CHAPTER 16

IMPROVING LONG-TERM VOCABULARY RETENTION THROUGH FLASHCARDS AND SPACED REPETITION TECHNIQUES

Sorokina Tetiana
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INTRODUCTION

The article examines the effectiveness of using flashcards within the framework of the spaced repetition method for learning foreign language vocabulary by students of higher education institutions majoring in "English for Specific Purposes." The study evaluates the impact of this method on the memorization and long-term retention of new vocabulary. Particular attention is paid to the analysis of learners' cognitive load and their motivation during the learning process. The role of motivation in the successful acquisition of educational material is characterized. The study highlights the convenience of using flashcards as an approach to foreign language learning, both for expanding vocabulary and for professional communication. As a result, a directions of studying this learning strategy in the long term are identified. In recent years, rapid technological development and the digital transformation of higher education have significantly influenced approaches to foreign language teaching and learning. Students increasingly rely on mobile devices and online educational platforms to support independent learning outside the classroom. Consequently, educators are seeking evidence-based teaching strategies that promote learner autonomy, increase engagement, and facilitate long-term knowledge retention. Among these strategies, spaced repetition combined with digital flashcards has emerged as one of the most promising approaches for systematic vocabulary acquisition. Its growing popularity is supported by advances in cognitive psychology, educational neuroscience, and learning analytics, which collectively demonstrate that repeated retrieval of information at optimally scheduled intervals substantially improves long-term memory. The acquisition of professional vocabulary is particularly important in English for Specific Purposes (ESP) courses, where students are expected to master terminology relevant to their future careers. Unlike general English

vocabulary, ESP terminology is often characterized by high lexical density, discipline-specific meanings, and limited opportunities for natural repetition in everyday communication. As a result, many students experience difficulties in retaining newly acquired professional vocabulary despite repeated classroom exposure. Flashcard-based learning addresses this challenge by providing structured, individualized repetition schedules that enable students to review terminology efficiently while minimizing unnecessary cognitive effort.

Another important aspect of flashcard-based learning concerns the development of learner autonomy. Modern educational paradigms emphasize the importance of self-directed learning, critical thinking, and continuous professional development. Digital flashcards encourage students to assume greater responsibility for their own learning by allowing them to organize review sessions according to their individual needs, monitor learning progress, and identify vocabulary items requiring additional practice. Such flexibility is particularly valuable in higher education, where classroom contact hours are often insufficient for mastering the extensive vocabulary required in professional disciplines. The effectiveness of flashcards is further enhanced through their compatibility with contemporary educational technologies. Many digital platforms incorporate adaptive algorithms, multimedia resources, gamification elements, and detailed learning analytics that improve learner engagement and facilitate personalized instruction. Audio pronunciation, visual illustrations, contextual examples, and interactive quizzes provide multiple pathways for encoding and retrieving lexical information. These features correspond to current theories of multimedia learning and cognitive load management, suggesting that appropriately designed educational materials can improve both learning efficiency and student motivation.

1. The problem's prerequisites emergence and the problem's formulation

The spaced repetition method underlying flashcard-based learning was developed by the German scientist Sebastian Leitner in the 1970s. His book «*So lernt man lernen*»[1] became a bestseller and the approach itself has been recognized as one of the most effective methods for learning new vocabulary. Leitner designed this approach based on the principles of spaced repetition. Instead of rote memorization, knowledge is transferred from short-term to long-term memory through the systematic sorting of flashcards in a box divided into several compartments (typically five). On one side of each card there is a word along with an example sentence in English, while on the other side

[1] Leitner S. So lernt man lernen: *Der Weg zum Erfolg*. Freiburg: Herder, 1972. 317 S.

there is its translation. The principle of use is simple: correctly recalled words are moved forward into subsequent compartments, whereas words that need further repetition are returned to the initial compartment. The effectiveness of this method can be explained by the process of active recall. When learners take a card and attempt to remember the word, the brain actively retrieves information, which leads to significantly better retention compared to passive reading or rote memorization. Thus, the moment of attempting to recall a word and then verifying the correct answer strengthens memory more effectively than simply reading word lists and their translations. Therefore, flashcards represent an effective tool for learning and consolidating educational material. In addition, their use helps overcome the phenomenon of forgetting as systematic repetition at specific intervals significantly slows down the rate of memory decay[2]. Subsequent research has confirmed that revising information at gradually increasing intervals not only improves initial memorization but also ensures its long-term retention in memory.

