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Spaced and Expanded Practice: An Investigation of Methods to Enhance Retention

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Abstract

In order to promote quality instruction and maximized student learning, it is essential for schools to integrate the most practical, effective, and efficient teaching methods into the curriculum. The purpose of this research was to investigate the effect of various spacing patterns between practice sessions on retention of information (expanded spacing, fixed interval spacing, and no-practice control). Participants included 42 3rd- and 4th-grade students from two different elementary schools. Participants were taught a set of eight unknown math vocabulary words and definitions using a flashcard intervention (incremental rehearsal), and then participated in practice sessions over four weeks, following the spacing pattern of their assigned condition. Retention of words and definitions were measured after four weeks for all participants. Results suggested no significant differences between expanded and fixed interval spacing of practice, but suggested a benefit of both practice conditions over the control condition. Retention increased across practice sessions within both practice conditions. These findings suggest that brief, spaced practice opportunities are beneficial to student retention.

Keywords: instruction, learning, schools, teaching, spaced, retention, consistent, intervals, expanded, incremental rehearsal, word definition, error correction, independent samples t-test

Spaced and Expanded Practice: An Investigation of Methods to Enhance Retention

In order to promote quality instruction and maximize student learning, it is essential for schools to integrate the most practical, effective, and efficient teaching methods into the curriculum. Implementing strategic practice and review is commonly cited as an element of effective instruction (e.g., Hattie, 2009), thus efficient and practical methods of implementing strategic practice should be investigated. The spacing effect is a method for implementing strategic practice and review, and suggests that retention is greater when practice is spaced across multiple sessions rather than massed into a single session (e.g., Rohrer & Taylor, 2006). This theory has been extensively researched, and meta-analytic research supports the effectiveness of spaced practice (e.g., Janiszewski, Noel, & Sawyer, 2003). Researchers suggest that the spacing effect is not frequently implemented in educational settings (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006), thus its potential for facilitating effective as well as practical and efficient methods for enhancing retention should be evaluated.

Prior to implementing spaced practice in a school setting, the most effective spacing approach must be identified. There are two primary methods of spacing practice: fixed interval, with equal time increments between practice sessions; and expanded practice, with increasing time increments between practice sessions. Research is equivocal regarding whether fixed interval or expanded practice is most effective; however, this research has primarily been conducted over very short practice and retention intervals (i.e., within a single session; Balota, Duchek, & Logan, 2007). Theoretically, however, one might expect that expanded practice would be superior to fixed interval practice (Balota et al., 2007). In theory, the benefit of expanded practice is based on the increasing difficulty of retrieval as you increase the amount of time between recall opportunities. Further, as an individual recalls information at increasing

intervals the information is likely to be related to more life events, increasing the encoding distinction level.

Purpose of Study

Although the spacing effect is a well-established phenomenon, patterns of spaced practice and applied research are not well established. Research is equivocal regarding whether fixed interval or expanded practice is more effective, and most of the research in this area uses very short practice and retention intervals. Applied research is needed to investigate spaced practice in schools as well as to investigate spacing patterns using practice and retention intervals that are meaningful in school settings. Thus, the purpose of this study was to investigate the effect of fixed interval practice, expanded practice, and no practice on retention for elementary-aged students in a school setting. Specifically, the following research questions guided this investigation: To what extent does retention differ based on the spacing of practice opportunities? To what extent are conditions with practice superior to the no-practice condition?

Methods

Participants and Settings

Participants were recruited from two rural elementary schools in the Upper Midwest. Forty-two students, whose parents provided consent to participate and who had also provided assent to participate, were assigned to one of three conditions: expanded practice, spaced practice, or no practice (control group). Thirty-two students in two classrooms were randomly assigned to participate in expanded and spaced practice conditions (with 16 in each condition), and 10 students in a third classroom comprised the control condition, allowing for a total of forty-two participants. Demographic information for the participants included 21 males (50%), and 21 females (50%); and 19 (45%) third grade students compared to 23 (55%) fourth grade

students. Each of the sessions was completed in various, available conference rooms within each of the schools. After the teaching session, students in fixed and spaced interval conditions participated in three practice sessions, corresponding to their assigned condition, conducted in the same room as the initial teaching session.

Experimental Conditions

All participants began with a teaching session in which students learned eight math words and definitions. Words were taught using a flashcard procedure called incremental rehearsal (IR), which is described below. Within the control group, students participated in the teaching session at Day 0 experienced zero practice session. Students in the control group participated in only one retention check on Day 28 of the study.

