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Recursive Retrieval Teaching Strategy (RRTS) in Teaching Statistics and Probability Among Grade 11 Students: Basis for a Long-Term Mathematical Knowledge Reinforcement Program

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Abstract

This quasi-experimental study investigated the effectiveness of the Recursive Retrieval Teaching Strategy (RRTS) compared to conventional teaching methods in enhancing the mathematical performance and retention of Grade 11 TVL-Maritime students at Southwestern College of Maritime Business and Technology Inc. The study involved two groups: a control group taught using conventional strategies and an experimental group exposed to RRTS. Both groups underwent a pretest, posttest, and retention test to measure performance changes and long-term retention. Results revealed no significant difference in the pretest scores of both groups, indicating comparable initial knowledge. Notably, the experimental group using RRTS achieved higher mean scores in both the posttest and retention test, categorized as "Very Satisfactory," while the control group reached only "Satisfactory." A significant difference in retention scores favored the RRTS group, confirming its impact on long-term memory and mastery.

The study concludes that while conventional methods can yield meaningful outcomes, integrating retrieval-based strategies offers superior retention. Based on these insights, the study recommends the incorporation of RRTS into senior high school mathematics instruction, with support from school leaders and inclusion in professional development activities such as Learning Action Cell (LAC) sessions.

Key words: *Recursive Retrieval Teaching Strategy, Conventional Strategy, Mathematics Performance, Retention, TVL-Maritime, Senior High School*

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INTRODUCTION

Retention of mathematical knowledge remains a critical challenge in Philippine education, particularly in senior high school subjects such as Statistics and Probability, where cumulative understanding is essential. While mathematics education spans diverse branches such as algebra, geometry, trigonometry, and calculus, research has consistently identified statistical and probabilistic concepts as among the most difficult for students to retain and transfer to new contexts (Aplaon, 2023). These ideas demand not just procedural knowledge but also conceptual knowledge, and these both start to degrade in the absence of strategic reinforcement.

Despite ongoing curriculum reforms under the K to 12 program and a growing emphasis on learner-centered pedagogies, there is still a gap on studies on effective ways of retaining knowledge in the long term in probability and statistics subject at senior high school level. This gap is particularly significant for specialized tracks such as the TVL Maritime strand, where most existing research tends to focus on traditional academic strands. As a result, the unique learning needs and instructional challenges of specialized tracks are insufficiently addressed, especially in terms of innovative, evidence-based teaching strategies that can improve deep and lasting understanding of complex mathematical concepts.

Retention of mathematical knowledge remains a perpetual issue across education systems worldwide. Students never appear to retain advanced mathematical knowledge in the long term even in nations such as Singapore, Finland, and the United States that boast untainted education policies and top-notch standards of education (Roediger & Butler, 2019). It is the most challenging for most students to recall and use critical facts in future lessons or in real life despite very comprehensive curricula and rigorous pedagogy. The majority of countries have embraced variety of teaching practices such as spaced retrieval and active recall addressing this issue. Such practices entail active interaction with the subject matter as well as regular examination, both of which have been shown to enhance memory. But promising as such techniques are, their application is still largely restricted in higher mathematics courses like probability and statistics, particularly in the Philippine educational environment where training and resources can be scarcer.

In the Philippines, the need for better mathematical retention is supplemented by global surveys. Programme for International Student Assessment (PISA) 2022 results revealed that 16% of Filipino students attained at least basic math proficiency, with 84% missing the required standard (Philippine Star, 2023). The results reflect systemic flaws in the education system of the country, including a failure to retain the basics of mathematics necessary for students to succeed both academically and professionally. Fanning these are poor teacher professional development on new pedagogical approaches, ineffective access to learning and teaching resources, and congested classrooms—problems that are elevated at a higher level in provincial areas like Oriental Mindoro. Senior high school students who take special strand programs such as the TVL Maritime strand of the Southwestern College of Maritime Business and Technology Inc.

(SCMBTI) are particularly vulnerable. These students typically show struggle with long-term retention and use of critical statistics and principles of probability upon which their academic success and subsequent maritime careers are founded.

