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A Comparison of 'Additive' and 'Multiplicative' Expanded Spacing Patterns in Flashcard-Based Vocabulary Retention

Comparando la Retención de Vocabulario de los Patrones de Espaciado Expansivo 'Aditivo' y 'Multiplicativo' mediante Flashcards

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Abstract:

This study examines the effects of two different Expanded Spaced Repetition patterns on vocabulary retention and recall in an English as a Foreign Language (EFL), primary-level context. Using a quasi-experimental design with two intact groups, participants attended five vocabulary review sessions over a three-week period. Group 'SIGMA' (n = 17) followed an Expanded Additive spacing schedule, while group 'MIKE' (n =18) followed an Expanded Multiplicative schedule. Vocabulary retention was assessed through three questionnaires administered to participants at three time points: before, immediately after, and two weeks after the intervention.

Pre-test results indicated low baseline vocabulary knowledge in both groups, with the MIKE group showing a greater score dispersion. Although both groups demonstrated improved performance across post-tests, with MIKE showing higher results than SIGMA, an ANCOVA controlling for pre-test variability revealed no statistically significant differences between groups, suggesting that neither Expanded patterns produced significant advantages over the other under the conditions examined, which reinforces the findings of previous studies referred to in a part of the literature review.

Keywords:

Spaced Repetition, Vocabulary Learning, Expanded Spacing Repetition, EFL Learners

Resumen:

Este estudio examina los efectos de dos patrones de Repetición Espaciada Expandida sobre la retención y el recuerdo de vocabulario en un contexto de la Enseñanza del Inglés como Lengua Extranjera (ILE) a nivel primaria. Mediante un diseño cuasiexperimental con dos grupos intactos, los participantes asistieron a cinco sesiones de repaso de vocabulario durante tres semanas. El grupo 'SIGMA' (n = 17) siguió un programa de espaciado expandido aditivo, mientras que el grupo 'MIKE' (n = 18) siguió un programa de espaciado expandido multiplicativo. La retención del vocabulario se evaluó mediante tres cuestionarios administrados en tres momentos: antes, inmediatamente después y dos semanas después de la intervención.

Los resultados del *pre-test* indicaron un bajo nivel de conocimiento léxico inicial en ambos grupos, con mayor dispersión de puntajes en el grupo MIKE. Aunque ambos grupos mostraron mejoras en el desempeño a lo largo de los *post-tests*, y que MIKE mostró mayor puntuación que SIGMA, un análisis de covarianza (ANCOVA) que controló la variabilidad del *pre-test* reveló que no hubo diferencias estadísticamente significativas entre los dos patrones expandidos bajo las condiciones en que fueron examinados, lo cual refuerza los hallazgos previos que refiere parte de la literatura.

Palabras Clave:

Repetición Espaciada, Aprendizaje de Vocabulario, Repetición Espaciada Expandida, Estudiantes de EFL

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Introduction

In the English as a Foreign Language (EFL) field, one of the earliest components, and perhaps one of the most essential that must be learned, is vocabulary. Throughout the years, a plethora of techniques and methods have been implemented in EFL classrooms all over the world, from drilling to the use of flashcards. A relatively recent addition to the use of flashcards has been the implementation of spaced repetition, rooted in Ebbinghaus' (as cited in Lafleur & Kanazawa, 2024) forgetting curve experiment, who then coined the terms 'Forgetting Curve' for the exponential loss of information, and 'Spacing Effect' as a means to improve said retention to mitigate said loss. A number of authors have written regarding the cognitive process behind it, such as Baddeley and Hitch's (1974) framework of the working memory, or Thornbury's (2002) 'articulatory loop' as a cognitive process that strengthens phonological traces, and that is quite related to Ebbinghaus' coinage.

Spaced repetition advantage over massed practice is well established (Balota et al., 2007; Cepeda et al., 2008; Lotfolahi & Salehi, 2017; Namaziandost, Sawalmeh, & Izadpanah Soltanabadi, 2020; Serrano, 2022); however, the optimal intersession interval (ISI) is yet to be defined, as studies show mixed and non-conclusive results (Serrano, 2022). Moreover, not all Spaced Repetition models work the same; in fact, there are two main models: the Uniform and the Expanded, each concerning different approaches to these intersession intervals (Lafleur, 2020). Lafleur's (2020) three types of Expanded spacing patterns (Additive, Multiplicative, and Exponential) lack conclusive research; as such, it is yet to be defined whether any of the patterns outperforms the other, as well as if they are suitable for a specific audience in particular.

Thus, the question the present research aims to answer is:

Which of the two Expanded patterns to practice vocabulary —Expanded Additive and Expanded Multiplicative— results in better vocabulary retention and recall in 11-12 years old Young Learners (YL)?

Literature Review

Lexical items and Lexical chunks; What 'knowing' a word means

A lexical item (also known as 'lexeme') is, as Schmitt (2000) notes, "an item that functions as a single meaning unit, regardless of the number of words it contains. (p. 2)" As such, a lexical item can either be a root word ('dog'), an inflected word ('dogs;' 'walked') or a multi-word phrase (such as idioms, phrasal verbs, and collocations), as long as it conveys a coherent meaning. Within this term, it is relevant to make a distinction between the items formed by single words and some very tightly linked two- or three-word combinations (e.g., stock market or compact disc), and that are also referred to as "vocabulary" and the concept of "lexis," which Scrivener (2002) defines as:

> Our 'internal database' of words and complete ready-made, fixed / semi fixed / typical combinations of words that we can recall and use quite quickly without having to construct new phrases and sentences word by word from scratch using our knowledge of grammar. (p. 186).

Thornbury (2002) mentions that, at the most basic level, in order for a learner to truly know a lexical item, it is required to know both the form (how it is written) and the meaning (what it represents, its register, its uses). Nation (as cited in Lafleur, 2015) further details on what "word knowledge" represents, stating that it must cover both the receptive and the productive aspects; for example, the form must not be limited only to understanding what the word sounds and looks like, but also being able to write it, spell it, and pronounce it.

When teaching lexical items in the classroom, a number of elements must be taken into account. Firstly, Scrivener (2002) states that, when lexical items are to be presented, it is useful to group them together based on any existing connection between them, such as a context (e.g. wedding vocabulary, animals), similar grammar or use (e.g. adjectives to describe people), or their use to achieve a specific task (e.g. useful expressions to persuade).

Another of Scrivener's suggestions is to provide learners with opportunities to identify and familiarize themselves with the items, such as matching the lexical items with pictures, fill-in-the-gaps exercises, or memory games.