Within the fixed interval practice condition, students participated in the teaching session at Day 0 and practice sessions on Days 7, 14, and 21. Some students completed their initial practice session on Day 8 and their second practice session on Day 15 as a result of a weather-related school cancellation. Finally, a retention check was completed on Day 28. Within the expanded practice condition, students participated in the teaching session at Day 0 and practice sessions on Days 2, 9, and 21. Practice sessions were initially intended to be held on Days 3, 9, and 21, but a weather-related school cancellation necessitated completing the first practice session one day early. Finally, a retention check was completed on Day 28. The no-no practice condition included a teaching session on Day 0 and a retention check on Day 28. Figure 1 provides a graphical depiction of these timeframes. Practice was sequenced so that each condition had 3 practice opportunities, and a retention check that was 7 days following the final practice opportunity, or third maintenance check.

Dependent Variables

The dependent variable within this study was the number of word definitions retained at the final retention check on Day 28. These data were reported as the number of definitions retained, with 8 being the maximum value. Initially, retention of the word itself was also considered a dependent variable. However, these data were not analyzed here because all students retained all words at the final retention check.

The extent to which participants recalled word definitions across the three practice opportunities was also investigated within this study to better understand how students progressed in their retention of this information across practice opportunities.

Procedure

Materials. For each of the two schools that were a part of this study, similar sets of flashcards were created using both known and unknown words. Both sets of words were selected by each school's classroom teachers to ensure appropriate words were selected. In other words, students were likely to know the known words. Unknown words included concepts that would likely appear on the Minnesota Comprehensive Assessment (MCA) in math but had not yet been covered at that point in the year. Sixteen known words were written on 6 x 8 flashcards, and the first 8 that the student confidently read were included as known words. Known word flashcards contained no images or definitions. These were utilized only in the teaching session during the implementation of IR. Two sets of eight unknown words were created, one for third grade and one for fourth grade. The same unknown words were taught to all participants. Each unknown word included the unknown word as well as a corresponding image on the front. The image was used to cue student responding during the teaching and practice sessions. On the back of the card, a concise definition taken from a website titled "Math is Fun" was written to ensure a consistent definition was used. These definitions were utilized during initial teaching and

practice. The unknown words for one school included parallel, perpendicular, sides, angles, vertices, perimeter, length, and width. The unknown words for the other school were transformation, translation, reflection, rotation, congruent, volume, surface area, and circumference. The pool of known words included digits, value, locate, fewer, more, less, round, nearest, closest, least, sum, difference, product, fraction, rule, and input. Data collection forms were constructed by the researcher to facilitate recording of session dates and words retained at each practice session and the final retention check. The time to complete the teaching session was also recorded on these forms and was measured using a manually operated stopwatch.

Teaching session. During the teaching session, all students were taught eight math vocabulary words and definitions which they had not yet learned in that year. Words and definitions were taught using IR (see Petersen-Brown & Burns, 2011 for a full review of procedures). IR is an academic intervention that helps improve student retention and fluency. IR is conducted one-on-one. First eight known words are identified; participants are asked to read the word on each card as it is presented. Once the student has read eight words correctly, these function as the known words. Next IR begins. The interventionist presents the first unknown word by saying the word and providing its definition. Then, the student is asked to repeat the word and its definition. Then, the first known word is presented. Next, the unknown word is presented, and participants must say the word and its definition. Then, the first two known words are represented. This process continues until the participant responds to the unknown word followed by all eight known words. Then, a second unknown word is introduced using the procedure described above. The first unknown word is now considered known, and the eighth known word is dropped from the stack, keeping the total number of flashcards the same. This process is repeated until all known words have been taught. All errors during the session were

corrected using the following verbiage: “This word is _____, and it means _____. What is this word and what does it mean?” This intervention method was selected because it has previously shown favorable retention across a range of information types and populations (Burns, Zaslofsky, Kanive, & Parker, 2014). Teaching sessions were conducted by the researchers in various available conference rooms within each of the schools. The researchers included one faculty member in psychology with a PhD in Educational Psychology, three graduate students studying School Psychology, and one senior undergrad student studying Psychology.

Practice sessions. Practice sessions were used in the fixed interval and expanded conditions, but not the control group, and all sessions were conducted one-on-one. Participants in the fixed interval and expanded practice conditions participated in three practice sessions as described above. During the practice sessions, participants were presented with the unknown words and asked to read each word and provide a definition. Feedback was provided in the form of error correct when students made an error. Error correction was provided using the verbiage described above if students made errors.

