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The Effect of Algebra Box Media on Addition and Subtraction of Algebraic Expressions

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Abstract:
Students' learning outcomes in algebra, particularly in the addition and subtraction of algebraic expressions, remain relatively low. This problem is mainly caused by students' limited understanding of like terms, variables, and algebraic operations due to the predominance of conventional teaching methods. Therefore, the use of innovative and concrete learning media, such as the algebra box, is expected to improve students' conceptual understanding and learning outcomes. This study employed an experimental, quantitative method with a one-group pretest-posttest design. The sample consisted of 14 seventh-grade students of MTs Al-Mizan. Data were collected through pretest and posttest instruments to measure students' learning outcomes before and after the implementation of the algebra box media. The data were analyzed using the chi-square normality test and the Wilcoxon signed-rank test because the data were not normally distributed. The findings showed a significant improvement in students' learning outcomes after the implementation of the algebra box media. The average pretest score increased from 37.71 to 85.46 in the posttest. The Wilcoxon test results indicated that Wcount = 105 and Wtable = 21 ($\alpha = 0.05$), meaning that the null hypothesis (H_0) was rejected and the alternative hypothesis (H_a) was accepted. The use of algebra box media significantly improves seventh-grade students' learning outcomes in the addition and subtraction of algebraic expressions at MTs Al-Mizan. This learning media can serve as an effective alternative to support students' conceptual understanding in algebra.

Keywords: Algebra Box Media; Learning Outcomes; Wilcoxon Test

Introduction

Mathematics plays an essential role in developing students' logical, critical, and systematic thinking skills. However, algebra remains one of the most challenging topics for junior secondary students due to its abstract nature. In particular, students often experience difficulties in performing addition and subtraction operations on algebraic expressions. Common errors include misidentifying like terms, misunderstanding variables, and incorrectly applying operational rules.

Previous studies indicate that students' weak understanding of fundamental algebraic concepts significantly contributes to these difficulties (Rahmawati & Pramono, 2021; Putri, 2023). Moreover, learning practices that rely heavily on conventional methods such as lectures and routine exercises, without the support of concrete learning media, tend to encourage procedural memorization rather than conceptual understanding. As a result, students' learning outcomes remain unsatisfactory.

The use of concrete instructional media is considered a promising strategy to bridge abstract mathematical concepts and students' cognitive development. The algebra box, as a manipulative learning tool, enables students to visually and physically represent algebraic forms, making abstract concepts more accessible and meaningful. Research by Putri & Hidayat (2023) demonstrates that the use of concrete media can significantly improve students' understanding and learning outcomes in algebraic operations. Similar findings were reported by Zainiar et al. (2020) and Koten & Zulhiyah (2024), who concluded that algebra box media effectively enhances students' comprehension of algebraic operations.

Based on preliminary observations conducted at MTs Al-Mizan in Sanggau Regency, seventh-grade students' learning outcomes in addition and subtraction of algebraic expressions are still relatively low. Many students have not achieved the Minimum Mastery Criteria (KKM). The primary difficulty lies in understanding basic algebraic concepts, which is closely related to the limited use of visual and concrete learning media in classroom instruction.

Therefore, the research problem of this study is focused on the low learning outcomes in addition and subtraction of algebraic expressions, which may be influenced by the lack of effective concrete instructional media. This study aims to examine the effect of algebra box media on seventh-grade students' learning outcomes in addition and subtraction operations of algebraic expressions at MTs Al-Mizan.

Theoretically, this study is grounded in constructivist learning theory, which emphasizes that knowledge is constructed through direct experience and meaningful representation (Hidayat & Rahman, 2022; Eka Saputri, 2019). Practically, this research is expected to provide an effective instructional alternative to improve students' algebra learning outcomes.

Literature Study

Algebra learning at the junior secondary level requires students to transition from arithmetic thinking to symbolic reasoning. This shift often creates conceptual difficulties, particularly in understanding like terms, variables, and operational rules in addition and subtraction of algebraic expressions. Rahmawati & Pramono (2021) explain that students' low achievement in algebra is closely related to their incomplete mastery of these foundational concepts. When learning remains procedural and symbol-oriented, students tend to memorize steps without constructing meaningful understanding, which ultimately affects learning outcomes.