Regarding the optimal vocabulary teaching process, Thornbury (2002) states that, when presenting vocabulary, the number of new items "should not overstretch the learners' capacity to remember them" (p. 76), and mentions that a vocabulary presentation should not exceed more than 12 items. Furthermore, Brown and Lee (2015) recommend the allocation of dedicated class time for vocabulary learning; in fact, Webb and Nation (as cited in Brown & Lee, 2015) note that, in order to gain the necessary knowledge of a vocabulary word, learners require to encounter this word between 7 and 16 times. Furthermore, they suggest spacing the repetitions in progressive intervals ends up being more effective than spending

the same amount of time all at once.

Incidental and Intentional Vocabulary Learning: 'Word Cards', and the Recall Technique

There are two main approaches when it comes to vocabulary learning: "incidental" and "intentional" learning. Incidental learning occurs when vocabulary learning is not intended to be the primary activity (Huckin & Coady, as cited in Sok, 2014) and is instead a by-product of other tasks, such as listening and reading. This approach is similar in concept to the 'Input Hypothesis' proposed by Krashen (1989), in which he states that "we acquire language by understanding messages" (p. 440). On the other hand, intentional learning takes place when learners explicitly learn lexical items through dedicated activities such as rehearsal (Hulstijn, 2001), which Richards and Schmidt (as cited in Lafleur, 2015) define as "a learning strategy that involves saying a new word or sentence to oneself in order to memorize" (p. 6).

Historically, the intentional approach and its resources (drilling, wordlists, definitions, and flashcards) had been favored by traditional language-teaching methods; however, with the rise of Communicative Language Teaching (CLT) and its focus on providing learners with classroom tasks and activities that felt more natural and authentic, the incidental approach took the spotlight since it "offered the seductive prospect that, provided the learners had access to sufficient comprehensible input, L2 vocabulary acquisition would largely take care of itself" (Read, as cited in Brown & Lee, 2015, p. 480).

Despite this appeal, incidental learning is far from being infallible; in fact, its main disadvantage is its effectiveness. Firstly, Schmitt (as cited in Brown & Lee, 2015) observed that many features of vocabulary demand deliberate attention from the learner in order to be fully comprehended, something that is often not possible for learners when they are focusing on the meaning of a task.

Furthermore, Lafleur (as cited in Lafleur, 2015) estimated in 2003 that EFL learners may need to read up to 200,000 words only to learn 108 from the context cues (which equals to only a 0.00054%). In contrast, intentional vocabulary studies allow participants to learn up to 86% of the words.

Despite its comparatively higher effectiveness, the intentional approach is considerably underused in classrooms all over the world. According to a number of studies by Godwin-Jones, Nakata, and Reid (as cited in Lafleur, 2015), this can be mostly attributed to the aforementioned CLT predominance and its precepts of reducing the pedagogical intervention, under which the intentional approach came to be perceived as mechanical, rigid, and out of touch.

The intentional approach uses two main tools for teaching: "wordlists" and "word cards," also known as "flashcards." The former thrived during the 60s and 70s, given its alignment with the behaviorist-cognitivist paradigm; however, CLT's rise cast a negative light on it due to that association. Furthermore, wordlists lack a focus on meaning and are affected by the "serial position effect," where the position of a word in the wordlist affects its recall, with the words in the middle of the list less prone to be remembered than those at the beginning or the end of the list (Baddeley, as cited in Lafleur, 2015). This effect is as also divided into two: the "recency effect," where the recall rate for recently reviewed elements is considerably higher due to their presence in the short-term memory; and the "primacy effect," which explains that the first items on the list are often better memorized than the rest. As such, flashcards became favored by modern researchers.

Flashcards work on an "active recall" principle; this is, making a cognitive effort to remember the information (Lafleur, 2015). Given that declarative knowledge, such as vocabulary, decays quickly (Ullman & Lovelett, as cited in Serfaty & Serrano, 2024), this recalling procedure ends up as a quite effective method to review vocabulary. Baddeley (as cited in Lafleur, 2015) attributes the effectiveness of this "recalling procedure" due to the greater cognitive effort that is required to recall/retrieve a word, which in turn increases the chances of remembering it. Moreover, given the possibility of reshuffling the cards, flashcards are immune to both the "recency effect" and the "primacy effect," as this reshuffling resolves any deficit in attention that could originate from a particular order (Lafleur, 2015).

Young Learners (YL) Characteristics: Age and Cognitive Factors and its impact on Vocabulary Learning

Although there is a widespread assumption that vocabulary teaching (and thus, learning) can fit a homogeneous learner profile, Brown and Lee (2015) note that learner characteristics, particularly age, can profoundly influence how vocabulary is learned and retained. Firstly, Brown and Lee underscore that Young Learners (YL) typically attend to linguistic input in a spontaneous and peripheral manner, contrary to most adult learners who deploy a more focal attention to language forms. Furthermore, adult learners often possess not only a wider vocabulary but also the ability to use a number of deductive and abstract processes to circumvent certain obstacles (for example, using contextual cues). Given these limitations, Coady's (as cited in Lafleur, 2015)

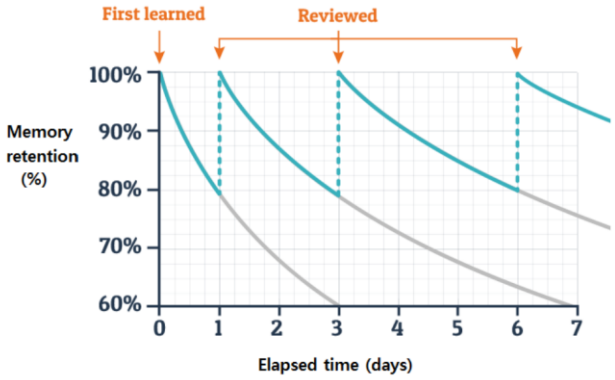
encouragement of teaching vocabulary explicitly (an intentional approach) during the early stages of language learning, what childhood represents, appears to be optimal.