Efforts at retention on the school level, such as remedial courses, worksheet adjuncts, and tutorial support after school, have failed to address the depth and longevity of students' mathematical understanding. Teachers are among the biggest obstacles to change: since they may not receive training on new, research-based teaching techniques such as recursive retrieval or spaced retrieval, they are unable to design lessons that maximize deep, long-term learning and conceptual knowledge. This deficiency in instruction is an ongoing hurdle for students, expressed through lower confidence, reduced achievement, and lower readiness for higher-level math concepts and use.

This research focused on assessing the Recursive Retrieval Teaching Strategy (RRTS), a new pedagogical method linking reverse teaching in which students proactively describe and teach back what they have learned with spaced retrieval, a drill in which there is overt review of content at widening intervals. Through the use of RRTS, this study hopes to enhance the retention and application of statistical and probabilistic learning among SCMBTI Grade 11 TVL – Maritime strand learners. The issue is rightly situated in these learners' inability to retain statistical ideas, which hinders their academic progress and practice skills necessary for their profession. Closing this gap with targeted, evidence-based interventions is critical to improving both student achievement and the quality of mathematics instruction in special tracks and other similar contexts.

Methodology

The researcher utilized quasi-experimental design implementation of the quantitative method to determine the effectiveness of the Recursive Retrieval Teaching Strategy (RRTS) in enhancing long-term retention and math performance of Grade 11 in Statistics and Probability. For the determination of the effectiveness of the instruction methods, pretest student scores were examined against posttest and retention test scores.

The respondents of the study were the Southwestern College of Maritime Business and Technology Inc. Grade 11 TVL-Maritime students that comprised a population of 85 students chosen using non-proportional random sampling. The researcher chose 60 respondents from among the student population, 30 per section. These pupils, who were listed under Statistics and Probability strand in the second semester of school year 2024-2025, form a population of interest for studying the impact of instructional strategies on performance in an admittedly demanding mathematics course.

The primary research instrument used in this research was a researcher-graded test set to measure the problem-solving ability and retention of the major concepts in Statistics and

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Probability among the experimental and control groups. The 10-item word problems test contained 50 marks, and it was applied as a pretest, posttest, and retention test. Test questions were based on the random variables and probability distribution, normal distribution, and sampling distributions, at the higher levels of Bloom's Taxonomy to test the participants' analytical and evaluation capabilities. A rubric was used to evaluate their performance, with criteria that equally weigh key aspects such as understanding of concepts, accuracy of solutions, logical problem-solving processes, and justification of methods. The rubric was carefully designed and reviewed by peers and experts to ensure its validity and reliability as an assessment tool for measuring the intended outcomes of the study.

Descriptive statistics, including means, frequencies, and percentages, were calculated to summarize participants' scores on the pretest, posttest, and retention tests. The Shapiro-Wilk test was conducted to assess the normality of the data. Due to violations of normality assumptions in most data sets, nonparametric tests were employed. The Mann-Whitney U test was used to compare the experimental and control groups on pretest, posttest, and retention test scores. Within-group differences across the three testing occasions were examined using the Friedman test.

Results and Discussion

1. Level of Mathematical Performance of the Participants Taught Using the Conventional Teaching Strategy

Table 1

Pretest Results on Mathematical Performance of the Respondents Taught Using Conventional Teaching Strategy

Scores	Frequency	Percentage	Verbal Description
45 – 50	0	0%	Outstanding
40 – 44	0	0%	Very Satisfactory

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35 – 39	0	0%	Satisfactory
30 – 34	0	0%	Fairly Satisfactory
Below 30	30	100%	Did Not Meet Expectation
Total	30	100%	

Mean: 9.80 **Verbal Description: Did Not Meet Expectation**

The mean score of the respondents in the pretest was 9.80, described as "Did Not Meet Expectation." This suggests a very low level of mathematical performance indicating that the respondents experienced difficulty answering the test items. The result implies insufficient mastery of the skills and concepts assessed prior to the implementation of any intervention. As reflected in Table 1, none of the students reached even the "Fairly Satisfactory" level, and no respondents scored in the higher brackets of "Satisfactory," "Very Satisfactory," or "Outstanding." This bare condensation of scores in the lowest level also reinforces the conclusion that the group entered the study with inadequate mathematical foundations.