With the development of the educational process, the concept of spaced repetition has undergone significant advancement, particularly as systematic approaches to revising learning material were introduced into educational practice to enhance learning effectiveness[3].

In recent decades, the spaced repetition method has gained particular relevance due to the emergence of various digital applications that employ spaced repetition algorithms to automate the learning process[4]. Applications such as Anki and SuperMemo are based on contemporary scientific research into memory mechanisms and enable the optimization of time intervals between repetitions of learning material. Flashcards as a didactic tool have been used in educational practice for a considerable period of time. Their simplicity and intuitive nature make them an effective means of self-directed learning, which is particularly important in online learning environments. In addition, they enhance visual perception of information, thereby engaging various cognitive processes and improving the effectiveness of learning material acquisition.

An important advantage of flashcards is their mobility and flexibility, which allows them to be used in a variety of contexts, both during classroom instruction and in independent study[5]. With the development of digital technologies,

[2] Ebbinghaus H. *Memory: A Contribution to Experimental Psychology*. New York: Dover Publications, 1964. 123 p.

[3] Cepeda N. J., Pashler H., Vul E., Wixted J. T., Rohrer D. Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological Bulletin*. 2006. Vol. 132, No. 3. P. 354–380.

[4] Cepeda N. J., Vul E., Rohrer D. et al. Spacing effects in learning: A temporal ridgeline of optimal retention. *Psychological Science*. 2008. Vol. 19, No. 11. P. 1095–1102.

[5] Kornell N. Optimising learning using flashcards: Spacing is more effective than cramming. *Applied Cognitive Psychology*. 2009. Vol. 23, No. 9. P. 1297–1317.

flashcards have become even more popular due to the emergence of specialized software and mobile applications that support their use. Digital flashcard versions enable the integration of multimedia elements, including audio, video materials, and illustrations, which significantly increases their effectiveness in foreign language learning. Modern platforms for creating and using flashcards, such as Quizlet, allow users to create their own sets of cards, share them with other learners, and organize collaborative learning activities, thereby expanding opportunities for cooperative educational practices. Students of technical and agro-biological specializations actively use Anki for:

- terminology acquisition
- preparation for English language exams

Moreover, the use of flashcards is consistent with the competency-based approach that has become a defining feature of contemporary higher education. Rather than focusing exclusively on the memorization of isolated lexical items, digital flashcards facilitate the acquisition of professional vocabulary in authentic communicative contexts. This is particularly important for students of technical and agrobiologically specialties, whose future professional activities require not only knowledge of specialized terminology but also the ability to apply it accurately in academic and professional communication. Well-designed flashcards usually include definitions, collocations, example sentences, visual representations, and pronunciation models, which contribute to the development of lexical, grammatical, and communicative competences simultaneously.

Another significant advantage of digital flashcards lies in their adaptability to individual learning needs. Unlike traditional classroom instruction, where all students typically follow the same pace, spaced repetition systems automatically adjust review intervals according to each learner's performance. Difficult vocabulary items appear more frequently, whereas well-mastered terms are reviewed after progressively longer intervals. Such personalization increases learning efficiency and reduces unnecessary repetition, allowing students to devote more time to concepts that require additional attention. Consequently, adaptive learning technologies contribute to higher learner autonomy and support the principles of lifelong learning. The effectiveness of spaced repetition can also be explained from the perspective of cognitive psychology. According to the theory of retrieval practice, every successful attempt to recall previously learned information strengthens memory traces and improves future accessibility of knowledge. Unlike passive review strategies, retrieval-based learning requires active cognitive engagement, leading to deeper processing of information. This phenomenon, commonly referred to as the "testing effect," has been extensively documented in educational research and demonstrates that frequent low-stakes retrieval activities produce greater long-term retention than repeated reading of the same material.

Flashcards naturally implement retrieval practice by requiring learners to generate an answer before receiving immediate feedback.

Furthermore, multimedia flashcards correspond to the principles of dual coding theory, according to which information presented simultaneously through verbal and visual channels is encoded more effectively than information delivered in only one modality. The integration of images, diagrams, pronunciation recordings, and contextual examples creates multiple cognitive associations that facilitate vocabulary acquisition and subsequent retrieval. This feature is particularly beneficial when learning technical terminology, where abstract concepts often become easier to understand through visual representation. The increasing availability of artificial intelligence technologies has further expanded the educational potential of flashcard-based learning. Contemporary AI-assisted platforms can automatically generate flashcards from digital textbooks, lecture notes, research articles, and other educational resources. Natural language processing algorithms identify key concepts, terminology, and definitions, significantly reducing the amount of time students spend preparing learning materials. Some applications are capable of generating example sentences, providing contextual explanations, detecting synonyms, and suggesting translations based on the learner's level of language proficiency.