Spaced Repetition Predecessors and Key Terminology

The concept of distributing the review of information over time is far from being a novelty; its earliest precedent can be traced back to Ebbinghaus' experiment of the curve of forgetting in 1885. In said seminal study, Ebbinghaus (as cited in Lafleur and Kanazawa, 2024) established two theorems that underpin the present research: 'Forgetting Curve ' and 'Spacing Effect.' The 'Forgetting Curve' refers to the exponential loss in the information retention strength that happens right after learning or reviewing it, before stabilizing into a curve with a progressively slower descent in time, thus its name. Notably, this forgetting of the information can regain its retention probability when being successfully remembered, and thus being less prone to memory decay **(see Figure 1)**. Subsequent successful reviews further stabilize the curve into an even slower descent, thus cementing the information. Meanwhile, the 'Spacing Effect' is regarded as the learning phenomenon that explains why the learners' information retention after multiple, short study sessions (commonly known as 'spaced learning') yields a significantly higher information retention than those who engage in fewer but longer sessions (known as 'massed' or 'crammed learning') (Lafleur, 2015; 2020). Moreover, Ebbinghaus' learning curve found massed learning rather inefficient, since "the most exponential gain in retention is already achieved by the first rehearsal within a study session and [...] consecutive rehearsals contribute exponentially less and less to increasing memory strength" (Lafleur, 2015, p. 19).

Figure 1

Ebbinghaus' forgetting curve and review cycle.



Note. Reproduced from *The effect of flipped learning on academic performance as an innovative method for overcoming Ebbinghaus' forgetting curve,* by Chun & Heo, 2018, *Proceedings of the 6th international conference on information and education technology* (pp. 56-60).

Serrano's (2022) and Kim and Webb's (2022) meta-analyses of multiple Spaced Repetition papers examined various aspects of it. Firstly, both analyses demonstrated that spaced practice significantly enhances retention when compared to massed or blocked repetitions. Nakata and Suzuki (as cited in Serrano, 2022) found that, while massed repetition may yield faster performance during training, spaced schedules produce significantly higher vocabulary gains at post-test. Furthermore, Lotfolahi and Salehi's (2017) classroom-based research with primary school EFL learners studying English–Farsi further corroborated the spacing effect by showing that the participants demonstrated greater retention when vocabulary was practiced over two sessions rather than in a single massed session. Finally, Namaziandost, Sawalmeh, & Izadpanah Soltanabadi (2020) worked with Iranian students and found as well that spaced repetition did considerably outperform massed repetition in both immediate and delayed post-tests.

Building upon the Spacing Effect and the robust support of spaced repetition as the ideal approach over massed learning, a phenomenon commonly known as the "Lag Effect" was found, which states that the use of longer intersession intervals (ISIs) yielded superior outcomes when compared to shorter ISIs. These ISIs are, in turn, the operational aspect of the aforementioned lag effect. However, the basis behind this phenomenon is not entirely clear, as there are contradictions between papers and authors; on one hand, some research has indicated that "short" ISIs produce in fact a better retention than "long" ISIs (Serrano & Huang, 2021, as cited in Serrano, 2022); on the other hand, other studies found no significant difference between using 1-day ('short') and 7-day ('long') ISIs, particularly when measured with a post-test several weeks later (Rogers & Cheung, 2021, as cited in Serrano, 2022). Furthermore, Rogers and Cheung (as cited in Serrano, 2022) examined in two different studies the lag effect in primary school students, and although they firstly found out that target words learned over a 1-day ISI were better remembered 28 days later than those learned over a longer 8-day ISI, no differences between ISIs were found in a posterior study replication. As Serrano (2022) notes, the concepts of "short" and "long" ISIs "were differently operationalized" (p.359) throughout the multiple research studies, which might have caused all of these results to be inconsistent.

Given these inconsistencies, Cepeda et al.'s (2006)

and Küpper-Tetzel, Erdfelder, & Dickhäuser (as cited in Serrano, 2022) suggest that the optimal ISI will depend on the retention interval, and that it is up to educators to calibrate said time intervals based on the anticipated retention intervals; this is, using "short" ISIs when the educator's goal is a near-term assessments (such as immediate post-tests), and "long" intervals when the goal is to aid long-term consolidation (which can happen in delayed post-tests).

Relevant to mention is that in Lafleur's (2020) outline of existing Spaced Repetition algorithms, the Equal can have either 'short' or 'long' lag intervals, depending on the interval established; moreover, the Expanded algorithm (and its three identified patterns), two of which the present research addresses, can present both the 'short' and the 'long' intervals, as the patterns start with a fairly short interval that increases exponentially.

Spaced Repetition from a Neuroscientific Point of View: The Working Memory and The Articulatory/Phonological Loop

It is imperative to be aware of how the human brain makes use of the aforementioned advantages in informational retention (Spaced Repetition) in order to avoid the steady memory strength decline (Ebbinghaus' Forgetting Curve). Baddeley and Hitch (1974) introduced a framework of three interconnected elements of the human's working memory: the 'Central Executive,' a supervisor or controller system responsible for the cognitive process, such as targeting the information and using the other two elements; the 'Visuospatial Sketchpad,' which stores visual-spatial information for it to be manipulated later; and the most relevant for the present research, the 'Phonological Loop,' which deals with the phonological information. It consists of a passive, short-term "phonological store" that holds auditory traces (any auditorial, speech-based information received by the listener) with a rapid decay, and an "articulatory rehearsal mechanism" that refreshes the aforementioned auditory traces by internally 're-speaking' them. Likewise, Thornbury (2002) established the term 'Articulatory Loop' to refer to this same process of subvocal repetition where the learner repeats the new vocabulary item in their mind to cement it, either by using it for a number of exercises or just via drilling. Furthermore, Thornbury proposed a number of techniques to ensure this articulatory loop works as intended and for learners to indeed remember the new vocabulary and send it into long-term memory. Precisely, is among these techniques that Thornbury lists the principle of 'distributed practice,' which, as the name's similarity suggests, refers to the distribution of the practice through time.

Expanded and Uniform Spaced Repetition Algorithms; Expanded spacing patterns

Amid the still ongoing efforts to determine the optimal ISI, Lafleur (2020) identified two main types of Spaced Repetition Algorithms: 'Expanded' and 'Uniform' or 'Equal' **(See Figure 2).** Firstly, a Uniform Algorithm sets ISIs at fixed intervals; e.g., every two days, which results in having sessions on day 1, day 3, day 5, and so forth. On the other hand, the Expanded Algorithm increases the ISI by following a fixed exponential pattern. Lafleur (2020) illustrates the latter algorithm with a 12-hour ISI that doubles on each iteration. Accordingly, the first session would occur on day 1; the second session could happen later that same day, either or on day 2 (depending on when the initial session was conducted and the 12-hour interval started to be counted). The following sessions would happen on days 3 (with 24 hours of spacing from the previous sessions), 5 (with 48 hours of spacing from the previous session), and so on. It is worth noting that the expanded patterns may be able to cover the two anticipated outcomes mentioned in the previous chapter (both the short intervals at the beginning and the long intervals at the end of the review sessions).

