UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Departamento de Lingüística Aplicada
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Ph.D. Thesis

Spatial mnemonics for L2 vocabulary recall. Customized training for 21st century students.

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Doctoral Degree in Languages, Literature and Culture, and their Applications

June 2023

Acknowledgements

First of all, I would like to express my sincere gratitude to my thesis supervisors, Dr. María Luisa Carrió Pastor, a Professor of English Language at the Applied Linguistics Department at Universitat Politècnica de València and Dr. Juan Carlos Tordera Yllescas, a Lecturer at the Department of Language and Literature Education at Universitat de València. They have helped me to find my path and gave me a valuable opportunity to progress at my own pace, always being very patient and encouraging. They asked me insightful questions and gave me generous advice thus creating perfect conditions to grow as a researcher.

In spite of my fields being linguistics and language teaching, I initially had an ambitious plan not only to design and to test a specific methodological framework but also to pitch and supervise actual product development (applications and games). This result would have been impossible without people who have been my team at different staged of this thesis work.

I need to express my gratitude to Dr. José María Font Fernandez, an Associate Professor in Games and Artificial Intelligence at the Department of Computer Science and Media Technology at Malmö University (MAU) and Dr. Soumyabrata Dev, an Assistant Professor in the School of Computer Science, University College Dublin (UCD), for giving me the opportunity to carry out research stays at the Game Lab at MAU and in THEIA: THE visIon and Analytics lab at UCD. I would like to thank my co-authors who applied their expertise in the fields of cognitive psychology and the function of the memory system (Dr. Stephen Darling, a Senior Lecturer at the Psychology, Sociology and Education Division in Queen Margaret University in Edinburgh), in the field of social and qualitative psychology (Dr. Clare Uytman, a Senior Lecturer in the Psychology, Sociology and Education Division in Queen Margaret University in Edinburgh), and finally in the field of videogame design (Dr. Ramón Pascual Mollá Vayá, an associate professor at the Department of Computer Systems and Computation (DSIC) of the Polytechnic University of Valencia (UPV) and Dr. Larkin Cunningham, a Lecturer in Computer Science at Munster Technological University (MTU)).

I would like to thank Mr. Minos Stavroulakis, a developer of the MnemoRoom4U application and Ms. Darina Dinkova Dimitrova, a developer of the Roman Palace videogame who used their talent and skills to contribute to this research. I would like to express special appreciation to Dr. F. Javier Casinos Mora, a Professor of Roman Law at the University of Valencia and Dr. Manuel Albaladejo Vivero, a Professor of Ancient History at the University of Valencia for their report on the historical adequacy of the Roman Palace videogame. I am also very grateful to Mr. Xavier de Jonge for his editing advice, to all the participants who took part in the experimental and control trials and to the anonymous peer reviewers for their suggested improvements in the manuscripts. I would also like to give special thanks to all my colleagues and friends for their encouragement and emotional support.

To finish, I want to express my deepest gratitude to my family, my parents, my husband and especially to my son David whose birth coincided with the first year of my Ph.D. research and whose growth has accompanied me throughout the thesis work bringing together the most important stages of my life.

Abstract

This thesis is aimed at promoting collaboration among L2 teachers, IT professionals, L2 students tackling 21st century technology, and the modern digitally minded public. Specifically, it seeks to provide practical solutions for efficient SL/FL/L2 vocabulary memorisation and engagement via the use of visuospatial mnemonics in immersive environments. Methodologically it counts on a collection of numerical data analysed statistically and by exploring a subjective perspective shared by the participants. The manuscript is a compendium of published papers that highlight different aspects of the thesis content. The author kept in mind a common question for quantitative studies which was if the experimental approach would demonstrate statistically significant results in comparison to control techniques while open-ended questions were the base for qualitative inquiries. In addition, surveys were used to obtain opinions in a standardized format. All the studies conducted both demonstrated the effectiveness of mnemonic spatialization in combination with AR, VR and within an explorative videogame, and collected valuable insights from individual participants. Supplementary research confirmed students' predilection for tailor-made courses and the need for didactic innovations.

Resumen

Esta tesis tiene como objetivo promover la colaboración entre profesores de L2, profesionales de las Tecnologías de la Información y estudiantes de L2 que abordan la tecnología del siglo XXI con una mentalidad digital. Específicamente, busca proporcionar soluciones prácticas para la memorización y el compromiso eficientes del vocabulario SL/LE/L2 mediante el uso mnemónico de memoria espacial y entornos inmersivos. Metodológicamente cuenta con la recopilación de datos numéricos analizados estadísticamente y con la exploración subjetiva compartida por los participantes. El texto es un compendio de artículos publicados que destacan diferentes aspectos del contenido de la tesis. El autor tuvo en mente una pregunta común para los estudios cuantitativos: si el enfoque experimental demostraría resultados estadísticamente significativos en comparación con las técnicas de control donde las preguntas abiertas eran la

base para las investigaciones cualitativas. Además, se utilizaron encuestas para obtener opiniones en un formato estandarizado. Todos los estudios realizados demostraron la efectividad de la espacialización mnemotécnica en combinación con AR, VR y dentro de un videojuego exploratorio, y reunieron información valiosa de los participantes individuales. Investigaciones complementarias confirmaron la predilección de los estudiantes por cursos personalizados y la necesidad de innovaciones didácticas.

Resum

Aquesta tesi té com a objectiu promoure la col·laboració entre professors de L2, professionals de les Tecnologies de la Informació i estudiants de L2 que aborden la tecnologia del segle XXI en una mentalitat digital. Específicament, persegueix proporcionar solucions pràctiques per a la memorització i el compromís eficients del vocabulari SL/L1/L2 mitjançant l'ús mnemònic de memòria espacial i entorns immersius. Metodològicament compta amb la recopilació de dades numèriques analitzades estadísticament i amb l'exploració subjectiva compartida pels participants. El text és un compendi d'articles publicats que destaquen diferents aspectes del contingut de la tesi. L'autor va tindre en ment una pregunta comuna per als estudis quantitatius: si l'enfocament experimental demostraria resultats estadísticament significatius en comparació a les tècniques de control on les preguntes obertes eren la base per a les investigacions qualitatives. A més, es van utilitzar enquestes per a obtenir opinions en un format estandarditzat. Tots els estudis realitzats van demostrar l'efectivitat de l'espacialització mnemotècnica en combinació amb AR, VR i dins d'un videojoc exploratori, i van reunir informació valuosa dels participants individuals. Investigacions complementàries van confirmar la predilecció dels estudiants per cursos personalitzats i la necessitat d'innovacions didàctiques.

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Prologue

Leaving behind a classical tradition of a monograph-based work, this doctoral thesis follows a new practice of a compendium of publications promoting the concept of double-blind peer review in academia. This approach has permitted the author to obtain expert opinion from reviewers globally, creating challenges and constantly encouraging for improvements.

The author of this thesis initially had a particular interest in the use of spatial memory in combination with immersive technologies (AR and VR) for L2 recall. As mentioned by Edmondson (1999), L2, foreign language (FL) and second language (SL) can be used as terms that are opposed to the person´s mother tongue, L1. The niche that required research was initially detected by overview of academic literature on the main topic with its posterior systemisation. The thesis consists of 8 published papers divided into two blocks: Main Research which focuses on spatial mnemonic tools for L2 vocabulary recall and Supplementary Research which focuses on tailoring of customized courses. Parts 4 and 5 discuss the obtained results (a brief self-report on the thesis work). Overall, the thesis sets premises for further research and technological development (RTD) in the field of modern L2 teaching and learning. The list of publications included into this thesis are as follows:

Publication 1 (Journal Paper): Larchen Costuchen, A., Darling, S., & Uytman, C. (2021). Augmented reality and visuospatial bootstrapping for second-language vocabulary recall. *Innovation in Language Learning and Teaching, 15*(4), 352–363. https://doi.org/10.1080/17501229.2020.1806848

Publication 2 (Journal Paper): Larchen Costuchen, A., Font Fernández, J. M., & Stavroulakis, M. (2022). AR-Supported Mind Palace for L2 Vocabulary Recall. *International Journal of Emerging Technologies in Learning (iJET), 17*(13), pp. 47–63. https://doi.org/10.3991/ijet.v17i13.25073

Publication 3 (Journal Paper): Larchen Costuchen, A., Mollá Vayá, R. P., & Dinkova Dimitrova, D. (2022). Roman Palace: A Videogame for Foreign-Language Vocabulary Retention. *International Journal of Emerging Technologies in Learning, 17*(5), 87–102. https://doi.org/10.3991/ijet.v17i05.27621

Publication 4 (Journal Paper): Larchen Costuchen, A., Cunningham, L., & Tordera Yllescas, J.C. (2022). *Bunker-Room Mnemonics For Second-Language Vocabulary Recall. International Journal of Virtual and Augmented Reality, 6*(1), pp 1-13; https://doi.org/10.4018/ijvar.304899

Publication 5 (Book Chapter): Larchen Costuchen, A. (2020). Chapter 7: From Generation Gap to Generation Lap: Gen Z Subcultures. In book: Estudios de lingüística aplicada IV. Editors: Carrió Pastor, María Luisa, Periñán Pascual, Carlos, Romero Forteza, Francesca & Olmo Cazevieille, Francoise. pp. 113 - 130. Editorial Universitat Politècnica de València

Publication 6 (Conference Paper): Larchen Costuchen, A., & Dev, S. (February 26–28, 2022). Confronting challenges of non-formal education: A shift from book-based EFL to tailor-made, experimental syllabi. In The 2022 5th International Conference on Big Data and Education (ICBDE'22), Shanghai, China. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3524383.3524450

Publication 7 (Journal Paper): Larchen Costuchen, A. (2020). Adaptación curricular: gamificación, el aula invertida y la aplicación de métodos mnemotécnicos. *Estudios Interlingüísticos, 8*, 111–123.

Publication 8 (Journal Paper): Larchen Costuchen, A. (2023). Guadalingo in Teaching Spanish as a Foreign Language (FL): Practical Insights. *International Journal of Learning and Teaching 9(*2). https://doi.org/10.18178/ijlt.9.2.84-89

Publications 1, 2, 3, 5, 7 and 8 are reproduced as Author´s Accepted Manuscripts (AAM) while publications 4 and 6 belong to the Author´s Original Manuscript (AOM) category. Co-authors with no Ph.D. degree (M. Stavroulakis for Publication 2 and D. Dinkova Dimitrova for Publication 3) declared their acceptance of the inclusion of the joint publication in the aforementioned doctoral thesis, together with their resignation to use the same publication as part of another PhD thesis.

PART 1: INTRODUCTION TO THE MAIN RESEARCH

a) From dual coding theory to AR and VR technologies

Processing visual information by human brain with the aim of memorization has been a subject of studies in cognitive psychology and education since the 70s (Stengel, 1971; Paivio, 1971, 1978, 1986; White et al., 1977; Fleming, 1977; Anderson, 1978; Shepard, 1978; Kosslyn, 2006; Yang et al., 2018). Stimuli can be encoded either as images or as words (Tversky, 1969) and processed simultaneously or serially (Das et al., 1975). According to the dual coding theory (DCT) a combination of both, verbal (keywords, descriptions, word groups, context etc.) and visual codes (images, objects, mind maps etc.) creates premises for efficient retention (Paivio, 1986). The evidence of positive effect in presenting text and images together has already been described in academic literature since the 80s (Wharton, 1980, 1988, Bernard, 1990; Glenberg & Langston, 1992; Reed & Beveridge, 1986, 1990;) when the 90s performed change from the text-only computer-assisted language learning to multimedia communication with text supported by images, audio, or animation (Harben, 1999; Cameron, 1999; Kukulska-Hulme, 2000) eventually passing from computer screens onto smaller, hand-held devices (Hwang and Tsai, 2011). The latter yielded portability, context sensitivity and customisation to its users thus promoting exploratory learning outside the classroom (Sharples et al., 2007; Frohberg et al. 2009; Sung et al, 2016).

To address the vocabulary learning difficulties, a widely recommended means of enhancing foreign language vocabulary has been by flashcards (Nation, 2001; Elgort, 2010; Nakata, 2011; Ashcroft, 2018), when deliberate study takes place through the translation of a concept from a foreign language to the learner´s original language (L1) with learners flipping the cards to check the meaning (Nation, 2001; Cross & James, 2001; Nation & Webb, 2011). Modern card versions can be translation-, image-, and sound- supported which makes those resources easy to use for digitally-minded generations at the same addressing the students´ learning style, the manner in which individuals perceive and process information in learning situations (Chun & Plass, 1996; Brown, 2000; Chun & Payne, 2004, Larchen Costuchen, 2020). Since the spread of computer-assisted language learning (CALL), technological progress has converted paper dictionaries to digital lexicography, substituted manual

translations by automatic, initiated text to image recognition or vice versa constantly improving the levels of accuracy. Google Creative Lab and independent coders (at https://experiments.withgoogle.com) have explored machine learning for a variety of purposes that could be applied for L2 vocabulary training (Quick, Draw!, n.d., Scribbling Speech, n.d.) Starting from 2021, more immersive, AR-enhanced (Vocabulary AR, n.d., Vocabulary Builder AR, n.d.) and AR/VR-enhanced (Mondly, n.d. & ImmerseMe, n.d.) applications and games were launched.

In the last decades immersive learning environments (ILEs) have been explored via game-based or simulation-enhanced practices relying on virtual reality (VR) or augmented reality (AR) acting as a catalyst for transformation and innovation among educators, researchers, game designers and users/learners. Augmented reality offers a real-time perspective of a physical environment that has been enhanced directly or indirectly by adding computer-generated 3D objects to it (Caudell, 1995; Azuma, 1997; Zhou et al., 2008) via smart devices or head-up displays (HUDs). Unlike this technology, virtual reality completely immerses users into a three-dimensional world providing them with a sense of spatial presence and allowing them to interact with objects and other inhabitants of that synthetic environment (Sutherland, 1968; Krueger, 1977; Kurt, 2007; NASA, 2016; Zhan et al., 2020). In her book, Hamlet on the Holodeck, Murray (1997) described the term immersion as a metaphorical term derived from the physical experience of being submerged in water, the concept being redefined by other authors´ as feeling of being surrounded (Witmer & Singer, 1998; McMahan, 2003; Ryan 2003; Ermi & Mäyrä, 2005). Since the release of Unity and Unreal Engine for computer game industry, potentials of virtual and augmented spaces have started to grow (Edler & Kersten, 2021) increasing productivity in a number of sectors and improving education (Ardiny & Khanmirza, 2018).

Two systematic reviews and one meta-analysis on efficiency of AR in educational setting (with no focus on language learning) based on publications between 2003 and 2018 demonstrated that outcomes and motivation were the main advantages, with a major limitation being technical problems (Bacca et al., 2014; Akçayır & Akçayır, 2017; Garzón et al., 2019). The state-of-the-art review by Parmaxi, and Demetriou (2020) with 54 publications between 2014 and 2019 revealed that top AR activities in TEFL were vocabulary-centred (23.9%), with reading (12.7%), speaking

(9.9%) writing (8.5%) and generic language skills (9.9%) being less popular categories. Another interesting outcome of that review was that the majority of the AR studies were conducted in tertiary education, in real-life classrooms whilst none of the AR experiments was conducted in a workplace or in vocational education. A revision on AR-enhanced and VR-enhanced language learning made by Huang et al. (2021) with 88 studies between 2011 and 2020 confirmed that immersive learners were mostly university and graduate students, that VR and AR technologies improved learning outcomes and increased motivation. Nearly thirty percent of those articles focused on second-language vocabulary acquisition. Intrinsic motivation for VR use in education was revealed by Kavanagh et al. (2017) with systematic revision of 99 papers published between 2010 and 2017. According to it, general education encompassed around 25 percent of VR with health being the leading domain. Within educational sector 51% of implementations were created for use in higher education. General reported issues and limitations of VR systems also yielded interesting results, with problems pertaining to cost, training, software and hardware usability. Particularly prevalent was the occurrence of software usability issues; occurring nearly twice as frequently as most of the other issue reported. A recent systematic revision conducted by Deng and Yu (2022) with 23 studies analyzing VR from the perspective of language learning and its target users revealed that vocabulary learning and tertiary education gained the most attention in academia and that future research is needed to explore effectiveness of VR and interdisciplinary collaboration.

b) AR/VR-enhanced spatial environment for L2 training: a systematic review

Literature review of scholarly publications demonstrated that spatial presence in VR and AR positively influences content retention in learners (Gupta, 2016; Huttner and Robra-Bissantz, 2017; Vazquez et al. 2018; Cho, 2018; Parmaxi & Demetriou, 2020; Huang et al., 2021). Participants can memorize sequential order of events or information by location either inside a synthetic environment or by interaction with 3D object in the real world (Patel & Vij, 2010; Järvinen & Verschure, 2011; Legault et al., 2019; Yang et al, 2020). The role of mnemonics in the overall learning process can be found in the first level of Bloom's revised taxonomy of learning according to which, the first level is defined as remembering followed by understanding, applying,

analyzing, evaluating, and creating (Krathwohl 2002; Huttner and Robra-Bissantz, 2017). The term mnemonics comes from Greek mnéemee (memory) and téchnee (art). It is a system that facilitates memorization of a large amount of information or complex data based on repetition and previous knowledge. Mnemonic strategies may count on rhymes, chunking, use of acronyms, encoding, and linking among other options. In the past, a strategy to recollect non-spatial information by making use of spatial memory was applied by Greek and Roman orators to remember long rhetorical treatises (Yates, 1966; 1999; Mungello & Spence, 1986; Madan & Singhal, 2012). Nowadays the method of loci (place = lat. locus, pl. loci [ˈləʊ.saɪ]) has become a memory-enhancing practice which consists in imagining oneself walking around a familiar environment and trying to memorize a set of spatially related pieces of information (Kliegl et al., 1990; Nyberg et al., 2003; Derwinger et al., 2003; Moé & De Beni, 2005; Gross et al., 2012; Knauff, 2013 & Krokos et al., 2019). A memory palace in the form of amphitheater was first visually described on paper by Giulio Camillo in 1511. Its goal was to provide spatial mapping to words or text and then recall those by mentally visualizing that part of the environment (Krokos et al., 2019). A spatial mnemonics study conducted by Legge et al. (2012) revealed that participants who used a virtual memory palace performed better in the task than those using a mental memory palace, and those who were not instructed on a memory strategy did not perform as well as those who were instructed to use the memory strategy (Krokos et al., 2019). Building an imaginary memory palace requires familiar loci, e.g., scenes in a story, a 3D-AR-enhanced scenes in real-life settings observed via smart devices or head-up displays (HUDs), a 3D virtual scene seen on a desktop or a 3D scene in virtual reality via HUDS etc. (Yang et al., 2021). The idea to integrate mnemonic methods into the students' curriculum was originally suggested by Levin and Levin (1990) however, such strategies were not fully welcomed in the teaching community (Putnam 2015; Huttner and Robra-Bissantz, 2017). Either spatial mnemonics or AR/VR may improve an individual's ability to recall information, however while mnemonics focuses on units of meaning (textual or numerical), AR/VR provides an interactive visual environment that presumably reinforces learning. It should also be highlighted that both spatial mnemonics and spatial memory rely on organizing information and associating it with the features of the surrounding environment (Krokos, 2018).

This study intended to answer the following review question (RQ): What does the literature say about using AR/VR-enhanced spatial mnemonics/ spatial memory in foreign/second language/L2 education from 2013 to 2023? The search included spatial memory together with the AR or VR components and it was narrowed to foreign/second language/L2 education in the last ten years. Bibliographic databases on scholarly literature used for this research encompassed Web of Science (WOS) and Scopus. Additionally, records obtained via personalized artificial intelligence–powered recommendations (Semantic Scholar) were added. The selection criteria established by title, abstract and keywords relied on the search from 2013 (the year of introduction of the first consumer-ready VR headset up to date) using the following terms: ("mnemonic*" OR "method of loci" OR "memory palace" OR "loci") AND ("learn" OR "acquisition" OR "train*" OR "recall" OR “retriev*” OR "memoriz*" OR "memoris*") AND ("augmented" OR "virtual" OR "immers*"). To select papers for review, inclusion, exclusion and search criteria in line with research question were defined (Table Int.T1).

Table Int.T1. Articles search under the established criteria

Inclusion criteria	Exclusion criteria	RQ-based search criteria
AR/VR technologies	Not AR/VR	Target and native languages (L2 and L1)
L2 domain/ Spatial Mnemonics/ Spatial Memory Component	Not Second Language/ Foreign Language/L2 domain	Language domain (e.g., vocabulary, oral communication, writing, listening, grammar, reading)
Age from 6 (average primary school age) to 65 (average retirement age)	Not spatial mnemonics/ not spatial memory	AR or VR
Language of publication: English	Non-empirical research	Country of study
Search from 2013 to 2023 (last 10 years)	Wrong age parameters or wrong age category	Participants
Search in topic categories:	Wrong language of publication	Study duration
Language and Linguistics,	Wrong topic category	Types of findings (qualitative, quantitative)
Educational Research,	Own research	Learning outcomes (positive, negative, no change)
Multidisciplinary	Participants’ learning disability (LD)	Participants’ comments (e.g., motivation, anxiety, etc.)

Psychology.

Table Int.T2 displays the articles selection process.

Table Int.T2. Identification of studies via databases from 2013 to 2023

Identification	**Screening**	**Selection/ Inclusion**
Total number of records published until February 8th, 2023 (n=188). Records identified from: Web of Science (n = 60) Scopus (n = 112) Records collected via personalised Semantic Scholar API: (n=16)	Records (170) removed: N= 44 duplicate records N= 119 out of RQ scope (e.g., spatial mnemonics/spatial memory in L2 but not AR or VR; AR or VR with spatial memory but not L2 domain; AR or VR in L2 plus mnemonics, but not spatial type) N=4 excluded as own research N= 17 excluded as non-empirical (category: state-of-the-art)	N=19 full-text potentially relevant articles N= 7 excluded after full-text screening (reason: out of RQ scope) N=12 full-text records included in the review

Initially, 19 studies reached the final stage. Seven of them, however, had to be excluded, either because they described the method of loci with word memorisation that did not form part of L2 acquisition or because they used technology-free mnemonic L2-vocabulary retrieval. Of the 12 studies that comprised the final selection (Appendix 1), only one paper (Hagström & Winman, 2018) specifically mentioned a method of loci (MOL) as part of its proposed methodology; one combined different text-, audio-, and visual experiences with augmented-reality objects (Nurkhamimi Zainuddin et al., 2018), and the rest used AR or VR in combination with a spatialized technologically simulated environment. The studies' designs were quantitative (n=5), mixed-method (n=5), and qualitative (n=2). Most were controlled studies, except two (Lee et al., 2019; Nurkhamimi Zainuddin et al., 2018). More than half (n=7) used pre- and post-test methodologies where an outcome assessment was performed both before and after the educational intervention, with results being compared within and between groups to see whether the intervention caused any improvement and, if so, whether this improvement was significantly different from the control group or not. Participants

were mostly university students (50%). One study involved intermediate-school students aged 12-15 (Alfadil, 2020), and one had grade-12 students aged 17-18 (Lai & Chen, 2021). On the whole, the participants' ages ranged from 12 to 41 years. Four of the 12 studies (33%) did not provide details on the participants' demographics. Most of the selected papers focused on teaching English as a second or foreign language (41%), and in the majority of the studies (25%) Chinese was the native language (L1). Fuhrman et al. (2021), Hagström & Winman (2018) and Ibrahim et al. (2018) also used counterbalanced methods (where the participants were divided into different groups and the order in which interventions were provided was balanced among all groups).

Table Int.T3. Study design and details about the technology interventions

Author & Year	Purpose of intervention	Study design	Comparison/ study conditions	Intervention details	Learning outcomes
(Papin & Kaplan-Rakowski, 2022)	Vocabulary acquisition	Qualitative and quantitative Three groups Pre-test/ post-test	Three groups: highly immersive VR using headsets, low immersive VR using PCs, 2D screens (control)	A 5-minute pre-test 5-6 minutes to study pictures 20 minutes to complete the receptive and productive post-tests	Vocabulary screening test Recall and production of the target vocabulary Recognition of the target vocabulary
(Hagström & Winman, 2018)	Grammar learning (gender assignment) Vocabulary acquisition	Counterbalanced design, quantitative and qualitative	1 group with 2 conditions The conditions were counterbalanced (dividing the sample into 4 groups)	Two sessions (1 week apart). 1 session for learning 1 session for testing	Cued recall Free recall
(Ibrahim et al., 2018)	Vocabulary acquisition, recognition and retention	Quantitative and qualitative 1 group with multiple conditions Pre-test/ post-	AR-based learning vs flashcards	3 learning phases of 90 minutes, each to learn 5 new words, 3 productive recognition	Productive recognition test Productive recall test

		test Counterbalanced		tests, 1 productive recall test. A delayed test was conducted 4 days later	
(Nicolaidou et al., 2021)	Vocabulary acquisition, engagement and immersion	Quantitative, two groups, pre-test/ post-test	Head-mounted VR vs mobile application	4 stages 1st stage: introduction to the study and its objectives, 2nd stage: vocabulary pre-test, 3rd stage: learning via experimental (20 min) or control conditions (10 min), 4th stage: vocabulary post-test	Vocabulary performance, engagement and immersion
(Fuhrman et al., 2021)	Vocabulary acquisition	1 group with 3 different learning conditions pre-test/ post-test, quantitative	VR watch-only condition, VR irrelevant movement, VR object manipulation	Each participant learned 13 or 14 different words in each learning environment	Computerized word-picture matching test to evaluate the voc. acquisition
(Lai & Chen, 2021)	Vocabulary acquisition	Qualitative and quantitative. Two groups, pre-test/ post-test	Control group comparison PC gaming vs VR gaming	Pre-test one week before the intervention 50 minutes introductory session 50 minutes for gameplay post-test one week after the	Vocabulary translation, vocabulary recognition, vocabulary retention

				intervention	
(Lee et al., 2019)	Vocabulary acquisition	Game development and qualitative survey			NA
(Alfadil, 2020)	Vocabulary acquisition	Quantitative, quasi-experimental Two groups, Pre/ post-test	VR game vs a traditional book-based method	35-45 minutes sessions (12 days) Each student had 5-8 minutes to play the game everyday	Vocabulary test
(Legault et al., 2019)	Vocabulary acquisition	Mixed counterbalanced design Qualitative and quantitative	VR vs traditional list of word pairs	3 sessions; total of 3 hrs. 1 session for pre-intervention, cognitive testing 1 session for learning 1 session for post-intervention, cognitive testing	Cognitive measures: Attentional Network Task (ANT), Language History Questionnaire (LHQ), Letter Number sequencing (LNS) task, Peabody Picture Vocabulary Test (PPVT-4), Spatial Reasoning Instrument (SRI)
(Chew et al., 2018)	Vocabulary acquisition of complex words (idioms)	Two groups Pre-test/ post-test Quantitative	Location-based learning with or without AR	A pre-test - introductory session. Learning procedures for both groups Control group was not provided with a VR	Vocabulary assessment System Usability Scale (SUS)

				set-up 16 idioms at 16 locations within 60 minutes Post-test	
(Nurkhamimi Zainuddin et al., 2018)	Vocabulary acquisition, satisfaction with technology	Single group Qualitative	Students were taught Arabic voc. using the AR. Satisfaction with the AR technology was measured.		Arabic vocabulary learning questionnaire
(Li et al., 2022)	Vocabulary acquisition for geography	Quantitative Two groups Pre-test/ post-test	VR-based vs video-based learning	10 minutes - pre-test, 60 minutes - learning activity. Abstract writing - 30 minutes. Post-test vocabulary level - 10 minutes. Post-test learning and engagement - 10 minutes	Vocabulary and engagement VR test for the experimental group

Study interventions also varied from study to study. Four of the 12 studies (33% of the total) used AR-enhanced strategies to teach vocabulary to students. Two of the four used augmented-reality flashcards (Ibrahim et al., 2018; Nurkhamimi Zainuddin et al., 2018), one used an AR learning application developed via Vuforia Augmented Reality SDK (Chew et al., 2018) and one was based on an AR mobile game developed using the Unity game engine and Vuforia Augmented Reality SDK (Lee et al., 2019). The experiment described by Ibrahim et al. (2018) made use of a Microsoft HoloLens, an augmented-reality head-mounted display which allowed users to interact with animated holograms. Object labels with L2 words in Basque were used for the AR learning task. The system offered the possibility of hearing words pronunciation

through the device's embedded speakers. The real-time mapping of the environment allowed the users to walk around the room keeping the labels in place and saving their location throughout the study. The experiment by Nurkhamimi Zainuddin et al. (2018) combined reading experience with explanations of the vocabulary words displayed through video, text, audio, and AR objects support via the Aurasma application. In the mobile-phone AR game the real-time camera image (user´s home or another environment) was overlayed by virtual figure which could be placed on top of the AR marker (Lee et al., 2019). The experiment conducted by Chew et al. (2018) required learners to move around their university campus from one location to another and to train different learning situations with idioms through the AR app (each location was assigned to one idiom). After completing the route via AR-enhanced training on the app, the result was checked by test questions. In another experiment, Lee et al. (2019) used a mobile-phone game AR block builder with QR codes as markers, a word-guessing game, and a revision section. The AR block builder allowed players to assemble virtual figures for English target words using colourful virtual building blocks of different types, which were overlaid on users´ home or other environments. For AR technology to work, mobile devices/tablets (Chew et al., 2018; Lee et al., 2019; Nurkhamimi Zainuddin et al., 2018), head-mounted displays and PCs were needed (Ibrahim et al., 2018).