As a result, flashcards are evolving from simple memorization tools into intelligent learning systems capable of supporting personalized educational trajectories. For students of engineering, information technology, veterinary medicine, agronomy, biotechnology, and environmental sciences, the acquisition of specialized English vocabulary represents one of the greatest challenges during professional training. Scientific publications, technical documentation, software interfaces, and international standards are predominantly available in English. Consequently, insufficient command of professional terminology may significantly limit students' academic mobility, participation in international projects, and future career opportunities. Regular work with flashcards enables students to build an extensive professional vocabulary gradually while minimizing cognitive overload through distributed learning sessions. Research also indicates that learners generally demonstrate higher motivation when using interactive digital learning tools compared with conventional vocabulary notebooks. Features such as learning statistics, progress visualization, achievement indicators, and gamification elements contribute to sustained learner engagement over extended periods of study. Motivation is further enhanced through the possibility of accessing learning materials from multiple devices, allowing students to review vocabulary during short periods of free time, such as while commuting or waiting between classes. Such flexibility transforms vocabulary learning into a continuous process rather than an activity

limited to classroom instruction. Despite numerous advantages, the successful implementation of flashcard-based learning requires careful instructional design. The quality of flashcards largely determines learning outcomes. Cards containing excessive information or poorly formulated questions may increase cognitive load and reduce retention efficiency. Educational researchers therefore recommend that each flashcard focus on a single learning objective, present information clearly and concisely, and include sufficient contextual support. In foreign language instruction, vocabulary cards should preferably include authentic example sentences, pronunciation guides, collocations, and, where appropriate, visual illustrations. Another important consideration concerns the integration of flashcards into broader pedagogical strategies. Although spaced repetition effectively supports vocabulary acquisition and factual knowledge retention, it cannot replace communicative practice, problem-solving activities, collaborative learning, or project-based instruction. Instead, flashcards should be viewed as one component of a comprehensive instructional model in which memorization is complemented by productive language use in authentic professional situations. Consequently, combining flashcard practice with classroom discussions, presentations, case studies, and discipline-specific tasks creates more favorable conditions for developing both linguistic competence and professional communication skills. Given these considerations, there is a growing need to investigate how modern flashcard technologies can be effectively integrated into English for Specific Purposes (ESP) courses offered to students of technical and agrobiologically higher education institutions. While numerous studies have confirmed the effectiveness of spaced repetition for vocabulary acquisition, comparatively fewer investigations have examined its application in discipline-specific language instruction, particularly within Ukrainian higher education. This research gap determines the relevance of further studies aimed at evaluating the pedagogical effectiveness of digital flashcards, identifying best practices for their implementation, and developing methodological recommendations for English language teachers working with future specialists in technical and agrobiologically fields.

2. The analysis of existing methods for solving the problem and formulating a task for the optimal technique development

An experimental study aimed at evaluating the effectiveness of using flashcards within the framework of the spaced repetition method for foreign language vocabulary acquisition was conducted with a group of students majoring in “Agronomy”. The research sample consisted of senior-year students studying English as a foreign language. All participants underwent a preliminary test to determine their initial level of vocabulary knowledge. The experiment

involved students with English proficiency levels ranging from elementary (A2) to upper-intermediate (B2) according to the Common European Framework of Reference for Languages (CEFR). This made it possible to cover a broad range of language competencies and assess the effectiveness of the proposed methodology at different stages of foreign language learning[6].

For the purposes of the experiment, a set of flashcards titled *"Agriculture for Students"* and *"English Grammar for Students"* was used (see Fig. 1). The set contained 100 and 168 words and phrases, respectively, corresponding to the lexical topics included in the curriculum at the relevant stage of training[7]. Each flashcard included a foreign-language word, its translation into the participants' native language, as well as contextual usage examples. In some cases, illustrations were added to strengthen visual associations.

The learning experiment lasted three weeks. Students used flashcards on a daily basis, dedicating at least 15 minutes per day to reviewing the learning material. Such an organization of work ensured a systematic and consistent approach to vocabulary acquisition. At the end of each week, participants completed interim tests aimed at assessing the level of acquisition of words and phrases, which made it possible to track the dynamics of memorization throughout the entire research period[8].