Figure 2

Comparative of Expanded, Uniform, and Massed Pattern.

Main Algorithm Types & Intervals	Initial Study	Interval ①	Interval ②	Interval ③	Interval ④
Expanded (x type) (~12h start → x 2)	day 1 (start point)	day 1 or 2 (~12 hours)	day 3 (1 day)	day 5 (2 days)	day 9 (4 days)
Uniform (same) (→ every 2 days)	day 1 (start point)	day 3 (2 days)	day 5 (2 days)	day 7 (2 days)	day 9 (2 days)
Massed learning or (cramming)	(Total study time compressed into a single session) E.g., If a study session lasts 5 minutes: 5 consecutive sessions x 5 = 25 minutes total.				

Note: Reproduced from *The Indirect Spaced Repetition Concept,* by Lafleur, 2020, *Vocabulary Learning and Instruction,* 9 (2), page 10.

Elaborating further into Expanded Algorithms, Lafleur (2020) outlined three different Expanded spacing patterns, based on how will the pattern augment the inter-study interval (ISI): the Expanded Additive pattern (+ type), the Expanded Multiplicative pattern (x type), and the Expanded Exponential pattern (a^b type), though the latter is not addressed in the present study due to contextual constraints **(see Design).** The additive spacing pattern increases the interval between review sessions by a fixed amount; for example, a two- day increment. In this scenario, sessions would occur on day 1, day 3, day 7, and day

13, with each successive interval extended by an additional two days. In contrast, a multiplicative spacing pattern increases the interval between sessions by multiplying the previous interval by a constant factor. For example, starting with an initial interval of one day and using a factor of two, subsequent sessions would occur on day 2, day 4, and day 8, with each interval doubling in length.

Figure 3

Schedule example for comparison between the three Expanded patterns: Additive (+), Multiplicative (x), and Exponential (a^b).

Factor of 2 (5 Intervals)	Initial Study	Interval ①	Interval ②	Interval ③	Interval ④	Interval ⑤
Expanded (+ type) (previous# → + 2 days)	day 1 (start point)	day 3 (2 days)	day 7 (4 days)	day 13 (6 days)	day 21 (8 days)	day 31 (10 days)
Expanded (x type) (→ x 2)	day 1 (start point)	day 1 (later)	day 3 (2 days)	day 7 (4 days)	day 15 (8 days)	day 31 (16 days)
Expanded (ab type) (E.g., → ~19sec$^{(R)}$)*	day 1 (start point)	day 1 (19 seconds)	day 1 (6 minutes)	day 1 (2 hours)	day 3 (1½ days)	~day 31 (~28½ days)

Note: Reproduced from *The Indirect Spaced Repetition Concept,* by Lafleur, 2020, *Vocabulary Learning and Instruction,* 9 (2), page 11.

However, research that explicitly focuses on these expanded patterns not only is scarce, as most research is focused on the other two types of spacing (Equal and Massed), but it is also non-conclusive. On the one hand, Balota et al. (2007), besides finding the superiority of spacing repetition over massed repetition, found no statistically significant difference between the equal and expanded spacing models; however, Schuetze and Weimer-Stuckmann (as cited in Lafleur and Kanazawa, 2024) found that the equal spacing pattern outperformed the expanded spacing pattern at 83% retention versus 59% when submitted to a nine-month-delayed post-test. Contrary to this, Nakata (as cited in Lafleur and Kanazawa, 2024) found that uniform spacing did not consistently outperform expanded spacing; in fact, when post-test scores were assessed with some leniency, expanded spacing showed a limited but statistically significant advantage over uniform spacing (a 4.6% score increase). Kim and Webb's (2022) meta-analysis of various experiments echoes similar results, as they found that while shorter spacing is as effective as longer spacing on immediate tests, it lost effectiveness in delayed post-tests; furthermore, they corroborate that both equal and expanded spacing yielded statistically similar results. As such, there is yet to be defined a clear optimal interval spacing. Hence, Lafleur (2020) mentions that an interesting course of action would be "to compare these three types of expanded spacing among themselves in future research" (p. 11).

Methodology

Design

This study adopts a quantitative and quasi-experimental design. According to Dörnyei (2007), quantitative research "involves data collection procedures that result primarily in numerical data which is then analyzed primarily by statistical methods" (p. 24). Furthermore, Dörnyei (2007) mentions the 'Experimental Researches,' variations of a panel study (a design that collects data over a considerably long time period) that are used when "part of the sample is exposed to some treatment, intervention, manipulation, or some planned learning experience" (Dörnyei, 2007, p. 85), with the objective of finding out whether or not the sample exposed to one of the aforementioned treatments experienced any changes when compared to a sample that did not receive any:

> A typical experimental design would be an intervention study, which contains at least two groups: the 'treatment' or 'experimental group', which receives the treatment or which is exposed to some special conditions, and the 'control group', whose role is to provide a baseline for comparison.
>
> (Dörnyei, 2007, p. 116)

Campbell and Stanley (as cited in Salkind, 2012) defined three categories of Experimental Designs: pre-experimental, true experimental, and quasi-experimental. Each differs from the others in the degree of variables control; the more control there is over said variables, the easier it is to attribute the outcomes to causality. In the educational context, random participant allocation results impractical; thus, the study followed a quasi-experimental design, a common decision in scenarios where the "group assignment" has already been done (Salkind, 2012).

Lastly, this study takes on a comparative treatment with intact groups (this is, not making modifications to the previously assigned groups following the school's fashion). Firstly, instead of comparing an experimental group with a classic control group, the present study shows two groups receiving two different treatments (in this case, each group working with one of the two expanded patterns), something that aligns with Salkind (2012):

> In some cases, the control group might receive no treatment whatsoever; in others, the control group might receive a different type of treatment from the others. [...] If the treatment group is compared with another group receiving treatment, then the question is: Which of the two is the more effective? (p. 233)

To observe and establish such a comparison, the present study followed two different Expanded patterns: Expanded Additive and Expanded Multiplicative, following Lafleur's (2020) explicit suggestion that comparing these patterns among themselves represented an interesting course of action for future research. The Expanded Exponential pattern was excluded due to its particularly unique interval growth (See **Figure 3)** which required a considerably larger amount of available instructional time, thus making it incompatible with the school calendar's constraints (such as the restriction of instruction to weekdays, the scheduled days off defined by Mexico's Department of Education, and the monthly teacher workshops).