Eight of the 12 studies (66%) used virtual reality as technology. The tasks performed differed from study to study. Four studies (33%) used immersive interactive environments to teach students L2 vocabulary (Fuhrman et al., 2021; Hagström & Winman, 2018; Lai & Chen, 2021; Legault et al., 2019), while four other studies (33%) focused on studying the learning material in 3D pictures or videos (Alfadil, 2020; Li et al., 2022; Nicolaidou et al., 2021; Papin & Kaplan-Rakowski, 2022). In the experiment described by Fuhrman et al. (2021), the participants were present in the virtual environment as avatars consisting of heads and hands. They moved around in their virtual environments, observing objects up close or from further away, and listening to their pronunciation in L2. In the study described by Hagström and Winman (2018), the 3D VR software

was created in Unity3D and the graphics designed using 3DS Max. The participants had to memorise nouns in L2 together with gender assignment in L2 (masculine, feminine, and neuter). The mouse buttons were used to move around the MOL-inspired spatial virtual environment on a computer with a 56.5 × 39.5 cm screen. Lai & Chen's 2021 experiment gave participants Oculus Go VR headsets to play a novel visual sci-fi game (Angels and Demigods) and to learn the target words in L2. The experiment by Legault et al. (2019) describes participants having to learn kitchen and zoo items in an immersive virtual reality (iVR) in which they used HTC Vive handsets to use their avatars' fingers to guide laser beams to virtual items and then listening to the corresponding words in the L2. In the study described by Alfadil (2020) students were immersed in the VR game House of Languages and sent on field trips such as a dramatic tour of a virtual zoo where they could see the animals and learn the new vocabulary using Samsung Galaxy VR headgear use experience. The VR experience in House of Languages places players in a cartoon house with a raccoon character who walks with the players through the environment, teaching them a foreign language. When players gaze at 3D objects within the game environment, they see the objects' names and hear their pronunciation. Li et al. (2022) describe an experiment in which HTC Vive Pro2 sets were used to teach L2 vocabulary related with the hydrologic cycle in a VR setting that facilitated the transformation of abstract geographical concepts into concrete experience. In the experiment described by Nicolaidou et al. (2021), students learned new vocabulary via conversations with virtual characters in different scenarios played out in the MondlyVR application using head-mounted Oculus Rift VR displays. The experiment described by Papin & Kaplan-Rakowski (2022) used Google Cardboard high-immersion virtual reality (HiVR) gear for L2 vocabulary learning, comparing it with a low-immersion environment (LiVR): PC desktops. Two out of all the VR studies compared the performance of highly immersive environments (VR-headset-based) vs low-immersive environments (mobile-phone/PC-based) in teaching L2 vocabulary (Lai and Chen, 2021; Papin & Kaplan-Rakowski; 2022). Overall, all the studies (AR and VR) reported positive outcomes with superior recall in comparison with control groups (see

learning outcomes in Table Int.T5), with participants describing the experimental techniques as highly engaging, interactive and enjoyable (Ibrahim et al., 2018; Lai & Chen, 2021; Papin & Kaplan-Rakowski, 2022).

Table Int.T4. Study outcomes: quantitative and qualitative results

Study	Results	Key Finding	Participants´ comments (qualitative results)
(Papin & Kaplan-Rakowski, 2022)	MANOVA indicated that productive measures did not differ significantly (p=0.18) whereas the receptive measures had a significant difference across the groups (p<0.01) LiVR performed best with a score of 11.65 for receptive vocabulary recall Perceived effectiveness and engagement between the control and both VR groups were statistically significant LiVR vs the control group (0.006 and 0.019) Students found LiVR easy to use compared to the HiVR	The VR students showed improvement in learning, retention, and reproduction vs the control group. LiVR group got highest scores for recognizing the vocabulary	Highly engaging, interactive, and effective
(Hagström & Winman, 2018)	Study mode had a significant effect on cued recall scores (p=.002), retention interval had a significant effect (p=<0.001) Study mode had a significant effect on free recall (p<0.001) The study also found that visualization ability could predict perceived efficiency of a VR (0.31) correlation	Both cued and free recall performance was superior when the material was learnt through the MOL-based 3D VR method, compared with when it had been presented in text (printed on paper). Visualization ability correlated with method efficiency in the cued recall test, advantage provided by the 3D spatiotemporal context. The efficiency of the MOL-based method was found to correlate with its perceived efficiency	Experimental study mode was more effective
(Ibrahim et al., 2018)	Better recall (7%, p<0.05) for the AR learning group compared to traditional flashcards Better productive recall (21%, p<0.01)	AR was better for learning vocabulary than flashcards	Effective and enjoyable
(Nicolaidou et al., 2021)	Vocabulary scores improved after the VR (pre-intervention score 1.28, post-intervention scores 3.78 p<0.01. The control	VR could help with the vocabulary acquisition (increasing engagement and immersion, but the results were not better than in the mobile application used as	

	group showed similar results. Even though the VR group showed high engagement, engrossment and immersion, the results were not significantly different from the control group	control	
(Fuhrman et al., 2021)	Watch-only group had the highest recognition accuracy right after the learning session whereas the object manipulation had the highest accuracy in delayed testing. Through the linear effects analysis, time was found to be the main effect with p<0l0001, learning condition and learning condition by time also had a significant effect on accuracy (p=0.001 and p=0.006). The decay of learning in manipulation movement was significantly lower than in the watch-only group. Whereas the translation and pronunciation recall was the highest for object manipulation (0.41) vs 0.16 and 0.22 for irrelevant movement and watch-only conditions	Object manipulation i.e., interactive VR is the best condition for learning new vocabulary	
(Lai & Chen, 2021)	Post-test scores for translation were 2 times higher for the VR group compared to the PC group. Delayed post-test results also indicated a better performance by the VR group (17.77) vs the PC group (13.23) Similarly, acquisition and retention scores were higher in the VR group ANOVA showed that the differences in group mean ranks were significantly different (p=0.07 for translation, p=0.18 for acquisition and retention) For vocabulary recognition tests, the VR group performed better than the PC group but ANOVA	Gained vocabulary knowledge The VR group showed higher scores in post-test assessment No significant improvement in the vocabulary recognition Significant positive effect on the retention of translation compared to the control group	The students were "delighted" with the virtual features of the game Mostly positive feedback for interactive learning Motivating

	results showed that the results were statistically insignificant (p=0.208 for recognition, p=0.108 for retention and recognition)		
(Lee et al., 2019)		Game players showed their positive attitude toward learning from the AR	
(Alfadil, 2020)	Post-intervention test indicated a significant difference between the scores in the experimental (81.47) and the control groups (71.16), ($p<0.05$) The study found that pre- and post-test scores were significantly different for both groups. Students using the VR game had a higher vocabulary acquisition compared to the control group as well as compared to the pre-test scores	The VR game was suitable to teach L2 vocabulary	
(Legault et al., 2019)	The iVR learning was more accurate compared to the word pairs ($p<0.05$. The item category also had a significant impact on learning accuracy with the kitchen items having higher accuracy compared to the zoo items ($p<0.05$) By dividing the sample into the least successful and the most successful learners and by performing a regression analysis, the researchers found that the less successful learners were more likely to benefit from the iVR .	The words learned through the iVR had a higher accuracy compared to words learned using traditional methods	Participants found that the iVR learning was more effective due to its high interaction, especially for the kitchen items. The ability to move objects also led to better learning
(Chew et al., 2018)	There was a significant difference between the post-test scores in the experimental (m=12.65) and the control group (m=10.90) with the experimental group performing better (p=0.007). The scores were higher for the experimental group indicating that the students rated AR higher than the traditional methods in terms	AR was a beneficial technology for learning idioms	

	of effectiveness, engagement and usability	
(Nurkhamimi Zainuddin et al., 2018)	"AR technology is attractive" received the highest score of 4.54. Whereas "AR technology is satisfactory" received the lowest score of 3.92. The students thought that the AR-enhanced flashcards improved their spatial skills (4.29)	AR was a beneficial technology for learning Arabic lexis. There was no control group, the sample size was small, no pre/post-test assessment
(Li et al., 2022)	The VR group (mean score 30.72) outperformed the control group (mean score 27.57) ($p<0.05$) Both groups differed in their cognitive, behavioural, and social engagement, with the VR group performing better ($p<0.05$). No differences were observed in the emotional engagement The experimental group had a higher frequency use and correct rate of target words during writing activities. The results of the t-test demonstrated that the experimental group performed better in the level of TF ($t = 2.143$, $p < 0.05$)	The use of the VR improved the learning outcomes

In spite of the interesting and promising quantitative and qualitative findings described in the academic literature, few reports have been found under the search criteria. Further research is required to explore L2 learners' abilities in AR/VR/PC-desktop spatial learning environments in relation to vocabulary memorisation. Special attention should be paid to the possibility of applying a combination of spatial mnemonics training and immersive technologies (AR or VR) to modern L2 vocabulary training.

PART 2: MAIN RESEARCH

Spatial mnemonics for L2 vocabulary recall

Publication 1 (Journal Paper): Larchen Costuchen, A., Darling, S., & Uytman, C. (2021). Augmented reality and visuospatial bootstrapping for second-language vocabulary recall. *Innovation in Language Learning and Teaching, 15*(4), 352–363. https://doi.org/10.1080/17501229.2020.1806848

Abstract

This paper examines second-language vocabulary memorization using two technology-driven flashcard-based vocabulary learning tools. The use of augmented reality (AR) under visuospatial bootstrapping (VSB), a novel approach developed from work on the cognitive psychology of working memory, was contrasted with an application, Quizlet. Both were implemented using mobile devices. Quizlet has been extensively used in foreign-language teaching and learning practice. The experimental AR-VSB technique offered superior vocabulary learning compared with the Quizlet method in delayed post-tests, although statistical data indicate a somewhat higher forgetting rate after a week in the AR-VSB method. Even so, the experimental technique still offers superior retention compared with the method used in the control group and could be used as an effective initial input method for acquiring vocabulary items in second-language learning. These results imply communication between cognitive systems involved in storing short-term memory for verbal and visual information alongside connections to and from knowledge held in long-term memory when the target information is shown in a familiar array, which are deployed during the AR task and which support enhanced vocabulary learning. The main novel finding in this research has been that the integration of immersive AR experiences into familiar physical space has been seen to improve vocabulary recall test performance among a sample of twenty-first-century university students attempting to learn a second language. The evidence gathered from the experiment can have future practical applications and might contribute to

immersive educational technology and innovative material development in second-language instruction.

Keywords: augmented reality; visuospatial bootstrapping; second-language learning; vocabulary learning

P1.1 Purpose of this research

Quizlet (n.d.) is a popular gamified application with 50 million monthly users) which teaches vocabulary in lexical sets. Quizlet flashcards represent an example of typical practice in modern second-language vocabulary learning. The present study attempts to see if a novel approach based on combining an augmented reality (AR) app with spatialization in the form of Visuospatial Bootstrapping (VSB) will offer the possibility of more effective learning of new vocabulary in a second language than the popular current Quizlet approach.

The experimental, AR-VSB enhanced method allows the possibility to use both visual and spatial memory as a support to verbal learning. This is in contrast the conventional method, which does not add spatial information to the process. While translational verbal aids on flashcards are used in the two input methods, the AR-VSB method also takes advantage of the possibility of linking to-be-learned vocabulary items to spatial locations. Spatial location can form a useful framework for integrating knowledge, a process that has become known as ‘spatialization’ (see, e.g. Guida et al. 2016).

P1.2 Review of current knowledge

Spatial intelligence has been associated with a heightened sense of situational awareness and of relationships in one’s own surroundings (Krokos et. al, 2019). The method of loci, a mnemonic strategy described by the ancient Greeks and Romans which links geographical location to items that need remembering (Yates, 1966; 1999) is currently used to improve memory in young people and elderly adults (Nyberg et al., 2003; Derwinger et al., 2003; Gross et al., 2012; Knauff, 2013 & Krokos; 2019). According to Qureshi et al. (2015) this technique relies on spatial relationships between “loci” (e.g., locations on a familiar route or rooms in a familiar building) to arrange and recollect memorial content. It was first attributed to Cicero in

55 BCE and it was used by medieval scholars to remember long speeches within the auditorium (Yates, 1999). The technique goes by a variety of names including the ‘Roman Room’, the ‘Memory Palace’ or the ‘Journey Method’. As stated by Moè & De Beni (2005), application of the method of loci involves first selecting a series of distinct loci along a familiar pathway; then, creating an image for each item to be remembered or, if applied to passages, for each cue word corresponding to a concept; and finally placing images of the items in the selected loci and retrieving them mentally when retracing the loci pathway in the recall phase. According to Huttner and Robra-Bissantz (2017), on such a tour any simple object like a chair, cupboard or table can serve as an adequate locus.

In psychology and neuroscience, memory capacity is assessed by retention of digits, nonwords, unknown words, etc. It is more difficult to remember numbers than words (Bellezza el al., 1992), but strategic mnemonic procedures (such as encoding numbers as letters, words, locations or other visual-imagery organization) can facilitate memorization (Higbee, 2001; Pressley et al., 1982; Worthen & Hunt, 2011). According to Maguire et al. (2003), brain regions responsible for visuospatial memory and navigation such as the retrosplenial and hippocampal areas were demonstrated to be engaged during mnemonic encoding in non-spatial tasks, giving an indication of the neural basis for some spatialized effects.

Mnemonics, a set of memory-improvement techniques, enables the encoding of items “in a manner that makes these segments more familiar, abbreviated, or somehow less demanding to recall” (Atkinson, 1975). As discussed by Huttner and Robra-Bissantz (2017), people with superior memory may tend to apply a learning strategy that is based on spatial elements. Investigation of participants’ brain activity with neuropsychological measurement instruments and brain imaging indicated that subjects had a higher engagement in brain regions associated with and crucial for human spatial memory. In accordance with the study performed by Maguire et al. (2003) and discussed by Huttner and Robra-Bissantz (2017), the effectiveness and longevity of the method of loci suggests a natural human tendency to use spatial context to memorize and recall information.

Visuospatial bootstrapping (VSB) is a term used to describe the support of verbal memory by visuospatial memory— It was first demonstrated by Darling and Havelka in 2010 but has been frequently replicated (Darling et al, 2017). In the initial study

(Darling & Havelka, 2010), three display conditions were employed: a condition in which digits were presented sequentially in the center of the screen, a linear condition in which digits were presented in a horizontal array across the screen and highlighted sequentially, and a keypad condition which used an array similar to that in the linear condition but based on the "T9" 3 x 4 mobile-phone keypad (Darling et al., 2017) familiar from ATM machines and push-button telephones. Short term memory for sequences in the keypad condition was demonstrated to be better than those of the other two conditions. Visuospatial bootstrapping is an example of spatialized knowledge and information being used to support participants carrying out an essentially verbal task. Vocabulary learning (in a second language or otherwise) is itself a verbal memory task, and so it was considered that the bootstrapping phenomenon may form a useful basis from which to develop materials that may enhance vocabulary learning.

Vocabulary-acquisition techniques in EFL teaching could potentially be based on verbal (language-related) and visual (visual imagination ('imagery') based) aids: according to Solso (1995) and Baddeley (1999), useful strategic mnemonic devices can be of two types: visual imagery and verbal. These approaches echo dual coding theory (Paivio, 1971), which suggests retention is more efficient when both verbal and nonverbal codes are processed by the brain. Verbal units, named logogens by Paivio (1978), represent letters, syllables, conventional words, set phrases, idioms or sentences, among other options, and they rely on visual and auditory encoding (Morton, 1979) as well as haptic (by touch) and motor (by movement) connections (Paivio,1986; Sadoski & Paivio, 2001). The nonverbal units were called imagens or pictogens (Paivio, 1978) and could be used to assist memorization by providing associative connections with the logogens. Paivio's theory suggests that there may be benefits accruing from combining the two. A widely recommended means of enhancing foreign-language vocabulary through deliberate study has been using flashcards incorporating visual images (Elgort, 2010; Nakata, 2011; Nation, 2015; Nikoopour et al., 2014; Ashcroft et al, 2018), a technique that clearly is built on these theoretical foundations.

Flashcard techniques place a word in the target language (L2) on the front part of a card and the original-language (L1) translation on the back (Nation, 2001; Cross & James, 2001; Nation & Webb, 2011). Modern digital flashcards can be additionally

supplemented with translations, images, sounds or animations (Chun & Plass, 1996; Chun & Payne, 2004). They are easily compatible with smart devices and provide more options to choose from for digital age teachers and learners. Quizlet is one example of a commercial product translating flashcards into a digital presentation space.

Evidence of a memory benefit from presenting text and images together has already been extensively described in the academic literature (Wharton, 1980, 1988; Bernard, 1990; Glenberg & Langston, 1992; Reed & Beveridge, 1986, 1990) while in the area of Computer Assisted Language Learning (CALL), there was a shift during the 1990s from hypermedia (hypertext improved by sound and pictures), to multimedia approaches (text, pictures and sound appearing on the computer screen and being available to the use of various devices; Cameron, 1999).

Augmented Reality bridges the gap between the real and virtual worlds (Klopfer & Squire, 2008; Bronack, 2011; Siriborvornratanakul, 2018) by adding digital content on top of the already existing environment and by incorporating text, images, videos or 3D objects into a real-world scenario in real time (Azuma, 1997; Zhouet al., 2008; Giglioli Chicchi et al, 2015; Tzima et al, 2019). Unlike virtual reality, AR uses the real world as the backdrop for its computer images, thus avoiding cybersickness as well as eliminating the miscalibration of visuo-motor coordination often produced by other virtual environments (Valimont, 2007). As augmented reality is less immersive than virtual reality, it can be placed between a real environment and augmented virtuality (Milgram & Kishino, 1994), thus providing optimum possibilities for AR integration with familiar spatial environments. Augmented Reality can integrate 3D models from digital archives and libraries into any real-world scene with the help of mobile devices. AR techniques offer potential benefits beyond traditional flashcards and their derivatives in vocabulary learning because they offer the possibility of the easy incorporation of useful spatialized knowledge to the learning situation.

The educational potential of AR has been already noted (Bai et al., 2013; Bacca et al. 2014; Santos et al., 2014; Santos et al., 2016; Walker et al, 2017), and the recent appearance of new mobile-phone augmented-reality applications for Android and iOS has changed the initial cost-related factors in the teaching/learning process, bringing new possibilities for educators and curriculum designers. Today it is increasingly common to find both teachers and students handling smart devices

equipped with multiple embedded sensory inputs such as multi-megapixel cameras, microphones, speakers, high-definition displays, 3D displays, and pico-projection technologies (Grier at al., 2016).

Currently, the explosive rise of free or affordable mobile-phone AR applications for Android and iOS has made it possible for individual researchers to easily investigate whether AR based approaches can help with vocabulary learning – and additionally they allow for the workflow adopted by the learner to integrate spatialized information as well to potentially benefit the tenacity of vocabulary acquisition.

The current study poses this as its principal research question, asking whether a spatialized implementation of AR based on ideas from the visuospatial bootstrapping literature (AR-VSB) might lead to a higher retention and lower forgetting rate in delayed tests of vocabulary learning among second language learners in comparison with the conventional method based on flashcards and implemented in Quizlet.

P1.3 Method

Sixty-two students (N = 62) from the teacher-training department at the University of Valencia (28 males, 34 females; mean 19.08 (SD=1.58) took part in this research. They took part as part of a series of research tasks related to language learning of which this was one. All the participants consented in writing to participate in the study, and the study was approved ethically by the University of Valencia and Queen Margaret University . Prior to the main experimental sessions, participants had undertaken the Cambridge English Placement Test (Cambridge Assessment English, 2019) to verify their grammatical ability level on the Common European Framework for Languages (CEFR) six-point scale (Council of Europe, 2019). They were also administered a diagnostic vocabulary test developed by the researcher that was based on the Nelson-Denny vocabulary subtest (Brown, Fishco & Hanna, 1993) with a multiple-choice structure. The test contained 100 questions with 7 response options each, based on the content of the book English Idioms in Use (McCarthy & O´Dell, 2017). The 10 items that were least well known by the participants were selected to be the learning set in the vocabulary learning task (Figure P1.F1: Items selected as the least-known vocabulary; Appendix 2).

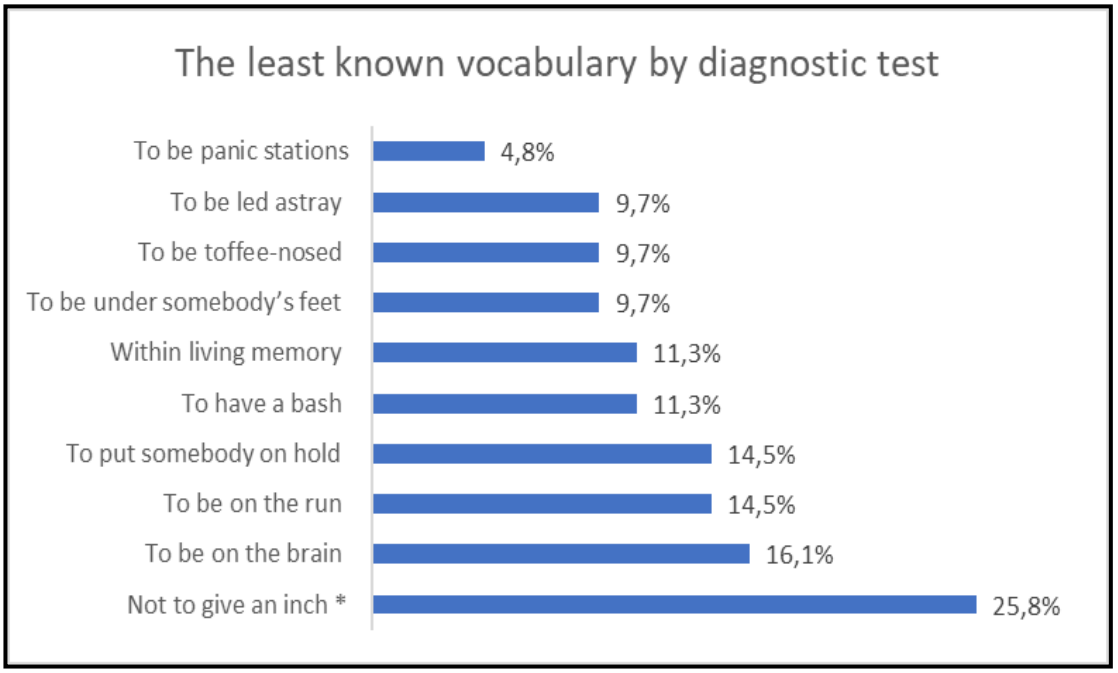


Figure P1.F1. Items selected as the least-known vocabulary

After these pre-tests, the total of 62 students were randomly divided into two groups of 31 participants corresponding to the input method. The control group received vocabulary training on the Quizlet app for mobile phones and tablets with Android or iOS operating system through the links created by the researcher. Optionally, the Quizlet website-based materials were also made accessible through laptops and desktop computers. The control (Quizlet) group was asked to dedicate 15 minutes to learning the ten set expressions introduced through digital cards featuring translations into Spanish and multimedia images. Students were advised to relate images to target words during the recall process (Figure P1.F2: Quizlet card (reverse side) and Figure P1.F3: Quizlet card (obverse side)).

Figure P1.F2. Quizlet card (reverse side)

Figure P1.F3. Quizlet card (obverse side)

The experimental (AR-VSB) participants were instructed to distribute paper-based cards with generated matrix barcodes prepared by the researcher around their houses either horizontally (on the floor) or vertically (on the walls) near familiar objects. They then had to dedicate fifteen minutes to learning ten idioms by scanning the quick-response codes through the Augment app (https://www.augment.com/)

with their mobile phones or tablets. The card scan activated augmented-reality items related to the to-be-learned vocabulary, visible on participants' device screens, and integrated with the background of the students´ homes. After the learning time, the students were asked to take an imaginary route through their houses recalling the familiar items one by one, associating them with the AR objects and thus with the target vocabulary (Figures P1.F4: AR-VSB card with a QR code to be scanned and Figure P1.F5: A 3D model after the card´s scanning).

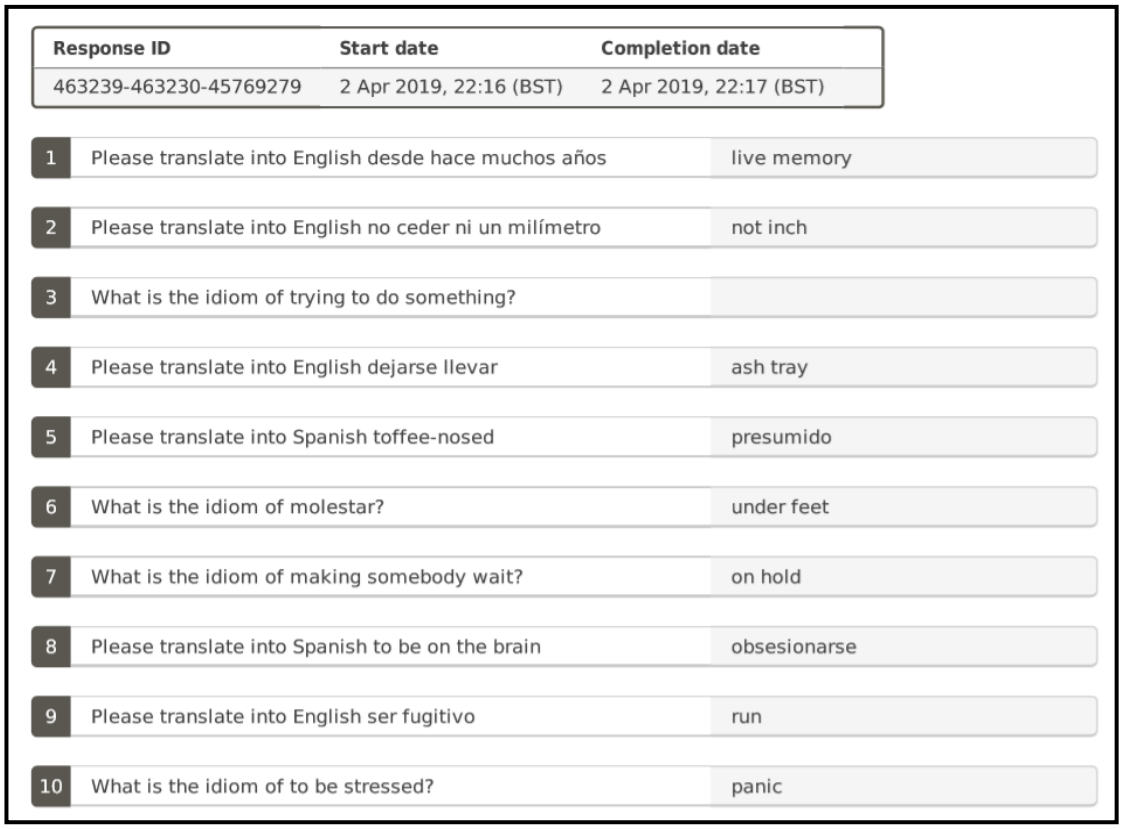
Figure P1.F4. AR-VSB card with a QR code to be scanned

Figure P1.F5. A 3D model after the card´s scanning

The rationale was to compare among subjects the efficiency and forgetting rate introduced by the two study methods by testing the learning of the vocabulary. Retention was checked by means of two tests: a fifteen-minute-delay test, accessed by the students through the links placed on the university's Moodle platform fifteen minutes after the Augment/Quizlet learning exercise, and a week delay test for each group, administered similarly. The design of both tests was based on definitions in English with a requirement to insert the necessary idiom and to translate them from Spanish into English or vice versa. The list of vocabulary items was the same, but the questions and definitions of the first and second tests were different so as to check the students' real understanding of the expressions. Participants were asked to refrain from any further learning or revision between the two tests. Test materials were identical across the two learning condition groups (Quizlet vs. AR-VSB).

The fifteen-minute-delay and week-delay tests required the learners to answer ten open questions about the learned idioms by completing free-text fields in the questionnaires (Figure P1.F6: An AR-VSB post-test at one-week delay). These were evaluated by the researcher and assessed by an independent evaluator on a scale from 0 to 3 for each idiom, which given the range of the test resulted in a total score from 0 to 30 points. Every response received the following values: 3 – excellent knowledge of the idiom; 2 – acceptable knowledge with mistakes in article use,

incorrect orthography, etc., but the expression can be understood; 1 – only (the) key word(s) is/are memorized and the idiom cannot be recognized; 0 – wrong idiom or no answer provided. The researcher was not the usual instructor for those groups, and was unaware of which condition in the experiment the work they were assessing was from. The data collection questionnaires were created and distributed using the JISC online survey tool (n.d.) and data were processed by Microsoft Excel 365 (n.d.) and IBM's SPSS V24 (n.d.) statistical packages.



Response ID	Start date	Completion date
463239-463230-45769279	2 Apr 2019, 22:16 (BST)	2 Apr 2019, 22:17 (BST)

1	Please translate into English desde hace muchos años	live memory
2	Please translate into English no ceder ni un milímetro	not inch
3	What is the idiom of trying to do something?	
4	Please translate into English dejarse llevar	ash tray
5	Please translate into Spanish toffee-nosed	presumido
6	What is the idiom of molestar?	under feet
7	What is the idiom of making somebody wait?	on hold
8	Please translate into Spanish to be on the brain	obsesionarse
9	Please translate into English ser fugitivo	run
10	What is the idiom of to be stressed?	panic

Figure P1.F6. An AR-VSB post-test at one-week delay

A new code was automatically generated by *the* JISC online survey tool for every test on every participant. Linkage between these codes was not configured by the JISC survey tool, excluding the opportunity for linking between background measures and experimental performance, and also meaning that it was not possible to take advantage of repeated measures statistical techniques to increase statistical power in comparisons between the 15 minute and 7-day tests. Nonetheless the use of between-subjects comparisons is conservative and does not increase the risk of statistical error. The anonymized raw data from the learning task presented in this

study are available for open download from https://osf.io/4snzf/ (DOI: 10.17605/OSF.IO/4SNZF)

P1.4 Results

Mean score on the Cambridge English placement test was 18.70 (SD =3.54), indicating an English level of B1-B2 in accordance with Common European Framework of Reference for Languages, CEFR.

Initially, the researcher considered a 2 x 2 factorial ANOVA approach for data interpretation, but as several of the variables did not meet parametric assumptions, that method was discarded. Instead, analysis focused on multiple two-group tests across four critical comparisons: Quizlet vs. AR-VSB at the fifteen-minute delay, Quizlet vs. AR-VSB at one-week delay, 15-minute delay vs. 1 week delay for the Quizlet group, and 15-minute vs 1 week delay for the AR-VSB group. Because of the implementation of multiple hypothesis tests, a Bonferroni correction was applied to adjust α for every comparison – meaning that a critical level $p < .0125$ was used to ensure that the familywise error rate remained below $p < .05$.

P1.4.1 Vocabulary Retention for Quizlet and AR-VSB at fifteen-minute delay

Mean score (out of 30) after the fifteen-minute delay (15MD) for the AR-VSB-enhanced experimental it was 20.38 (SD = 6.29) and for the Quizlet-enhanced control group was 12.07 (SD = 6.26). The groups are visually represented in the boxplot (Figure P1.F7: Comparisons between the methods and the delay). The highest scores were densely concentrated in the group that used the AR-VSB learning technique. Thus, 75% of students in the treatment group obtained a value higher than 17 points out of 30, while the same value was only reached by 16.9% of the Quizlet-input participants. There were two atypically high values in the control group and one atypical low value in the experimental group, while the rest of the data distribution is close to being symmetrical for both samples, with a denser distribution in the higher scores for the treatment group. Nonetheless, the Shapiro-Wilk test for normality and the Levene test for homogeneity of variance suggested that the data were suitable for parametric analysis (Shapiro-Wilk test: $W = 0.99$, $p = .71$, Levene's test $F(1,60) = 0.09$, $p = .77$). Therefore, a t-test for independent samples was conducted to determine if there was a significant difference between

the means in the two conditions, which was confirmed (t(60) = 5.22, p < .01, Cohen´s d = 1.33), indicating that vocabulary retention after fifteen minutes was significantly higher with the AR-VSB method than with the Quizlet technique.