Retention checks. Twenty-eight days after the teaching session, participants in each condition engaged in a final retention check. These retention checks were performed individually with an interventionist in the same location as the initial teaching and practice sections. In this check, the participants were once again asked to read and define the unknown words taught in the teaching session. Error correction was not used during the retention check. Researchers recorded whether students correctly or incorrectly read and defined each word.

Fidelity checks. Fidelity checks were performed during this study to ensure the accurate and consistent use of the above methods and procedures. Fidelity checklists were created for the teaching and practice sessions and were used to measure the presence of key steps within each of

those sessions. The teaching session checklist included 15 steps and included the key steps of IR (e.g., “Present the first unknown word with definition,” “Error correction is used for all errors...”). The practice session checklist included 3 steps and included instructions provided to students, appropriate error correction, and appropriate recording of student responses. Fidelity during the teaching session averaged 98.9% (93%-100%) and was collected on 6 of 42 sessions. Fidelity during practice checks averaged 100% and was collected on 14 of 130 sessions.

Results

Words retained were investigated, but was at or near the ceiling across practice sessions and at the ceiling for the retention check. Participants retained 7.69 words and 7.75 words at the first practice session in the expanded and spaced conditions, respectively. Participants retained 8 words at all other practice sessions and the retention check in the spaced, expanded, and control conditions.

Word definitions retained within the fixed interval, expanded, and control conditions across the three practice sessions and retention check is shown in Table 1. On average, participants retained 3.75 and 3.19 word definitions at the first practice session, 4.06 and 3.69 definitions at the second practice session, 4.88 and 5.33 definitions at the third practice session, and 5.69 and 6.07 words at the retention check in the expanded and fixed interval conditions, respectively. Within the control condition, students retained 4.00 words on average at the retention check. One-way analyses of variance (ANOVAs) were used to test the statistical significance of the differences between conditions at various practice sessions and retention checks. Differences at the final retention check were significant, $F(2, 35) = 11.69, p < .05$. Post hoc comparisons using the Tukey HSD test indicated that the word definitions retained were greater in the fixed interval condition than the control condition ($p < .05$), and this effect was

large ($d = 1.45$). The difference between the expanded condition and the control condition approached statistical significance ($p = .09$), and this effect was also large ($d = 0.92$).

A one-way repeated measures ANOVA was conducted to investigate the effect of time on the number of word definitions retained across spaced and expanded. There was a significant effect of time, Wilks' Lambda = .21, $F(3, 21) = 25.96$, $p < .05$, where retention increased across practice sessions and to the final retention check. No significant effect was found regarding condition. Partial eta-squared was .79, indicating a large effect.

Discussion

The results of this study showed no significant difference between fixed interval and expanded practice. However, there was a benefit to practice, despite the brevity of the practice opportunities. Therefore, any variation of spaced practice, or revisiting the material over time, is important for improving retention, but the pattern of spacing may not impact retention.

There was no significant difference between the expanded and spaced conditions in word definitions retained. There was, however, a significant difference between the fixed interval and no practice conditions in word definitions recalled as well as a difference between the expanded and control condition that approached statistical significance. These effects were both large in magnitude, suggesting a lack of statistical power.

This study contributes to the research supporting the spacing effect. Efficient retention checks conducted between 2 and 12 days apart led to progressively better retention across the study period. The length of practice and retention intervals is critical as longer retention intervals are underrepresented in existing research. These differences were large and statistically significant. This suggests that spaced practice is an effective and efficient strategy for maintaining and improving recall of information.

Figure 2 illustrates an interesting trend in performance across practice sessions and the final retention check that may present avenues for future research. It pertains to fixed interval condition, which initially lagged in retention over the first two practice sessions, but showed a substantial increase in retention by the first practice session, after which it surpassed the expanded practice condition. Future research may investigate the number of practice opportunities that confer the greatest benefit to students. Future research may also investigate the practice interval length that is optimal; it is possible that as practice intervals lengthened in the expanded practice condition, retention suffered. These are important questions for the optimal use of spaced practice in schools.