Setting and Participants

The study consisted of 35 EFL learners with a CEFR A2 level from a private primary school located in Central Mexico, divided into two entire groups following the school's fashion: group **'SIGMA'**, consisting of 17 participants (9 male participants and 8 female participants); and group **'MIKE'** with 18 learners (8 male participants and 10 female participants). At the time of the research, both groups were in 6th grade and ranging between the ages of 11-12 years old. The groups showed no significant demographic differences from each other, neither on age nor on gender composition, thus being demographically comparable at the moment of the research.

Both groups attended an English course during weekdays as part of their regular school courses, during 80 minutes a day for a total of 6 hours and 40 minutes per week. The school used English coursebooks aligned with the CEFR; however, it did not use any technological devices such as TVs, tablets, or smartphones. The vast majority of the participants had been learning English during their basic education in that same school (five years at the moment of the study), while a few of them entered the school in the following years, thus ranging between one to five years of studying English in total.

Group SIGMA's sessions were arranged using the Expanded Additive pattern, whereas Group MIKE followed the Expanded Multiplicative pattern.

Procedure

The intervention period took off with a 30-question questionnaire that served as a pre-test, meant to assess participants' baseline knowledge of the lexical items, via multiple-choice questions. In this pre-test, the 9 lexical items were presented for the first time to both groups, thus testing participants' ability to infer the items' meaning and form before properly learning about the items.

The following three weeks were dedicated to the vocabulary review sessions, conducted at the beginning of 5 of the groups' English classes throughout that timespan, with an approximate duration of 20 minutes each. In these sessions, the "active recall" principle mentioned by Lafleur (2015) was implemented as follows: each group's teacher first showed a flashcard's front side with the visual aid to the participants, eliciting from them the lexical item. After the participants' attempt to recall, whether successful or not, the teacher showed the back of the flashcard with the lexical item written on it for learners to self-check their answer. If successful, the teacher placed the flashcard on a 'correct' pile; otherwise, it was placed on an 'incorrect' pile and immediately re-review with the participants. The instructor then pronounced the lexical item, prompting participants to repeat after him, and then asking participants to pronounce the item on their own. Finally, the teacher asked each learner to spell the lexical item, using the flashcard as a guide if necessary. The teacher repeated this procedure with the 9 lexical items.

At the end of the intervention period, a second 30-question, multiple-choice questionnaire was applied to both groups, thus serving as its immediate post-test. Lastly, a third 30-question questionnaire was administered to the two groups 15 days after the immediate post-test, serving as a delayed post-test that measured the participants' retention of the lexical items over a longer term.

The sessions' schedule arrangement was done based on Lafleur's (2020) model of Expanded algorithms sessions. It is important to mention that the precise formulation of these schedules represented a minor difficulty in itself, as the days available for instruction were considerably limited due to the presence of two main factors. Firstly, the school's timetable; by following the same fashion as most schools around the world, it considerably restricted the days available for instruction to only weekdays (from Monday to Friday), especially when compared to Lafleur's (2020) original proposal, in which the entirety of the month was considered as available for instruction. The second factor, also related to the research's context, was the existence of days off for a variety of reasons, whether they were school events, day-offs defined by Mexico's Department of Education (SEP), as well as the monthly teacher's workshop (known as 'CTE') in which students would have no classes. As such, the recurrences had to be carefully designed in a way that all five sessions were to happen on available instruction dates, something

that was not entirely possible. In order to work around this issue, a deterministic forward-adjustment rule was applied: if a session's intended date coincided with a weekend or an unavailable instructional day, the session was moved forward to the next available instructional day. Crucially, this adjusted date served as the new reference point for computing subsequent intervals, being this an operation consistent with what spaced repetition platforms (such as Anki or SuperMemo) refers to as rescheduling or postponing. Furthermore, it is conceptually equivalent to the use of right-shift rescheduling in operations scheduling research. Under this re-basing procedure, any delay produced at one point in the schedule propagates to all remaining sessions.

Research instruments

The study used 5 instruments: firstly, a 9-lexical items list retrieved from the learners' coursebook **(See Appendix 1)**, aligned with Thornbury's (2002) suggested number of lexical items to be taught per session.

The second instrument was the physical flashcards used during the review sessions. Said flashcards had dimensions of 21 cm x 30 cm, thus fitting a standard printer's printing sizes, following the study's purpose of aiding under-resourced environments with their EFL practice. Each flashcard consisted of a front side with a picture about the lexical item, meant to work as the visual aid; and a backside with the lexical item written on it **(See Appendix 2).**

The third, fourth, and fifth instruments were the pre-test, the immediate post-test, and the delayed post-test respectively, each consisting of 30 questions that addressed what both Nation (as cited in Lafleur, 2015) and Thornbury (2002) considered essential for truly 'knowing' a word **(See Appendixes 3-5).**

Data Collection and Analysis

Data was collected via the three tests that participants sat during the aforementioned three moments throughout the intervention process: before the intervention, right after the intervention, and two weeks after the intervention. All data analyses were performed using JASP software.

Findings and Discussion

Pre-test scores revealed that SIGMA (n = 17, meaning 17 participants) had an average score (M) of 8.529 out of 30 with an SD (Standard Deviation; how spread out participants' scores were around the group average) of 5.038; whereas MIKE (n = 18) had an M of 8.166 out of 30, and an SD of 6.473; this means that, while group average scores were comparable, MIKE showed a greater score dispersion **(see Figures 4 and 5).**

Figure 4

SIGMA and MIKE's pre-test scores.

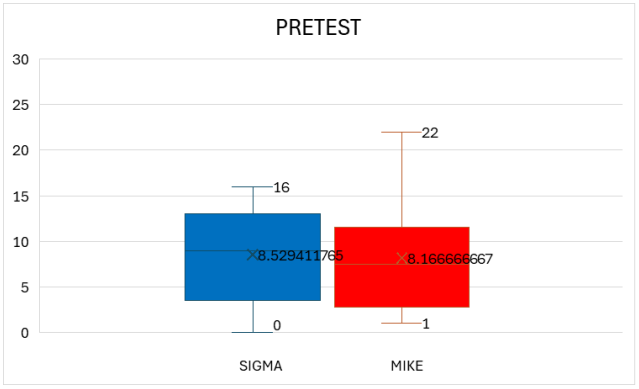
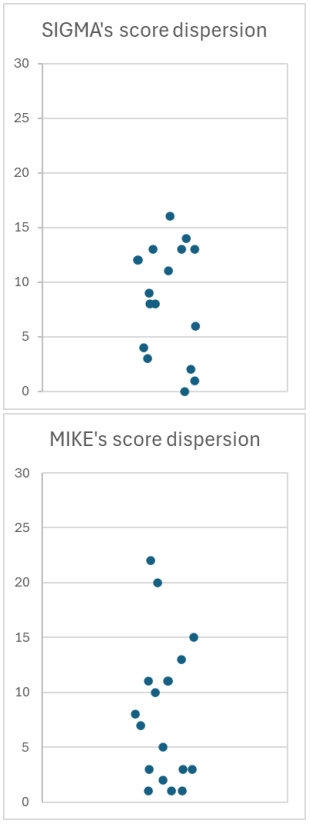


Figure 5

SIGMA and MIKE's pre-test score dispersion.