From a theoretical perspective, constructivist learning theory provides a strong foundation for addressing this issue. Learning is viewed as an active process in which students build knowledge through interaction with objects and experiences (Hidayat & Rahman, 2022). Abstract mathematical symbols become more comprehensible when supported by visual and manipulative representations. Therefore, the integration of concrete media in algebra instruction is not merely supplementary but pedagogically essential to facilitate conceptual construction.

Empirical findings further reinforce this theoretical assumption. Zainiar et al. (2020) demonstrated that the use of algebra box teaching aids helped students overcome conceptual difficulties in algebraic operations. Similarly, Musabik (2021) reported that combining problem-based learning with algebra box media significantly improved students' problem-solving abilities in algebraic calculations. Koten & Zulhiyah (2024) found that KABA Box media effectively enhanced student achievement in binomial algebra multiplication, indicating that manipulative tools are effective across various algebraic topics. In addition, Situmorang (2016) revealed that algebra puzzle media improved learning outcomes in addition and

subtraction of algebraic forms, highlighting the broader effectiveness of concrete media in symbolic operations.

Synthesizing these studies reveals a consistent pattern: concrete and manipulative media contribute positively to students' conceptual understanding and academic performance in algebra. However, most previous studies focused on multiplication of algebraic expressions, general algebra operations, or integrated instructional models. Limited research specifically examines the direct effect of algebra box media on learning outcomes in addition and subtraction operations at the seventh-grade MTs level, particularly within the context of MTs Al-Mizan.

In evaluating instructional effectiveness, appropriate research design is crucial. Quantitative experimental approaches are suitable for measuring the causal impact of educational interventions (Rahmawati & Pramono, 2021; Dangkua et al., 2023). When data distribution does not meet parametric assumptions, the Wilcoxon Signed-Rank Test is recommended as a reliable non-parametric alternative for hypothesis testing (Fadilahtunisa & Putri, 2024; Anggraini et al., 2025). The integration of rigorous methodology strengthens the validity of conclusions regarding the effectiveness of algebra box media.

Based on theoretical principles and empirical evidence, algebra box media aligns with constructivist learning theory and demonstrates strong potential to improve students' conceptual understanding and learning outcomes. Therefore, examining its effect specifically on addition and subtraction of algebraic expressions at the seventh-grade MTs level represents both a theoretically grounded and empirically relevant investigation.

Research methods

This study employed a quantitative approach using a pre-experimental method with a one-group pretest–posttest design. In this design, a single group of seventh-grade students was given a pretest before the implementation of the algebra box media and a posttest after the treatment. The comparison between pretest and posttest scores was used to identify changes in students' learning outcomes following the instructional intervention (Sugiyono, 2022; Rahmawati & Pramono, 2021).

The research instrument consisted of a learning achievement test focusing on addition and subtraction of algebraic expressions. The test items were developed based on curriculum-based learning indicators, including identifying like terms, applying operational rules correctly, and simplifying algebraic expressions. To ensure instrument quality, several validation procedures were conducted. First, content validity was established through expert judgment by two mathematics education lecturers who evaluated the relevance, clarity, and alignment of each item with the intended learning objectives. Revisions were made according to their recommendations to ensure representativeness and accuracy of measurement (Hidayat & Rahman, 2022; Khotimah & Risan, 2019).

Second, empirical validity testing was conducted through a pilot study involving students outside the research sample. Item validity was analyzed using item-total correlation, and only items meeting the acceptable correlation criteria were retained. Items that did not meet the validity threshold were revised or removed. Reliability testing was then performed using Cronbach's Alpha to measure internal consistency. A reliability coefficient above 0.70 indicated that the instrument was sufficiently reliable for measuring students' learning outcomes (Sugiyono, 2022).

Data analysis was conducted using descriptive and inferential statistics. Prior to hypothesis testing, a normality test was performed. When the data did not meet parametric assumptions, the Wilcoxon Signed-

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Rank Test was applied as a non-parametric alternative to determine the significance of differences between pretest and posttest scores (Fadilahtunisa & Putri, 2024; Ramadan, 2024).