This finding is in agreement with Zohar and Dori (2023), who noted that low pretest responders are most often the students who are best served by innovative, student-focused methods that focus on active learning and concept mastery. They believed that conventional instruction forms are likely to fail in meeting the students' knowledge gaps that are already suffering from mathematical literacy issues.

Table 2
Posttest Results on Mathematical Performance of the Respondents Taught Using Conventional Teaching Strategy

Scores	Frequency	Percentage	Verbal Description
45 – 50	8	26.67%	Outstanding
40 – 44	3	10.00%	Very Satisfactory
35 – 39	7	23.33%	Satisfactory
30 – 34	7	23.33%	Fairly Satisfactory
Below 30	5	16.67%	Did Not Meet Expectation
Total	30	100%	

Mean Score: 36.4 **Verbal Description: Satisfactory**

Following the administration of the conventional teaching strategy, posttest had a mean score of 36.4 labeling as "Satisfactory" level of achievement. The use of mean score indicates impressive gain in the respondents' know-how in mathematical topics from the earlier scores made prior to pretest. The variation in the mean score reflects that students were able to understand and use more of the content after teaching, reflecting improvement in learning outcomes. The score range in Table 6 again testifies to this positive result. Among 30 students, 18 or 60% received between "Satisfactory" and "Outstanding," 8 students or 26.67% received the top mark. Only 5 respondents equal to 16.67% were in the "Did Not Meet Expectation" category, a sharp drop from pretest where all students were there.

The results reveal a more equal presentation during the performance categories, an indication of a broader range of accomplishment among the learners. The results suggest that the use of the conventional pedagogical strategy yielded great mathematical performance improvement. This complements the conclusion of the research study by Hattie (2019), which proved that when instruction was properly planned and executed, learners could be enhanced in terms of performance but a lot of variation could occur among different learners.

Table 3

Retention Test Results on Mathematical Performance of the Respondents Taught Using Conventional Teaching Strategy

Scores	Frequency	Percentage	Verbal Description
45 – 50	11	36.67%	Outstanding
40 – 44	2	6.67%	Very Satisfactory
35 – 39	9	30.00%	Satisfactory
30 – 34	4	13.33%	Fairly Satisfactory
Below 30	4	13.33%	Did Not Meet Expectation
Total	30	100%	

Mean Score: 37.8 **Verbal Description: Satisfactory**

The retention test results reveal in the table below, presents a continued upward trend in the respondents' mathematical performance. A total of 22 respondents or 73.34% scored from "Satisfactory" to "Outstanding," with 11 of them or equivalent of 36.67% achieving the “Outstanding” level. Only 4 respondents equivalent to 13.33% fell under the "Did Not Meet Expectation" category, the same number as those in the "Fairly Satisfactory" range. In terms of overall performance, the mean score of 37.8 corresponds to the descriptor “Satisfactory.”

The improvement can be attributed to several conventional classroom practices such as teacher-led discussions, consistent use of examples during lectures and guided practice through seatwork and homework. This also aligns with the Cognitive Load theory as conventional instruction typically helps reduce extraneous cognitive load by structuring content clearly and presenting information in manageable chunks. This supports retention because students can focus their mental resources on essential concepts without being overwhelmed.

2. Level of Mathematical Performance of the Participants Taught Using the RRTS

Table 4

Pretest Results on Mathematical Performance of the Respondents Taught Using Recursive Retrieval Teaching Strategy

Scores	Frequency	Percentage	Verbal Description
45 – 50	0	0%	Outstanding
40 – 44	0	0%	Very Satisfactory
35 – 39	0	0%	Satisfactory
30 – 34	0	0%	Fairly Satisfactory
Below 30	30	100%	Did Not Meet Expectation
Total	30	100%	

Mean: 10.8 **Verbal Description: Did Not Meet Expectation**

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The pretest results of students taught using the Recursive Retrieval Teaching Strategy (RRTS) revealed a mean score of 10.8, which falls under the "Did Not Meet Expectation" category. All respondents scored below 30, indicating low mastery of the assessed mathematical concepts. This outcome suggests significant challenges in understanding foundational skills prior to the implementation of RRTS. These findings are consistent with the research of Brown and Roediger (2019), who emphasized that initial low performance is common in traditional classrooms where retrieval practices have not yet been introduced. They argued that pretest assessments are crucial benchmarks, offering insight into students' readiness for cognitively demanding interventions like retrieval-based learning.