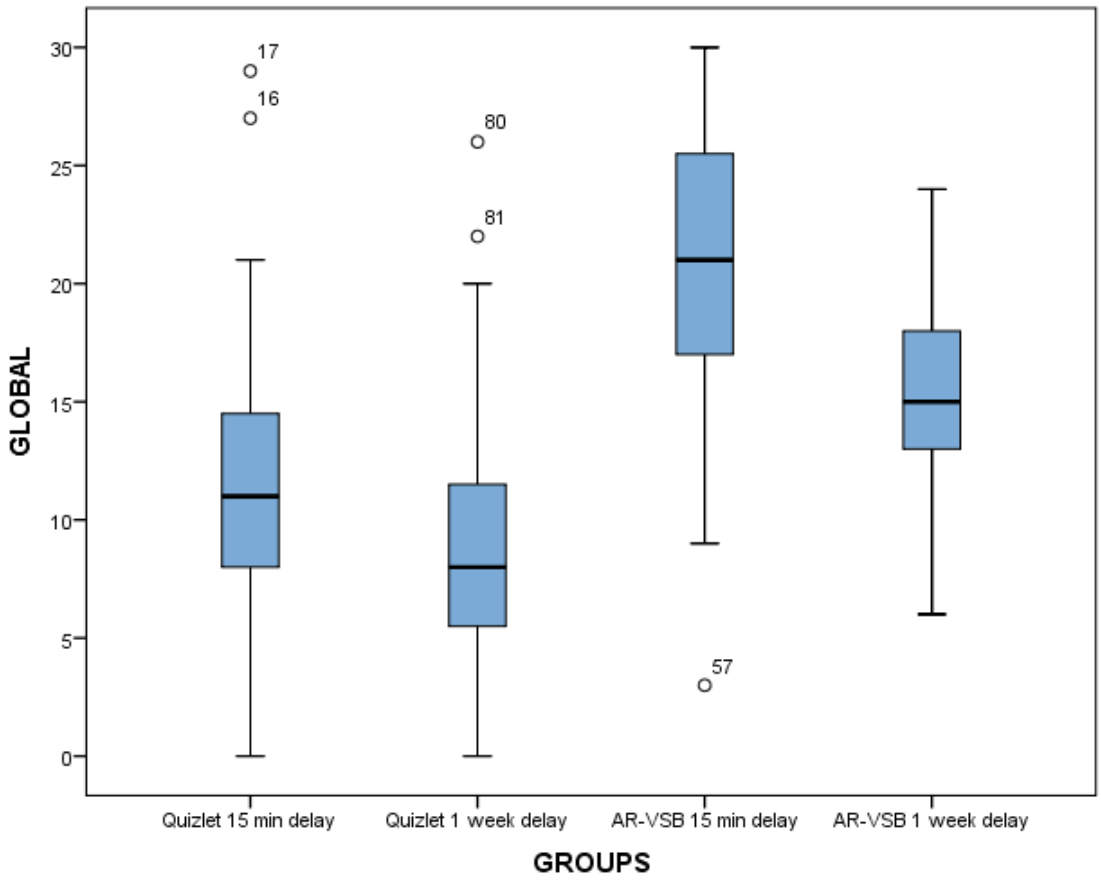


Figure P1.F7. Boxplot illustrating distributions of data broken down by learning method and delay

P1.4.2 Vocabulary Retention for Quizlet and AR-VSB at one-week delay

The global-score distribution after a week's delay maintained the tendency seen after 15 minutes, with higher scores being seen in the AR-VSB condition. Mean score in AR-VSB at 1 week was 15.07 (SD=3.88), whilst in the Quizlet condition it was 8.94 (SD = 6.10). Analyses of normality and homogeneity of variance was applied to check the parametric conditions. Assumptions of normality but not homogeneity of variance were violated (Shapiro-Wilk test: W = 0.95, p =.01, Levene's test F(1,60) = 3.10, p=.08). Hence in this comparison, a Mann-Whitney U non-parametric test was used to compare the scores between the samples. This

indicated a significant difference between the two conditions (U=162.00, p < .01; Cohen´s d = 1.20).

P1.4.3 Retention for the Quizlet group compared between timepoints

The boxplot for Quizlet fifteen-minute delay and Quizlet week delay shows the score declining over a weekly period (Figure 7: Comparisons between the methods and the delay). The median score (/30) was 11 after 15 minutes but only 8 after 1 week's delay. Mean learning score at 15 minutes was 12.07 (SD = 6.26) whereas after a week it was 8.94 (SD = 6.10). Assumptions of normality but not homogeneity of variance were violated (Shapiro-Wilk test: W = 0.94, p =.004, Levene's test F(1,60) = 0.020, p=.89). Hence, a Mann-Whitney U test was used to see if the score varied between the samples. The results (U = 323.50, p = .03, d = 0.51) showed significant differences between the two time points in the Quizlet condition.

P1.4.4 Global-score distribution for AR-VSB compared between timepoints

The boxplot for AR-VSB fifteen-minute delay and AR-VSB week delay demonstrates that the score decline is faster compared with Quizlet over the week period (Figure 7: Comparisons between the methods and the delay). As the boxplot shows, the median decline value between the two AR-VSB samples is 7 points, while the median decline for the two Quizlet samples is 3 points. Mean score (/30) for the AR-VSB participants at 15 minutes was 20.38 (SD = 6.29) whilst at one week it was 15.07 (SD=3.88). There was no evidence against normality in the data, but homogeneity of variance between the samples was rejected (Shapiro-Wilk test: W = 0.97, p =.10, Levene's test F(1,60) = 5.78, p=.02). Hence a Mann-Whitney U test was used which showed the AR-VSB performance after a week was significantly lower than at 15 minutes (U = 210.00, p < .001, d = 1.02).

P1.5 Discussion

The experimental AR-VSB method was significantly more efficient for second-language vocabulary learning than digital flashcards supported by image and translation after both 15 minutes and 1 week. The data also reveal that despite a higher forgetting rate, the AR-VSB technique still offers superior retention after an interval of a week compared with the Quizlet method used in the control group. This is an important observation as it suggests that AR-VSB is a technique that can

enhance second language vocabulary learning, though as this is the first demonstration of that pattern we recommend further research to replicate and enhance understanding of this finding.

Under Paivio's dual-coding model, the use of augmented-reality 3D models in a familiar physical space likely enables better connections between logogens and imagens and eventually facilitates memorization due to the additional provision of useful spatialized information that can be integrated in the learning process. The apparently increased rate of forgetting in the experimental group might indicate that this technique could be used as the initial input method for vocabulary items, to be supported later with contextual vocabulary use, textual or auditory cues gained during subsequent encounters with the word (Schmitt, 2008 and Nation, 2015). We note that Paivio's model is not the only model allowing for the integration of verbal and spatial memory in learning – modern models of working memory (e.g. Baddeley, 2000; Cowan, 2010; Baddeley et al, 2020;) also allow for this. It is also worth noting that the work of Calia et al (2019) indicates that bootstrapping related spatialized benefits in memory may be relatively automatic, and unrelated to basic processes of memory (see also Race et al, 2015) – meaning that the benefits of spatialized AR-VSB presentation may accrue to all learners rather than just those who are already of a high level of ability. Further research should test this hypothesis.

This study has adopted an experimental methodology – hence it is likely that differences in performance are strongly linked to the differences between the AR-VSB and Quizlet conditions. It is worth paying some attention to these, because this research represents a pragmatic comparison between the current educational practice and a new technique. There are numerous differences between the AR-VSB technique and the flashcard Quizlet technique. For example, it may simply be more interesting to use the AR app than the Quizlet app. We do not know for sure which aspect of the comparison between conditions in the current study underlies the benefit to performance. It is likely, based on extensive evidence of the mnemonic benefits of spatialization (see introduction) that this effect is due to spatialization, but on the basis of the current results we cannot be certain. Future research should address this – and might begin by systematically addressing the differences between Quizlet and AR-VSB approaches. Another important approach to extend these findings would be to ask learners to introspect about their experience – to ask them

about which aspects of the experience of the AR-VSB technique or the Quizlet approaches they felt best supported their learning. In a user-focused environment these are crucial questions, as a learner's experience of the effectiveness of a method will likely determine their willingness to continuously engage with it. Such research efforts would be timely and useful.

To sum up, verbal and spatialized elements of AR-VSB technique potentially offer new "edutainment" opportunities in second language vocabulary training by transferring learning activity from the classroom into other informal environments where the spatialization can help contextualize learning. This current research is a possible stepping stone to a larger-scale study with a final goal of developing such practical outcomes as tailored AR-supported smart-device second language learning applications. We look forward to such research being conducted.

Publication 2 (Journal Paper): Larchen Costuchen, A., Font Fernández, J. M., & Stavroulakis, M. (2022). AR-Supported Mind Palace for L2 Vocabulary Recall. *International Journal of Emerging Technologies in Learning (iJET), 17*(13), pp. 47–63. https://doi.org/10.3991/ijet.v17i13.25073

Abstract

MnemoRoom4U is an AR (Augmented Reality) tool that uses a memory-palace strategy for foreign-language training. A memory palace helps information recall with the aid of object association in visualizations of familiar spatial surroundings. In MnemoRoom4U, paper or digital flashcards are replaced with virtual notes containing L1 words and their L2 translations that are placed on top of real physical objects inside a familiar environment, such as one's room, home, office space, etc. The AR-supported notes aid associative memory by establishing a relationship between the physical objects in the user's mind and the virtual lexis to be retained in L2. Learners first set up a path through their familiar environment, attaching virtual sticky notes - each containing a target word to be memorized together with its corresponding source-language translation - to real-life objects (e.g., furniture in their homes or offices). They then take the same path again, reviewing all the words, and finally carry out a retention test. MnemoRoom4U is a technological artefact designed for specific didactic purposes in the Unity game engine with the ARCore augmented-reality plug-in for Android. This work takes a Design-Science approach with phenomenological, exploratory underpinnings tracking back to the efficiency of spatial mnemonics previously reported quantitatively and combines it with AR technology to effect L2 vocabulary recall.

Keywords: augmented reality, mnemonics, visuospatial bootstrapping, second-language learning, vocabulary retention

P2.1 Background

Vocabulary learning difficulties, although considered to be a norm in second-language (L2) acquisition, have always caused worries among learners, motivating researchers, teachers, and application designers to look for new ways to stimulate

memory. To be able to communicate in a new language, it is recommended a learner obtain at least 2,000 items of high-frequency vocabulary (Schmitt & Schmitt, 2012). This means that efficient visualization techniques are crucial to retaining any meaningful amount of vocabulary. Vocabulary memorization can be defined as the ability to remember things after an interval of time. In language teaching, retention of what has been taught may depend on the quality of teaching, the interest of the learners, or the meaningfulness of the materials. The most common techniques implemented in classroom vocabulary instruction until now rely on verbal (learning through context, definition, keywords, synonyms, antonyms, scales, word grouping) and visual aids (drawings, photos, common objects, physical response, schemes, semantic mapping). Flashcard-supported memorization through repetition is easy to use in daily life (Brown, 2002), which influenced the method´s popularity. A word card (flashcard) was identified by Nation (2001) as writing a word in a target language on the front part of a card (form) and providing its definition in the language of origin (meaning) on the back side. Modern flashcards can be translation-, image-, sound-, or animation-supported, among other options.

Traditional vocabulary instruction gave way to the contextual learning and application of mnemonics in L2 acquisition proposed by Schmitt (1997), which was in turn followed by a search for new methods and experimental approaches to word memorization. Technological and methodological progress also had an impact in this field through computer-assisted language learning (CALL) and its later subset of mobile-assisted language learning (MALL), which during the latter half of the 20th century and the start of the 21st century significantly transformed the way languages were taught (Levy, 1997; Shield & Kukulska-Hulme, 2008). Since the advent of the Internet and mobile applications, self-study language-learning proprietary, freemium (i.e., freely available but with in-app purchases that grant certain advantages), and freeware applications have been developed and made available to the public, with Babbel (n.d.), Busuu (n.d.), and Duolingo (n.d.) among the highest-ranking ones. Such self-instruction possibilities have made learning a new language more accessible and casual (Diehl, 2019; Brown, 2020).

The success of the Pokémon Go (n.d.) mobile game—released in 2016 by Niantic, the developers of another augmented-reality mobile game called Ingress drew researchers' attention to the use of augmented reality in education (Cochrane et al.,

2016; Mozelius et al., 2017; Bruno, 2018; Ruiz-Ariza et al., 2018). Ingress' innovative use of game design relied on displaying virtual game characters among real world objects by tracking the camera's position and orientation in relation to the environment. Augmented reality overlays a virtual environment on top of a projection of the real world, unlike virtual reality (VR), which projects a fully virtual environment that follows the movements of the observer (Milgram & Kishino, 1994). Practical applications of AR can be found as early as 1957 in the cinema industry, and later during computer-graphics research and experiments with head-mounted displays. By 1980 a photographically overlaid reality was achieved on a portable-computer prototype (Heilig, 1962; Sutherland, 1968; Krueger et al., 1985; Mann, 1997). The United States Air Force tested the system in the 1990s, obtaining positive results (Azuma, 1997). The educational possibilities of this technology have since been observed and explored for pre-school use in such applications as AR Flashcards (n.d.) for alphabet and animal learning, Quiver Education (n.d.) for coloring, and Narrator AR (n.d.) for writing. Primary- and secondary-school applications include Amazing Space Journey (n.d.) for astronomy use, Experience Real History (n.d.) for history, Anatomy 3D Atlas (n.d.) for natural science, biology and anatomy, and AR Critic (n.d.) for foreign-language study and translations. Research has also been conducted on how AR can be used for 3D visual aids for books (Billinghurst et al., 2001), as well as for teaching geometry (Kaufmann & Schmalstieg, 2003) and science vocabulary (McMahon, 2016). A variety of sources describe the educational possibilities of AR, but there is still a lack of research in this field, and more study is required to obtain enough evidence of its practical benefits (Khan et al., 2019).

Augmented reality is less immersive than virtual reality as it combines both real-world and virtual-world elements, but it also provides possibilities for integration into any familiar environment. Linking geographical locations to items which need to be remembered is called the method of loci. First applied by the ancient Greeks and Romans, it entails associating a word or image to an attribute on a layout of the environment so that one can recall this word or image through the association of the two. The mental map of the surroundings that is thus created supposedly aids recall, and research attests to the efficacy of the technique (Yates, 1966; O'Keefe & Nadel, 1979). There are parallels between the method of loci and AR technology: they both rely on visualization, and since L2 acquisition requires large amounts of

memorization, the three could potentially be combined to create an AR language-learning application applying the method of loci to a flash card-like map of the user's familiar environment. Previous research shows that separately flashcards, the method of loci, and AR show positive results in the domain of education, so it is logical to assume that combining them can produce an effective tool. The MnemoRoom4U prototype was designed for mobile devices with the Android operation system (optionally iOS), thus providing a technologically accessible alternative to commercially available software such as Loci Memory Palace (n.d.), developed by In Formation, Inc. for mixed-reality immersive head-sets. The experimental app is meant to be used for second-language vocabulary recall, but its use could be extended to other, educational and non-educational sectors that require the efficient memorization of nonrelated items.

The research question of the study was: how the implementation of MnemoRoom4U (the experimental technique) can improve second-language vocabulary retention in comparison with conventional alternatives? The hypothesis of the study was that MnemoRoom4U offers a more motivating and immersive environment for L2 non-related vocabulary recall than traditional techniques. The aim was to provide a holistic picture of the use of the application and its alternatives based on users' experiences. Related research in psychology conducted by Darling, Allen, and Havelka (Darling et al. 2017) under the name of visuospatial bootstrapping revealed that it was more productive for recalling numbers to map them out on a keypad-like grid than to display them one by one in sequence or mapped out linearly. In other words, there is an advantage in memory retention when items are visually linked with spatial locations. A recent quantitative study in applied linguistics conducted by Larchen Costuchen et al. (2020) showed that augmented-reality cards under visuospatial bootstrapping and taking a real and an imaginary route through various objects in participants' households helped to retain formulaic language (idioms) more efficiently than the conventional method of digital flashcards on devices. The AR-VSB method was significantly more efficient for second-language vocabulary learning than digital flashcards supported by image and translation after both 15 min and 1 week, despite a higher forgetting rate, which is promising for this research paper's hypothesis.

A number of sources (Paivio, 1965; Roediger, 1980; Paivio & Lambert, 1981; Thompson & Paivio, 1994) attest to the efficiency of a similar mnemonic technique, the method of loci, applied to different fields. This work proposed replacing imaginary elements with augmented-reality technology (virtual sticky notes) in foreign language vocabulary training and to bring to the foreground the holistic user-experience approach when dealing with the technological artefact MnemoRoom4U.

P2.2 Method and application development

This proposal focuses on Design-Science Research (DSR), whose goal is pragmatic, aiming to design solutions to a problem (Hevner et al., 2004; Peffers et al., 2007). Specifically, this work follows a DSR subtype, Design-Inclusive Research (DIR), proposed by Horváth (2007), which consists of three phases: (1) exploration of the problem, the context, and the activities; (2) design and testing of the solutions; (3) validation of the research. The application was developed in the Unity (https://unity.com) game engine (Figure P2.F1: Development environment – Unity) with the ARCore augmented reality plug-in for Android. The necessary scripts were written in C# using Visual Studio (Figure P2.F2: Development environment – Visual Studio), (https://visualstudio.microsoft.com), which handled the creation of sticky notes in the app and the words that should appear on them using the existing Google sample scenes found in the ARCore Extensions package. Google Cloud (https://cloud.google.com.) was used to create an API key that allowed cloud anchors to be hosted from the target device for up to one day. The application was built into an APK file for downloading and installing on any Android device that supports ARCore, or Google Play Services for AR as it is known on Google Play (only a limited number do).

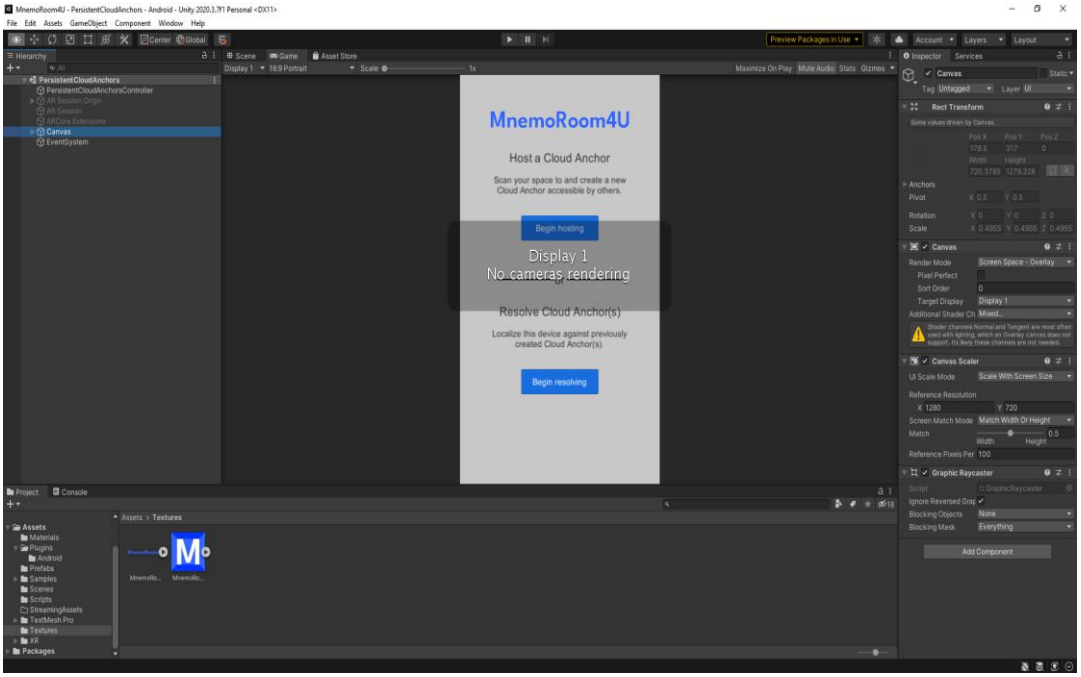


Figure P2.F1. Development environment – Unity

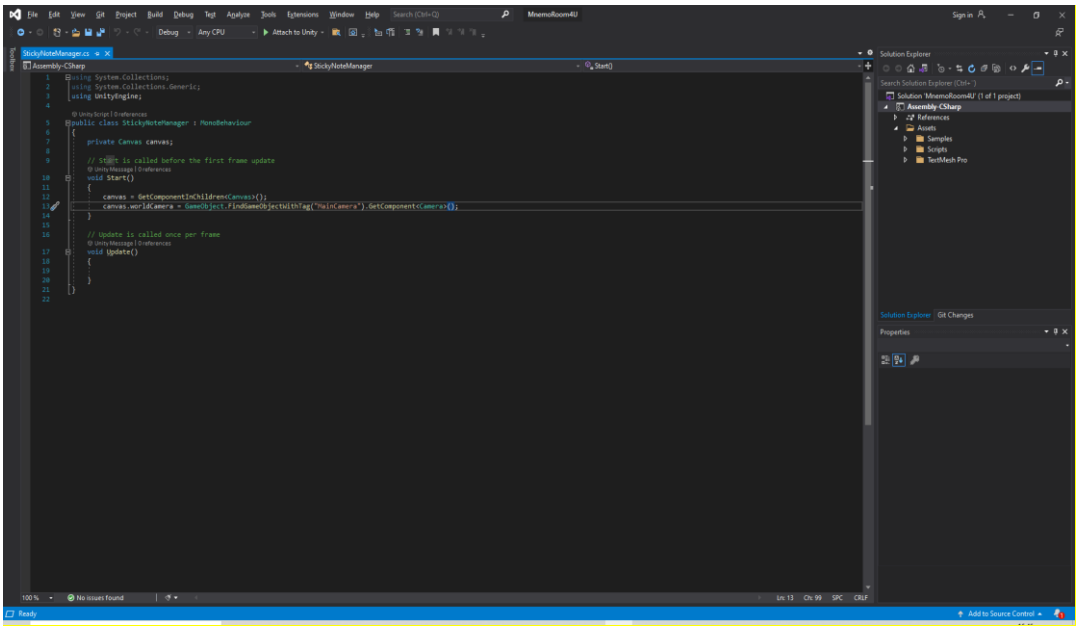


Figure P2.F2. Development environment – Visual Studio

The conceptual design of the app consists of 5 steps: (1) the user distributes the L2-L1 words on the virtual sticky notes around the familiar environment (e.g., the user's home or office) close to the selected objects (e.g., entrance door, television, window, painting, etc.); (2) the user observes the spelling and translation of each item; (3) the user repeats the route as many times as necessary (moving always in the same direction and keeping in mind the order of the objects on the route); (4) the user

does the posttest. The research population (N = 12) consisted of Spanish native or bilingual speakers who had no previous knowledge of Swedish. All the participants consented to participate in the study and were subsequently randomly distributed into three groups (one experimental and two control) with 4 participants in each (n = 4). One group was asked to use translation-based cards presented one by one, another group was instructed to use paper sticky notes combined with a route or routes around some familiar environment, and the experimental group used the application combined with a route or routes around some familiar space. The post-tests (immediate delay) were used to collect the scores; however, this study took a phenomenological perspective of lived experiences, relying for its analysis on field notes and semi-structured interviews. In all the groups, learners were not time-restricted during acquisition, but they were asked to check how long it took them to feel ready to do the post-tests. The current prototype did not use any deep-learning API, which is why the list of 15 non-related vocabulary items in Swedish (Table P2.T1) had to be included into the programming stage.

Table P2.T1. A list of words selected as L2

L2 (Swedish)	**L1 (Spanish)**	**English (Transl.)**
tangentbord	teclado	keyboard
penna	lapiz	pencil
handel	comercio	commerce
högtalare	altavoz	speaker
dom	juicio	trial
ansluta	conectar	connect
skön	bonito	beautiful
förstöra	destruir	destroy
svår	dificil	difficult
tak	techo	roof
väska	bolso	bag
kunskap	conocimiento	knowledge
väg	carretera	road
tvivel	duda	doubt
flygplan	avion	airplane

The post-test design for immediate delay used an orthographic structure. The posttests (Table P2.T2 and Table P2.T3) were presented sequentially, not simultaneously.

Table P2.T2. Post-test 1

Post-test 1: choose the correct letter among the three options		
tan*entbord (k, j, g)	kuns*ap (h, j, k)	hand*l (e, a, i)
hög*alare (t, d, i)	t*ivel (w, v, y)	do* (n, m, r)
*nsluta (e, a, u)	väs*a (c, h, k)	sk*n (o, ö, n)
för*töra (s, z, c)	*enna (r, p, t)	*vår (z, f, s)
*ak (l, t, i)	v*g (ö, u, ä)	fl*gplan (o, y, a)

Table P2.T3. Post-test 2

Post-test 2: choose the L2 equivalent among the three options				
Lapis a. penna b. tena c. henna	Bolso a. wäska b. väska c. väkka	Altavoz a. högtalare b. högtalere c. gögtalare	Conectar a. ansluta b. alzluta c. anslata	Techo a. taf b. tuk c. tak
Bonito a. sfön b. skön c. sken	Teclado a. tangentbort b. tangentbord c. fangenbord	Juicio a. tom b. dom c. don	Duda a. dvivel b. tvivel c. tviwel	Avion a. flugplan b. flygplan c. fligplan
Comercio a. handell b. jandel c. handel	Carretera a. wäg b. väh c. väg	Destruir a. törstöra b. förstöra c. förstöry	Conocimiento a. kunskap b. hunskap c. kunzkap	Dificil a. svår b. svus c. sver

The pedagogical approach for method evaluation used a 3W3H model integrated with the DIR. It was guided by the following questions: (1) Who are the method users? (2) What vocabulary items are used for recall? (3) How is the method used? (4) Why is the method efficient? (5) How did the participants feel? (6) How can the method be improved?

P2.3 Results

The 3W3H model was applied to collect data on the participants' experiences and opinions in relation with the experimental and the control techniques.

P2.3.1 Participants and input

The participants were all Spanish C2 speakers (native or bilingual); graduates of the Polytechnic University of Valencia (UPV) or University of Valencia (UV); holders of a Master´s, Postgraduate, or PhD degree; and active users of mobile phones and computers, with 91.6% belonging to the "digital native" category as defined by Prensky (2001), according to whom "children raised with the computer think differently from the rest of us. They develop hypertext minds". The participants´ ages ranged from 26 to 48, with all but one of them having been born in the digital era. None had any prior knowledge of Swedish, but all spoke other L2s at different levels. The L2 lexis was composed of non-related items in Swedish selected randomly and checked for possible similarities with the participants' L1 (Spanish) to avoid interference.

P2.3.2 Experimental group

In the experimental group, MnemoRoom4U was combined with one or several routes around a familiar environment (Figure P2.F3: Virtual sticky notes placed beside an object in a household). L2 and L1 were presented on the same side of the virtual cards. The system required the use of a compatible mobile phone. The task consisted of carefully looking at the L2-L1 virtual notes distributed on or beside the objects in the household or office while walking through the route or routes (time-limited: no; time-controlled: yes; post-tests: immediate delay). Innovative elements presented in this work include the use of AR instead of imagery elements and the use of AR instead of paper-based or digitally presented notes with textual information. This study collected information on the motivational factors related to this method, on how the participants felt, and on how this method/application can be improved according to users' opinions. Table P2.T4 summarises the post-test scores (maximum score = 29), the time required (in minutes) to set up the environment and to recall the items, the Likert scale on motivation (1 = very boring, 7 = very

entertaining), and the Likert scale on the application's design (1 = very difficult to use, 7 = very easy to use).

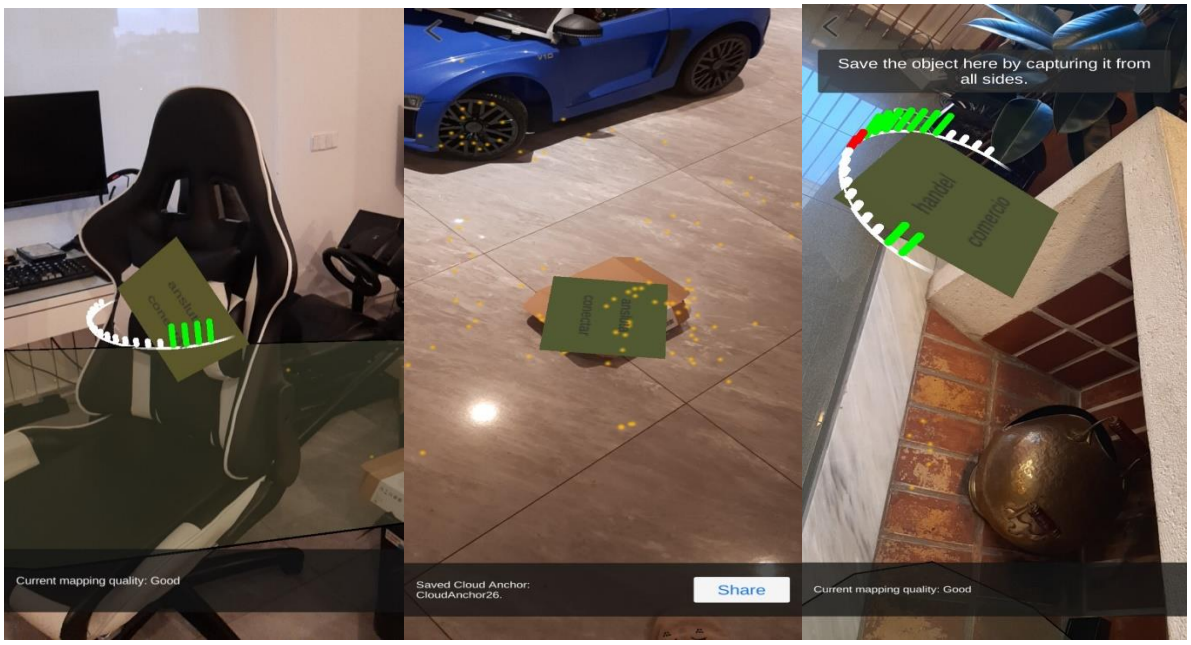


Figure P2.F3. Virtual sticky notes placed beside an object in a household

Table P2.T4. Experimental Group

	Participant EG-1	**Participant EG-2**	**Participant EG-3**	**Participant EG-4**
Post-test score	28	29	28	27
Time	32	28	23	40
Motivation	7	7	7	6
Design	7	7	7	6

Participant EG-1 "The easiest words to memorise were tvivel (I remembered that the first letter was t) and tak (probably because it's short). I thought about Taco Bell at that moment. The most difficult words for me were those that contained ä and ö. In one part of the test, I had to choose between sfön, skön and sken. I was sure that it was not the last one, but I had a doubt between the previous two. There was a curious thing with the word förstöra. When I saw it, I thought that it was the most difficult of all because it contained two ö. In the end, it was the word that I best remembered." "I used it in my house, it worked best with medium-size furniture pieces or objects (preferably on the floor or walls). I am sure I would use it faster

next time. The objects that are a bit far (on the ceiling) generated a smaller card. It should be kept in mind." **Improvement tips:** "Some cards looked reverse, but it was ok. The text was clear to read."