After the intervention, both groups showed an improvement: SIGMA's M rose to 12.588, and its SD was 5.958, whereas MIKE's M was 13.833, with a much higher SD of 7.648 **(see Figures 6 and 7).** After the delayed post-test was administered, both groups' scores remained higher than their baseline

knowledge, confirming that **it did improve participants' vocabulary retention:** SIGMA's M slightly decreased to 12.529, with an SD of 7.682; however, MIKE's M rose to 14.944, and its SD rose up to 8.453 **(see Figures 8 and 9).**

Figure 6

SIGMA and MIKE's immediate post-test scores.

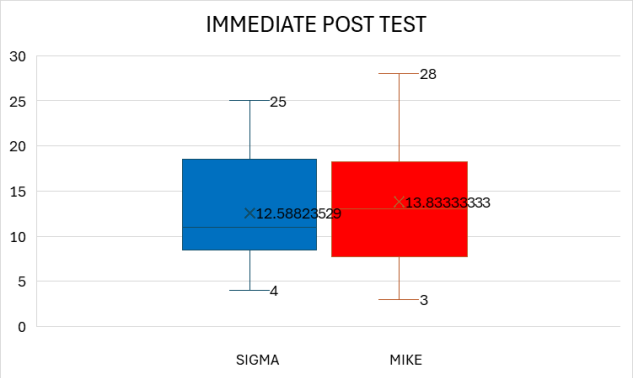


Figure 7

SIGMA and MIKE's immediate post-test score dispersion.

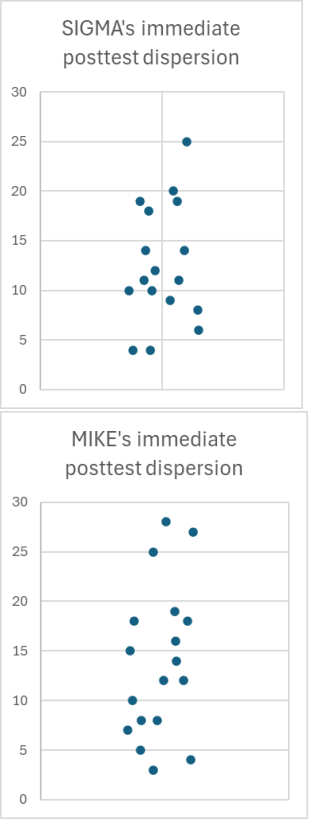


Figure 8

SIGMA and MIKE's delayed post-test scores.

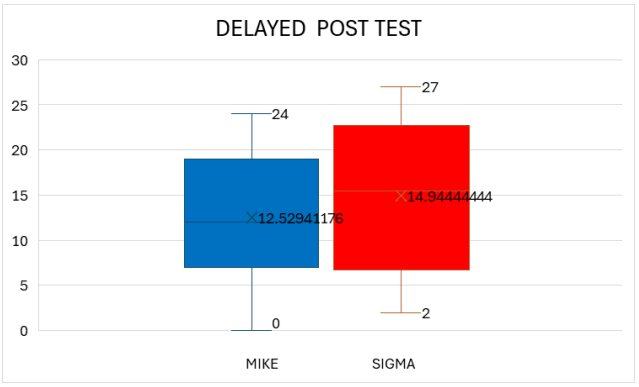
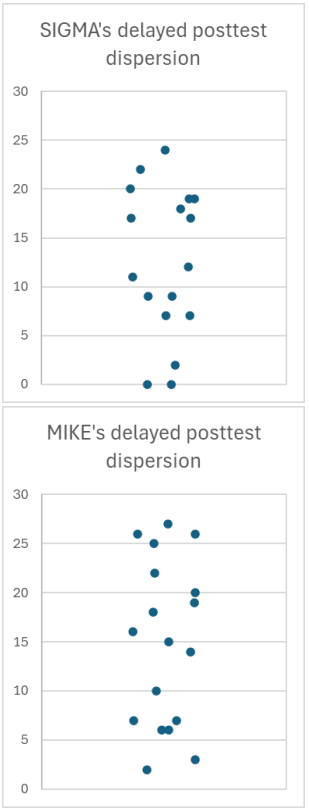


Figure 9

SIGMA and MIKE's delayed post-test score dispersion.



Given MIKE's higher score dispersion in the pre-test, a difference not reflected in the groups' demographics, an analysis of covariance (ANCOVA) was used to compare post-tests while statistically adjusting for the pre-existing differences observed in the pre-test. Before analysis, assumption checks confirmed that score variability was comparable across both groups, and that pre-test scores predicted post-test performance for both groups as well, both of which indicate that an ANCOVA is valid.

After controlling for pre-test scores, **no statistically**

significant difference was detected under the present conditions between MIKE and SIGMA on either the immediate post-test [**F**(1, 32) = 1.76, **p** = .194, **η²** = .014], or the delayed post-test [**F**(1, 31) = 0.71, **p** = .404, **η²** = .011]. Here, **'F'** is the test statistic the ANCOVA produces; **'p'** is the probability that this result occurred by chance, in which values above .05 (such as those seen in the present research) indicate **no significant difference;** and η² (eta-squared) measures effect size, or how much of the variation in scores is explained by group membership; values near zero (such as the ones visible here) indicate a negligible effect. In contrast, **pre-test performance was a strong and consistent predictor of both immediate and delayed outcomes** ($p < .001$ in both cases), indicating that learners' initial vocabulary knowledge was the dominant factor shaping results rather than the patterns in use.