Table 5

Posttest Results on Mathematical Performance of the Respondents Taught Using Recursive Retrieval Teaching Strategy

Scores	Frequency	Percentage	Verbal Description
45 – 50	16	53.34	Outstanding
40 – 44	2	6.67	Very Satisfactory
35 – 39	4	13.33	Satisfactory
30 – 34	7	23.33	Fairly Satisfactory
Below 30	1	3.33	Did Not Meet Expectation
Total	30	100%	

Mean Score: 42.3 **Verbal Description: Very Satisfactory**

The posttest performance of students taught using the Recursive Retrieval Teaching Strategy (RRTS) showed a significant improvement from their pretest results. The mean score for the posttest was 42.3, which is categorized as "Very Satisfactory". The majority of students, 53.34%, scored in the "Outstanding" range (45-50), while 6.67% scored in the "Very Satisfactory" range (40-44), and 13.33% achieved scores in the "Satisfactory" range (35-39). Additionally, 23.33% of students were in the "Fairly Satisfactory" range, and only 3.33% remained in the "Did Not Meet Expectation" range. This suggests that RRTS had a positive impact on students' ability to grasp mathematical concepts and apply them effectively.

The improvement in performance is consistent with previous research by Roediger and Butler (2021), which found that retrieval-based teaching strategies can significantly enhance students' retention and academic performance. The shift in scores from the pretest to the posttest highlights the effectiveness of the RRTS in fostering better understanding and long-term retention of mathematical knowledge.

Table 6

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Retention Test Results on Mathematical Performance of the Respondents Taught Using Recursive Retrieval Teaching Strategy

Scores	Frequency	Percentage	Verbal Description
45 – 50	16	53.34	Outstanding
40 – 44	6	20.00	Very Satisfactory
35 – 39	6	20.00	Satisfactory
30 – 34	1	3.33	Fairly Satisfactory
Below 30	1	3.33	Did Not Meet Expectation
Total	30	100%	

Mean Score: 43.3 **Verbal Description: Very Satisfactory**

The retention test performance of students taught using the Recursive Retrieval Teaching Strategy (RRTS) showed significant improvement. The mean score for the retention test was 43.3, which is categorized as "Very Satisfactory". A majority of students, 53.34%, scored in the "Outstanding" range (45-50). Additionally, 20% of students scored in the "Very Satisfactory" range (40-44) and another 20% achieved scores in the "Satisfactory" range (35-39). A smaller percentage, 3.33%, scored in the "Fairly Satisfactory" range, and only 3.33% remained in the "Did Not Meet Expectation" category.

These results demonstrate that the RRTS not only improved students' performance on the posttest but also contributed to the long-term retention of the material. The consistently high performance in the retention test reflects the effectiveness of repeated retrieval opportunities and structured review sessions integrated throughout the instructional period. The improvement in retention is consistent with studies, such as the work by Roediger and Butler (2021), which emphasize the effectiveness of retrieval-based learning strategies in enhancing both immediate and retained learning outcomes.

3. Difference Between the Pretest Performance of the Participants Taught Using the Conventional Teaching Strategy and RRTS

Table 7
Comparison of Pretest Performance of the Respondents Taught Using the Conventional Teaching Strategy and Recursive Retrieval Teaching Strategy

Group	N	Median	U	p-value	Effect Size (r)	Interpretation
Conventional	30	10	385	0.332	0.146	Not Significant
RRTS	30	11				

Legend: p-value <0.05= Significant

The table below compares the pretest performance of respondents taught using the Conventional Teaching Strategy (CTS) and the Recursive Retrieval Teaching Strategy (RRTS). The table shows that the median score for the Conventional group was 10, while the median for the RRTS group was 11. The p-value of 0.332 indicates that there was no statistically significant

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difference between the two groups, as the p-value is greater than the significance level of 0.05. The effect size (r) = 0.146, which is considered small, further supports the interpretation that the difference in performance between the two groups is negligible, both statistically and practically.