Although the one-group pretest–posttest design allows measurement of learning improvement before and after treatment, it has limitations in establishing strong causal inference due to the absence of a control group and randomization. Therefore, the findings of this study are interpreted as evidence of instructional effectiveness within the observed group rather than definitive causal claims. Future research employing quasi-experimental or true experimental designs is recommended to strengthen causal validity.

Results

This research was conducted at MTs Al-Mizan Balaikarangan on January 7–8, 2026. Initially, the population consisted of 28 seventh-grade students. During the research process, the number decreased to 26 due to student transfers. At the time of data collection, 14 students were present and participated fully in both the pretest and posttest sessions.

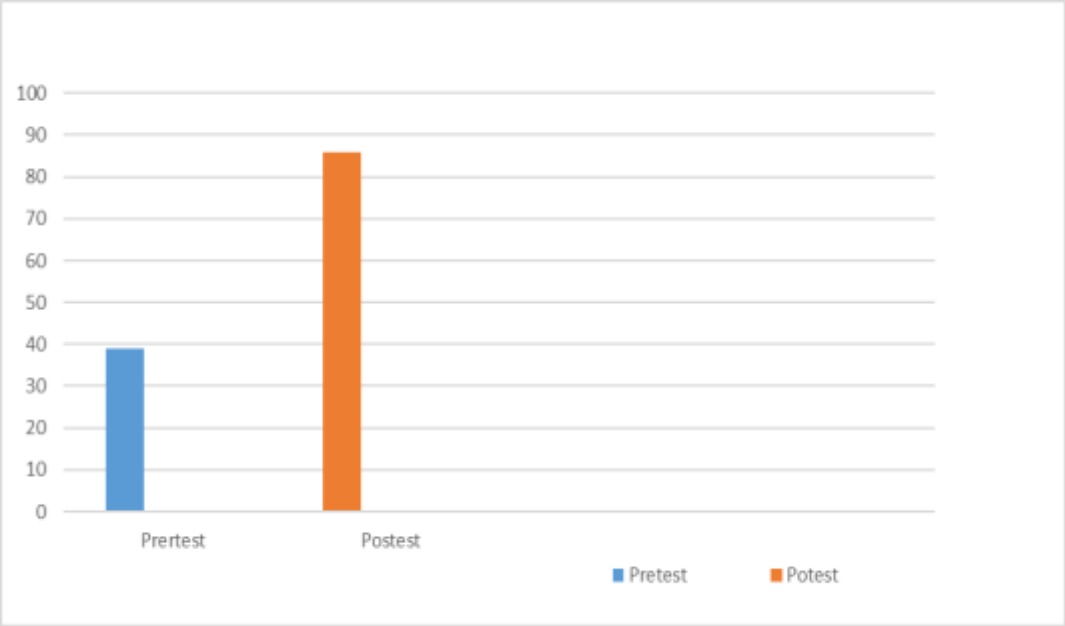
Before the implementation of the algebra box media, students were given a pretest to measure their initial understanding of addition and subtraction of algebraic expressions. After the treatment, a posttest was administered to measure changes in learning outcomes.

Table 1. Pretest and Posttest Data Results

No	Student Code	Pretest	Posttest
1	AK	75	100
2	AMTD	45	92
3	A A	22	82
4	AFY	68	98
5	DA	40	90
6	GRA	18	78
7	HN	60	97
8	HA	35	88
9	KN	12	62
10	KM	0	55
11	LS	30	87
12	MA	55	95
13	MH	27	85
14	MI	50	94
	Total number	546	1,203
	Average	39	85.92

The average pretest score was 39, while the average posttest score increased to 85.92.

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Graph 1. Pretest and Posttest Data Results

The graph illustrates a substantial increase in student learning outcomes after the implementation of algebra box media.

A. Results of the pretest normality test

The following are the steps for calculating the normality of pretest data.

1. Summarizes all data of variables whose normality is tested

Table 2. Pretest Result Data

No	Student Name	Pretest
1	AK	75
2	AMTD	45
3	A A	22
4	AFY	68
5	DA	40
6	GRA	18
7	HN	60
8	HA	35
9	KN	12
10	KM	0
11	LS	30
12	MA	55
13	MH	27
14	MI	50

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2. Determining the interval class.