Participant EG-2 "The words would not be too difficult to remember. I had to use them for speaking, but I tried hard to recall the spelling and that was pretty challenging." "I would call it some fairy-tale-like experience. It was great fun. Never tried such a system before. I would be happy to use this or a similar app to improve my French. The easiest word to memorise for me was skön. I associated it with a name of a small cute white dog. It still sounds like a name to me. Probably another association was with the word guapo – cute." **Improvement tips:** "I would appreciate some video on how to use the application. The ReadMe document was clear and well written, but I am a very visual learner. I prefer videos and pictures."

Participant EG-3 "Associating foreign words with the objects was a curious thing. It was weird, but it worked." "The easiest word to memorise was dom. I memorised it as mod read backwards. The object to host was a VRAM box. I associate the word väg with vago in Spanish and vague in English. I imagined somebody who was lying on the sofa and did not want to go on a business trip. He did not feel like driving that day. The object that I used to host that anchor was my backpack on the floor, not far from the sofa." "I liked the colour of the cards (green) and the system of lights that appeared when you scanned the objects. It was also quite intuitive to observe red, yellow, and green indicators of the correct scanning of an object." "I think such an app would be useful to memorise passwords (e.g. strong bitcoin wallet password)." **Improvement tips:** "Probably I would enjoy it even more if the application had a pronunciation option and an image option too. However, I understand that not all the words can be presented as an image, especially when it comes to some abstract terms."

Participant EG-4 "The easiest words to memorise were tak (association with a word in Ukrainian that sounds the same and means yes, so) and dom (association with a Russian word that sounds the same and means home). I associated the word ansluta with connect not only because of the translation but also because the reference object in the household was an electric water boiler with a cable." "The objects around the house helped me to recall the words in the following order (e.g.: the frog – kunskap, the ball – tvivel, the painting of a house – the word destruir in

Spanish, the plant – lapiz - penna). First I recall the object, then the word in Spanish and only then the word in Swedish." "Sometimes I couldn´t remember the last element, the word in Swedish." **Improvement tips:** "It takes some time to get accustomed to the application and to scanning the objects. The application provides a beautiful blend between real and virtual elements, but you should keep in mind the safety measures when you move around your household scanning the objects."

P2.3.3 Control Method 1

Translation-based, L2-L1 word cards were presented to the participants one by one in random order (Figure P2.F4: L2-L1 word card on a digital device). L2 and L1 were introduced on the same side of the cards, which could be either printed out or presented virtually on a mobile-phone device. The task consisted of carefully looking at the L2-L1 notes (time-limited: no; time-controlled: yes; post-tests: immediate delay).

Figure P2.F4. L2-L1 word card on a digital device

Table P2.F5 summarises the post-test scores (out of 29) and the time required (in minutes) to train recall. Seven-point Likert scales were used to measure user's motivation (1 = very boring, 7 = very entertaining) and their evaluation of the application's design (1 = very difficult to use, 7 = very easy to use). The cards were

prepared by a peer - a friend or family member who needed from 5 to 10 minutes to prepare the activity (not included in the table).

Table P2.T5. Control Method 1

	Participant CG1-1	**Participant CG1-2**	**Participant CG1-3**	**Participant CG1-4**
Post-test score	26	26	29	29
Time	15	10	10	12
Motivation	1	3	1	4
Design	7	7	2	6

Participant CG1-1 “The easiest words to remember for me were penna (association with pen in English), dom (association with doomed which means ill-fated or condemned in English), tak (association with tall in English and with a word combination tall/high roof). Skön (association with Ikea furniture). The technique that I sometimes use to memorise unrelated information, or a list of new vocabulary is writing that list down a lot of times (by hand). Another option is writing short notes or making some scheme or a drawing. Such things work quite all right for me. The second part of the test was easier for me than the first one. I thought I remembered the word, but then I could not remember what the missing letter was.” **Improvement tips:** “Probably the same card system could be used on mobile phones with the option of note writing, drawing making, and pronunciation recognition.” “For note writing, mobile phones like Samsung Note are really handy.”

Participant CG1-2 “Easiest words to memorise were handel (association with hand in English and del in Spanish; I thought about a person with coins in his hand). I associated the word dvivel with the Spanish imperative vive – live in English and doubt, like live with a doubt, dvivel.” “I used paper flashcards in the past. The great thing is to pass them from one pocket to another (one pocket for those words that you have already learnt, and the rest go to another pocket). I also know that there are apps for mobile phones which use the same system with sound / pronunciation.” **Improvement tips:** “A visually attractive app would be better than just looking at white paper with some text.”

Participant CG1-3 “The easiest words to memorise were penna (association with pencil in English), tangentbord (association with board in English), flygplan (association with fly and airplane in English). Two words looked a bit similar, skön and svår, which made it difficult for me.” “I don't like this method for vocabulary memorisation.” **Improvement tips:** “Well, I guess that the foreign-language words could be linked to images. The learner would need to listen to pronunciation several times and look at the image at the same time.” “Probably some contextual use of a new work would be a necessary element, something similar to a dictionary text but on a separate card.”

Participant CG1-4 “All the words were easy to memorise except for dom, kunskap, and väska because they are not similar to their equivalents in the languages I know.” “The associations that I had were the following: Tangentbord – teclado, keyboard and board in English. Skön – bonito – schoon in Flemish. Väg – carretera – weg in Flemish, way in English, Weg in German. Penna – lapis – You write with a pen. Förstöra – destruir – sufficiently similar in meaning to verstoren in Flemish. Tvivel – duda – this one confused me a bit at first because it made me think of duivel in Flemish, which means devil. But then I saw twijfel in Flemish, which is duda, doubt. Handel – comercio – Exactly the same in Flemish, handel. Svår – dificil – Schwer in German, zwaar in Flemish. Flygplan – avion – Flyg is very transparent, but I was confused because I thought of flight plan. Then I associated plan with airplane. **Improvement tips:** “When the participants have to choose between three options, make it easy on them to indicate their choice.”

P2.3.4 Control Method 2

Paper sticky notes were combined with one or more routes around a familiar environment. Materials could be printed or hand-written. When hand-written, the sticky notes had to be prepared by a peer, i.e. a friend or family member with clear handwriting (Figure P2.F5: A paper sticky note placed beside an object in a household). L2 and L1 were introduced on the same side of the cards. The task consisted of carefully looking at the L2-L1 notes distributed on or beside the objects in the household or office during the route or routes (time-limited: no; time-controlled: yes; post-tests: immediate delay).

Figure P2.F5. A paper sticky note placed beside an object in a household

Table P2.T6 summarises the post-test scores (out of 29), time required (in minutes) to train recall, the Likert scale on motivation (1 = very boring, 7 = very entertaining) and the Liker scale on application design (1 = very difficult to use, 7 = very easy to use). This activity was peer-assisted, which required from 5 to 7 minutes of additional time to prepare the environment (not included in the table).

Table P2.T6. Control Method 2

	Participant CG2-1	**Participant CG2-2**	**Participant CG2-3**	**Participant CG2-4**
Post-test score	28	24	28	29
Time	20	5	17	18
Motivation	4	6	4	5
Design	6	6	5	7

Participant CG2-1 “The easiest words to recall were penna (association with pen in English), svår – association with schwer in German and flygplan - association with Flughafen in German.” “The system of distributing sticky notes around my house was unusual and I had to understand how and why it worked. It did. It was neither

very entertaining nor uninteresting, it was all right." **Improvement tips:** "Probably in the near future gadgets will provide much more data to us about anything in the physical world (scanning for information about anything around you)."

Participant CG2-2 "I was guided by the root of words like: penna, flygplan, tangentbord, one letter substitution like: skön (schön), väg (weg), multiple letter substitution: tak, ansluta and some faraway relation (e.g.: dom in German is cathedral but in Swedish - juicio)." "Associations: penna - pen (English), skön – schön (German), ansluta - anschliessen (German), tangentbord - keyboard (Eng-lish), wäg - weg (German), tvivel - zweifel (or something similar) förstöra - zerstören (German), kunskap - kenntnis (German), tak - dach (German), flygplan - flugzeug (German), sver - schwer (German)." **Improvement tips:** "Learning a new language is always tough at the beginning, so different techniques can help people and motivate them." "To memorise unrelated vocabulary items I normally use flashcards, write down words that I heard during the day together with the situation."

Participant CG2-3 "A difficult word was väg. In a test I chose wag. I had an association with a Volkswagen car, and I was not sure if it was correct to write Wolksvagen or Volkswagen. It was very confusing. The sticky note with a word was placed on my aircon." "At first I thought that such a system would be great if you used the sticker to indicate what the real object meant (for example, let's take the gas stove and translate this word into a couple of other languages. Then I thought that we cannot put a sticker on everything, and there are more complex concepts that require specific translation." "It was my first experience with the mind-palace system. I could try to use it to remember speeches that I have to prepare in English). One of the easiest words to remember was väska (I remembered the part ska and I imagined a black handbag with a big golden V letter). The word kunskap was also relatively easy. I associated it with kunst, which means art. I never studied German, but somehow I know the word." **Improvement tips:** "This system could be more interesting if we could use some technology (probably some voice assistant and a writing assistant; all - on an electronic device)."

Participant CG2-4 "The shortest words with no special symbols were the easiest." "I just used the instructions and was trying hard to memorise. What helped me to learn was the order of the words and the objects. It was really helpful. This system made me feel more relaxed than when you try to memorise for example a shopping list not

in a given order.” **Improvement tips:** “I just thought of a room with empty walls that could be filled with any learning content (by projections, for example).”

P2.4 Discussion

The Likert-scale findings demonstrate that the use of the experimental technique was significantly more appealing and motivating to participants than the control methods. However, it took the learners more time to set up the environment and to do the training. The application produced a positive effect on the users, with all of them finding it intuitive and quite easy to deal with. The important general takeaway from this study is that the majority of the participants used associations based on the similarities between the unknown words and the languages they had some knowledge of. Moreover, some participants in the experimental groups in Control Method Two linked objects with the chains of associations, which is another interesting issue for further research and updates of MnemoRoom4U. The control groups’ participants mentioned the possibility of adding personalised images and pronunciation options, which will be included in new MnemoRoom4U versions. All the participants performed quite well in the post-tests, although due to the nature of the qualitative study we cannot make any conclusions based on numerical information and comparison between the groups. More research (qualitative and quantitative) will be required to test the updated MnemoRoom4U versions that may contain a wider range of possibilities (API for Indo-European languages, personalised images or doodles, hearing and reproducing pronunciation). All these elements provide additional technology-related challenges at the programming and testing stages.

P2.5 Conclusion

Combining AR technology with mnemonics and language didactics was an exciting goal, however developing the current application was not an easy task for the author and the developer, as it required interfacing with Google Cloud’s very unwieldy API. Creating an API key that supported cloud anchors that could be hosted for up to one day was feasible but hosting them for a longer period of time (up to 365 days) required maintaining the locations of all the loci, and an OAuth 2.0 client ID was needed. After trying to get it working for several weeks, the effort was abandoned in favour of the simpler API-key method. Due to the aforementioned issues, the rest of

the application was developed for experiments to be conducted within a 24-hour time period. Future versions of the application will foreseeably feature other AR frameworks as well as more and richer data. Since context-based learning in AR is another highly promising emerging pedagogy, its elements are planned to be added to MnemoRoom4U as an alternative to mnemonics. We hope to expand this research with more analysis of digital and non-digital generations in second-language vocabulary recall (applied to a variety of Latin-based languages), and to consequently verify if there may be any statistically significant differences in performance between genders. We hope to contribute to innovations in education, in teaching languages, and in lexis memorisation, and finally to make vocabulary recall more fun.

Publication 3 (Journal Paper): Larchen Costuchen, A., Mollá Vayá, R. P., & Dinkova Dimitrova, D. (2022). Roman Palace: A Videogame for Foreign-Language Vocabulary Retention. *International Journal of Emerging Technologies in Learning, 17*(5), 87–102. https://doi.org/10.3991/ijet.v17i05.27621

Abstract

The goal of this work was to develop a serious game which would aid in the retention of foreign-language non-contextualized vocabulary items in different age categories. To this end, the loci method was used to enhance visual and spatial memory among the game's players. The novelty of this proposal lies in combining mnemonic strategies within an exploratory video game environment. Structurally, this project consists of three main pillars: pedagogical foundations, the development of the serious game, and the evaluation of the game's efficiency through qualitative and quantitative study. The 3D game was developed through the Unity game engine in its version 2020.3. The prototype's efficiency was assessed quantitatively in an experimental group of 21 participants who were compared with a control group of 27 participants. All the data were displayed in R Studio using the ggplot2 library. The study was complemented with qualitative findings collected through semi-structured interviews with a group of 7 participants. The experimental method proved to be more efficient and more entertaining than the conventional method used in the control group.

Keywords: serious game, mnemonics, method of loci, vocabulary, memorisation, foreign-language learning

P3.1 Background

The use of educational videogames is constantly expanding, together with the fast development of information technologies. The methodological progress of the last decades has led to the development and adaptation to the demands of the 21st century of technologies such as Computer Assisted Language Learning (CALL), started by Levy (1997), Technology-Enhanced Language Learning (TELL), investigated by Bush and Roberts (1997), and the Serious Games Initiative,

introduced by Sawyer (2002). While various authors (Gee, 2005; 2007; Klopfer et al., 2009; Robertson, 2009) have reported the benefits of videogames in education in general, the didactic core of serious games distinguishes them from commercially distributed products that were initially designed for entertainment only (Zhonggen, 2019). As mentioned by Nazry (2017), the educational element of serious games is thoroughly integrated into their design, thereby offering players both learning content and an entertaining structure.

The Roman Palace prototype presented in this study is an example of a serious game developed to enhance the retention of foreign-language (L2) vocabulary. Retention is obtained through the use of virtual flashcards and the implementation of spatial memory. In linguistics, a flashcard is typically a card that has a word on one side and its translation on the other, thus establishing the connection (Nation, 2005; 2007). The main function of the game Roman Palace is to do this by establishing spatial connections between the words on the cards and the objects in the Roman villa (through association, organisation, and the loci method). The players are told to imagine what every new word reminds them of, as well as to remember where in the game it appears (for example, the room or a nearby object). All these elements create extra memory support. From the point of view of psychology, mnemonic techniques use combinations, relations, and associations of ideas while at the same time exploring our capabilities (Jiménez, 1994).

One of the methods used, the loci method, was described as far back as 55 BC by Cicero (Yates, 2013). “Loci” in Latin is the plural of “locus”, which means place or location. This concept is also known by other names, such as the Roman Room or the Memory Palace. They all refer to a mnemonic strategy in which a familiar environment activates a mechanism of association (Godwin-Jones, 2010) that facilitates memorisation. The number of vocabulary items and the amount of time allotted for retention in Roman Palace in the pilot study is based on the results of a study published by Larchen Costuchen, Darling and Uytman (2021) which showed that retention of 10 new vocabulary items in 15 minutes was significantly better with the experimental method (flashcards linked to 3D models and viewed in a familiar environment on mobile devices) than with the conventional method consisting of flashcards with images presented through the application Quizlet for Windows, Android and iOS. The serious game Roman Palace aims to serve for different age

groups as well as a variety of Indo-European languages. The pilot study focused on the 18-to-60 age group. The language used was not a real one but rather a group of pseudowords generated by an external tool. The effectiveness of vocabulary retention was measured in-game by testing the participants' translation and spelling of the words. The game also stored the time used to complete each level, the failed words in each test, and the scores obtained. Even though mnemonic strategies have been in use since Cicero's age (Yates, 2013) and are often mentioned in the academic literature (Yates, 2013; Bower, 1970; Briggs et al., 1970; Crovitz, 1971; Roediger, 1980; Nyberg, 2003; Derwinger et al., 2003; Knauff, 2013; Qureshi et al., 2015; Krokos et al., 2019) , they are not widely used in immersive environments for specific uses (such as L2 vocabulary acquisition), and scientific publications in this field are rare.

According to Levin and Levin (1990) and Jiménez (1994), mnemonic techniques can have positive effects not only on language learning, but on any type of learning. They do require a specific systematic approach. The loci method, for instance, involves selecting different elements within a familiar environment and then creating a mental image for every element that will be remembered together with each associated word (Maguire et al, 2003; Moè & De Beni, 2005; Huttner & Robra-Bissantz, 2017; Reggente et al., 2020; Larchen Costuchen et al., 2021). Recent studies show that visual immersive environments are more efficient for vocabulary memorisation than traditional methods. These studies include virtual reality (Huttner & Robra-Bissantz, 2017; Reggente et al., 2020) augmented reality (Larchen Costuchen et al., 2021) and the program Memory Palace Beta (Larchen Costuchen, 2020). The latter is a multiplatform application available for Windows, Android and iOS devices that enables the construction of memory palaces using the loci method (https://www.memorypalace.com/). These palaces are composed of digital images of interconnected rooms where objects are placed on. These objects are associated with the information that is to be memorised. Routes are then drawn connecting all the rooms and objects. The present study has gone one step further, designing an exploratory game centred around its educational objectives.

P3.2 Method and game development

This study aimed to design a serious game for non-contextual vocabulary learning in a foreign language (L2) using the loci mnemonic method. In this in-stance, the game

used a set of pseudowords for L2, but future studies will collect data from different combinations of existing Indo-European Latin-alphabet languages. At start-up, the game first asks players to consent to the use of their data for statistical purposes. Once the permission is given, the app collects certain demographic data (gender, age, mother language, and country of residence). The game has specific training and entertainment objectives. The entertainment objectives include familiarising players with the Roman-era-inspired setting, locating the cards hidden among the objects in the rooms, and overcoming the obstacles and time limits. The educational objectives include memorising the words on the cards and passing the tests. The main research question is whether the retention of new L2 vocabulary is enhanced by the serious game Roman Palace (the experimental method) in comparison with an alternative conventional method (a list of words presented in the form of a table on screen devices). The experimental hypothesis is that the serious game *Roman Palace* is more efficient than the screen-device tables for L2 vocabulary retention. Both qualitative and quantitative data were collected to analyse the results. The ages of the study participants ranged anywhere from 18 to 60 years.

This project used the videogame engine Unity (v. 2020.3), the database-management system SQLite; and the graphical user interface (GUI) LeanTween, an animation tool developed by Dented Pixel. The game was written in C#, a multiparadigm programming language developed by Microsoft, who also created the integrated-development environment (IDE) used, Visual Studio 2019, which was chosen for its wide range of extensions and programming facilities available for Unity. Most of the game's Roman-era-inspired models came from Unity Asset Store, Blend Swap and 3D Warehouse. We used the modelling tool Blender for creating some objects and model the Roman villa. As for the textures, most were obtained from 3D Textures, a free online texture library. The remainder was created using Adobe Photoshop CC 2020, a photo editor developed by Adobe Systems Incorporated that was also used to create the graphical user interfaces. The first version of Roman Palace's prototype was evaluated by two experts on the Roman era and ancient history whose suggestions improved the design of the game.

In order to determine the influence of Roman Palace on vocabulary learning in L1 and L2, this study enlisted 48 participants divided into two groups: an experimental group and a control one, both of whom used the same words. The L2 was not an

existing language but a series of pseudo-words created by a random word generator (n.d.). The experimental group used Roman Palace to memorise a set of 10 vocabulary items and another of 20, with the game itself calculating the scores and the time used (Figure P3.F1). As for the control group, they were given two lists (Figure P3.F2) containing the words that needed to be learned for each test (10 and 20 respectively). They also recorded the time used in the vocabulary-learning and problem-solving phases themselves.

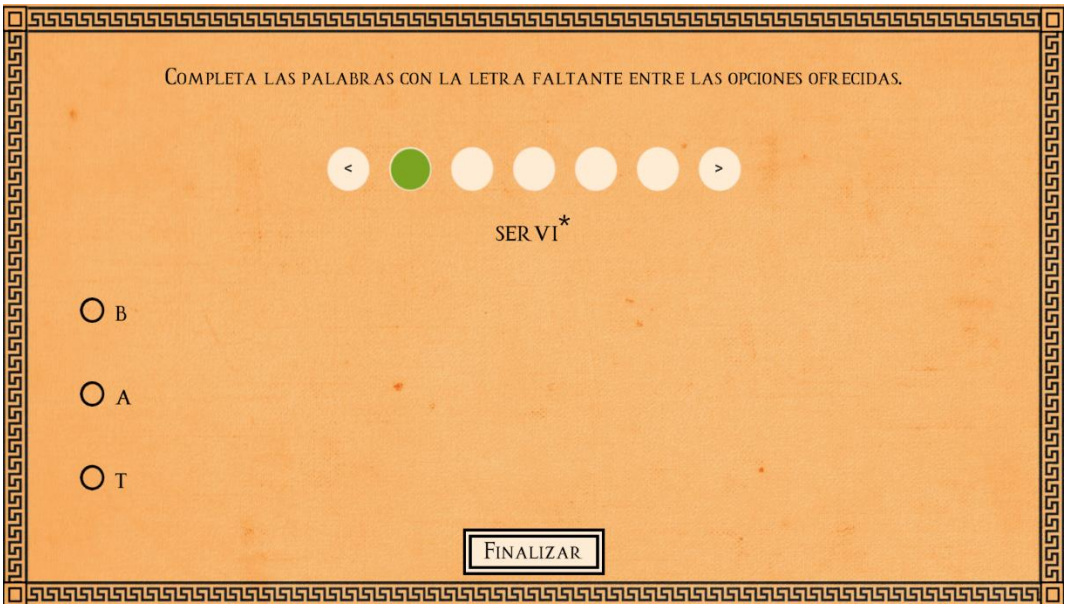


Figure P3.F1. Learning the vocabulary with Roman Palace

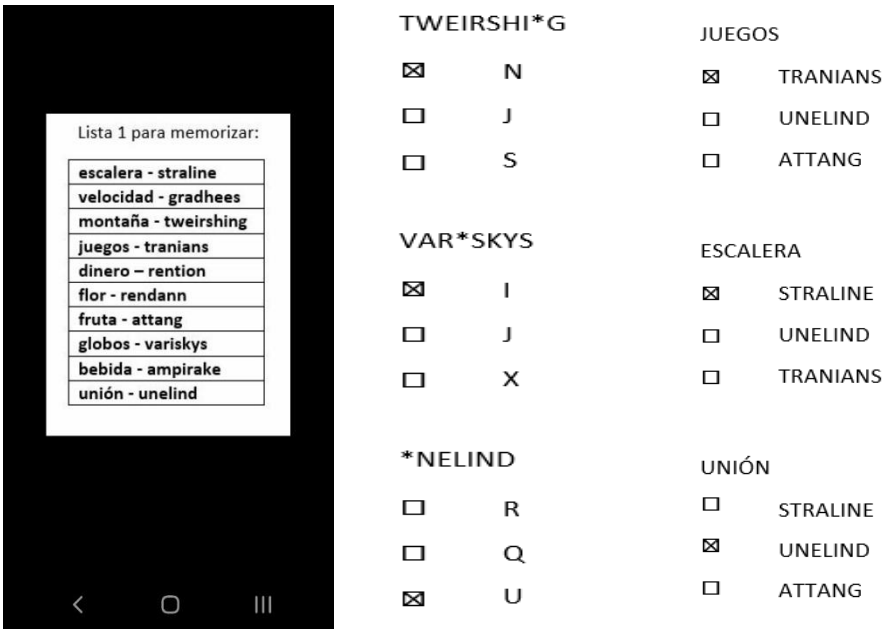


Figure P3.F2. Learning the vocabulary using a list on a screen

In addition, individual semi-structured interviews were conducted with the participants from both groups to obtain confirmation about their experiences.

P3.3 Quantitative Results

The graphics showing the results obtained by the 21 participants from the experimental group (the Roman Palace video game) and the 27 controls that used the traditional method (lists of words in L1 and L2) were created using R Studio's ggplot2 library.

Figure P3.F3 shows the scores obtained on the final test by the participants in the experimental and control groups, the latter using the traditional method to memo-rise the 10 and 20 vocabulary items. The scores are ordinal variables expressed in round numbers: 0, 10, 20, 30, 40, 60, 70, 80, 90, and 100. The graph shows the percentage of each score obtained by each group on each test (10 and 20 items). In conclusion, the 10-word list yielded maximum test results (100 points) in a similar proportion (more than 50%) in both groups. The 20-item list, however, yielded a notably lower test result in the control group (around 30%) compared with the experimental group (46%). On the other hand, the experimental group obtained similar proportions (80%) of high results (90 points or more) on both tests, almost doubling the proportions of high test results obtained by the control group on both tests. Finally, the only failing grades (<60) occurred among control-group participants on the 20-word test.

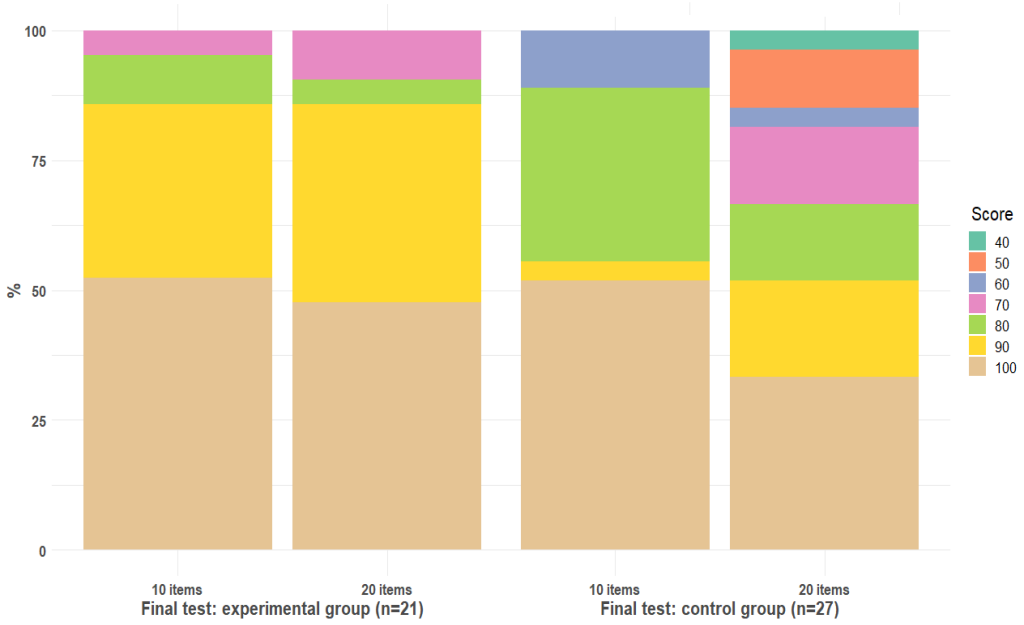


Figure P3.F3. Diagrams of the scores obtained on the final 10- and 20-word tests by the participants in the experimental and control groups

A gender-based comparison of the results in the experimental group (Figure P3.F4) shows that 7.1% more women than men obtained the highest possible score (100%) on the 10-word test. In the 20-word test, however, this advantage in-creased to the point where twice as many women as men obtained the highest possible score. Overall, however, the percentage of participants that obtained high scores (>80) was similar for both genders (80%).

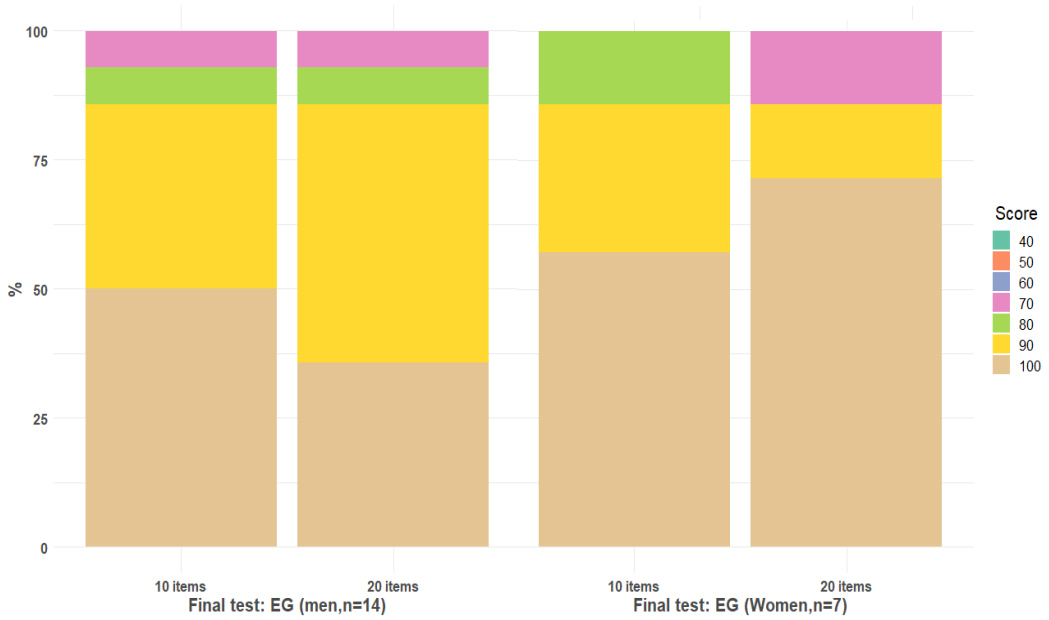


Figure P3.F4. Diagrams of the scores obtained on the final 10- and 20-word tests by men and women using the experimental method

A gender-based comparison of the control group's results (Figure P3.F5) shows men obtaining higher scores on both tests. Significant differences were found in the 20-item test, with only half of the women scoring >80 and 21% failing, while no men failed the 20-word test.