Overall, the results of the study indicate that, **while both of Lafleur's expanded patterns produced measurable learning and retention, neither the Expanded Additive (SIGMA) nor the Expanded Multiplicative (MIKE) produced a statistically reliable advantage for immediate learning or for delayed retention** once baseline vocabulary knowledge was controlled, thus addressing the research question about which of the patterns would result in better vocabulary retention and recall in 11-12 years old Young Learners. The absence of a statistically significant difference implies that initial proficiency was the dominant determinant of outcomes in this sample rather than the patterns in use. Given the small effect sizes observed ($η² = .014$ and $η² = .011$ respectively), which meant that group membership (which spacing pattern a learner received) explained only 1.4% and 1.1% of the variation in scores respectively, and the study's sample size (n = 35), these results should be interpreted as an absence of a detectable difference under the present conditions rather than as evidence of equivalence between patterns.

These findings align with a constant present throughout existing literature: the use of spaced repetition patterns does generate an improvement on vocabulary retention on participants over time, regardless of the ISI in use (Lotfolahi & Salehi, 2017; Namaziandost et al., 2020). However, the scarcity of research explicitly focused on comparing Lafleur's Expanded patterns makes it difficult to find similarities between the present study and previous papers; nonetheless, it represents a stepping stone on the understanding of the spaced repetition and the Lag effect.

Beyond the constraints of existing literature, a contextual factor that may account for the absence of a significant difference between patterns is the aforementioned impact of prior lexical knowledge. As Webb and Nation (as cited in Brown & Lee, 2015) suggested, between 7 and 16 meaningful encounters with a word are required for consolidation; considering the five review sessions alongside the two post-tests in which participants actively retrieved the target items, the total number of encounters per word reaches the lower boundary of this threshold. It is therefore plausible that the volume of exposure, while sufficient to produce the measurable retention gains observed in both groups, may not have been extensive enough for the spacing pattern itself to emerge as a differentiating factor, with initial proficiency filling that explanatory gap instead.

Furthermore, a noteworthy pattern in these data is that, while SIGMA's mean remained virtually unchanged between post-tests, MIKE's continued to rise, which suggests an ongoing consolidation that extended past the intervention process. While the literature surrounding the Lag Effect and the optimal ISIs remains inconclusive, MIKE's trajectory is nonetheless consistent with the theoretical core of the Lag Effect outlined by both Cepeda et al. (2006) and Serrano (2022).

Conclusions

Relevance of the study

The study findings can represent a valuable insight for EFL teachers who are seeking to implement spaced repetition patterns in their classroom for vocabulary retention purposes. Furthermore, given the simplicity of the instruments used in this research, the findings may be especially relevant for EFL teachers or schools in under-resourced contexts (such as developing countries), or for teachers that simply prefer not to rely on the use of technology (such as the assisted use of computer-based programs for learning purposes) in their classrooms for a number of reasons.

Scope

As the study was done with sixth-grade students, ranging within the ages of 11 and 12 years old and with an A2 English level according to the Common European Framework of Reference for Languages (CEFR), therefore, the findings may not be directly applicable to learners of different age groups or proficiency levels without further research. Furthermore, the study compared two out of the three Lafleur's Expanded patterns due to contextual constraints and under-resourcing.

As such, this study should be seen as a stepping

stone towards a better understanding of Expanded spacing patterns to provide educators with information for better decision-making, rather than as a conclusive or defining study.

Further research

Given the small effect sizes for the groups and the amount of sessions, practical implications and future work should consider (a) replication with larger samples to increase power, (b) replicating with less restrictive contexts, in a way that makes it possible to compare all three Lafleur's Expanded spacing patterns at once, or (c) replicating the experiment over a longer timespan or with more sessions to better fulfill Webb and Nation's (as cited in Brown & Lee, 2015) suggestion of 7-16 encounters per word.

References

[1] Baddeley A. D., Hitch G. (1974). Working Memory. Psychology of Learning and Motivation. Vol. 2. Academic Press. pp. 47–89.

[2] Balota, D. A., Duchek, J. M., & Logan, J. M. (2011). Is expanded retrieval practice a superior form of spaced retrieval? A critical review of the extant literature. The foundations of remembering, 83-106.

[3] Brown, H. D., & Lee, H. (2015). Teaching by principles: An interactive approach to language pedagogy. Pearson.

[4] Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. Psychological Bulletin, 132, 354–380.

[5] Chun, B. A., & Heo, H. J. (2018). The Effect of Flipped Learning on Academic Performance as an Innovative Method for Overcoming Ebbinghaus' Forgetting Curve. ICIET`18: Proceedings of the 6th International Conference on Information and Education Technology, 56-60.

[6] Dörnyei, Z. (2007). Research methods in applied linguistics. Oxford University Press.

[7] Hulstijn, J. H. (2001). Intentional and incidental second-language vocabulary learning: A reappraisal of elaboration, rehearsal and automaticity. In P. Robinson (Ed.), *Cognition and Second Language Instruction* (pp. 258–286). Cambridge University Press.

[8] Kim, S. K. & Webb, S. (2022). The Effects of Spaced Practice on Second Language Learning: A Meta-Analysis. Language Learning. 72. 269-319. DOI: 10.1111/lang.12479

[9] Krashen, S. (1989). We acquire vocabulary and spelling by reading: Additional evidence for the input hypothesis. *The modern language journal*, *73*(4), 440-464.

[10] Kroeger, P. R. (2005). Lexical entries and well-formed clauses. In Analyzing Grammar: An Introduction (pp. 66–86). chapter, Cambridge: Cambridge University Press.

[11] Lafleur, L. (2015). The Conceptualization of Balanced and Multifaceted Vocabulary Learning Systems (M.A.). Available on researchgate.net. doi:10.13140/RG.2.2.22161.84327/1

[12] Lafleur, L. (2020). The Indirect Spaced Repetition Concept. Vocabulary Learning and Instruction, 9 (2), 9–16. https://doi.org/10.7820/vli.v09.2.lafleur

[13] Lafleur, L., & Kanazawa, Y. (2024). The Effects of Interleaved Spaced Repetition Learning on Vocabulary Knowledge. Computer-Assisted Language Learning Electronic Journal, 25(3), 172-194.

[14] Lotfolahi, A. R., & Salehi, H. (2017). Spacing effects in vocabulary learning: Young EFL learners in focus. Cogent Education, 4(1), 1287391.

[15] Namaziandost, E., Sawalmeh, M. H. M., & Izadpanah Soltanabadi, M. (2020). The effects of spaced versus massed distribution instruction on EFL learners' vocabulary recall and retention. Cogent Education, 7(1), 1792261. https://doi.org/10.1080/2331186X.2020.1792261

[16] Perrett, J. *Now I Know 6.* Pearson Education

[17] Salkind, N. J. (2012). Exploring research (8th ed.). Pearson Education.