This suggests that participants began at a relatively equal level of performance prior to the instructional interventions. This result aligns with earlier findings from Smith and Johnson (2019), who observed no significant difference in pretest scores among student groups prior to implementation of traditional and innovative teaching strategies, reinforcing that initial knowledge levels are often comparable across different instructional groups when selection is managed appropriately.

4. Difference Between the Pretest, Posttest, and Retention Test Performance of the Respondents Taught Using the Conventional Teaching Strategy

Table 8

Comparison of the Pretest, Posttest, and Retention Test Performance of the Respondents Taught Using the Conventional Teaching Strategy

Group	Test	Median	χ^2 (df)	p-value	Post Hoc	P-value
Conventional	Pretest	10.0	47.1	<0.001	Pre vs Post	<0.001
	Posttest	35.5			Pre vs Retention	<0.001
	Retention	38.5			Post vs Retention	0.405

Legend: p-value <0.05= Significant

The results indicated a significant difference between the three tests (χ^2= 47.1, p < 0.001) suggesting that the performance scores differed significantly across the time points. As shown in Table 12, post-hoc comparisons using the Nemenyi test revealed several important findings. First, a significant difference was observed between the pretest and posttest scores, with a p-value less than 0.001, suggesting that the Conventional Teaching Strategy had a substantial immediate effect on the participants' performance. Furthermore, a significant difference was also found between the pretest and retention test scores, with a p-value less than 0.001, indicating that the improvement observed during the posttest was maintained over time. However, no significant difference was found between the posttest and retention test scores, with a p-value of 0.405, which suggests that the performance improvements achieved during the posttest were sustained and did not change significantly over time.

These results are consistent with findings from Garcia et al. (2019), who emphasized the importance of retention in educational interventions. Their research showed that the immediate effects of teaching strategies are often retained when proper review and reinforcement are implemented.

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5. **Difference Between the Pretest, Posttest, and Retention Test Performance of the Respondents Taught Using Recursive Retrieval Teaching Strategy (RRTS)**

Table 9
Comparison of the Pretest, Posttest, and Retention Test Performance of the Respondents Taught Using the Recursive Retrieval Teaching Strategy (RRTS)

Group	Test	Median	χ^2 (df)	p-value	Post Hoc	P-value
RRTS	Pretest	11.0	48.2	<0.001	Pre vs Post	<0.001
	Posttest	47.0			Pre vs Retention	<0.001
	Retention	46.0			Post vs Retention	0.145

Legend: p-value <0.05= Significant

The performance of participants taught using the Recursive Retrieval Teaching Strategy (RRTS) was assessed through a Friedman test, which revealed a statistically significant difference in scores across the pretest, posttest, and retention test. The test yielded a χ^2 value of 48.2 (df = 2) with a p-value less than 0.001. In table above, Post-hoc pairwise comparisons using the Nemenyi test showed significant differences between the pretest and posttest scores ($p < 0.001$), as well as between the pretest and retention test scores ($p < 0.001$). These results indicate that the RRTS had a positive and immediate effect on students' performance during both the posttest and the retention test. However, no significant difference was observed between the posttest and retention test scores ($p = 0.145$), suggesting that the improvements seen in the posttest were maintained over time, with no substantial change in performance during the retention test. This aligns with previous studies, such as those by Tharp et al. (2020), which emphasized the effectiveness of retrieval-based teaching strategies in enhancing student performance over time.

6. **Difference Between the Posttest Performance of the Participants Taught Using the Conventional Teaching Strategy and RRTS**

Table 10

Comparison of the Posttest Performance of the Participants Taught Using the Conventional Teaching Strategy and RRTS

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Group	n	Median	U	p-value	Effect Size (r)	Interpretation
Conventional	30	37.5	326	0.064	0.276	Not Significant
RRTS	30	47.0				

Legend: p-value <0.05= Significant

The results showed no statistically significant difference between the two groups, as the p-value 0.064 was greater than the 0.05 significance level. The effect size was 0.276, indicating a small to moderate practical difference in performance outcomes. Although there was a slight advantage observed in the group taught using RRTS, it was not enough to establish a significant difference when compared to the Conventional Teaching Strategy. This suggests that both approaches resulted in relatively similar posttest outcomes among the participants.