Limitations

The limitations of this study are important to consider when interpreting its findings. For instance, the small and relatively homogenous sample population may not be generalizable to the entire school population. Future research should investigate these trends in a larger and more diverse sample. In addition, there was some deviation from the anticipated intervals between retention checks in the spaced practice condition due to school cancellations. A third limitation to this study involves the possibility of students learning words in other settings, outside of the study. While researchers were careful to select words that had not been reviewed in class, it is difficult to detect and control exposures that may occur in other settings. Additional exposures may have led to inflated retention. A fourth limitation that interventionist exposure was not controlled across students and settings. Although trained to implement the same procedures in the same way, interventionists may have varied in their effectiveness and exposure to various students and conditions.

Conclusion

The purpose of this study was to investigate the effect of spaced practice sessions on retention of verbal information. Understanding the effect of spaced practice sessions on retention of verbal information is very significant when offering teaching suggestions on how to improve students' success in the classroom. Periodic review is an effective and efficient strategy maintaining and improving recall of information, which was examined throughout this research study. From the data that has been gathered, it is suggested that providing opportunities for students to review and gain feedback for newly introduced terms will aid in their retention of the new terms. This study has confirmed previous studies finding that spaced and expanded practice are equivocal, as well as that practice greatly improves retention compared to no practice. The data used to describe these relationships confirms this idea, allowing for accurate recommendations to be made to teachers and educational staff.

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Table 1

Definitions Retained by Student

	Practice 1	Practice 2	Practice 3	Retention Check
	Definition (SD)	Definition	Definition	Definition
Expanded	3.75 (2.35)	4.06 (2.11)	4.89 (1.20)	5.69 (2.18)
Spaced	3.19 (1.97)	3.69 (1.55)	5.33 (1.83)	6.07 (1.44)
Control	N/A	N/A	N/A	4 (1.41)

Note: This table describes the average results produced in each practice session, as well as the final retention check; and the various individual standard deviation values for all of the condition's practice sessions. The numbers represent the average number of words and definitions that were correctly recalled by all thirty-two students who participated in spaced and expanded conditions, as well as the additional ten students who comprised the control condition.

Sequencing of Retention Checks Across Conditions:

