.01$). Lastly, a weak but still significant relationship transpires between expressing variable equations and solving problems involving equations ($r = 0.337$, $p < 0.05$).

The results demonstrate a strong positive relationship between the subtopics of determining variable values and formulating formulas based on situations ($r = 0.771$, $p < 0.01$). Apart from that, there is a positive moderate relationship between determining variable values and solving equation-based problems ($r = 0.560$, $p < 0.01$).

Finally, the results show another significant and strong relationship between formulating formulas based on situations and solving problems involving equations at $r = 0.694$ with a p-value < 0.01. The statistical relationships provide valuable insights into the interconnections among subtopics of different algebraic expressions, offering a nuanced understanding of their associations. These findings align with Gyampoh et al. (2020), who emphasized the importance of foundational understanding in algebra, noting that students often rely on earlier concepts to grasp more complex procedures.

The correlation analysis in Table 7 provides additional insights into the interconnectedness of algebraic expression concepts. Strong and moderate relationships between different subtopics emphasize the need for a holistic understanding. The finding suggests that proficiency in one area is related to success in others. This knowledge is invaluable for educators seeking to design targeted interventions that address interconnected algebraic concepts.

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Table 8: Students' Marks Based on The Revised Bloom's Taxonomy Levels in SUAET

Level	Minimum Mark	Maximum Marks	Mean	Std. Deviation (SD_
Remembering	0	16	2.40	3.536
Understanding	0	6	0.96	1.835
Application	0	13	1.11	3.059

Table 8 presents the results of SUAET by Revised Bloom's Taxonomy Level. The results highlight the highest mean performance for the remembering level at 2.40 (SD = 3.536). It suggests a commendable level of proficiency in recalling information within the context of SUAET. Meanwhile, the second-highest performance is for the application level, with a mean score of 1.11 (SD = 3.059). This is followed by the lowest performance, the understanding level, with a mean score of 0.96 (SD = 1.835).

The findings offer insights into the varying degrees of achievement across different cognitive levels. It emphasizes strength and potential improvement in the students' performance in understanding algebraic expressions. Most students attempted the questions at the remembering level, but many made mistakes, particularly in fundamental mathematics and algebraic concepts. Challenges arose when solving equations involving positive and negative numbers, and confusion persisted about changing variables in denominators when multiplying or dividing. Notably, a prevalent misconception was noticed for square root questions, indicating a weaker grasp of basic mathematical and algebraic concepts. Additionally, common careless mistakes were observed, stemming from a lack of clear understanding and a failure to follow a step-by-step approach. The errors often occur during the final stage of solution simplification, aligning with the findings of Maat & Zakaria (2011).

Moving to the understanding and application levels, most students struggled to comprehend questions, particularly those requiring them to formulate equations from provided statements. Difficulty understanding questions led to uncertainty in solving them. It resulted in instances where students left questions unanswered. Furthermore, students exhibited limited knowledge of simple formulas, such as the area of a square or rectangle. Consequently, they made simple mistakes and misconceptions when attempting questions at the understanding and application levels.

The findings are similar to Schliemann et al.'s (2003) study, which proves that errors and misconceptions in algebra often manifest during equation solving. It emphasizes students' overall weakness in understanding questions at these levels, indicating a tendency to repeat similar mistakes and misconceptions when answering questions on algebraic expressions. Applying Bloom's Taxonomy to assess cognitive levels (Table 8) offers a nuanced perspective on student performance. While recalling information demonstrates strength, the lower mean scores in understanding and application indicate areas for improvement. This information guides educators in tailoring teaching strategies to foster higher-order thinking skills and ensure a comprehensive understanding of algebraic concepts.

Table 9 reveals strong relationships among the Revised Bloom's Taxonomy levels on the test. A statistically significant link exists between remembering and understanding ($r = 0.741$, $p = 0.00 < 0.01$). Additionally, a significant and strong relationship is observed between the remembering and application levels, with a correlation coefficient (r) of 0.664 and a p-value of $0.00 < 0.01$. The highest scores were recorded at the remembering level, whereas understanding and application remained low.

This pattern aligns with the findings of Samsudi et al. (2024), who reported that Malaysian secondary students exhibit a steep decline in performance as questions progress from factual recall to conceptual reasoning. Furthermore, the strong positive correlations between the three Bloom's levels (e.g., $r = .789$ between understanding and application) reinforce Orhani's (2024) conclusion that higher-order thinking in algebra requires a solid cognitive foundation, which is often underdeveloped due to insufficient emphasis on deep understanding in early instruction.