[18] Schmitt, N. (2002). Vocabulary in Language Teaching. Cambridge University Press.

[19] Scrivener, J. (2005). Learning teaching (Vol. 2). Oxford: Macmillan.

[20] Serfaty, J, & Serrano, R. (2024). Lag effects for foreign language vocabulary learning through Quizlet. Language Learning & Technology, 28(1), 1–21. https://hdl.handle.net/10125/73567

[21] Serrano, R. (2022). A state-of-the-art review of distribution-of-practice effects on L2 learning. Studies in Second Language Learning and Teaching, 12(3), 355-379.

[22] Sok, S. (2014). Deconstructing the concept of 'incidental'L2 vocabulary learning. *Studies in Applied Linguistics and TESOL*, *14*(2).

[23] Thornbury, S. (2002). How to teach vocabulary (5th ed.). Pearson Education Limited.

[24] Xiao, Q., & Wang, J. (2024). DRL-SRS: A Deep Reinforcement Learning Approach for Optimizing Spaced Repetition Scheduling. Applied Sciences, 14(13), 559

Appendixes

APPENDIX 1

Coursebook lexical items list

1	Residence	**2**	Attraction	**3**	Bird's-eye view
4	Panoramic	**5**	Challenging	**6**	Out of the ordinary
7	Decipher	**8**	Instigate	**9**	Tedious

Partially retrieved from: Perrett, J. *Now I Know 6.* Pearson Education

APPENDIX 2

Flashcards sample

APPENDIX 3
Pre-test

1. Listen and circle the phrase you hear.

a.	• Resident	• Residence	• Residences
b.	• Attraction	• A fraction	• Abstraction
c.	• Outer ordinary	• Out of the ordinary	• One of the ordinarily
d.	• Panoramical	• Panorama	• Panoramic
e.	• Bird's-eye view	• Birds I view	• Bear's-eye view
f.	• Instigate	• Investigate	• Make a craft
g.	• Decipher	• Decider	• This cipher
h.	• Challenging	• Challenge in	• Chalk inning
i.	• Tedious	• Tidius	• Teadius

2. Choose from the word bank. Use one word per blank.

(residence · decipher · panoramic · tedious · attraction · instigate)

1. The beach festival is the town's biggest _____.
2. They needed a map to _____ the old handwriting.
3. The castle has a _____ view of the whole coastline.
4. Moving to a new _____ means buying boxes and packing.
5. The homework was so _____ that it took too long.
6. He did not want to _____ a fight, so he stayed quiet.

3. Unscramble and write the correct word. There is a hint for each word.

1. **E R E E C I S N D**
   Hint: a place where someone lives
   Answer: _____
2. **N C G I E N L G L A H**
   Hint: difficult in a way that makes you try harder
   Answer: _____
3. **S D T E U O I**
   Hint: long, boring, and repetitive
   Answer: _____
4. **H I P D E C E R**
   Hint: to figure out the meaning of a secret or code
   Answer: _____
5. **T T A N I A C T O R**
   Hint: something that people wants to visit or see
   Answer: _____
6. **T U O F O E H T R R O D Y N I A**
   Hint: unusual; not normal (it's a phrase, four words)
   Answer: _____

4. Match the words to their definitions.

1. residence	a. something that people visits
2. attraction	b. to make something happen
3. bird's-eye view	c. very wide view that shows a large area
4. panoramic	d. a place where someone lives (like a house or apartment)
5. challenging	e. not usual; strange
6. out of the ordinary	f. to understand something that is written in code or difficult handwriting
7. decipher	g. difficult but interesting to try or do
8. instigate	h. a photo taken from above, as if taken by a bird flying
9. tedious	i. boring because it is long or repetitive

APPENDIX 4. Immediate Post-test

1. Listen to the teacher and complete the sentences.

1. I saw a rainbow umbrella on the street! That's something _____ for sure!
2. The museum created a new activity to _____ students' interest in history.
3. From the top of the building, we got a beautiful _____ of the entire city.
4. The puzzle was so difficult that it took us an hour to _____ the hidden message.
5. Some students find doing homework extremely _____.
6. Beating the final boss of this videogame was very _____.
7. The castle used to be the royal family's _____ many years ago.
8. From the hill, we enjoyed a _____ view of the storm forming in the distance.
9. The new park became the biggest _____ for visitors this month.

2. Unscramble the letters to form the words.

a. **D I R E N E C E S** —>

b. **T R A T C A T O I N** —>

c. **T I G A N S T I E** —>

d. **D R I B ' S - Y E E W E I V** —>

e. **R O M A N A P I C** —>

f. **C H E P R I E D** —>

g. **T U O F O E H T N I D R O A R Y** —>

h. **O U D I E S T** —>

i. **L A N G L I C H E N G** —>

3. Complete the text. You can use each word once.

Word Bank: **residence · attraction · instigate · panoramic · decipher · tedious**

Last weekend, my family and I visited a famous _____ (1) in our city. From the top, we had a _____ (2) view of the mountains and the lake — it was amazing!

After that, we went to an old building that used to be the king's _____ (3). Inside, there were many paintings and symbols that were difficult to _____ (4).

At first, the guide tried to _____ (5) our curiosity by asking us some riddles about history. The visit was fun and exciting, not _____ (6) at all!

APPENDIX 5. Delayed Post-test

1. Listen to the teacher spelling the vocabulary; write it on the lines.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

i. _____

2. Choose the correct option to complete each sentence. Use each phrase once.

residence | out of the ordinary | decipher | tedious | panoramic | bird's-eye view | attraction | instigate | challenging

a. That's the royal family's _____! It's where the king lives! We need to take a photo!

b. This 1000-piece puzzle is so _____! I can't find the missing piece.

c. I saw a purple car on the street! That's something _____.

d. I've been reading about hieroglyphics. If we go to Egypt, I can _____ them easily.

e. When we go to Paris, the very first _____ we need to see is the Eiffel Tower!

f. We are a very numerous family. Every Christmas, we take a _____ photo so everyone appears!

g. I want to know what happened to them, so I will _____ them.

h. Oh my god, this homework is so _____. All I do is write and write and write!

i. When I use Google Maps, I see the _____ pictures and imagine I'm the one flying over the city.

3. Write the correct item next to each picture.

_____

_____

_____

_____

_____

 _____

 _____

 _____

 _____