Sequencing of Retention Checks Across Conditions

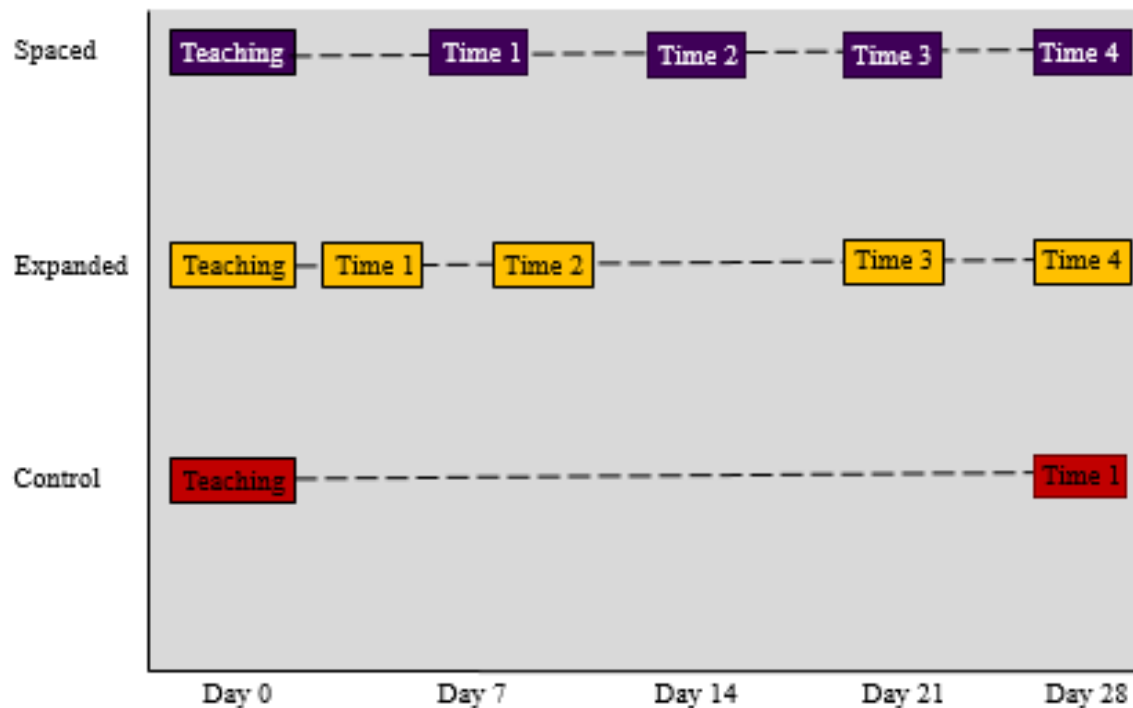


Figure 1. This figure shows the timeline for when each condition was exposed to the teaching, practice, and retention check sessions. Spaced practice had practice sessions 7, 14, and 21 days after the teaching session, and a retention check on the 28th day. Expanded practice had practice sessions 2, 9, and 21 days after the teaching session, and a retention check on the 28th day. The control condition was taught the words then checked for retention 28 days later.

Words Retained Across Retention Checks:

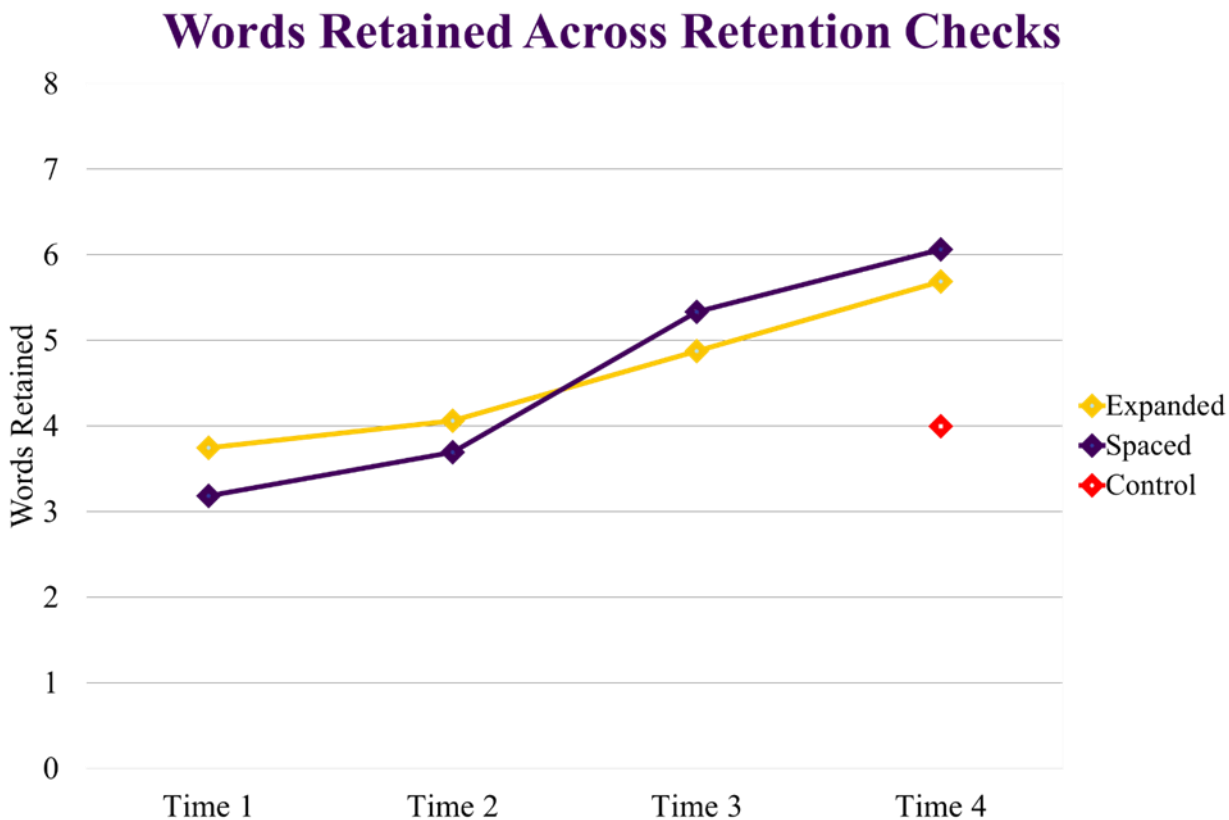


Figure 2. This figure shows the increase in student retention on definitions as students completed each practice session. Definitions retained for spaced and expanded practice improved from 3.8 (expanded) and 3.2 (spaced) to 5.7 (expanded) and 6.1 (spaced). The figure also shows the statistically significant difference ($p < .05$) in words retained between the control group, having no practice sessions, and the spaced and expanded conditions.