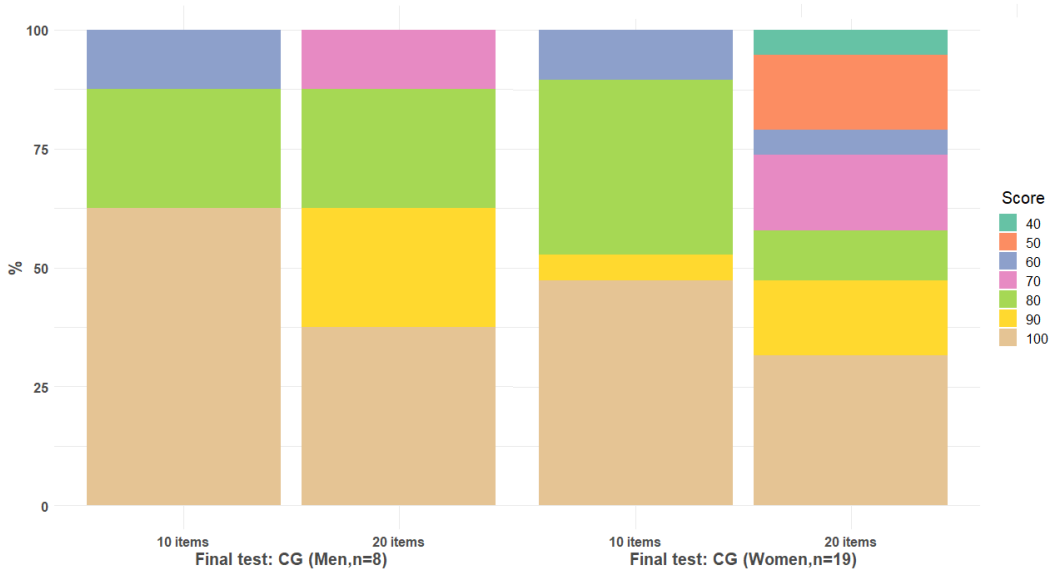


Figure P3.F5. Diagrams of the scores obtained on the final 10- and 20-word tests by men and women using the traditional method

A comparison of the time needed to memorise the 10 and 20 vocabulary items using both methods (Figure P3.F6) shows that the traditional method proved to be the fastest one for the 10-item list, with an average of 6 minutes (7 minutes in the experimental group), but it was also the slowest one for the 20-item list, needing an average of 12 minutes compared with the experimental group's 10 minutes. The box diagrams of the times needed for word memorisation and test completion show that the two groups perform in opposite ways. Thus, as the grouping of the control group's participants around low time values shows, the control group generally needed less time to memorise the 10-item list than the experimental group. When it came to the 20 vocabulary items, however, the control group needed more time than their experimental counterparts, with 50% of the controls requiring more than 12 minutes, compared with only 25% of the experimental group.

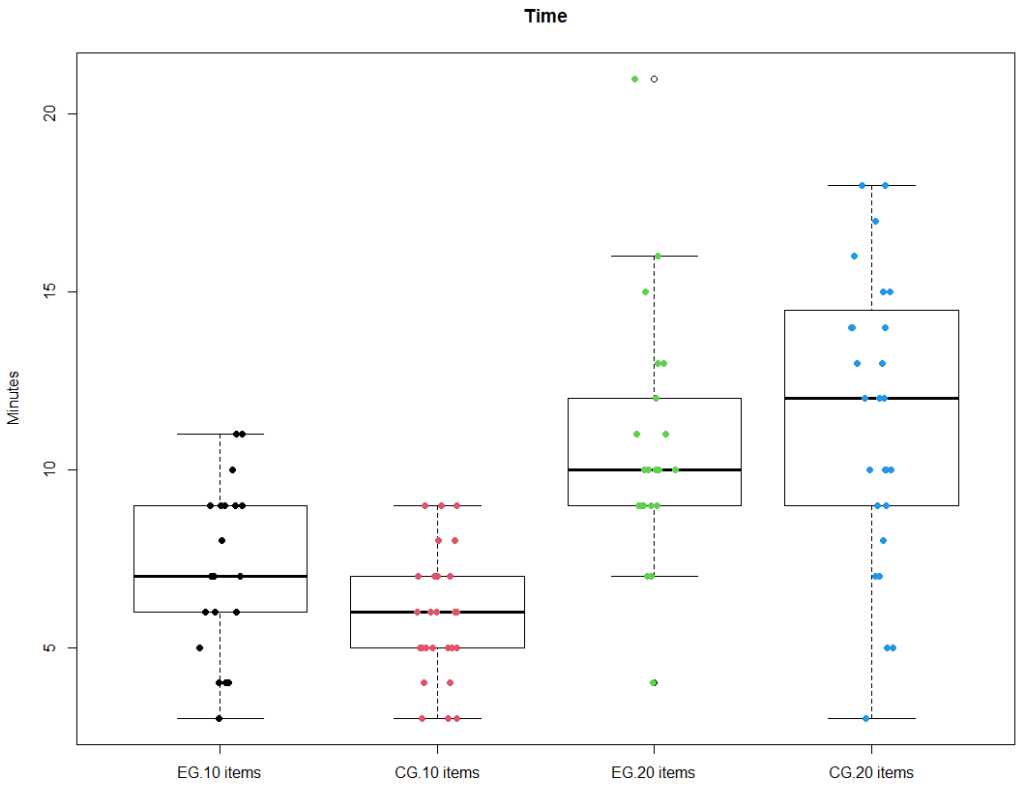


Figure P3.F6. Box diagrams of the time in minutes needed to memorise 10 and 20 items

Figure P3.F7 shows the average time needed by both genders for both tests. In both the control and experimental groups the women needed an average of between 12 and 24 more seconds to learn the 10 words. In the 20-item test the women in the control group show an even more marked gender difference, needing almost a minute more. The results are similar for the experimental group, although it is the only group where the men took slightly more than the women (6 seconds on average).

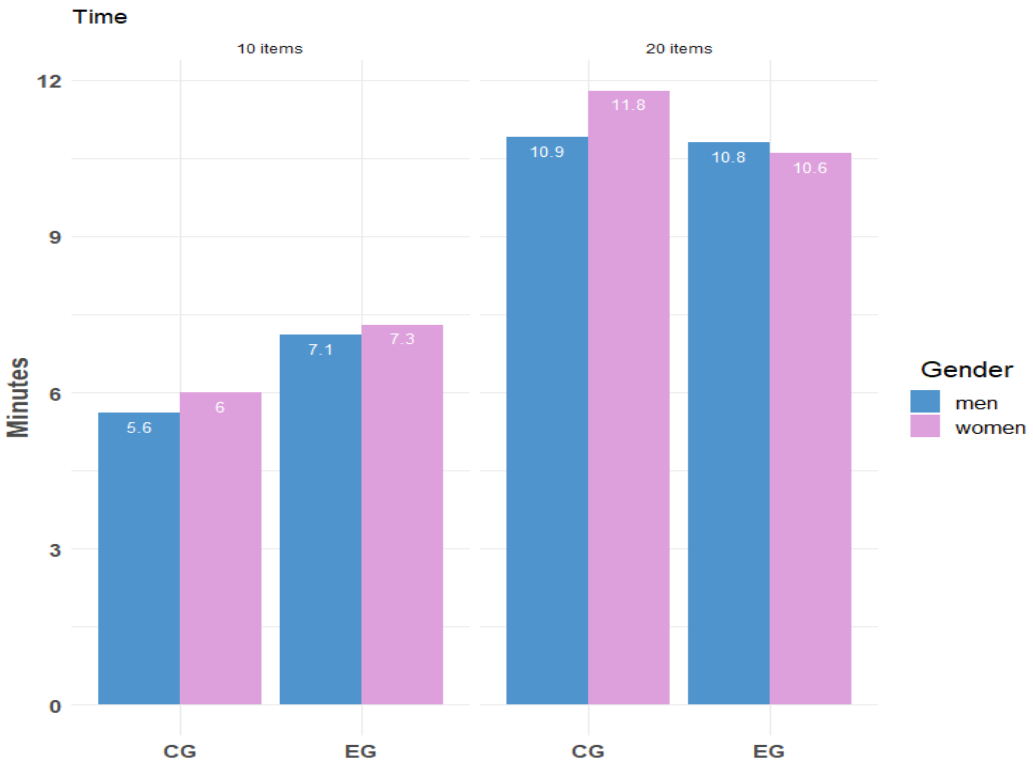


Figure P3.F7. Box diagram of the average time needed by men and women to complete the 10- and 20-word tests

Figure P3.F8 shows how long it took both groups to complete the two tests by age and gender. Both graphics show the linear regression accompanied by the 95% confidence interval. There appears to be no relation between age and time needed in the experimental group, while the control group shows a clear linear relation in both genders, i.e. the older the person, the more minutes needed.

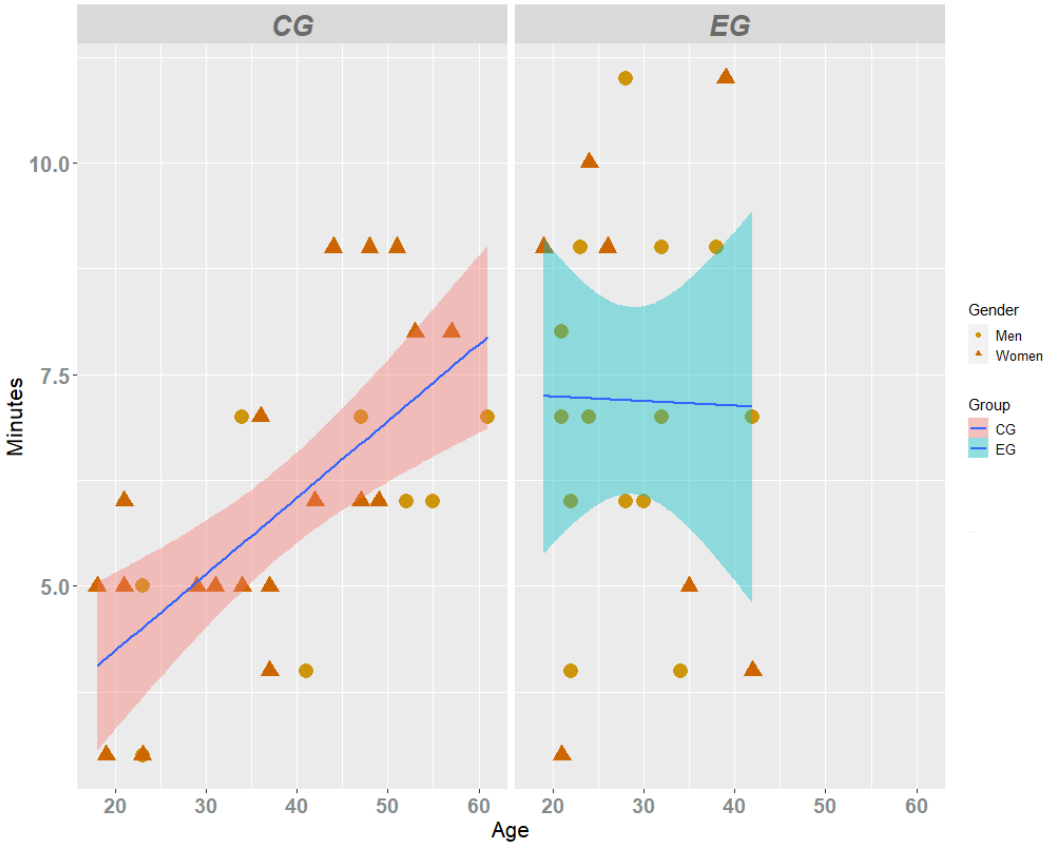


Figure P3.F8. Graphic showing memorisation time by age and gender for both groups

P3.4 Qualitative Results

A total of 7 people (experimental group/EG = 4 and control group/CG = 3) were interviewed about their experiences with the methods used. The interviews were individual and semi-structured, conducted on the platform Zoom and lasting between 15 and 20 minutes. No group interviews were conducted because they were considered to entail the risk of participants influencing and interfering with one another. The data were analysed using a four-category semantic scale: “Question 1. Opinion of the method used”, “Question 2. How did I feel during the tests”, “Question 3. Highlights”, and “Question 4. Prior experience with the method used.” The results are shown below.

Quantitative Profile EG-14: man, 30 years, time 10 items: 7 minutes; time 20 items: 11 minutes; score level 1: 90%, score level 2: 100%. Opinion of the meth-od (semantic methods used): “very easy”, “fun”. How they felt during the tests: “Actually, I was more focused on finding the objects than on memorising the words, but it worked. When I got to the tests, I did get it right. I remembered al-most everything.”

“When I started playing, I first did a little tour towards the fountain to see how many rooms there were. Then I returned to the starting point and started entering the rooms, looking at the type of rooms and the modern objects. Some rooms looked quite similar. What set them apart was their location with reference to the fountain. I tried not to get lost and to take into account the number of objects I had already found. Even so I entered some rooms more than once”. Highlights: “Some combinations of objects and their positions in level 2 were funny. The helmet that was on the statue and the glasses that, instead of being on the table, were on a bust.” Prior experience with the method used: the participant has no prior experience with mnemonics, but has played video games before. “When I was young I played *Doom* and as a kid some 2D and 3D games.” “I haven’t played in years.”

Quantitative Profile EG-9: man; 38 years; time 10 items: 9 minutes; time 20 items: 16 minutes; score level 1: 100%; score level 2: 90%. Opinion of the meth-od (semantic methods used): “easy”, “more fun than a notebook with translations”, “I would try again with other words, I liked it.” How they felt during the tests: “I had to enter some rooms more than two or three times. Things got especially complicated at the end of level 1 with my last object (a rocket in the water). In level 2 there was this new room (kitchen/pantry) that I just couldn’t find.” Highlights: “There were some funny combinations. For example, in the kitchen there was a modern milk carton with a drawing of a cow and on the card it said “*horse* – *theoscorian*.” Prior experience with the method used: the participant has no prior experience with mnemonics, but has played video games before. “I used to play *Monkey Island* and other graphic adventures.” “My favourite now: MMOG.”

Quantitative Profile EG-7: woman; 26 years; time 10 items: 9 minutes; time 20 items: 9 minutes; score level 1: 90%; score level 2: 100%. Opinion of the method (semantic methods used): “it takes getting used to”, “I liked the idea”, “it’s not a hard method at all”. How they felt during the tests: “Curiously, level 1 was harder for me than level 2. I had to learn to understand the system and how to use the mouse and keys. I went more slowly in level 1, but level 2 was really fast. I was very aware of where I was going and of whether I had been there before. I tried not to lose any time. I found the translation tests easier than the ones where you had to fill in letters. In any case, I had no trouble remembering the vocabulary. When I saw the list in the beginning, I thought it was going to be much harder.” Highlights: “It took me a while

to find a modern object in the vegetable pantry. I got stuck, and then I realised it was the potatoes." Prior experience with the method used: the participant has no prior experience with mnemonics, but has played video games before. "I used to play Super Mario and some other games with my brother. Right now I'm not playing anything. A couple of years ago I tried *Angry Birds* on my phone, and I was hooked for a few weeks."

Quantitative Profile EG-8: woman; 24 years; time 10 items: 10 minutes; time 20 items: 10 minutes; score level 1: 100%; score level 2: 100%. Opinion of the method (semantic methods used): "fantastic", "very user-friendly". How they felt during the tests: "I would have preferred to play on my phone or tablet, but I un-derstand that this type of game has been designed for computers. I used the 34KB version because with the 64KB version the character would move a bit slowly on my laptop. The game looked nice and fun to me in spite of it being an educational tool. Even now I remember many words. I would use it again to improve my English." Highlights: "In general, I remember not only the words but also where I found the cards, in which rooms, and near which objects. Sometimes some element escapes me. If I have to go over all the words, I first remember the room, then the object, and then the word in Spanish with its translation into the made-up language. When I did the tests, it was the other way around: first the word, then the object, then the room." Prior experience with the method used: the participant has no prior experience with mnemonics, but has played video games before. "I used to play when I was little, but I don't remember the names. I tried *Pokémon Go* a few years ago, but I didn't like it. Sometimes I do Sudoku on my cell."

Quantitative Profile CG-45: woman; 37 years; time 10 items: 5 minutes; time 20 items: 12 minutes; score level 1: 100%; score level 2: 90%. Opinion of the method (semantic methods used): "difficult", "requires a lot of patience". How they felt during the tests: "I looked at the screen and repeated the combination in order: first column and second column." "The words that were more than two syllables were more difficult to memorise than the monosyllabic ones or those that were two syllables." "One thing that I found very complicated was the absence of vowels between some combinations of consonants." Highlights: "The 10-item test felt much easier to me than the 20-item test. Spelling tests 1.1 and 1. 2 were more complicated than tests 2.1 and 2.2. Maybe because the second time I knew what to expect and I was better

prepared.” Prior experience with the method used: the participant has no prior experience with mnemonics, but has used similar methods for learning vocabulary before. “I had often taken notes and made diagrams to memorise formulas and words in English, French, and Valencian. It’s an easy method but very monotonous.”

Quantitative Profile CG-43: woman; 49 years; time 10 items: 6 minutes; time 20 items: 15 minutes; score level 1: 100%; score level 2: 100%. Opinion of the method (semantic methods used): “It’s not very hard, but it’s repetitive”, “The more words you have to memorise, the more tiring it gets.” How they felt during the tests: “I realised that I got very easily distracted by anything else (cell phone, my cat, etc.). I found it impossible to stay concentrated during the whole exercise.” Highlights: “Some of the words in the test were rather easy, and I remembered them almost immediately (*chair – straline, games – tranians, and union – unelind in part 1, and shop – servit, bear – nocobot, dogs – mulaps and italiano – milato* in part 2).” Prior experience with the method used: the participant has no prior experience with mnemonics, but has used similar methods for learning vocabulary before. “I take notes both on my phone and in a notebook, and I also like to use cork wallpaper with reminders and schedules.”

Quantitative Profile CG-39: woman; 36 years; time 10 items: 7 minutes; time 20 items: 13 minutes; score level 1: 100%; score level 2: 100%. Opinion of the method (semantic methods used): “complicated”, “requires a lot of dedication”, “might have been easier on a printed sheet”. How they felt during the tests: “To better memorise I had to repeat the words out loud. The language looked like Latin or some Nordic language. It might have been easier for me with another language (English, German, French, or Italian).” Highlights: “The 20 words were more complicated than the 10. As for the tests, I found translating easier than the spelling test. The most complicated words for me were *brinercionized* and *kisheanicirch*.” Prior experience with the method used: the participant has no prior experience with mnemonics, but has used similar methods for learning vocabulary before. “I’m used to memorising texts, sentences, words, and telephone numbers at my job (office clerk). I use paper notes, Post-Its next to the computer, Samsung Notes, and electronic files on the computer.”

P3.5 Results

The experimental method proved to be more efficient (according to the numerical data) and more entertaining (according to the opinions of the participants) than the conventional method used in the control group. There were more men in the experimental group but fewer in the control group. The highest scores were obtained by women in the experimental groups, but in the control group they obtained the lowest scores. This leads us to believe that future studies should explore these differences and record how men and women in both experimental and control groups memorise, play, and behave, as well as whether any gender pays more attention to the play elements of the game than to the learning tasks. It would also be worthwhile to analyse how many seconds and how often participants spend looking at the word cards and whether this bears any relation to their results both in the intermediate and final tests.

P3.6 Conclusion: Limitations and Future Prospects

This project is the prototype of a much more complex serious game. It is meant to be the base on which will be built a mnemonic system that will enrich the field of new-language learning by offering an alternative to conventional study methods. However, time restraints prevented some useful improvements from being incorporated: customisation of the character's appearance (this could increase immersion and thus enhance retention), more interactive user interfaces, the possibility of saving progress in a non-finished level (currently the program can only save one's progress at the completion of a level), internationalising the application (the availability of multiple languages would make the game accessible to a much wider audience, allowing data to be collected from disparate regions), offering a more complex and memorable story, adding the specified levels and tests, using a translation service (the user would only have to complete the L1 word list and choose the L2, and the system would automatically translate everything else; this would also make it possible to add auditory and pronunciation tests, creating a more all-round, complete learning experience), adapting to virtual reality (generating a version of the game that can be played in a VR environment, greatly enhancing player immersion), improving the game's performance, and, finally, replacing the game's database-management system SQLite with one that is cloud-based,

centralising and thus facilitating the collection of data. We believe the modern world is changing us and that more attention needs to be paid to the possibilities that new technologies can offer us (Canessa, & Tenze, 2021; Yamani, 2021; Hamzi et al., 2021). Our objective with this project is to turn the memorisation of non-contextualised vocabulary items or any other pieces of information into a more exciting and immersive task.

Publication 4 (Journal Paper): Larchen Costuchen, A., Cunningham, L., & Tordera Yllescas, J.C. (2022). Bunker-Room Mnemonics For Second-Language Vocabulary Recall. *International Journal of Virtual and Augmented Reality, 6*(1), pp 1-13; https://doi.org/10.4018/ijvar.304899

Abstract

This paper presents a proposal for designing a short Serious Game (SG) aimed at helping second-language learners memorize a list of non-linked vocabulary items under visuospatial bootstrapping, system introduced by Darling et al. (2017). The usefulness of such a tool was suggested by the efficient outcomes of spatial mnemonics in TEFL providing 21st-century teachers, students and game designers with new possibilities and it represents a new application of CALL. The game design is based on a modified version of Kalmpourtzis' AMSTP serious game design model (2019) and it uses the aesthetics, mechanics, story, technology, and pedagogy as its basis, adding a sixth element to its core: user expertise. The resulting AMSTP-UE framework allows in-game analysis from the point of view of an L2 teacher, L2 learner or game designer. The game is a first-person walking simulator using the medium of virtual reality (VR) to provide its players with the feeling of presence in a virtual world. This proposal suggests using visuospatial recall of pseudowords at the pilot stage with further expansion to audio-visual input and output for latin-script languages and deep learning APIs, with in-game data capture that will support learning analytics.

Keywords: serious game, virtual reality, visuospatial bootstrapping, vocabulary recall, computer-assisted language learning

Video abstract: https://youtu.be/RIrJaboqEsE

P4.1 Introduction

The benefits for educators of technology-related competences have been pointed out by researchers on numerous occasions (Cunningham, 2000; Lam, 2000; Rakes & Casey, 2002; Baumann et al. 2008; Krumsvik, 2008; Comas-Quinn, 2011; Fullan & Langworthy, 2014, and Pettersson & Olofsson, 2019), even taking us back to the

origins of Computer-Assisted Language Learning (CALL) in Second-Language Acquisition (SLA). The OECD 2030 paper defines these competences as key to meeting the challenges of a volatile, uncertain, complex, and ambiguous world, harnessing digital tools and artificial intelligence (European Council, 2018; OECD, 2018; Caena & Redecker, 2019). As noted by Chapelle (2003), CALL offers second-language learners the opportunity to receive enhanced input outside the classroom, but Kukulska Hulme (2005) argues that some of the devices available to learners are simply not designed for educational purposes, which makes it difficult for teachers to use them. It is important to mention that computers have changed the role of the teacher (Cunningham, 2000), the source of information now being information technology and the teacher being a facilitator of learning.

Nevertheless, as stated by Li (2012), teachers are more likely than game designers to design educational games that align pedagogical objectives, curriculum standards and students' needs because building an educational game is, in itself, a pedagogical process. As pointed out by Theodosiou and Karasavvidis (2015), if pedagogical experts want games to be more educational, they should get actively involved in their design themselves. This would, ideally, result in game designers and teachers combining their expertise and turning out games that are both entertaining and educationally efficient at the same time (Marne et al., 2012). The motivational aspect of videogames applied for didactic purposes have been amply discussed by different authors (Prensky, 2001; Gee, 2003; Jenkins & Klopfer, 2003; Squire, 2003; Squire, 2005; Cheng & Su, 2012; Osma-Ruiz et al, 2015; Hartmann & Gommer, 2019). However, it is important to note that an effective game design considers both the intrinsic and extrinsic rewards for play (Dodlinger, 2007), with intrinsic motivation pushing players to act on their own behalf while extrinsic motivation pushes them to act through factors external to the activity (Denis & Jouvelot, 2005). It is essential to remember that players' experiences can be both frustrating and life-enhancing (Gee, 2003) and that the game generation has developed such cognitive approaches as active versus passive, playing versus working, fantasy versus reality, and pro-technology versus anti-technology (Prensky, 2001), which eventually affects the kind of teaching/learning strategies that should be offered to these learners both inside and outside the classroom. Augmented and virtual reality in foreign language education offer an ambitious, immersive gaming experience in the educational

context, thus providing challenges and opportunities to teachers, students, and game designers.

P4.2 Didactic foundations

Originally appearing as a task-based procedure aligned with specific achievable goals, CALL gradually evolved into a multimedia-rich system or serious games environment, which now offers a switch from in-class to out-of-class activities, and from teacher-guided to self-directed study. Based on graphics, visual effects, and supported by music, games can stimulate chemical changes in the brain and enhance a teaching-learning process (Greitzer et al., 2007, Neville et al., 2009, Cobb & Horst, 2011, Thomas, 2011, Squire, 2011, Di Zou, Huang & Xie, 2019). Play is a knowledge-acquiring process and it opens doors to cognitive training. This concept, grounded on Bruner's (1974) and Vygotsky's (1978) research, has been fruitfully applied to starting up a serious-game movement (Sawyer & Rejeski, 2002) and its practicality has been highlighted in recent academic literature (Malaquias et al., 2018, Jiang et al, 2019, Ouchaouka et al, 2020). The game Bunker-Rooms Mnemonics traces its roots back to a research report by Larchen Costuchen, Darling and Uytman (2020) which describes a framework supported by visuospatial bootstrapping (VSB), mobile-assisted language learning (MALL), and AR-enhanced flashcards. That recent didactic model showed efficient results among university students in a fifteen-minute-delay test and was picked up for designing a mnemonic tool for second-language vocabulary instruction. This proposal, however, makes a shift from augmented reality on mobile devices and suggests using VR for an immersive experience in a virtual world. Research has suggested that VR can improve language learning (such as Vazquez Machado et al 2018) and so it was decided to explore VR as a medium for the teaching and learning of language.

P4.3 Game Design

Schell (2008) states there are four main game-design elements (aesthetics, mechanics, story, technology). Kalmpourtzis (2019) adds an extra, core element (pedagogy). The basic game-design frameworks date back to the Mechanics, Dynamics, and Aesthetics (MDA) model by Hunicke et al. (2004) and the Design, Play and Experience (DPE) framework by Winn (2011), which was later expanded with four items for each component (learning, storytelling, gameplay, and user

experience). Serious game-design tools such as the Experiential Gaming Model (EGM) by Kiili (2005), the Four-Dimensional Framework (4DF) by Freitas & Jarvis (2009) with further Game-Based Learning Framework (GBLF) by Staalduuinen & Freitas (2011), and the latest Game-Object Model (GOM II) by Amory (2007) all contain learning as a nuclear component (Figure P4.F1).

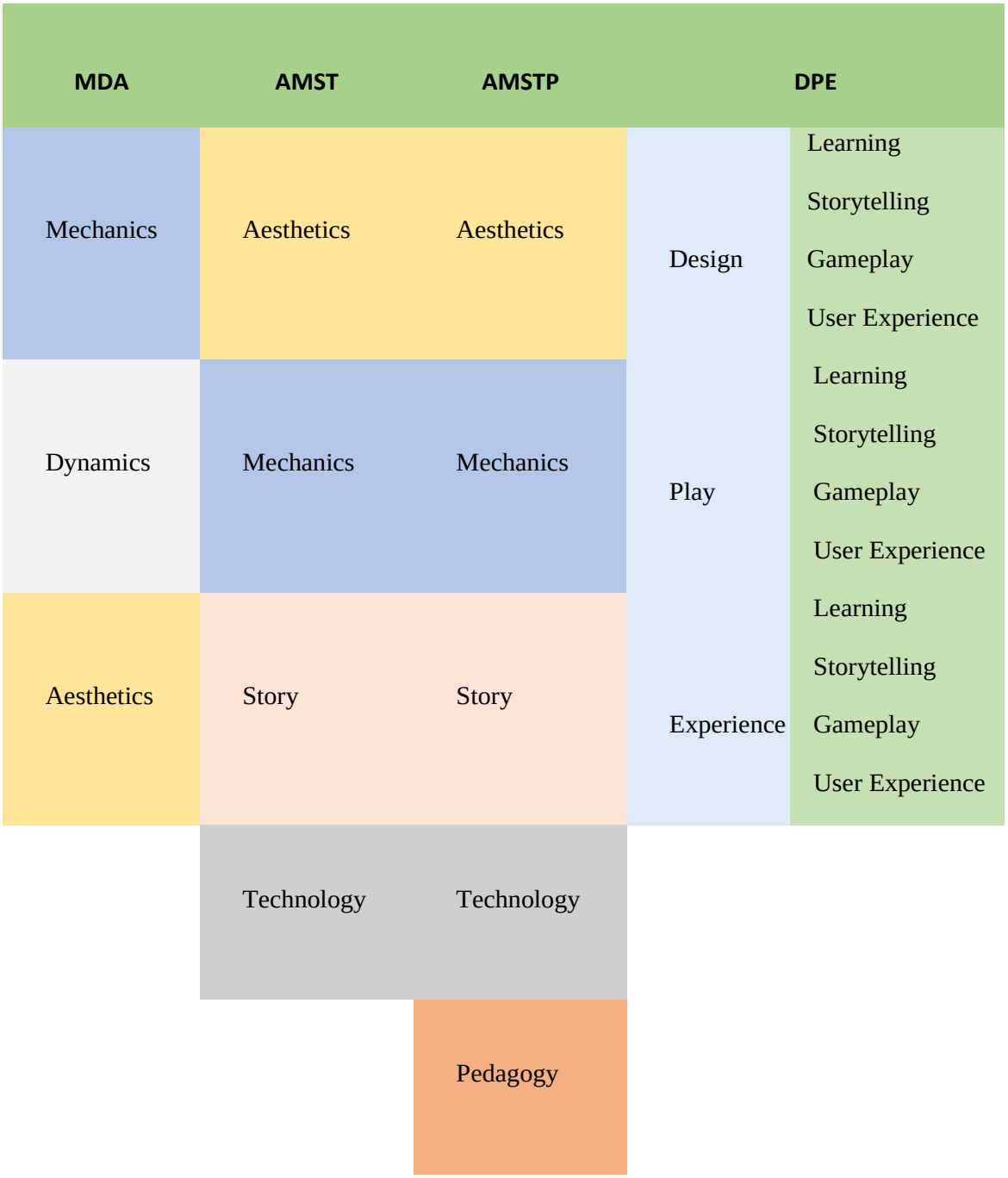


Figure P4.F1. Game-Design Models

McMahon’s (2009) Document-Oriented Design and Development for Experiential Learning (DODDEL), with its seven planning elements (situation analysis, design proposal, design documentation, production documentation, prototype, document, and implementation), is the best model for designing courses for digitally native generations (Prensky, 2001) thanks to the easy adaptability of its already established curriculum structure to a game interface.