   K =1+ 3.3 log N

   K =1+ 3.3 log 14

   K =1+ 3.3 log (14)

   K =1+ 3.78

   K = 4.78 is made into 5

3. Determining the length of the interval class, namely the largest data - the smallest data divided by the number of interval classes.

   Data range = largest data – smallest data

   = 75 -0

   Class length = 75/5= 15

4. Determine the depth of the frequency distribution table which is also a criteria table for calculating the chi square value.

Table 3. Criteria for Finding the Standard Deviation of Pretest Data

Interval Class	Fi Frequency	Xi	Fi. X	Xi - X	(Xi – X) ^{2}	$\sum Fi(Xi - X)^2$
0 – 15	2	7.5	15	-30.21	912.64	1,825.26
16 - 31	4	23.5	94	-14.21	201.92	807.64
32 - 47	3	39.5	118.5	1.79	3,2041	9,6123
48 – 63	3	55.5	166.5	17.79	316.48	949.44
64 - 79	2	71.5	143	33.79	1,141.76	2,283.52
Amount	14		528			5,875.4

5. Calculating the average: S = $\sum \frac{Fi\ .Xi}{\sum Fi} = \sqrt{\frac{528}{14}} = \sqrt{37,71}$

6. Calculating the standard deviation = $\sum Fi \frac{(Xi-X)2}{n} = \frac{5.875,4}{14} = 419.67$

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Table 4. Criteria for Finding the Chi-Square Value of Pretest Data

Interval class	Frequency fi	Class limits		Z		Z table		Class interval width	Fe	$\sum fi\frac{(xi}{}$
		lower	on	lower	on	lower	on			
0 - 15	2	0	15.5	0	-0.05	0.0000	0.5199	0.5199	7,2786	-3,828
16 - 31	4	15.5	31.5	-0.05	-0.01	0.5199	0.5040	-0.0159	-0.2226	64,294
32 - 47	3	31.5	47.5	-0.01	0.02	0.5040	0.5080	0.004	6,056	154.77
48 - 63	3	47.5	63.5	0.02	0.06	0.5080	0.5239	0.0159	0.2226	34,762
64 - 79	4	63.5	79.5	0.06	0.09	0.5239	0.5359	0.012	0.168	19,977
amount	14									64,499

7. Calculate the expected frequency (F_h) by multiplying the percentage area of each normal curved area by the number of sample members.
8. $_h$ values and calculate the $f_o - f_h$ values and $\frac{(fo-fh)2}{n}$ add them together.
9. Compare the calculated Chi Square value with the Chi Square table.

   a. X h 2 (x count) = 64,499

   b. X t 2 (x table)

   = DK = K -1

   = 5-1 = 4

   Then X 2 table of 5% = 9.488

   X 2 count >X 2 table is 64, 499 >9,488 so it can be concluded that the data is not normally distributed.

B. Post-test normality test results

The following are the steps for calculating the normality of post-test data.

1. Summarizes all data of variables whose normality is tested.

Table 5. Posttest Result Data

No	Student Code	Posttest
1	AK	100
2	AMTD	92
3	A A	82
4	AFY	98
5	DA	90
6	GRA	78
7	HN	97

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8	HA	88
9	KN	62
10	KM	55
11	LS	87
12	MA	95
13	MH	85
14	MI	94

2. Determining the interval class.
   K =1+ 3.3 log N

   K =1+ 3.3 log 14

   K =1+ 3.3 log (14)

   K =1+ 3.78

   K = 4.78 is made into 5

3. Determining the length of the interval class, namely the largest data - the smallest data divided by the number of interval classes.

   Data range = largest data – smallest data

   = 100 – 55 = 45

   Class length = 45/5= 9

4. Determine the depth of the frequency distribution table which is also a criteria table for calculating the chi-square value.