Table 9: Correlations Among The Revised Bloom's Taxonomy Levels in SUAET

Level		Remembering	Understanding	Application
Remembering	Pearson Correlation Sig. (2-tailed)	1	.741** .000	.664** .000
Understanding	Pearson Correlation Sig. (2-tailed)	.741** .000	1	.789** .000
Application	Pearson Correlation Sig. (2-tailed)	.664** .000	.789** .000	1

**. Correlation is significant at the 0.01 level (2-tailed).

Table 10: Students' Grades on SUAET

Grade	Frequency	Percentage
A	1	1.8
B	1	1.8
D	5	9.1
E	48	87.3
Total	55	100

Table 10 concludes the section by presenting the grades attained by the students in SUAET. The distribution of grades indicates a relatively small percentage of high performers, with only 1.8% achieving 'A' and 'B' grades. In contrast, 87.3% of students received an 'E' grade, indicating challenges or areas for improvement in their understanding of algebraic expressions. Furthermore, 9.1% of respondents earned a 'D' grade. Additionally, the descriptive statistics for students' total scores on SUAET further highlight students' overall performance. The scores range from 0 to 100, with a mean percentage of 12.78%, suggesting that, on average, students' performance on the test is low. The grade distribution in the table underscores a prevalent challenge: a significant majority of students receive an 'E'. The result emphasizes the collective need for targeted interventions and instructional enhancements. It suggests that students grapple with fundamental concepts, warranting a closer examination of teaching methods and curriculum design. The student's performance on SUAET in this study was notably low, with a significant proportion failing to secure any marks—50 percent of students scored zero. The outcome indicates the challenges students faced in comprehending and mastering algebraic expressions. Consistent with Marpa (2019), students commonly perceive Algebra as a challenging subject in Mathematics. The difficulties, as highlighted by Subramaniam & Banerjee (2004), can be traced back to a foundational struggle with two key concepts: variables and algebraic expressions.

To investigate the potential significant difference in students' performance on the test between genders, the hypotheses were formulated as follows:

H_0 = There is no significant difference in students' performance on SUAET between genders.

H_1 = There is a significant difference in students' performance on SUAET between genders.

The set of hypotheses was designed to determine if there is a noteworthy disparity in how male and female students perform on the algebraic expression test. A statistical analysis was employed to assess the data and determine whether any observed differences were statistically significant.

Table 11: Independent sample t-test between mean scores

	Levene's Test for Equality of Variances		**t-test for Equality of Means**						
	F	**Sig.**	**t**	**dif**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
								Lower	Upper
Equal variances assumed	7.390	.009	-2.270	53	.027	-12.861	5.667	-24.227	-1.495
Equal variance not assumed	-	-	-2.216	41.357	.032	-12.861	5.804	-24.578	-1.144

Table 11 presents the results of the independent-samples t-test. It examines the significant difference in mean scores for students' performances on the SUAET by gender. The t-test output, assuming unequal variances, reveals a t-value of -2.216 with a p-value of 0.032, which is less than the significance level of 0.05. Therefore, there is sufficient evidence to reject the null hypothesis (H_0) and conclude that there is a statistically significant difference in students' performances on the test of understanding algebraic expressions between genders. The significant difference in mean scores between genders warrants a closer examination of the implications of the findings. The disparity may indicate gender-related variations in how students' approach and comprehend algebraic expressions. Understanding these differences is crucial for educators and policymakers to tailor interventions and teaching strategies that address the specific needs of different genders. The finding aligns with existing research on gender differences in mathematical performance. Hence, it is essential to note that while the difference is statistically significant, its practical significance may require further investigation. Factors such as social and cultural influences, stereotype threats, or variations in learning styles could contribute to gender-based differences.

To explore whether a significant difference exists in the mean scores of students' performances on SUAET based on study frequency, the hypotheses were formulated as follows:

H_0 = There is no significant difference in the mean score of students' performance on SUAET with respect to the number of times students study Mathematics per week.

H_1 = There is a significant difference in the mean score of students' performance on SUAET against the number of times students study Mathematics per week.

The set of hypotheses aims to assess whether variation in study habits, specifically the frequency of studying Mathematics, has a discernible impact on students' performance in understanding algebraic expressions. The statistical analysis, involving an appropriate test, provides insights into whether the observed differences, if any, are statistically significant.