Among useful game-analysis tools, we definitely want to highlight Learning Mechanics-Game Mechanics (LM-GM) by Arnab et al. (2015) and the Activity Theory- based Model of Serious Games (ATMSG) by Carvalho et al. (2015) and Callaghan et al. (2018), which Silva (2020) says join pedagogical and game features but lack game-design methodology. ATMSG uses a modified version of the LM-GM and is based on Vygotsky and Leontiev´s (1978) activity theory/Cultural-Historical Activity Theory (CHAT), which describes humans as motivated to act through the use of tools. The system is supported by three main pillars: the gaming activity, the learning activity, and the teaching activity, with the learner (player/student) and the teacher (whose roles include game design and development) being involved in different tasks—fulfilling a course requirement on the part of the learner, and engaging students on the part of the teacher (Callaghan et al., 2018).

This paper uses a modified AMSTP model by Kalmpourtzis (2019) as its game-design base and adds an additional, sixth element to its structure: user expertise. The result is an AMSTP-UE framework in which the user can easily adopt any role (L2 Teacher / L2T, L2 Learner / L2L or Game Designer /GD). The user also shares their experience, thereby contributing to the improvement of the game’s aesthetics, mechanics, story, technology, and pedagogy at all the stages, from prototype planning to postproduction (Figure P4.F2).

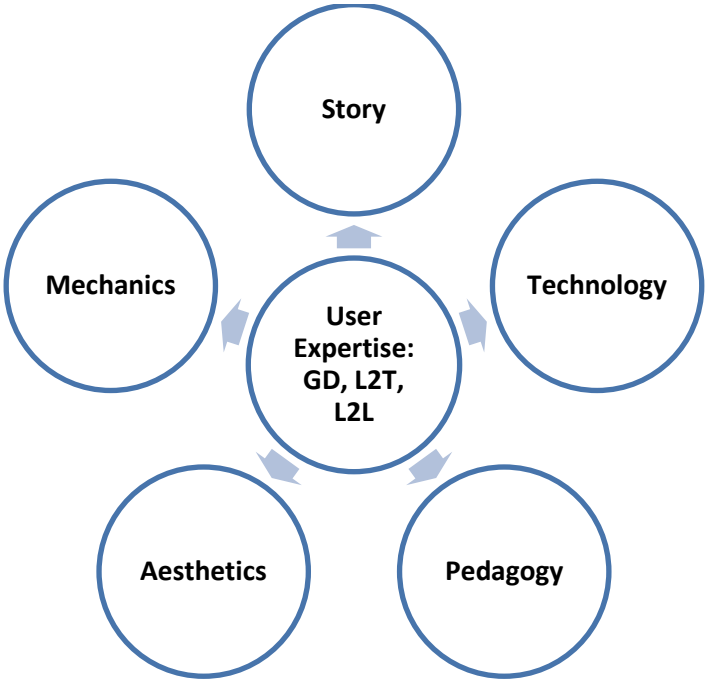


Figure P4.F2. AMSTP-UE Serious Game-Design Model

In addition to AMSTP-UE, an ATMSG four-element structure is applied for the design evaluation of Bunker-Rooms Mnemonics, with gaming, learning, game, and teaching being analysed under the general category of player and the specific category of learner, game designer or teacher, through the examination of the activity, by identifying the subject, and by supporting the description (Table P4.T1).

Table P4.T1. Activity-Subject-Description in ATMSG

Activity	Subject	Description
GAMING	PLAYER	Why is the subject playing? What are the objectives in the game?
Learning	L2L	Why is the subject engaging with the game? What are the game´s learning objectives?
Game	GD	Why was the game produced? How is the game conveying its ludic and learning contents?
Teaching	L2T	Why is the subject using the game? How is the game applied for didactic purposes?

The didactic content of Bunker-Rooms Mnemonics is viewed through visuospatial bootstrapping (Darling et al., 2017) and flashcards-based input (Nation, 2003, 2005). It is based on the environmental exploration in virtual reality, with players required to make spatial associations between the objects in the rooms and lexis to be recalled. The pilot stage in the development of game offers visual input, while stage 3 expands to the audio-assisted input and output. All the stages are necessary for posterior complex data analysis (Table P4.T2).

Table P4.T2 Didactic Components of Bunker-Rooms Mnemonics

Player's data	**Player´s role (L2L, L2T or GD).** Player´s non-identifying data: gender, age, nationality, native language, target language and level of proficiency in target language
Musical background	Classical or muted, on the choice of the player
Language settings	Translation L2-L1 and vice versa
Game development	Pilot Stage: visual input of automatically generated pseudowords. Experimental phase controlled by L2 teachers with students from different L1 backgrounds. Stage 1: visual input of latin-script lexis (items selected by users in line with their requirements with in-game automatically stored data for further statistical analysis). This stage counts on deep learning APIs and Learning Analytics. Stage 2: visual input of non-latin-script alphabet and lexis (items selected by users in line with their requirements with in-game automatically stored data for further statistical analysis). This stage counts on deep learning APIs and Learning Analytics. Stage 3:

	expanding to the audio-assisted input and output with the option of alphabet and accent selection for lexis (items selected by users in line with their requirements with in-game automatically stored data for further statistical analysis). This stage counts on deep learning APIs and Learning Analytics.
Number of lexis	Pilot stage (two independent routes): Route 1: 15 items, Route 2: 25 items
Input time/ Time to play	Pilot stage: Time limit for both routes - 15 minutes. More timeline options will be offered at posterior stages
In-game assessment	Pilot stage: lexis translation and spelling (L1-L2, L2-L1). Definitions based on Nelson-Denny Vocabulary subtest at the end of Route 1 and Route 2 (independent non sequential levels that suggest the difficulty of the game). Route-one-test includes 15 questions with 1-out-of-5 options of answer. Route-two-test includes 25 questions with 1-out-of-5 option of answer Time limit for route-one-test is 5 minutes. Time limit for route-two-test is 7 minutes. Pilot stage: Minimum completion rate initially set at 60 percent within the time limit with in-game automatically stored data for further statistical analysis.
In-game data collection	Ws&Hs starting points: 1) Who is playing the game (e.g., L2T, L2L or GD)? 2) Who is evaluating the game elements? 3) What is the quantitative evaluation scale (7-point Likert)? 4) What are the qualitative findings about the

game elements (advice to improve the game)? 5) What is the player´s demographic data (gender, age, nationality, native language, target language, level of proficiency in target language)? 6) What alphabet is used (L1 and L2 pair)? 7) What vocabulary items are used for the recall (single words, word-combinations, part of speech, L1 and L2)? 7) What are the results (number of items used for the input, time in the game, test score, interference between L1 and L2)?

P4.3.1 Game Genre, Mission Statement and Target Audience

The game will be developed using the popular Unreal Engine 4 game engine (n.d.), which has comprehensive support for virtual reality. Initial support will be for the Oculus Rift (n.d.) platform on Windows, though it is envisaged that support could follow for HTC Vive and Valve Index (both Windows-based) and the wireless Oculus Quest. Support for dynamic language translation will be added using an application programming interface such as Google Translate API.

The game will target Latin-script Indo-European languages providing a virtual world environment to facilitate second-language vocabulary acquisition to players who are also learners. The game development is aimed to be supported by five key pillars: aesthetics, mechanics, story, technology, pedagogy and a sixth, core element, user expertise, impacting on the other five elements through the figure of either a teacher, game designer or learner. The game's design is planned to be divided into the following sequential stages: proposal, design, production, pilot testing, and post-production with a RT-FU (regular testing–further updates) structure.

Bunker-Rooms Mnemonics introduces a first-person graphical perspective (Figure P4.F3).

Figure P4.F3. First-Person POV

The first-person POV provides the player with the experience of embodiment and presence, with virtual hands helping with proprioception and active learning (for example, through reaching for and grabbing objects), which allows a gamer to perceive the virtual world through the eyes of the protagonist (Galvan Debarba et al., 2017). The backstory explains that the main character comes from a wealthy family, but instead of a university career decides to take military memory tests and enter the military intelligence unit. According to the narrative the protagonist is locked in a bunker room and the player will need to memorize a list of vocabulary items in a foreign language in order to unblock an exit door (Table P4.T3 and Figure P4.F4).

Table P4.T3. Route 1: pseudowords for Pilot Study

Pseudowords L1	**Translations into L2**
1. wpatent	1. patent
2. diccount	2. discount
3. cnst	3. cost
4. markeu	4. market
5. recessiwn	5. recession
6. suprly	6. supply
7. poney	7. money
8. demaid	8. demand
9. bncome	9. income

10. tav	10. tax
11. intest	11. invest
12. proguction	12. production
13. pricg	13. price
14. profib	14. profit
15. effikiency	15. efficiency

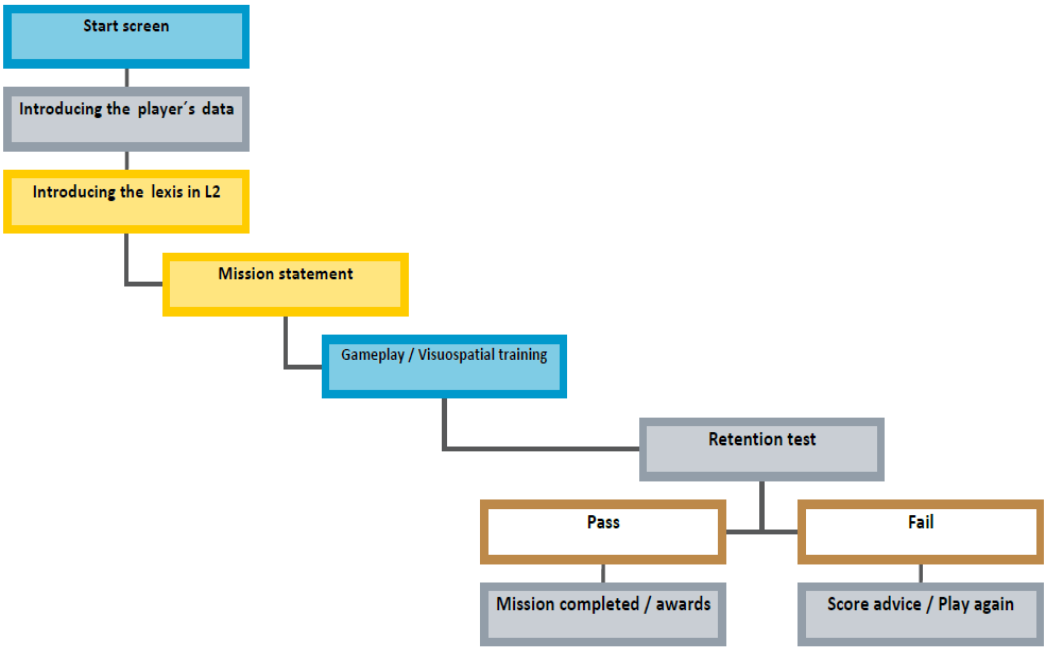


Figure P4.F4. Game Flowchart

The protagonist explores the bunker area, to search for notes, using teleportation to reduce the possibility of visually induced motion sickness (VIMS) which common symptoms are dizziness, disorientation, and stomach awareness (Lawson 2015). (Figure P4.F5). Classical music or muted mode are offered to the player as gameplay background**.**

Figure P4.F5. A teleportation beam used for locomotion in the game

The word items from the list appear when the player moves or somehow interacts with an object in the room (opening the wardrobe, switching on a TV, taking a book etc.). All the vocabulary items (in two languages) look like notes (Figure P4.F6).

Figure P4.F6. An example of a note card. L1 and L2

When the route is explored and the lexis are viewed and collected as cards the protagonist must take a retention test to obtain the rewards (badges, points and finally the military unit contract). The décor in the rooms and the doors in different colours are designed to facilitate memorization of the route to the player. Route 1 and Route 2 retention tests are both automatically generated, translation-based and

time-limited. They take into consideration phonetic and orthographic similarity of the target word with some random options checking the learner's visual memory (Table P4.T4). The test-passing score is set at a minimum of 60 percent for the established time.

Table P4.T4. Example of the pilot-stage retention test. Structure based on Nelson-Denny vocabulary subtest with 1-out-of-5 choice.

1. Choose the correct translation of *price*
a. prikg
b. frice
c. pricg
d. precg
e. pticg
2. Choose the correct translation of *tax*
a. vat
b. tav
c. fatt
d. tot
e. VIT
3. Choose the correct translation of *recession*
a. pecessiwn
b. recessivn
c. recessiwn
d. recesciwn
e. ricessiwn
etc.

First-person graphical perspective/the players hands are seen when selecting 1 correct answer out of 5 options. (Figure P4.F7).

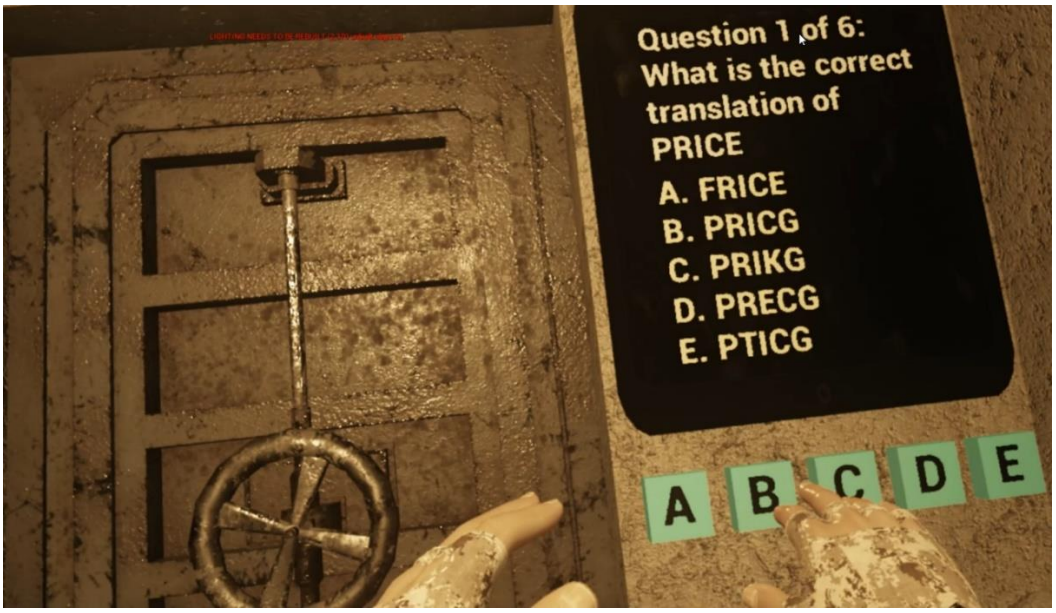


Figure P4.F7. Retention test in the game

In addition to being a mnemonic training tool for second-language vocabulary memorisation, the game can be applied to other training purposes that are currently being worked on. The game collects some non-identifying demographic data from players. The players are duly asked to provide permission to have their training results used for statistical analysis in order to improve the game at postproduction stages. One of the game's novelties is that it is not only meant for second-language learners of different ages, but also EFL teachers and game-design specialists. One of the game´s limitations is that the final test's multiple-choice structure may reduce the reliability of scores, which is why thorough pre- and postproduction analysis will be required to identify specific game-structure limitations and to guide updates.

P4.4 Summing Up and Final Thoughts

Bunker-Rooms Mnemonics suggests an immersive alternative to traditional wordlist-based or flashcard-based recall method for non-linked lexis. It calls for collaboration among 21st century teachers, learners, and game designers and for combining Virtual Reality environment with a mnemonic pegging mechanism. It suggests a transition from task-based assignments to game-based (self) training. It targets both digital and non-digital generations and its goal is to provide a tool which would be of interest to a wide range of digitally literate candidates who are eager to enrich their second-language vocabulary.

PART 3: INTRODUCING SUPPLEMENTARY RESEARCH

Customized training for 21st century students

Customizing curriculum in order to adapt to learners´ needs and preferences has shown improvement not only in engagement and learning outcomes (Kerr et al., 2006; Davis et al., 2017; Littenberg-Tobias et al., 2016; Penuel, 2017) but has also been beneficial for teachers who design and manage productive environments (Matuk et al., 2015; Ye et al., 2015; Debarger et al., 2017). It allows students to take initiative at syllabus planning and course delivery stages either individually or collectively. The flexibility of this process depends to a large extent on the type of relationship between the teacher and the students and the type of contents, that is, how the group is organized to learn, how they are evaluated and what resources are selected to facilitate that teaching-learning process (Paulsen,1992; Davis & Krajcik, 2005; Gerard et al., 2010). The rise of digital technologies brought up a new discourse on generations (Riley, 1987; Fortunati et al., 2019) according to which the youngest generations were considered as innately technology savvy (e.g. Prensky, 2001a, 2001b) which had to be taken into consideration at instructional level (Becker, 2000; Holmes, 1999; Selwyn & Bullon, 2000). This vision was criticised by authors who stated that access to technology does not automatically mean that the digital natives can independently acquire all the necessary skills (Bennet et al., 2008; Hargittai, 2010; Herold, 2012; Jones et al., 2010; Fortunati et al., 2019).

Producing adaptive courses is complex, time consuming and expensive (Eklund et. al. 1999; De Bra et. al. 2003) be it paper-based or technology-supported. Constant research is needed to provide tools to support syllabi customization process via collection of qualitative and quantitative data, by making innovative frameworks visible, leveraging open-education resources and amplifying support for teachers (Gerard et al., 2022). The impact of new technologies as a motivational tool in educational context has been widely discussed in the last decades. If learners can take advantage of new technologies learning tasks may become less tedious, however we should not assume that any new format would be more appropriate or efficient compared with traditional approaches. Innovative materials should meet the learning goals, be easy to obtain and to use, fit the teaching-learning contexts and be

compatible with the equipment available. The possibility of customizing courses based on new software, new devices and practices definitely has potential, but it also provide new challenges for teaching and research professionals and eventually expands the field of educational technology.

Publication 5 (Book Chapter): Larchen Costuchen, A. (2020). Chapter 7: From Generation Gap to Generation Lap: Gen Z Subcultures. *Estudios de lingüística aplicada IV.* Editors: Carrió Pastor, María Luisa, Periñán Pascual, Carlos, Romero Forteza, Francesca & Olmo Cazevieille, Francoise. (pp. 113 - 130). Universitat Politècnica de València.

Resumen

Los objetivos del presente estudio fueron, en primer lugar, determinar unos patrones en cuanto a las preferencias de memorización del vocabulario como parte del aprendizaje de un segundo idioma de alumnos pertenecientes a la Generación Z; y, en segundo lugar, determinar su experiencia con aplicaciones de realidad aumentada y tarjetas de aprendizaje de vocabulario en dispositivos móviles. Los resultados indicaron, que, aunque existen hábitos globales relacionados con la tecnología entre los alumnos de la Generación Z, pudo haber otros factores que afectaran a sus preferencias de memorización, tales como el uso tradicional de lápiz y papel o la utilización de las últimas novedades tecnológicas. Este tipo de datos pueden ser la base de una mayor investigación, con vistas al futuro diseño de programas informáticos adaptativos para apoyar la enseñanza personalizada.

Palabras claves: enseñanza personalizada, memorización del vocabulario, generación Z, preferencias de aprendizaje

P5.1 Introduction: generation cohorts

The growing immersiveness of digital media, entertainment and learning environments has triggered the reconsidering of the characteristics of digital and non-digital generations and raised the need for remodelling the existing structure. From a sociological perspective, a generation can be defined as a group of people that are born during the same time period, have roughly similar ages, share at roughly the same time significant life events occurring at critical developmental stages, and form their habits and values under the influence of the same environmental factors during adolescence and early adulthood (Strauss & Howe, 1991; Schewe & Meredith, 1994; Kupperschmidt, 2000; Rogler, 2002; Codrington & Grant-Marshall, 2004; Parry &

Urwin, 2011). This concept, often mentioned in the academic literature, was developed in depth and structured by Karl Mannheim in Das Problem der Generationen (1928/1952), which drew attention to the importance of socio-historical impact. In chapter VII Mannheim takes the concept of generations beyond the mere chronological succession of groups, considering also shared intellectual, social, and political experiences (Dilthey cited in Mannheim, 1952).

In sociology, a group of people who share a habitus, lifestyle and similar experiences is called a cohort (Parry & Urwin, 2011). By most definitions, each generational interval is approximately twenty years long, which represents the average length of time between birth and childbearing or the beginning of the next generation (Sandeen, 2008). As stated by the same source, twenty years is also the length of each of the four distinct phases into which an average human lifespan of roughly eighty years can be divided: youth, rising adulthood, midlife, and old age.

Examples of generation cohorts in the United States could be the World War II cohort (the Greatest Generation), whose members are characterized as patriotically minded, and the post-war cohort (also known as the Depression Cohort, the Silent Generation, or the seekers), which was associated with the country´s economic growth and strong family values. The next generation was the baby boomers, the result of the previous generation´s increased birth rate. They tended to be freedom-minded, idealistic, and experimental, with a hippy subculture in music and lifestyle. The boomers were succeeded by Gen X or the baby busters, who were notoriously entrepreneurial, flexible, and culturally diverse. Next came Generation Y, also known as the millennials or Generation Next, who were computer-minded and became rapidly accustomed to the use of mobile phones and social media.

As calculated by Strauss and Howe (1991), the WWII Generation was born between 1901 and 1924, the Silent Generation from 1925 to 1942, the Baby Boomer Generation between 1943 and 1960, Generation X or the Thirteenth Generation from 1961 to 1981, and the Millennial Generation or Generation Y between 1982 and 2003. Tapscott (1999) and Oblinger & Oblinger (2005) also outline a Net Generation, born between 1981 and 1994 which coincides with the early millennials of Strauss and Howe. The most recent generation by now is known as Generation Z (Generation Next, the iGeneration, or the screensters). As reported by Glum (2015), Generation Z is growing up in a time of complexity, it does not want to be tracked, it

would rather use Snapchat, Secret, or Whisper than communicate, it wants to co-create and live stream, it has an attention span of eight seconds, it prefers to communicate through images, icons, and symbols rather than texts, and it multitasks on five screens (smartphone, TV, laptop, desktop and iPod) instead of just one or two.

In the 1960s, the shifts that took place between generations became widely known as the 'generation gap', which referred to value changes and a growing lack of understanding between the older and newer generations. Since the 1980s, we also have to keep in mind a generation lap, or the generations´ experience with the new technologies(Tapscott, 1999). In 2001, Marc Prensky coined the terms digital natives (2001) for members of Generation Y and digital immigrants for anyone born before the Internet and ICTs became such a major part of the information landscape (Combes, 2009). Digital natives, also known as cyberkids (Holloway and Valentine, 2003), the Net Generation (Tapscott, 1999) or the Google Generation (Callan, 2008) have changed the way people communicate, socialise, create, and learn (Helsper & Eynon, 2010) as compared with the digital immigrants. As outlined by Prensky (2001), digital immigrants to some degree retain their own digital accent, that is, they are still with one foot in the past, which can be seen in such things as their tendency to turn to the Internet for information second rather than first, or when they read a program's manual instead of just assuming that the program itself will teach us how to use it.

Generation Y has been described as possessing better digital literacy skills and an increased readiness to use information in innovative ways (Dorman, 2000; Skiba & Bar- ton, 2006,) which establishes the digital native/digital immigrant dividing line between the cohorts. However, the new generation of Gen Zers is the most tech-savvy of them all. As described by Oblinger & Oblinger (2005), to them the internet is like oxygen, something they cannot imagine living without. They use devices and online interaction as part of daily lives (Voorveld & van der Goot, 2013; Moulton, 2015; Castellano, 2016; Rickes, 2016) and they are more self-directed, and more able to multi-task than previous generations (Igel & Urquhart, 2012; Cowan, 2014).

A workshop-based study, conducted by Kinash et al. (2013) in Australia and the US highlighted the generational differences in perspective between teachers and students, finding that apart from the obvious and expected gap between the tools that

teachers are willing to use and those that students expect, there exists another, conceptual gap between what teachers and students define as technology. As shown in Table P5.T1., the generations´ technological and educational backgrounds provide some general guidelines that may be useful in guiding educational processes.

Table P5.T1 Generational overview through technologies, teaching, and learning (Adapted from Pegler et al. (2010), McCrindle and Wolfinger (2010), Kinash et al. (2013), Johnston (2013), Bevan-Dye et al. (2012), and Bencsic et al. (2016))

Generations	Characteristics	Technological context	IT skills	Learning and development	Teachers/ Students
The baby-boom generation (1943-1960)	Digital Immigrants Late digital adopters	Iconic technology: TV, audio cassette & transistor radio. Communication via telephone	Self-instructed users with incomplete knowledge	General description: holistic and experiential learning. Format: structured. Training focus: technical data & evidence	Teachers
Generation X (1961-1981)	Digital Immigrants	Iconic technology: VCR, Walkman & IBM PC. Later: satellite and digital TV, personal computers, palm pilots and mobile phones. Communication via email and IM	Confident users of technology	General description: flexible, mimicry, interactive and just-in-case learning. Format: spontaneous & interactive. Training focus: case studies & applications	Teachers
Generation Y (1982-1991)	Digital Natives	Iconic technology: internet, email, SMS, DVD, PlaySlation & iPOD. Later: 24/7 access to virtual social networkimg (Facebook), virtual social reporting (Twitter) and virtual media (YouTube). Communication via text messages and social media	Everyday users of technology	General description: rapid, IT-based and just-in-time learning. Format: multi-sensory and visual. Training focus: story-based, emotional and participative	Teachers/ Students

Generation Z (born after 1991)	Hyper-Connected Generation/ Technoholics	Iconic technology: MacBook, iPad, Google, Wii, PS3, Android & iOS. Ubiquitous communication via hand- held devices	Intuitive users of technology	General description: interest-based and informal learning. Format: student-centered; kinesthetic. Training focus: multi- modal, interactive & eLearning-based	Students

The research presented in this chapter was aimed at examining Gen Z students´ habits surrounding second-language vocabulary memorisation, their experience with augmented reality on devices, and their familiarity with the digital-flashcard application Quizlet. The findings from the questionnaire-based survey are discussed using a Gen Z-based generational approach.

P5.2 From 2D to 3D and then from screens to moving around

A look at the history of educational technology in the EFL classroom brings us to Computer-Assisted Language Instruction (CALI), which later transitioned into Computer-Assisted Language Learning (CALL). Eventually this system was adapted to the demands of digital-age teachers and students under the umbrella of Mobile-Assisted Language Learning (MALL), where people started using lightweight devices such as mobile phones and personal digital assistants (PDAs). Technology-Enhanced Language Learning (TELL) another umbrella term for the use of technology in language learning in general highlighted these gadgets´ multimedia functions, their portability, interactivity, connectivity, and immediacy.

In the mid-1990s, two-dimensional computer-simulated environments transitioned into three dimensions, a move most prominently seen in mainstream games affecting the millennial generation´s experience, like Super Mario World (n.d.), among many others. As stated by Cabrera (2019), 3D level design is much more conducive to slower-paced, exploration-based worlds than tightly packed platforming challenges. Simply navigating a 3D world with Mario´s new moveset was fun enough, and having varied objectives allowed players to explore more lifelike worlds than were ever possible in 2D. The massive 3D worlds of Mario 64 blew people´s minds back in 1996, and their open- ended structure combined with Mario’s diverse moveset gave them a replay factor that was unmatched by 2D games in the series.

In the 1990s the launch of augmented reality (AR) on digital devices saw 3D models moving from inside computer screens out into the real world, into real physical space. As stated by Chicchi Giglioli et al (2015) and Chavan (2016), AR permitted the overlaying of new information on top of the already existing physical environment. Although the term is attributed to Caudell during his work on an industrial project for Boeing, augmented reality was first practically applied in the cinema industry by Heilig (1957), in computer-graphics research by Krueger et al. (1985), during experiments with head-mounted displays by Southerland (1968, and in 1980 by Mann, who achieved a photographically overlaid reality on a portable-computer prototype. The system was tested by the US Air Force, obtaining positive reviews, and later spread to the mainstream in games and other fields.

Modern educational applications of AR technology have been explored for pre-school use in such applications as AR Flashcards (n.d.) for alphabet and animal learning, Quiver (n.d.) for coloring, and Narrator AR (n.d.) for writing. For primary and secondary school, some of the mainstream options for Android and iOS include Elements 4D (n.d.) for chemistry; Zooburst (n.d.), Arloon Plants (n.d.) and Anatomy 4D (n.d.) for natural science, biology and anatomy; Civilizations AR (n.d.) for art, culture and history; Amazing Space Journey (n.d.), Star Walk (n.d.) and Sky Map (n.d.) for astronomy use; and AR Translator (n.d.) and Mondly AR (a.d.) for foreign-language study along with 3D pop-up story books. AR application, according to various authors (Salmi et al., 2010; Bower et al., 2014; Ibáñez et al., 2014; Chiang et al., 2014; Huang et al., 2016), can enhance the effectiveness of the learning process, strengthen students´ intrinsic motivation, and improve low school achievement, offering a rich gaming experience and enhancing users´ educational- realism-based practices.

The 2016 launch of Pokémon Go (n.d.), a popular augmented-reality and location-based game, not only influenced the commercial, travel, and other sectors, but also increased gamers´ physical activity and reduced sedentary behaviors (Althoff et al., 2016; Nigg et al., 2017). The system combines a real-world neighborhood captured on the mobile phone camera with AR-animated Pokémons that the players have to seek out and collect by exploring their surroundings (Rasche at al., 2017). The Pokémon Go achieved worldwide success, attracting an estimated 27 and 67 million

iOS and Android users in 2016 and 2020 respectively in the United States alone (Statista, 2019). It strongly influenced the development of AR-supported language-learning applications. What set it apart from other applications, developed by individual researchers and not as rich in resources, was that it did not use optical sensors to create AR experience but physical location instead (Godwin-Jones, 2016).

During the past decades, and in step with CALL, MALL and TELL development, second-language vocabulary acquisition has shifted from word lists and paper flashcards to web-based platforms which can be run on portable devices. After its launch in 2007, Quizlet software became one of the most popular applications rapidly spreading among digitally minded teachers and learners and demonstrating excellent results in facilitating vocabulary retrieval by e-flashcards among secondary school and university students in different countries (Sanosi, 2018; Andarab, 2019; Meunier et al., 2019). On the other hand, the use of new, augmented-reality flashcards with 3D graphics, resulted in significant improvements in vocabulary memorization in early childhood education (Lee et al., 2017; Hashim et al, 2018; Chen & Chan, 2019), providing a rationale for research with more age groups, countries and student categories.

P5.3 Data collection and findings

In order to ascertain Generation Z preferences and expectations in vocabulary memorization tasks, a research was conducted in March and April of 2019 in the Teacher Training Department of the Universitat de Valencia (UV). The sample consist- ed of a total of sixty-two university students (N=62) aged 18 to 22, born from 1997 to 2001. Gender differences were not part of the focus of the study but will be considered in all subsequent research.