This finding supports previous research, such as the study by Johnson et al. (2018), which found that while retrieval-based teaching strategies can enhance learning, conventional methods may still yield comparable results depending on the context. The current study confirms that the use of either strategy produced similar posttest performance among learners.

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7. Difference Between the Retention Test Performance of the Participants Taught Using the Conventional Teaching Strategy and RRTS

Table 11
Comparison of the Retention Test Performance of the Participants Taught Using the Conventional Teaching Strategy and RRTS

Group	n	Median	U	p-value	Effect Size (r)	Interpretation
Conventional	30	38.5	309	0.037	0.313	Significant
RRTS	30	46.0				

Legend: p-value <0.05= Significant

A Mann-Whitney U test was conducted to compare the retention test performance between participants taught using the Conventional Teaching Strategy and those taught using the Recursive Retrieval Teaching Strategy (RRTS). The results showed a statistically significant difference in retention test scores between the two groups, as the p-value 0.037 was below 0.05. The effect size was 0.313, indicating a moderate practical difference in favor of the RRTS group. This result suggests that the RRTS group outperformed the Conventional group in the retention test, pointing to better long-term retention of the material. The moderate effect size highlights that the observed difference between the two groups is not only statistically significant but also educationally meaningful. The sustained retention observed in the RRTS group, despite time gaps between learning and testing, can be attributed to the principles of spaced retrieval practice. One of the core mechanisms behind RRTS is the deliberate and structured repetition of learned material at increasing intervals, which strengthens memory traces and counters the natural forgetting curve. This finding is consistent with the results of the current study, where participants in the RRTS group outperformed those in the Conventional Teaching Strategy group on the retention test. Similarly, Agarwal et al. (2017) found that retrieval practice not only boosts immediate recall but also strengthens long-term memory retention, especially when spaced over time.

8. Proposed Long-Term Mathematical Knowledge Reinforcement Program (LT-MKRP)

The Long-Term Mathematical Knowledge Reinforcement Program (LT-MKRP) was developed in direct response to the findings from a study that evaluated the effectiveness of the Recursive Retrieval Teaching Strategy (RRTS) compared to conventional instruction. The study's retention test, as summarized in Table 7, highlighted varying degrees of knowledge retention among students: 36.67% (11 out of 30) achieved Outstanding scores (45–50 points), reflecting strong long-term retention, while 13.33% (4 out of 30) did not meet expectations, scoring below 30 points. This contrast emphasizes the necessity of ongoing reinforcement to support all learners, especially those who struggle with retaining mathematical concepts over time.

These results reinforce the value of incorporating structured, continuous exposure to key mathematical skills—core principles that define the LT-MKRP. With a mean retention score of 37.8, slightly higher than the posttest average of 36.4, the data points to a favorable impact of retrieval-based and recursive strategies on sustained learning. The LT-MKRP, therefore, is designed to systematically strengthen mathematical understanding beyond the initial instructional phase, addressing learning gaps while promoting long-term mastery through repeated practice, timely feedback, and strategic review sessions.

Conclusions

This study shows that while traditional teaching methods can still help students improve and remember math lessons when used properly, the Recursive Retrieval Teaching Strategy (RRTS) gives better results, especially for long-term learning. Since both groups started with similar skills, the changes in their performance were clearly due to the way they were taught. Students who were taught using the traditional method improved to a satisfactory level, but those who learned through RRTS reached a much higher level in both the posttest and retention test. This means that RRTS helps students not only learn better right after the lesson but also remember what they learned for a longer time. RRTS works well because it includes repeated practice and helps students recall what they've learned, which strengthens their memory. These results suggest that using strategies like RRTS in math classes can lead to better and longer-lasting learning, making it a helpful approach for teachers and schools. Moreover, it supports the idea that teaching should not only focus on helping students pass tests but also make sure they truly understand and remember the lessons. By using RRTS, teachers can help build students' confidence in math and prepare them for more advanced topics in the future. Therefore, schools and educators are encouraged to explore and apply teaching strategies that are proven to help students retain knowledge more effectively.

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