The first repetition of a new word occurred several hours after its initial exposure. This stage is extremely important, as short-term memory retains information only for a limited period, and without timely repetition it is quickly lost. The second repetition was carried out on the following day, when the information begins to transfer into long-term memory. Subsequently, the intervals between repetitions were gradually increased: the third repetition took place after three days, the fourth after one week, and the fifth after two weeks. Such a progressive increase in time intervals contributed to the activation of memory consolidation processes and more reliable retention of lexical material[9].

Quantitative indicators were assessed based on the results of regular testing conducted weekly throughout the experiment[10]. At the initial stage, before the introduction of flashcards and the spaced repetition method, the average percentage of correctly recalled words in the control group was approximately

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[6] Roediger H. L., Karpicke J. D. Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*. 2006. Vol. 17, No. 3. P. 249–255.

[7] Dunlosky J., Rawson K. A., Marsh E. J., Nathan M. J., Willingham D. T. Improving students' learning with effective learning techniques. *Psychological Science in the Public Interest*. 2013. Vol. 14, No. 1. P. 4–58.

[8] Nakata T. Computer-assisted second language vocabulary learning in a paired-associate paradigm. *CALICO Journal*. 2011. Vol. 28, No. 1. P. 1–21.

[9] Nation I. S. P. *Learning Vocabulary in Another Language*. Cambridge : Cambridge University Press, 2013. 624 p.

[10] Schmitt N. *Vocabulary in Language Teaching*. Cambridge : Cambridge University Press, 2000. 224 p.

Fig. 1. Example of flashcards

30%. This can be explained by the fact that participants had different initial levels of language proficiency, and most of the lexical items presented were new to them or insufficiently learned.

After the first week of the study, the average level of vocabulary acquisition increased to 45%. By the third week of the experiment, after participants had completed several cycles of spaced repetition with extended intervals, the average rate of successful vocabulary retention reached 75%. The obtained results indicate that repeated exposure to learning material at progressively increasing intervals ensures effective consolidation of lexical items in long-term memory[11].

The final test conducted after the completion of the experiment showed that more than 80% of the studied vocabulary was correctly recalled by the participants, which serves as convincing evidence of the high effectiveness of the proposed methodology[12]. This confirms that spaced repetition not only accelerates the memorization process but also ensures long-term retention of learning material, which is particularly important in the context of foreign language learning for specific purposes.

The results of the study also demonstrated that the use of spaced repetition with flashcards helps reduce excessive cognitive load compared to traditional learning methods, particularly intensive memorization of large volumes of material within a short period of time. This effect is achieved through the even distribution of learning workload and the gradual increase of intervals between repetitions, allowing students to acquire new vocabulary progressively without overloading memory processes[13].

An important factor in successful learning is also learner motivation.

[11] Baddeley A. *Working Memory, Thought, and Action*. Oxford : Oxford University Press, 2007. 412 p.

[12] Kang S. H. Spaced repetition promotes efficient and effective learning. *Policy Insights from the Behavioral and Brain Sciences*. 2016. Vol. 3, No. 1. P. 12–19.

[13] Settles B., Meeder B. A trainable spaced repetition model for language learning. *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (ACL)*. 2016. P. 1848–1858.

Traditional memorization methods often lead to fatigue and loss of interest in studying, which negatively affects academic performance[14]. In contrast, the use of flashcards contributes to long-term learning outcomes, and the experiment showed that students find it significantly easier to recall words that are intended for active use. In any case, such practice is considerably more effective than short-term cramming followed by forgetting, which is commonly used for exam preparation.

CONCLUSIONS

Despite the proven effectiveness of spaced repetition, several aspects of its application warrant further investigation. One promising area for future research is the examination of how individual cognitive styles influence the effectiveness of this learning approach. As learners differ in the ways they perceive and process information, tailoring spaced repetition techniques to their individual characteristics such as preferences for visual or auditory modes of content presentation may further enhance learning outcomes.

In addition, the influence of different types of instructional content on long-term retention remains insufficiently explored. In particular, further empirical research is needed to determine whether multimedia materials, such as videos and audio resources, provide significant advantages over traditional text-based flashcards for foreign language vocabulary acquisition.