The study was aimed at obtaining the students´ preferences and experiences related to the use of the new technologies in second-language vocabulary memorization, and the Hypothesis 0 (H0) of the study was that the students had extensive experience working with digital flashcards for vocabulary memorization. The Hypothesis 1 (H1) of the study was that the students had little experience working with digital flashcards for vocabulary memorization. The Hypothesis 2 (H2) of the study was that the students had extensive experience with 3D models and augmented reality on digital devices. The Hypothesis 3 (H3) of the study was that the

students had little experience with 3D models and augmented reality on digital devices.

Ninety-three volunteers were given a preference-and-experience survey (Appendix 3. Quantified data for student survey), which sixty-two of them completed (Figure P5.F1, Figure P5.F2, Figure P5.F3, Figure P5.F4). The data obtained from a multiple-answer questionnaire show that most of the learners (almost 60%) preferred learning-by-seeing, more than 45% of the research population opted for learning-by-doing, and only 21% chose the option of learning-by-hearing (Q10 in Appendix 3: Preferred ways to perceive information). The study also reported that no more than 19.4% of the students were motivated to learn English as a Second Language by personal issues; many of the subjects (more than 72.6%) were driven by the need to pass exams and by motives related with their job future (Q3 in Appendix 3: Learning objectives related to English as a Second Language).

The most common vocabulary-training choice among participants was the use of vocabulary lists in notebooks (61.3%), which is a traditional memorization method typical of Gen Xers (Q4 in Appendix 3: Vocabulary memorization strategies based on personal preferences). Surprisingly, students stated they had little experience with digital media for vocabulary memorization (Q6 in Appendix 3: The use of software applications for vocabulary memorization). Almost 80% had never used them and 14.5 % almost never. The same was the case with augmented reality on digital devices (Q7 in Appendix 3: The use of augmented reality on digital devices). More than 58% had never used it and 22.6 % almost never. However, the students explained this as a simple matter of habit carried over from their school days and eagerly accepted to try out new strategies and use digital media instead of paper and pencil.

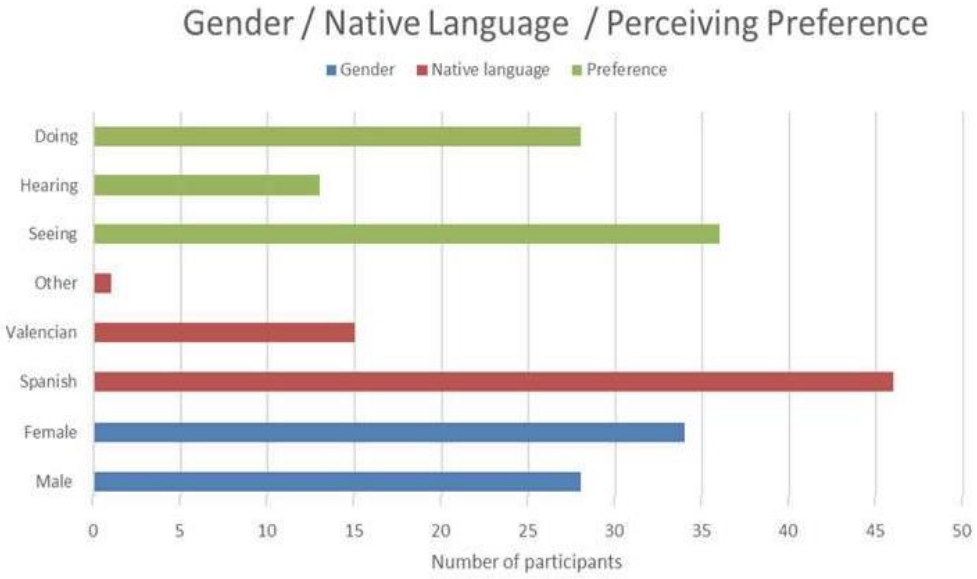


Figure P5.F1. Graphical presentation of dataset from Q1, Q2 and Q10

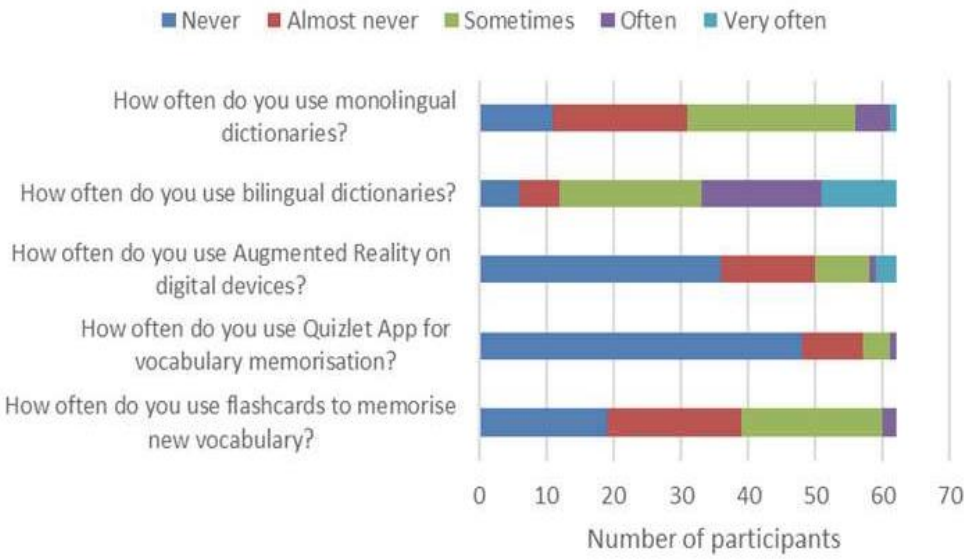


Figure P5.F2. Graphical presentation of dataset from Q4

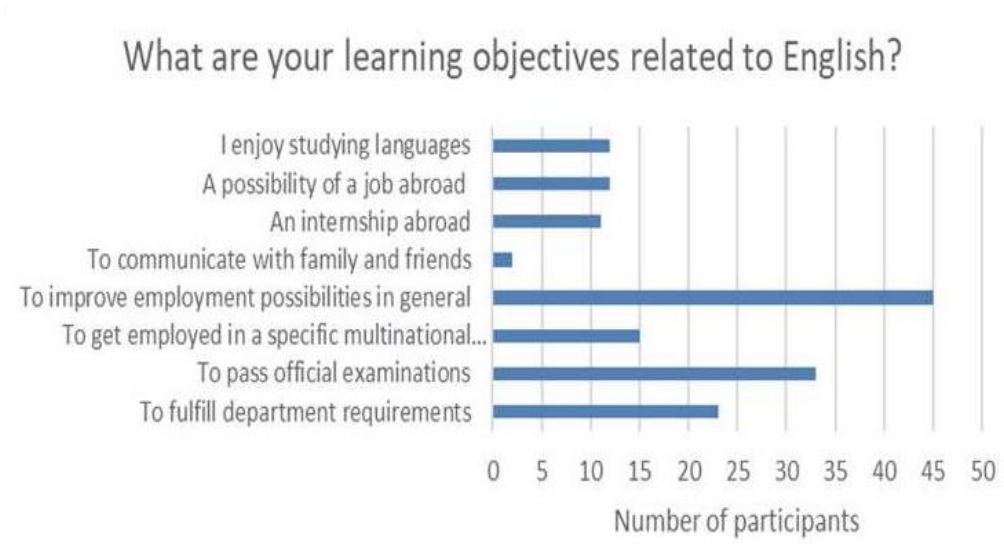


Figure P5.F3. Graphical presentation of dataset from Q3

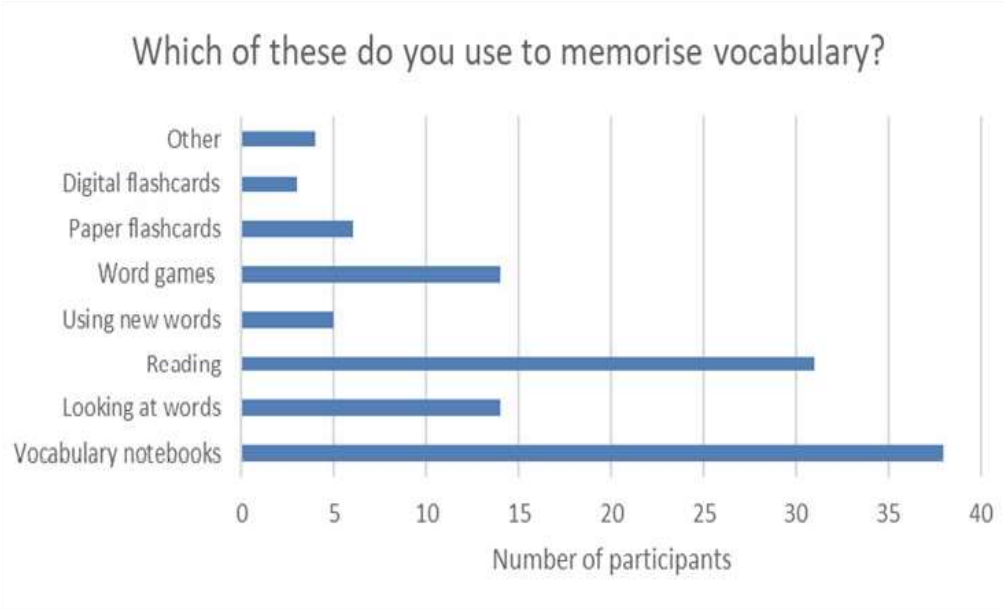


Figure P5.F4. Graphical presentation of dataset from Q4

After the survey data and the experimental findings were processed, hypotheses 1 (H1) and 3 (H3) were confirmed, while hypotheses 0 (H0) and 2 (H2) were rejected.

P5.3 General discussion

The study data reveal that although by age classification the students belonged to Gen Z, their study habits were influenced by previous cohorts.

As a result, the finding raised the following questions on the part of the researcher:

1. Could the described research population be named generation Z or should it be seen as a Gen Z subculture?
2. Could there be any other subcultures within Generation Z?
3. How to address Gen Zers in second-language vocabulary acquisition?

Answering these questions would require more study among the age groups belonging to Generation Z about their ICT experiences and preferences. The analysis of the student survey consisted of the quantifying of such data as demographics, learning objectives, preferences and habits. Apparently, as demonstrated by the data, not all the Gen Z students are techies, which does not mean they would not be receptive to new technologies when given the opportunity. Students´ free-time habits, such as sports, reading, writing, and playing games on computers and other devices, would need to be taken into consideration in order to offer them the most suitable memorization strategies in second-language vocabulary acquisition. Of special interest is the effect of place-based games on Gen Zers and the reduction in sedentary habits among players, because several recent studies (Nigg, Mateo & An, 2016; Wong et al., 2017; Ma, Ng, Schwanen et al., 2018) have pointed out that the popularity of the Pokemon Go game altered its users´ lifestyles. Gen Z subcultures would also need to be specified for second-language vocabulary input because while there are some global technology-related habits among Gen Zers, on a social and personal level their preferences may range from pen-and-pencil to the latest technological advances. Teachers and researchers would need to search new methodological approaches to raise intrinsic motivation among Gen Z students when dealing with monotonous tasks that learners need to perform as part of home assignments and under deadline pressure. When more information is collected and analyzed, new prospects for designing, developing and testing of adaptive-technology-enabled tools in the second-language classroom will reveal themselves.

Publication 6 (Conference Paper): Larchen Costuchen, A., & Dev, S. (February 26–28, 2022). Confronting challenges of non-formal education: A shift from book-based EFL to tailor-made, experimental syllabi. In The 2022 5th International Conference on Big Data and Education (ICBDE'22), Shanghai, China. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3524383.3524450

Abstract

The main objective of this study was to survey a population aged 22 to 55 years from the Valencian Autonomous Community in Spain (n=72, current or former users of the national education system) about their experiences and opinions surrounding English as a Foreign Language (EFL) in the context of lifelong learning. In addition, qualitative data were collected from participants on their preferences regarding EFL for the second and third terms of the 2021-2022 academic year (n=7), taking into account the changes in teaching methods caused by the pandemic. The study applied a mixed design, first gathering numerical data and then complementing these with narrative data analysed on a semantic scale. The results show that the new non-formal EFL course requirements present challenges related to the transition from fixed-syllabus textbooks to tailor-made courses where students (as indicated by 69,4% of respondents) can determine the subject matter and the percentage distribution of the components of their language courses.

Keywords: English as a foreign language, post covid, non-formal education, tailor-made syllabi

P6.1 Introduction

The purpose of education systems is to impart formal training (FT) that is assessed by the formal criteria established by countries' educational standards (European Commission, 2020). Non-formal training runs parallel to the formal system but allows students more freedom to determine elements such as the subject matter of a course, the stage in their lives in which they prefer to take that course, the course's duration, the intensity of its schedule, the course material, and in some cases even the teaching staff. While generally formal education is rigidly structured, non-formal

training is usually more student-centered and more flexible. The global objectives of the strategic framework for European cooperation in education and training (ET 2020) include the expanding of the connections between formal and non-formal education, and between in-person and distance learning, while also modernizing education through the use of new technologies (Larchen Costuchen et al., 2021). Lifelong learning requires dialogue, cooperation, and the setting of global standards (Berjon et al., 2021) that are adapted for regional and national use This study is about the learning of English as a foreign language as part of continuing education in the context of the Valencian Community (Spain). The digital era started to change curriculum-design methods by incorporating digital technologies (smartphones, tablets, interactive whiteboards, etc.) into the classroom (Molina & Chirino, 2010; Larchen Costuchen, 2020). During the covid-related pandemic their popularity rose thanks to the flexibility and ease with which they can be updated and to their lower price in comparison with traditional book-based materials. As mentioned by different researchers, the spread of technology and gadgets extended its impact on education, work and social interactions (Larchen Costuchen, 2020; Prensky, 2001; Autry & Berge, 2011), thus setting the stage for possible syllabi updates in non-formal EFL for the second and third terms of 2022.

P6.2 Regulatory framework and objectives

Spain follows the guidelines of the Common European Framework of Reference for Languages (CEFR) set by the Council of Europe for the assessment of language competences and the distribution of the levels (A, B and C) and sublevels (A1, A2, B1, B2, C1 and C2). This system is regulated at the national level by Royal Decree 1041/2017, of 22 December 2017, which sets the minimum requirements for certification (B2 level) and establishes the basic curriculum of special language learning governed by Organic Law 2/2006, of 3 March 2006, on Education. At the autonomous-community level it is the regional government, which creates a competency-recognition system for foreign languages and institutes the Competency Level Certification Commission. Formal training is part of the Spanish official education system and comprises the following stages: preschool education, primary education, compulsory secondary education, baccalaureate, vocational training, university training with official degrees, and specialized education (artistic and language). At the same time, the non-formal training system runs parallel to the

formal system and provides certifications from universities, schools, and private study centers that can prepare students for official exams and/or meet students' specific objectives. This research was conducted in the Spanish autonomous community of Valencia. This study complies with the ET2020 criteria, and aims to answer the following questions: Are students satisfied with the way English as a formal language is taught in the formal-education system? Do students resort to non-formal English learning to complement compulsory education? What type of class attendance do students prefer? What types of course and material are they interested in? This study is aware that change is needed not only because of administrative requirements and tendencies in the first two trimesters of 2022, but also because of the pandemic, which has modified the way classes are taught.

P6.3 Method

This study has a mixed design. It analyses two categories of data obtained through a combination of both quantitative and qualitative methods: 1) Questionnaires with closed- and open-ended questions were administered to non-formal-education EFL students. 2) A focus-group interview with semi-structured questions that sought to obtain information by promoting interaction between participants. The first category was composed of 72 participants who all consented to participate in the study and were over 18 years, residents of the autonomous community of Valencia, and current or former users of the Spanish education system. The participants in this category answered the closed- and open-ended questions presented to them in questionnaires created using the program Microsoft Forms, a component of the Office 365 suite. Another component of this suite, Microsoft Excel, was used to perform numerical calculations, classify the qualitative data by category, and make graphical presentations. The second category was composed of seven people who participated through the online platform Zoom. All consented to participate in this study and to have their participations recorded and transcribed by the session moderator. It was agreed that no personal details, video clips or still images from said clips would be disclosed or released.

P6.3.1 Quantitative and qualitative findings

The first sample consisted of 72 participants (N = 72): 31 men (43.1%) and 41 women (56.9%) with an average age of 34.8 years and a standard deviation of 2.27. They all reported being Spanish or Valencian native speakers and having studied EFL at different stages in their formal or non-formal education. To be precise, 88.9% had studied English in secondary education, 69.4% in university, and 63.9% with private teachers. Only 26.4% of the sample had received EFL training through their employers, and almost a third (29.6%) had taken EFL courses in an English-speaking country, generally short courses lasting less than a month (66.7%). The most widely held upper academic level was a master's degree (43,8%), followed by a university degree (37%). More than half of the participants were working full-time (51.4%), with the rest either being unemployed job seekers (19.4%) or part-time workers (15.3%).

The participants' levels of English proficiency were almost equally B1 (36.6%) and B2 (38%), with an additional 16.9% of advanced levels. The most common official certifications among participants were the Escuela Oficial de Idiomas (Official Language School) (30.6%) and Cambridge ESOL (22.4%), with the Trinity ISE (14.3%) and ACLES (10.2%) tests bringing up the rear. The preferred mode of class attendance was in-person (68.9%), combined with computer- and cell-phone-based didactic resources (Figure P6.F1). Students also tended to choose courses that were tailor-made to match their personal interests and that used a combination of digital and paper-based learning materials as opposed to fixed-syllabus textbooks (Figure P6.F2), (Appendix 4: Language, Birth Rates, Education, and Employment and Appendix 5: EFL- related Data).

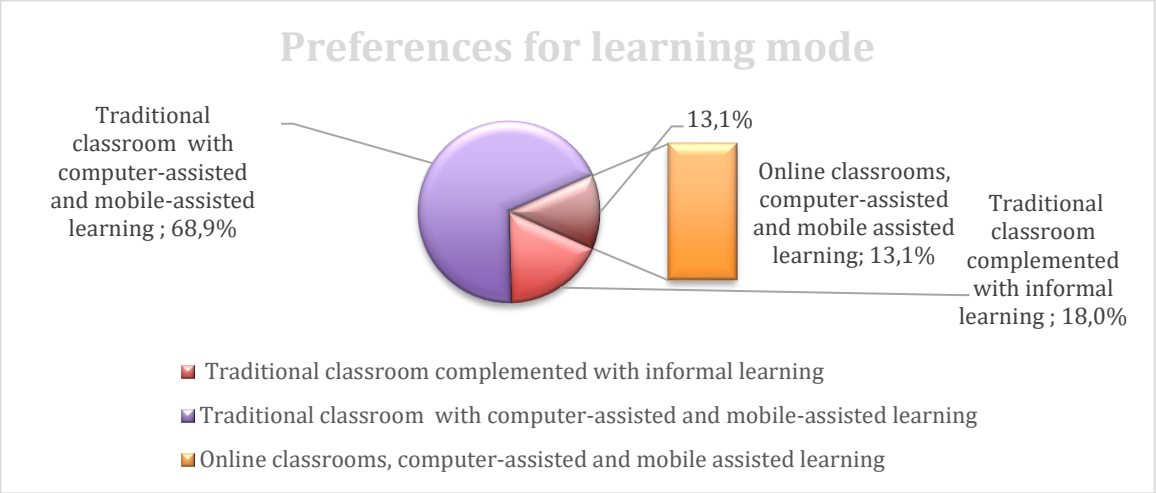


Figure P6.F1. Preferences for learning mode

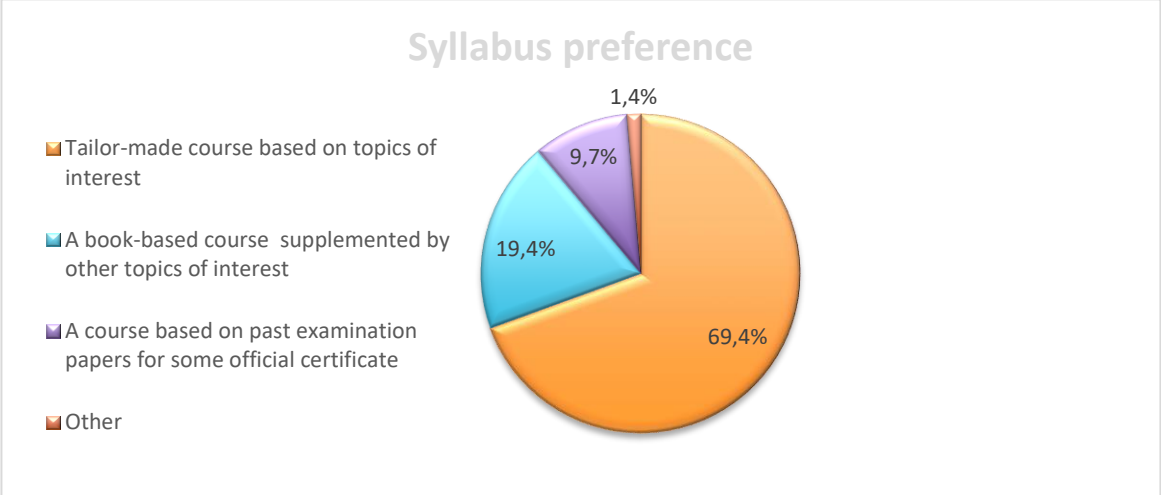


Figure P6.F2. Syllabus preference

The second data set in this study was obtained through an online group interview with the second group of participants (N = 7), who shared their opinions, first about the type of course they would be interested in for the second and third trimesters of the 2021–2022 academic year and, second, about their preferred percentage distribution of the reading, writing, listening, and speaking components. Category 1: percentage distribution among CEFR framework components (reading, writing, listening, and speaking) on a scale from 0 to 100. Category 2: type of syllabus. How important is it for you to be able to choose a list of topics for a syllabus? Category 3: post-covid perspective. Guidelines for efficient teaching/learning process based on

personal opinions. Students' non-identifying data and transcribed notes. The language has been improved for this paper.

St_1. Gender: woman. Age: 42. Profession: accountant. Currently studying English: one-to-one in a language school. Current level: B2. Official certificate: B2 (EOI) obtained in 2016. Objectives of studying English: "maintaining level and improving speaking skills". Personal explanation: "I enjoy studying English. It is my way of switching off. It´s a hobby." Preferred distribution of CEFR framework components in class: 50% speaking, 30% listening, 10% reading, and 10% writing. Type of syllabus: "It is highly important for me to participate in setting the objectives. I want to form part of the whole process and to suggest my topics of interest (biographies of famous people, modern short stories, recipes in English, and viticulture) or the topics that I may need for work (specific vocabulary for my routine at work)". "I am not into technology, but I enjoyed my online classes during the lockdown. I needed to get accustomed. If I can choose, I still prefer traditional, in-person learning, but the use of some technology (Kahoot on a mobile phone, quizzes, and games) can be quite fun."

St_2. Gender: man. Age: 24. Profession: unemployed. Currently studying English: in a group in a language school. Current level: B2+. Official certificate: no. Objectives of studying English: "obtaining GESE 10 from Trinity". Personal explanation: "I studied management at university, and I guess that I will need to speak at least one foreign language in a good job." "I would like to work in a multinational company in Valencia, somewhere in Spain (in Madrid or Barcelona) or abroad, preferably in the UK (could be Birmingham) or in Italy (I can speak some Italian)." Preferred distribution of CEFR framework components in class: 70% speaking, 5% listening, 5% reading and 20% writing. Explanation: "I listen to songs in English at home and watch all the movies in original version. I think I don´t need to train listening or reading in class. Well, I could, but as part of speaking or writing activities." Type of syllabus: "It´s rather important for me to choose the topics. I am personally interested in talking about sports (football, tennis, and cycling. I also need specific preparation for the GESE exam." "I am OK with the use of new technologies in class. No problem. My main preference is a traditional classroom with more peers."

St_3. Gender: woman. Age: 31. Profession: receptionist in a transport company. Currently studying English: in a group in a language school. Current level: B1. Official certificate: PET (Cambridge) obtained in 2019. Objectives of studying English: "I want

to obtain the FCE and have more employment possibilities just in case." Personal explanation: "I currently don´t use any English at work, but I may need it in the future. Preferred distribution of CEFR framework components in class: 40% speaking, 30% listening, 15% reading, and 15% writing. Type of syllabus: "It is very important to choose the topics to feel motivated. I enjoy playing board games in my free time. Would be interesting to be able to do the same in English. I also need to get prepared for the B2 (FCE), but I am not in a hurry." "I am also interested in such specific topics as 'going to the hairdresser's' or 'beauty center'. They are never part of the typical students´ books." "I use a computer every day at work. In my free time I use my mobile phone. In class I am fine with technology or games, but probably not too much. Role play and dialogues would be great in class."

St_4. Gender: woman. Age: 27. Profession: unemployed. Currently studying English: in a group in a language school. Current level: B1. Official certificate: yes, B1 from EOI. Objectives of studying English: "I want to find a job as a nursery teacher." Personal explanation: "I want to be able to speak fluently in English, to know how to play games in class, and to give instructions in English." Preferred distribution of CEFR framework components in class: 50% speaking, 20% listening, 10% reading, and 20% writing. Type of syllabus: "It is better to be able to select interesting or necessary topics for a course." "I am interested in retelling and discussing fairy tales in English, training some nursery rhymes, and singing children's songs. Such topics cannot be found in students´ books." "I frequently use my mobile phone. In class I am fine with technological or technology-free games (guessing games, pelmanism, picture descriptions, monologues, etc.). Training a theatre play would be very helpful for me."

St_5. Gender: man. Age: 25. Profession: waiter. Currently studying English: in a group in a language school. Current level: B1. Official certificate: no. Objectives of studying English: "I want to find a job in a hotel or in a pub." Personal explanation: "I want to be able to speak better in English, to explain menus, and to give directions when I am asked to." Preferred distribution of CEFR framework components in class: 60% speaking, 30% listening, 5% reading, and 5% writing. Type of syllabus: "It is great to be able to choose topics." "I am interested in everything related with catering, my job, tourism, and football." "In in-person classes I prefer not to use too much

technology. In online classes it´s impossible to avoid. My preference is traditional classes in a friendly environment."

St_6. Gender: man. Age: 21. Profession: student (specialization: architecture). Currently studying English: in a group in a language school. Current level: B2. Official certificate: no. Objectives of studying English: "Just my personal interest, for travel and for career opportunities in the future." Preferred distribution of CEFR framework components in class: 40% speaking, 20% listening, 20% reading, and 20% writing. Type of syllabus: "It is rather important to set the topics." "I am interested in video games and graphic novels. Would be nice to do something related to those in the classroom." "I don´t really like online classes because I want some social activity, and doing a class online is a bit boring. At least from my experience."

St_7. Gender: woman. Age: 37. Profession: teacher (specialization: engineering). Currently studying English: in a group in a language school. Current level: B2. Official certificate: yes, B2 (FCE from Cambridge) in 2014. Objectives of studying English: "Travelling and personal interest." Preferred distribution of CEFR framework components in class: 80% speaking, 10% listening, 5% reading, and 5% writing. Type of syllabus: "It is necessary to be able to negotiate the course contents to maintain interest." "In my free time I like reading, sometimes in English (historical novels and theatre plays). I also like wine, and I always visit wineries and breweries when I go abroad. I visit museums and art galleries, too. Would be nice to do something related to all that in class." "I love speaking in English. I prefer in-person classes, because it is easier to understand the teacher and the classmates. The quality of the sound is always better in a traditional classroom."

P6.4 Discussion and conclusion

The results obtained show that formal education does not meet students' EFL needs, leading them to turn to non-formal training. It needs to be stressed that the majority of participants possess the minimum level required by current regulations but still continue to study. EFL teachers must consider students' predilection for tailor-made courses and in-person learning. The pandemic situation and EFL teachers' growing use of online training should lead to increased interest in renewing curricula in such a way that both students and teachers find them appealing. This study has gathered

data in order to make didactic innovations in post-covid non-formal education a policy objective.

The students in this study were interested in such varied topics as sport, art, music, viticulture, literature, graphic novels, and video games, among others (kitchen recipes, specific job-related vocabulary, board-game language, role play, etc.). These topics could be used to experiment with new ways of preparing courses and holding classes, both from students' and teachers' perspectives. The students from the focus group confirmed that they were flexible about the curriculum and were willing to, for example, let all students in group classes choose an equal number of topics of interest. All participants were excited about the idea of being able to participate in assigning course topics, describing this possibility as "very important", "quite important", "rather important", "highly important", "necessary", and "better", among others. One noteworthy finding was that a considerable percentage of the students considered speaking skills a priority (between 40% and 80%), assigning less importance to listening (between 5% and 30%), writing (5% and 20%) and reading skills (5% and 20%). The justification they provided for their preference was that speaking is the most active of the four skills and also the one that received the least attention in formal high-school and university education. Because of the limited sample size, quantitative conclusions could not be drawn, but some technology-related tendencies were observed that teachers should take into account at the beginning of every new term in order to motivate their students and make their classes more entertaining.

Publication 7 (Journal Paper): Larchen Costuchen, A. (2020). Adaptación curricular: gamificación, el aula invertida y la aplicación de métodos mnemotécnicos/ Curriculum adaptation: gamifying, flipping the classroom and applying mnemonic techniques Estudios Interlingüísticos, 8, 111–123.

Abstract

This paper analyses the use of gamification, the flipped classroom approach, and mnemonic tools to adapt English courses to the needs of students in order to increase learners´ intrinsic motivation. This proposal is based on a case study involving a Valencian food-sector company one of whose subsidised English training courses yielded lower results than expected. Qualitative methods were applied to identify the problems, and a new strategy to improve the syllabus was developed based on the information collected. The resulting proposal received the highest possible score on a 7-point Likert scale from 81.25% of the respondents, with the remaining 18.75% only requesting minor modifications.

Keywords: gamification, flipped classroom, mnemonic techniques, corporate English course

P7.1 Introducción

P7.1.1 Presentación del caso práctico

Según la Fundación Estatal para la Formación en el Empleo (FUNDAE, 2020) todas las empresas, independientemente de su tamaño y fecha de creación, disponen de un crédito para la formación gratuita de sus empleados para mejorar su productividad y competencias profesionales. Desde la crisis económica del 2008, en España aumentó la demanda de conocimientos de inglés, tanto para las empresas en búsqueda de soluciones como para los empleados en búsqueda de una nueva oportunidad laboral en el país o en el extranjero. Siguiendo las pautas de la UNESCO 2014-2021, los sistemas de educación deberían tomar en cuenta las diversas maneras innovadoras en que los alumnos se benefician de las TIC para la comunicación, el aprendizaje y el intercambio de conocimientos, facilitando un aprendizaje más efectivo y el desarrollo de un servicio educativo más eficiente.