Table 6. Criteria for Finding the Standard Deviation of Posttest Data

Interval Class	Fi Frequency	Xi	Fi . X	Xi - X	(Xi – X) ^{2}	$\sum Fi(Xi - X)^2$
50 - 59	1	54.5	54.5	-30.96	-958.52	-958.52
60 - 69	1	64.5	64.5	-20.96	-439.32	-439.32
70 - 79	1	74.5	74.5	-10.96	-120.12	-120.12
80 - 89	4	84.5	338	-0.96	-0.92	-3.68
90 - 100	7	95	665	9.54	91.01	637.07
Amount	14		1,196.5			2,158.71

5. Calculating the average: S = $\sum \frac{Fi\ .Xi}{\sum Fi} = \sqrt{\frac{1.16,5}{14}} = \sqrt{85,46}$

6. Calculating the standard deviation = $\sum Fi \frac{(Xi-X)2}{n} = \frac{2.158,71}{14} = 154.19$

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Table 7. Criteria for Finding the Chi-Square Value of Posttest Data

interval class	fi frequency	class boundaries		Z		Z table		class interval area	fe	$\sum fi\frac{(xi-x)2}{n}$
		lower	on	lower	on	lower	on			
50 - 59	1	49.5	59.5	-0.23	-0.16	4090	4364	274	3,836	3,836
60 - 69	1	59.5	69.5	-0.16	-0.10	4364	6402	238	3,332	3,332
70 - 79	1	69.5	79.5	-0.10	-0.03	4602	4880	278	3,892	3,892
80 - 89	4	79.5	89.5	-0.03	0.02	4880	0.508	-4,372	-61,208	-979,328
90-100	7	89.5	100.5	0.02	0.09	0.5080	0.5359	279	3,906	191,394
amount	14									-776,874

7. Calculate the expected frequency (F_h) by multiplying the percentage area of each normal curved area by the number of sample members.
8. $_h$ values and calculate the $f_o - f_h$ values and $\frac{(fo-fh)2}{n}$ add them together.
9. Compare the calculated Chi Square value with the Chi Square table.

   a. X h 2 (x count) = -776,874

   b. X t 2 (x table)

   = DK = K -1

   = 5-1 = 4

   Then X 2 table of 5% = 9.488

   X 2 count >X 2 table is -776.874 >9.488 so it can be concluded that the data is normally distributed.

   Based on the pretest and posttest calculations above, it can be concluded that the pretest data is not normally distributed and the posttest data is normally distributed and the calculations are carried out in the hypothesis test calculations using the Wilcoxon test.

C. Hypothesis Test Results

This calculation is used after the pretest data is found to be non-normally distributed and the posttest data to be normally distributed. Therefore, the Wilcoxon test is used to assess the impact of the research results.

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Table 8. Wilcoxon test

No. of respondents	X	Y	X - Y	(X - Y)	Rank	Rank	
1	75	100	-25	25	1	(+)	(-)
2	45	92	-47	47	6		1
3	22	82	-60	60	13.5		13.5
4	68	98	-30	30	2		2
5	40	90	-50	50	7.5		7.5
6	18	78	-60	60	13.5		13.5
7	60	97	-37	37	3		3
8	35	88	-53	53	9		9
9	12	62	-50	50	7.5		7.5
10	0	55	-55	55	10		10
11	30	87	-57	57	11		11
12	55	95	-40	40	4		4
13	27	85	-58	58	12		12
14	50	94	-44	44	5		5
Amount							105

Determining critical values

$W_{table} = W(\alpha,n)$

Information:

α = significance level

n = number of samples

So the following data is obtained:

$W_{count} = 105$

W_{table}: N = 14

$\alpha = (0.05; 14) = 21$

$W_{count} > W_{table} = 105 > 21$

Determining Hypothesis Testing Criteria

$W_{count} < W_{table,}$ then H_o is rejected

$W_{count} > W_{table,}$ then H_a is accepted

Conclusion

$_{Calculated}$ W value = $105 > W_{table} = 21$

So H_o is rejected and H_a is accepted

This means that the use of algebraic box media in learning has an impact on student learning outcomes. The related theory is nonparametric statistical theory, specifically the Wilcoxon test, which is used to test

the effect of algebraic box media through pretest and posttest data.
The following are the student's pre-test scores based on learning outcome indicators.