Table 12: ANOVA Test Between the Mean Scores of Students' Performance and Study Frequency

	Sum of Squares	df	Mean Square	F	Sig.
Between groups	1031.717	4	257.929	.525	.718
Within Groups	24565.909	50	491.318	-	-
Total	25597.625	54	-	-	-

Based on the findings in Table 12, the ANOVA test results indicate an F-value of 0.525 and a p-value of 0.718. Given that the p-value exceeds the significance level of 0.05, there is insufficient evidence to reject the null hypothesis (H_0). Thus, it is unreasonable to conclude that there is a significant difference in the mean scores of students' performance on SUAET with respect to the number of hours spent studying mathematics per week. The outcome implies that, on average, study frequency does not affect performance. It suggests that other factors may play an influential role in determining students' proficiency in algebraic comprehension. The non-significant result prompts reflection on potential reasons for the finding. Those may include students' approaches to studying Mathematics, the effectiveness of study methods, or the quality of study sessions; these are more relevant factors than the sheer quantity of study time. Furthermore, individual differences in learning preferences and the specific challenges posed by learning algebraic expressions may contribute to variability in students' performance.

The severe performance deficits uncovered across the cognitive spectrum culminate in an 87.3% failure rate (Grade E). It indicated that traditional, one-size-fits-all instructional delivery is insufficient for lower secondary algebra classrooms. To translate these diagnostic performance gaps into actionable classroom interventions, a matrix of targeted pedagogical strategies must be deployed by mathematics educators, such as the Concrete-Representational-Abstract (CRA) Sequence (Zhang et al., 2022). To address the widespread errors discovered at the remembering level regarding negative integers, basic fractions, and variable manipulation, teachers should utilize physical algebra tiles. Students visually manipulate physical or digital blocks to balance equations before drawing them on paper and finally transitioning to pure symbolic manipulation. The next example is dynamic digital interventions. It is to target the lack of procedural fluency observed during final solution simplifications. Teachers should embed dynamic interactive platforms such as PowerPoint (Othman et al., 2017), GeoGebra (Othman et al., 2024), and Desmos (Hakim et al., 2025) into their weekly lesson plans. These tools provide real-time visual feedback on mathematical balance, allowing lower-performing students to safely explore the properties of variable denominators and square roots without inducing mathematics anxiety.

In a nutshell, the multifaceted discussion in Section B provides a holistic view of students' understanding of algebraic expressions. The variations in subtopic performance, correlations among algebraic concepts, and the analysis of cognitive levels provide a comprehensive foundation for educators and researchers to refine instructional approaches and enhance students' mastery of algebraic expression.

CONCLUSION

In conclusion, the study explores Form Two students' understanding of algebraic expressions, employing a quantitative approach and a series of assessments. Section A examines demographic information, study habits, and midterm examination grades, revealing notable variations in performance by gender, study patterns, and academic outcomes. The findings suggest the need for tailored interventions and instructional approaches to address potential challenges among students. Section B examines students' performance in SUAET, unraveling nuanced insights into their grasp of algebraic concepts. The results show variations in mean scores across subtopics, underscoring the need for targeted instructional strategies. Correlation analyses highlight strong relationships between various algebraic expression concepts, guiding educators in fostering a holistic understanding of the subject. The application of Bloom's Taxonomy provides a layered perspective on cognitive levels, showcasing students' strengths in recalling information but pointing to areas for improvement in understanding and application. The interrelation of various cognitive levels stresses the importance of integrating conceptual understanding with practical application in the teaching approach. The grade distribution reflects a prevalent challenge: most students receive an 'E'. It reiterates the need for targeted interventions and instructional enhancements, prompting a reevaluation of teaching methods and curriculum design.

While this diagnostic study provides a crucial foundational snapshot of early algebraic challenges within a Malaysian suburban school context, several explicit limitations This diagnostic study offers a crucial foundational snapshot of early algebraic challenges within a Malaysian suburban school context, but we must acknowledge several explicit limitations. First, the small sample size (55) drawn from a single school restrains the absolute generalizability of the findings across broader urban or rural demographics. Second, the cross-sectional nature of the data captures student errors at an isolated point rather than charting long-term developmental trajectories or instructional treatment effects. Furthermore, the non-formal testing environment of the SUAET may have introduced variations in individual student motivation, potentially skewing performance metrics downward. To expand the boundaries of these findings, future research should embrace a mixed-methods design, pairing quantitative diagnostic exams with qualitative student interviews to unlock deeper cognitive pathways. Future experimental methodologies should implement actual numerical metrics for out-of-class study hours rather than broad categorical intervals to unlock precise, continuous quantitative analyses. Finally, subsequent investigations should utilize advanced multivariate modeling—such as structural equation modeling (SEM) or path analysis—to explore how hidden variables such as mathematics anxiety, prior academic achievement, and individual learning styles actively interact with gender to dictate algebraic success.

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Authors' Contribution

Abu Bakar, M. H and Mohamed Nadzri, A. Z. conceived and planned the experiments and carried out the experiments and simulations. Othman, Z. S. contributed to interpreting the results and led the writing of the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

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