Another important direction for future research involves expanding the application of flashcard-based spaced repetition systems particularly through the integration of artificial intelligence (AI) technologies into language education. Future studies should examine the effectiveness of these systems not only for vocabulary acquisition, but also for learning grammatical structures, mastering discipline specific terminology, developing communicative competence, and supporting other key components of foreign language learning. Such research may contribute to the development of more personalized, adaptive, and efficient language learning environments. The findings presented in this study confirm that flashcard-based learning supported by spaced repetition represents an effective pedagogical strategy for improving vocabulary acquisition in English for Specific Purposes courses.

By promoting active recall, distributed practice, and systematic revision, this approach contributes not only to faster memorization of new lexical items but also to their durable retention in long-term memory. Furthermore, digital flashcard systems provide students with flexible opportunities for autonomous

[14] Webb S. Receptive and productive vocabulary learning: The effects of input modality. *Studies in Second Language Acquisition*. 2005. Vol. 27, No. 1. P. 33–57.

learning, enabling them to organize study sessions according to their individual pace, learning objectives, and available time. Such characteristics make spaced repetition particularly valuable in higher education, where independent learning constitutes an essential component of professional training. The educational value of flashcards extends beyond vocabulary memorization. Their integration into contemporary digital learning environments encourages students to develop self-regulated learning skills, including planning, monitoring, and evaluating their own academic progress. These competencies are increasingly recognized as fundamental for lifelong learning and continuous professional development. In addition, the accessibility of mobile applications enables students to engage in frequent short learning sessions, thereby making more effective use of otherwise unproductive periods throughout the day. Such flexibility contributes to maintaining regular revision schedules, which are essential for maximizing the benefits of spaced repetition. The results also suggest that successful implementation of flashcard-based learning depends not only on the algorithm underlying spaced repetition but also on the pedagogical quality of the learning materials. Flashcards should be carefully designed to include meaningful contextual examples, authentic professional vocabulary, appropriate multimedia support, and opportunities for active retrieval rather than simple recognition. Consequently, educators play a crucial role in selecting or creating high-quality instructional materials that correspond to students' linguistic proficiency and professional specialization. Combining flashcards with communicative classroom activities, collaborative learning, and authentic professional tasks may further strengthen the transfer of acquired vocabulary to real-life communication. The rapid development of educational technologies creates additional opportunities for enhancing flashcard-based learning systems. Artificial intelligence, adaptive learning algorithms, natural language processing, and learning analytics have the potential to provide highly individualized learning experiences by automatically identifying students' strengths and weaknesses, predicting optimal review intervals, and generating personalized learning content. These technological advances may significantly increase both learning efficiency and learner motivation while reducing the amount of time required for preparing educational materials.

Overall, the growing body of evidence supporting spaced repetition indicates that this approach should be considered an important component of modern foreign language instruction in higher education. Its successful integration into English for Specific Purposes curricula may facilitate the development of professional communicative competence, improve students' readiness for international academic and professional collaboration, and promote more sustainable learning outcomes. Therefore, continued interdisciplinary research

involving educational psychology, applied linguistics, and educational technology is essential for optimizing the design and implementation of flashcard-based learning systems and for identifying the conditions under which they can provide the greatest educational benefit for learners across different academic disciplines.

SUMMARY

This study examines the effectiveness of the spaced repetition method implemented through flashcards for foreign language vocabulary acquisition. The research reviews the theoretical foundations of spaced repetition, originally proposed by Sebastian Leitner, and highlights its role in transferring information from short-term to long-term memory through systematically increasing review intervals. An experimental study involving university students with English proficiency levels ranging from A2 to B2 (CEFR) was conducted over three weeks. Participants used a set of 268 flashcards daily, while regular assessments measured vocabulary retention throughout the experiment. The findings demonstrated a substantial improvement in vocabulary acquisition, with the percentage of correctly recalled lexical items increasing from approximately 35% before the experiment to over 80% by its completion.

The results confirm that spaced repetition combined with flashcards significantly enhances vocabulary retention, reduces cognitive load, and increases learners' motivation through active recall, self-assessment, and interactive learning. The study concludes that this approach is an effective strategy for English language learning and suggests further research into the influence of cognitive learning styles, multimedia content, and the application of spaced repetition to grammar, cultural competence, and other aspects of proficiency language competence.

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Information about the author:
Sorokina Tetiana,
Candidate of Technical Sciences,
Associate Professor at the Department of English
for technical and agrobiological specialties,
National University of Life and Environmental Science of Ukraine
15, Heroiv Oborony Street, Kyiv, Ukraine