Table 9. Pretest Learning Outcome Indicators

No	Indicator	No Items	Student Score	Qualification of Results (%)
1	Remembering the rules of addition and subtraction	1	5 students (correct) 9 students (incorrect)	35%
2	Understand the solution steps	2	4 students (correct) 10 students (incorrect)	28%
3	Applying addition and subtraction operations of algebraic forms using algebra box media	3	3 students (correct) 11 students (incorrect)	21%
4	Analyzing similar and dissimilar algebraic forms	4	0 students (correct) 14 students (incorrect)	0%

Based on the data in the table above, the indicators that students can master the highest are those in indicators 1, 2, and 3, and the lowest are those in indicator 4.

Table 10. Posttest Learning Outcome Indicators

No	Indicator	No Items	Student Score	Qualification of Results (%)
1	Remembering the rules of addition and subtraction	1	9 students (correct) 4 students (incorrect)	64%
2	Understand the solution steps	2	12 students (correct) 1 student (incorrect)	85%
3	Applying addition and subtraction operations of algebraic forms using algebra box media	3	11 students (correct) 2 students (incorrect)	78%
4	Analyzing similar and dissimilar algebraic forms	4	012 students (correct) 1 student (incorrect)	85%

Based on the data in the table above, the indicators that students can master the highest are those in sections 2, 4, and 3, and the lowest are in indicator 1. It can be concluded that there are differences and changes in each indicator obtained by students in the pretest and posttest data.

Discussion

The findings demonstrate a significant improvement in students' learning outcomes after the implementation of algebra box media. The increase from a mean score of 39 to 85.92 indicates that students experienced meaningful conceptual development in performing addition and subtraction of algebraic expressions.

The improvement across all learning indicators suggests that algebra box media effectively supports conceptual understanding, particularly in higher-order skills such as analyzing like and unlike terms. Before

the intervention, none of the students mastered this indicator. After the intervention, mastery increased to 85%, indicating that the manipulative and visual characteristics of the media helped students internalize abstract symbolic relationships.

These findings align with constructivist learning theory, which emphasizes that students construct knowledge through active engagement and concrete representation. The results are also consistent with previous studies reporting that algebra box media and other manipulative tools enhance algebra learning performance.

Although the one-group pre-experimental design limits strong causal inference due to the absence of a control group, the statistically significant Wilcoxon test result supports the conclusion that the algebra box media contributed positively to improved learning outcomes within the observed group.

Overall, the results suggest that integrating concrete media into algebra instruction can serve as an effective pedagogical strategy to reduce conceptual difficulties and enhance student achievement in algebraic operations.

Conclusion

The findings of this study indicate that the use of algebra box media significantly improves seventh-grade students' learning outcomes in addition and subtraction of algebraic expressions at MTs Al-Mizan. This improvement is reflected in the substantial increase in the mean score from 37.71 in the pretest to 85.46 in the posttest. The Wilcoxon Signed-Rank Test further confirmed this result, with Wcount (105) exceeding Wtable (21) at a 0.05 significance level, leading to the rejection of the null hypothesis. These results demonstrate that algebra box media effectively facilitates students' conceptual understanding and procedural accuracy in algebraic operations.

From a practical perspective, this study suggests that mathematics teachers should integrate concrete and manipulative media, such as algebra boxes, into classroom instruction to support students' transition from arithmetic thinking to symbolic reasoning. Schools are encouraged to provide adequate instructional resources and professional development opportunities to help teachers implement interactive and student-centered learning strategies. The integration of visual and hands-on media can reduce students' misconceptions and foster more meaningful engagement with abstract mathematical concepts.

However, this study employed a one-group pre-experimental design, which limits the strength of causal inference. Therefore, future research is recommended to use quasi-experimental or true experimental designs involving control groups and larger sample sizes to enhance external validity. Further studies may also explore the long-term retention effects of algebra box media, its impact on different algebraic topics, or its integration with other instructional models such as problem-based learning. Investigating students' attitudes and motivation toward algebra learning when using manipulative media may also provide deeper pedagogical insights.

In conclusion, algebra box media represents a promising instructional tool for improving algebra learning outcomes, particularly in supporting students' conceptual understanding at the junior secondary level.

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