Los retos del aprendizaje continuo en general, y de los cursos de inglés en empresas en particular, son temas poco estudiados en la literatura académica tanto a nivel cuantitativo como cualitativo, lo que por un lado permite llenar una brecha en los estudios, pero por otro lado nos exige acumular datos previos antes de poder hacer un análisis sistemático o sacar conclusiones generalizadas. El estudio de casos como método de investigación en las ciencias sociales es particularmente válido cuando se presentan preguntas del tipo "cómo" o "por qué", esto es, cuando el investigador tiene poco control sobre los acontecimientos y cuando el tema es contemporáneo (Yacuzzi, 2005). Según la clasificación de Stake (1994) este artículo representa un estudio instrumental, un caso particular que se examina para aportar ideas en torno a una teoría, facilitando el entendimiento del problema, explorándolo a fondo y pudiéndose verse o no como típico de otros casos (Arzaluz Solano, 2005).

La empresa que se describe en esta propuesta se ubica en la Comunidad Valenciana y pertenece a la denominación de PYME, entre 50 y 250 trabajadores, ajustándose al concepto de mediana de acuerdo con los estándares de la Unión Europea. Con vistas a unas posibles ventas de su producto en el extranjero, se demandaron externamente cursos deformación en inglés para los empleados que ocupaban puestos administrativos. En los años anteriores no se habían hecho cursos de formación de inglés en la empresa, pero algunos de los empleados ya tenían títulos oficiales de idiomas y habían hecho cursos de idiomas por su cuenta. Después de una prueba gramatical accesible online en septiembre de 2019 se formó un grupo de nivel A2 (elemental), dos grupos de nivel B1 (intermedio bajo) y 2 grupos de nivel B2 (intermedio) según el modelo del Marco Común Europeo de Referencia para la Lenguas(MCERL). Durante las primeras semanas del curso en octubre se ajustó la distribución de los alumnos a sus niveles y se hicieron cambios en grupos formativos. Los libros propuestos para el curso pertenecían a la serie de English File de la cuarta edición (Latham-Koenig et al., 2019) para los grupos A2 -B1 y de la tercera edición para los alumnos de nivel B2 (Latham-Koenig, 2014). Es importante mencionar que la editorial lanzó materiales actualizados en enero de 2019 para los niveles desde A1 hasta B1, sin embargo, para el nivel B2 estuvo disponible solo la tercera edición del 2014. Al principio, todos los alumnos se mostraron de acuerdo con la elección del material didáctico y con el horario

propuesto de 3 horas semanales de clases presenciales distribuidas en una hora y mediados días a la semana. Al final del primer trimestre bajaron los niveles de asistencia a clase entre los alumnos de los 2 grupos de nivel B2 y la prueba final demostró unos resultados menos satisfactorios de lo esperado, lo que causó preocupación que causó preocupación tanto entre los alumnos como entre los organizadores de cursos de cara al segundo trimestre.

P7.1.2 Los objetivos establecidos para enfrentarse a la situación problemática

Los objetivos establecidos por los organizadores de los cursos y el investigador colaborador externo eran los siguientes: El objetivo general fue mejorar la propuesta didáctica para los grupos de nivel B2 para el segundo trimestre con vistas a obtener mejores resultados en comparación con el curso anterior. Los objetivos específicos fueron diagnosticar los impedimentos que llevaron a resultados poco satisfactorios en los grupos de nivel B2 a base del análisis de la situación problemática y proponer soluciones a base de fundamentos didácticos y tecnologías disponibles.

P7.1.3 Método de investigación y soluciones didácticas aplicadas al caso

Se ha elegido la metodología cualitativa de investigación teniendo en cuenta el tamaño de la muestra (N=16), 2 grupos con 8 alumnos en cada uno y el escenario social de los objetivos centrado en los alumnos. Sin embargo, algunos datos han sido cuantificados para demostrar las respuestas obtenidas de manera más proporcional a través de los porcentajes. Cuestionarios de preguntas abiertas diseñadas con la herramienta Google Forms fueron enviadas a los empleados mediante correo electrónico. La información se recopiló de manera anónima y después del análisis de la misma se preparó una entrevista presencial (semiestructurada) con cada grupo para poder explorar el fenómeno más a fondo.

Problemas identificados por los alumnos tanto del grupo 1 de nivel B2 como en el grupo 2 han sido los siguientes: “poco tiempo de clase para practicar inglés hablando e interactuando”, “demasiados deberes relacionados con gramática y hacer ejercicios por escrito”, clases “poco entretenidas”. Varios alumnos mencionaron que “por asuntos personales y profesionales no podían dedicar tiempo a hacer los deberes”. Algunos alumnos mencionaron que “el curso no les daba soluciones para unas tareas prácticas que han empezado a desempeñar estos

meses, como por ejemplo dar discursos y presentaciones en inglés con público". Muchos alumnos señalaron que tenían "mala memoria para reproducir información en inglés" y que se sentían "inseguros a la hora de conversar en otro idioma". Se mencionó el problema que, aunque el libro English File tenía actividades digitales, iTutor y iChecker, para hacer deberes de manera un poco más entretenida, la mayoría de los alumnos destacaron que sus portátiles no tenían lector de CD. Se mencionó también el problema del horario cuando se impartían las clases (la hora de comer o después de acabar la jornada laboral). A estas horas los alumnos se sentían cansados y despistados. Algunos alumnos mencionaron que, aunque en su tiempo libre habían probado ver películas en VO (en inglés) o escuchar canciones de artistas anglosajones, no tenían nivel para entender bien el contenido. A varios alumnos les gustaba leer y usaban libros en papel con textos adaptados a su nivel de la serie Penguin Readers. El problema que se descubrió en una de las entrevistas era que, aunque así aprendían nuevo vocabulario, no siempre sabían pronunciar estas palabras correctamente.

Durante las entrevistas presenciales con los grupos, todos los alumnos solicitaron aumentar el tiempo de conversión en clase, algunos de ellos pidiendo solo clases de conversación. La mayoría de los alumnos confesó que si hubieran tenido la opción de acceder a los deberes a través de dispositivos móviles esto habría aumentado las posibilidades de preparar los deberes en sus momentos libres. Varios alumnos pidieron incluir en el curso la preparación de un discurso en inglés. Se puso de relieve también el problema de que, a la hora de preparar presentaciones, había poco margen temporal (uno o unos días) lo que causaba estrés y las personas responsables de aquello incluían largos textos en las presentaciones de Power Point y acababan leyendo sus apuntes desde un dispositivo o pantalla, lo que no quedaba bien ante el público.

En base a los problemas identificados, se ha decidido proporcionar las siguientes soluciones didácticas: El enfoque de aula invertida (Flipped Classroom) permitiría dejar entre el 60% y 80% de tiempo de clase para las actividades de expresión oral en inglés e intercambio de opiniones o dudas relacionadas con los deberes. Las estrategias de gamificación (Gamification) de los contenidos en un orden específico para trabajar en casa permitirían estudiar, practicar gramática, actividades lectoras, de escucha y todo a través de entornos lúdicos. Su acceso desde los dispositivos

móviles permitiría a los alumnos acceder a ellas en cualquier momento libre y desde cualquier lugar. El uso de los métodos mnemotécnicos como el palacio de los recuerdos o método loci permitirían a los alumnos memorizar discursos de manera rápida y eficaz proporcionándoles seguridad a la hora de dar un discurso sin mirar los apuntes. Todas las soluciones didácticas mencionadas estaban previstas llevarse a cabo a través del uso de plataformas o aplicaciones digitales basándose en los materiales del libro.

P7.2 Fundamentos teóricos y aplicaciones prácticas de la propuesta

P7.2.1 Invertimos el aula y gamificamos los contenidos

Según los datos de EDUCAUSE Horizon Report (Alva de la Selva, 2019) la educación superior actual se ha visto afectada por tendencias como el aprendizaje adaptativo (Adaptive Learning) y los enfoques gamificados (Gamification). La gamificación de contenidos dentro del aula inversa (Flipped Classroom), de acuerdo con Prieto Martin (2017), crea tan buenas prácticas como crear: un sentido de misión, un sistema de bonificación por pequeñas recompensas, elementos personalizados de la experiencia de aprendizaje, un sistema de respuestas rápidas e introducir actividades divertidas. El sistema del aprendizaje invertido (Flipped Learning*)* traslada fuera del aula la exposición de contenidos y, por tanto, el trabajo a niveles cognitivos más bajos (Marqués, 2016), mientras que en el aula el docente actúa de manera más personalizada, orientando a los estudiantes en lugar de impartiendo clases magistrales; las tecnologías, por tanto, sirven aquí de apoyo para sustituir las clases magistrales y dedicar el tiempo presencial de clase a una enseñanza activa (Active Learning) centrada en los alumnos (Herrera Sierra y Prendes Espinosa, 2019).

La programación elaborada para el caso práctico adapta los materiales de English File de la tercera edición a las metodologías del aula invertida y gamificación. Las herramientas como Kahoot (n.d.), Quiz Maker Offline (n.d.), y Quiz It: Multiple Choice Game (n.d.) se han empleado para crear pruebas de preguntas de opción múltiple y para que los alumnos pudieran trabajar con la información recibida a través de la lectura o actividades de escuchar. Se usaron también para trabajar la gramática de manera lúdica y cómoda a través de dispositivos móviles con sistemas operativos de Android o iOS. El programa Quizlet ha sido elegido para el

aprendizaje de nuevo vocabulario a través de tarjetas digitales y juegos. Mind Meister (n.d.) y Popplet (n.d.) han servido para la organización de ideas a través del diseño de diagramas conceptuales (actividades realizadas individualmente, en pareja o en mini grupos). El programa Learnclick (n.d.) permitió crear textos con huecos para completar y trabajar algunos ejercicios de gramática. Plataformas Pearltrees (n.d.) y Padlet (n.d.) han servido para hacer actividades colaborativas y para que los alumnos pudieran compartir materiales de elaboración propia, opiniones e ideas a través de dispositivos digitales. Explain Everything (n.d.), Adobe Spark (n.d.), Canva (n.d.) y WordPress (n.d.) han sido útiles para el trabajo individual, en parejas o en grupos creando videocasts, cuentos digitales, comics y blogs. Los programas de pizarras digitales (IWBs) han servido de apoyo durante el trabajo en el aula. La actividad final de esta unidad didáctica ha sido un discurso de parte de cada alumno impartido sin apuntes o presentaciones en Power Point (PPTs). La preparación tuvo lugar a través del uso de métodos mnemotécnicos y con el apoyo del programa Memory Palace Beta (n.d.).

Los bloques de abajo es un ejemplo de descripción y organización de los contenidos de la unidad 4 del libro English File con el temario Failure and Success. Modern Manners. Las actividades se basan en la estructura flexible que se adapta a las necesidades e intereses de los alumnos. Los contenidos están distribuidos en 4 bloques de acuerdo con el modelo del Marco Común Europeo de Referencia para la Lenguas (MCERL) que son: comprensión lectora (listening), expresión oral (speaking), comprensión lectora (reading) expresión escrita (writing) aparte de las actividades de refuerzo y de extensión. Se ha añadido los bloques la comprensión lectora de las reglas gramaticales y el uso de la lengua. La unidad didáctica consiste en 4 sesiones de 90 minutos cada una. La tarea final es hacer una presentación con el tema Describing a company and its products.

BLOCK 1: COMPREHENSION OF ORAL TEXTS

(Listening. Home Assignment Activities):

- Watching or listening to Rob interviewing Kerri. What is she happy / not happy to talk about? True or false multiple-answer choice test among four options with the help of Kahoot.
- Watching or listening to the conversation at lunch. What do the speakers disagree about? Answer the multiple choice or general idea questions. Activity provided

through Quiz It – Multiple Choice Game. Working with some extracts from the conversation. “Can you remember the missing words?” Gap-filling activity on Pearltrees.

- Listening to six advanced students of English giving a tip which has helped them to learn. Completing their tips on the worksheet. Listening to the recording again and adding more details about each tip with the use of Mind Meister. Share your notes with a peer.
- Listening and matching the phone sentences with the sounds. Flashcards, Learn, and Match mode supported by Quizlet.
- Listening to Miranda, who is married to Alexander, talking about the difference between manners in her and her husband´ countries. What was their problem? How have they managed to solve their differences? Ideas organisation on Popplet. Share your notes with a peer. Listening to the recording again and marking the sentences true or false on Quiz It: Multiple Choice Game.

BLOCK 2: PRODUCTION OF ORAL TEXTS: EXPRESSION AND INTERACTION

(Speaking. Classroom Activities):

- “If at first you don´t succeed, try, try, try again” is a well-known English saying. What does it mean? Activity supported by images on IWB found through search engines. Some images and notes are saved on Pearltrees on the students´ devices.
- There are different ways of continuing the saying “If at first you don´t succeed, …give up, …blame your parents, destroy all the evidence you tried, …do it the way your mother told you to, …skydiving is not for you”. Which one do you like best? Activity supported by Google search on digital devices. Pair work. A mind map is created with a central image and surrounding textual clues on Popplet.
- Guessing game. A randomly selected pair of students go to the Interactive Whiteboards (IWB). One of them is offered to draw the description of one of the topics: 1) Something you´ve tried to learn, but you have never been able to do well. 2) Something you learned to do after a lot of effort. 3) Something you can do, but you´d like to do better etc. Another student should guess and describe the story based on the peer´s drawings. Then the first student provided the original version of it.
- Dialogue-making activity in pairs on the topic “You and your phone”. The third student is to the interviewer and the interviewed and makes notes on the Mind Meister. Later he or she uses the notes to retell the information he or she remembers.
- Talk about traditions in your country. Make sentences using “should/shouldn´t” for something which you think is a question of manners, and with “must/ mustn´t/ have to” for something which is a law or rule. Pair work. Sharing ideas in class.

Activity supported by Google search on digital devices and showing images on the IWB.

Note: The classroom warm-up begins with the home assignment discussion and sharing doubts or ideas. After working on the block 2 activities, some time is left for further suggestions and opinions.

BLOCK 3: COMPREHENSION OF WRITTEN TEXTS AND GRAMMAR RULES

(Reading and Grammar. Home Assignment Activities):

- Reading the text about people who have tried but failed to learn something. Making questions to the text on Quiz Maker Offline Pair work. Exchanging the tests. Proving answers to the peer test. Matching activity through Kahoot.
- Reading the article “He is English, but he can speak eleven languages” and do the matching activity on Quiz Maker Offline. Look at the highlighted words and phrases related to language learning and work out their meaning from the context. Give your definitions on a Padlet board. Have a look at your peers´ notes.
- Reading the extract from Debrett´s guide to mobile phone etiquette. Match the highlighted phrases with their meaning on Quizlet (Match mode). Do the gap-filling activity on Learnclick.
- Reading the article “Mother-in-law from hell…” Answer the questions to the text and share them on a Padlet board. Do the word-matching activity on Quizlet (Match mode). Exchange ideas with peers about the possible solutions in the situation described on Padlet.
- Grammar Bank 4A. Read about “can”, “could” and “be able to”. Share what you remember with your peers on a Padlet board.
- Grammar Bank 4B. Read about “must”, “have to” and “should”. Share what you remember with your peers on a Padlet board.

BLOCK 4: PRODUCTION OF WRITTEN TEXTS AND THE USE OF ENGLISH

(Writing and Grammar. Home Assignment Activities):

- “Good and bad manners in my country”. Working in pairs. Creating a videocast on Explain Everything.
- Local celebrations in my city. Working in groups of four. Digital-story activity with magazine-like design on Adobe Spark.
- “What are stereotypes?” Autonomous work with images and dictionaries. Making comic strips on Canva.
- “Doing business in Spain”. Pair work. Preparing a blog on WordPress.

- Grammar Bank 4A. Complete the gapped sentences with the correct form of be able to on Learnclick. Choose the correct form of “can”, “could” or “be able to”. Both options can be possible. Activity done on *Kahoot.*
- Grammar Bank 4B. Complete the gapped sentences with the correct form of have to on Learnclick. Choose the correct form of “should”, “shouldn´t”, “don´t have to”, “mustn´t” or “ought to”. Both options can be possible. Activity done on Kahoot.

Aunque esta unidad didáctica tenía como base los materiales del libro English File que fueron gamificados y adaptados a la metodología de aula invertida, la programación era flexible y podía ser adaptada parcialmente o de manera significativa a las necesidades e intereses del grupo o un temario especifico.

P7.2.2 Usamos métodos mnemotécnicos (el palacio de los recuerdos o método loci)

Los métodos mnemotécnicos se usaron por los antiguos griegos y romanos para memorizar tratados retóricos en 477 a. c. lo que fue descrito en la anónima Rhetorica ad Herennium y en De Oratore de Cicerón. Según Yates (1999) la técnica consistía en asociar la información necesaria con lugares familiares (loci) y luego hacer una ruta imaginaria recordando la orden de los objetos y así la información que se asociaba con ellos. De acuerdo con Bellezza (1996) y Carney y Levin (2013) el uso de memoria espacial aumentaba la atención al material y mejoraba su organización, lo que también se refleja en la teoría de codificación dual de Paivio (1986) refiriendo a las asociaciones verbales con imágenes visuales. El método de loci también se conoce como la técnica del palacio de los recuerdos y se usa ampliamente en el aprendizaje de idiomas y retención del nuevo vocabulario en la memoria a través de gamificación (Rawendy et al., 2017) o de programas de realidad virtual (Vindenes et al., 2018; Huttner et al., 2020; Gelsomini et al., 2020).

Esta unidad didáctica describe el uso del programa Memory Palace Beta para que los alumnos aprendieran a dar presentaciones en inglés sobre el tema Describing a company and its products con confianza y sin uso de notas digitales o en papel enfrente al público. La aplicación se puede usar para dispositivos con sistemas operativos de Windows, Android o iOS y tiene varios palacios de memoria editables que son Euro Penthouse, Casa Naranja o Casa Roja. Las casas y sus habitaciones es un espacio para ser utilizado construyendo palacios de recuerdos, llenándolos

con objetos digitales y haciendo una ruta por la casa siempre en el mismo orden (desde una habitación a la otra, desde un objeto al otro).

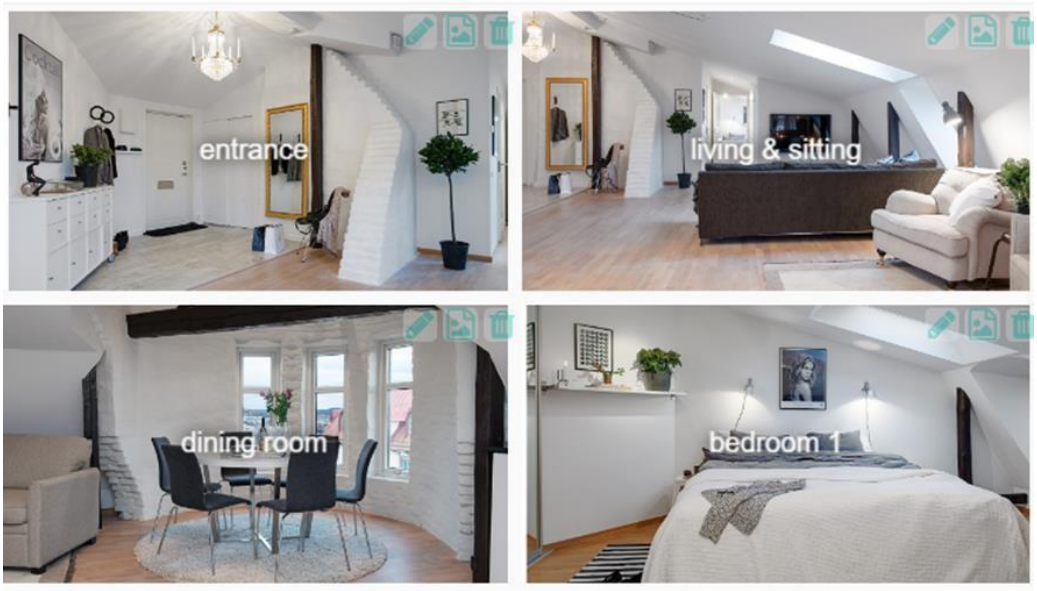


Figura P7.F1. Elementos y 4 habitaciones de la casa Euro Penthouse

Las capturas de abajo demuestran cómo se puede incorporar partes del texto Zumo - Creating a Global Brand del libro Market Leader para alumnos de nivel intermedio alto, utilizando la técnica del palacio de los recuerdos y el programa Memory Palace Beta.

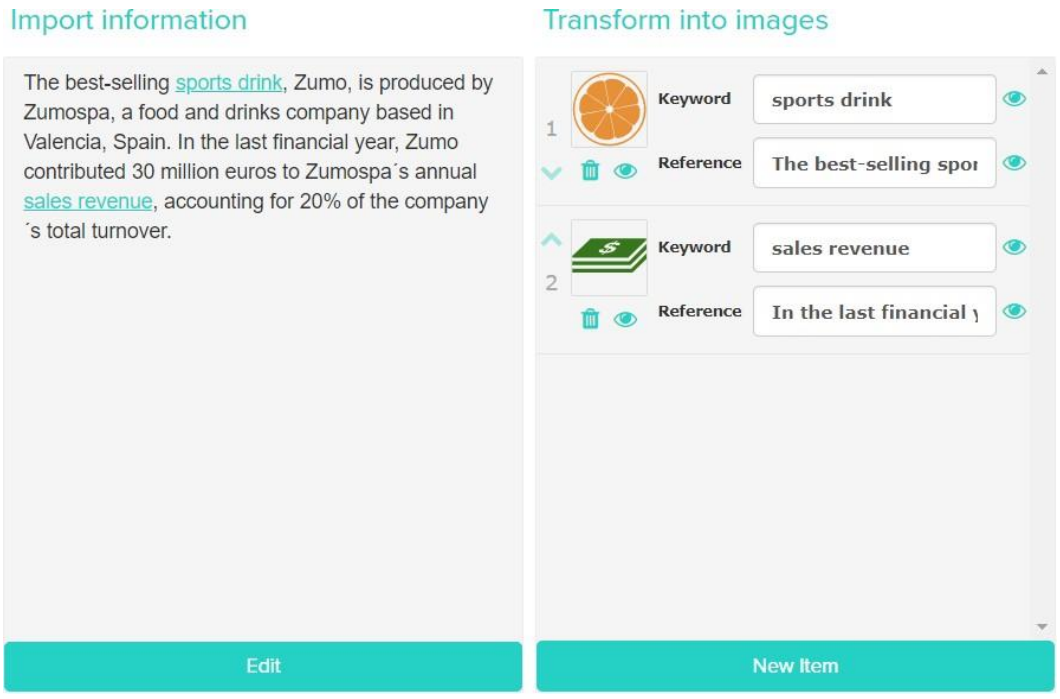


Figura P7.F2. Transformando el texto en imágenes

Las referencias se han usado para introducir el texto mientras que las relaciones entre el icono y la palabra clave se presentan de manera asociativa y no necesariamente como una traducción directa.

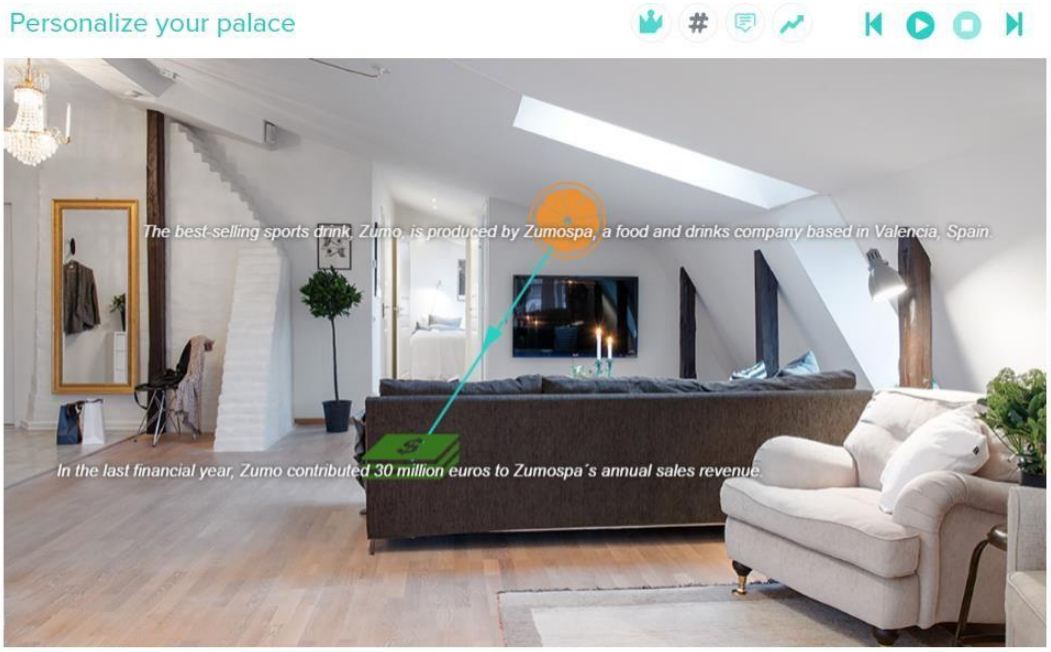


Figura P7.F3. Creando la ruta

La ruta de cada habitación puede llenarse desde dos hasta ocho objetos representados por keywords. El Euro Penthouse contiene una entrada, dos dormitorios, un baño, 2 salones, un comedor, cocina, cúpula y almacén que se pueden usar para un palacio de recuerdos de hasta 420 ítems. Otra alternativa (aconsejable) es adoptar el mismo sistema para las fotos de las casas de los alumnos que les resulten más conocidas. Según los datos de los cuestionarios, a la mayoría de los alumnos les resultaba más cómodo usar entre 1 y 3 objetos en cada habitación. Asociaban la ruta con sus rutinas habituales como “mis momentos preferidos de estar en el salón son poner la tele y cenar en el sofá viendo mi programa favorito,” “por las mañanas cuando me levanto me voy a la cocina a prepararme un café y abrir la despensa donde guardo los cereales, luego me siento en la mesa con los demás miembros de mi familia.” Todas estas pequeñas rutinas se pueden adaptar a las fotos y poner imágenes memorables al lado de estos lugares en un orden especifico. Se aconsejaba emplear la misma ruta para diferentes textos-presentaciones lo que les pareció bastante cómodo a los alumnos, aunque requería tiempo y dedicación al principio.

P7.3 Resultados de valoración de la propuesta y conclusiones

Para elaborar esta propuesta se recogieron datos cualitativos previos de los 16 alumnos a través de cuestionarios para identificar los problemas con el curso en el semestre anterior y averiguar sus preferencias y sugerencias. A base de los datos proporcionados se prepararon entrevistas presenciales semiestructuradas con cada uno de los grupos. Posteriormente, las dos sesiones de la unidad didáctica propuesta fue impartida en cada uno de los grupos de 8 alumnos junto con la tarea final, presentación con el tema Describing a company and its products. Al final de cada sesión los alumnos rellenaron un cuestionario de satisfacción con la propuesta (valoración de la escala de Likert de 7 puntos (I was satisfied with the didactic unit proposal: 1) Strongly Disagree – 7) Strongly Agree). Las muestras de la unidad didáctica propuesta obtuvieron la valoración más alta de la escala de Likert de 7 puntos entre el 81,25% de los 16 participantes. El 18,75% de los participantes solicitaron unas pequeñas adaptaciones y han sugerido crear un grupo de intercambio de mensajes para teléfonos inteligentes con el objetivo de consultar dudas técnicas a los compañeros y el profesorado, lo que se tomó en cuenta por la parte de los organizadores del curso. En general, aunque todos los alumnos se mostraron entusiasmados con el uso de nuevas tecnologías para esta programación didáctica, algunos de ellos mencionaron que “se debería dedicar un corto tiempo en clase para explicar cómo utilizar las aplicaciones”. Algunos alumnos mencionaron que “acostumbraste a este sistema iba a ser un reto al principio, pero si se explica su uso en clase y se puede consultar dudas a través del sistema de mensajería móvil, no veían problemas en utilizarla”. Había alumnos que sugirieron alternativas “más nuevas y cómodas” a las aplicaciones utilizadas en la propuesta lo que también se tomó en cuenta por el profesorado. La mayoría de los alumnos mencionaron que estaban contentos de poder “negociar la programación” y hacerla más entretenida y útil para sus objetivos. Todos los alumnos mostraron una alta motivación para formar parte del curso del segundo trimestre.

Entre las limitaciones de este estudio se puede mencionar que un caso práctico apoyado con metodología cualitativa cuyos objetivos era elaborar una propuesta didáctica y analizar el nivel de satisfacción de los alumnos con ella en el futuro, debería ser complementada con un análisis cuantitativo de la metodología tradicional vs la experimental aplicadas a una muestra de tamaño más amplio.

El estudio de cada caso en concreto a la hora de impartir cursos de inglés en empresas puede ser útil, y para la adaptación de los cursos a las necesidades del alumnado puede resultar beneficioso cambiar la motivación extrínseca, relacionada con las obligaciones y necesidades laborales de los alumnos, por una motivación intrínseca que implica interés personal en mejorar sus habilidades relacionadas con el curso.

Publication 8 (Journal Paper): Larchen Costuchen, A. (in press) *Guadalingo* in Teaching Spanish as a Foreign Language (FL): Practical Insights. International Journal of Learning and Teaching 9(2).

Abstract

The main objective of this study is to provide practical solutions in the teaching of Spanish as a foreign language (FL) based on the Common European Framework for Languages (CEFR) in combination with a video game, adapting it to the requirements of L2 language learners. Since video games appeared, they have been increasingly used globally as tools for learning and teaching subjects related with languages, culture, social topics, gender, education, and global citizenship. This article focuses on how to use the serious game Guadalingo and does so through a reflexive approach and using qualitative data. The research was a three-month qualitative study supplemented with numerical values for pre-course information related to participants´ attitude to traditional homework, game-based activities, and device predilection (handheld mobile devices with a touchscreen interface versus PC with a physical keyboard). The findings reveal high presence of female participants and their readiness for playing a video game to learn a new language. Further work is required in the study of motivational out-of-classroom tasks in teaching Spanish with focus on gender (male versus female), age (digital and/or not digital generations), and game graphics.

Keywords: video games, didactic application, serious games, foreign language teaching, computer-assisted language learning

P8.1 Introduction

Since the outbreak of the internet, technology and gadgets have been influencing social interactions, education, work, and leisure time of both digital and non-digital generations (Smith, Kahlke & Judd, 2020; Fernández-Gutiérrez, Gimenez & Calero, 2020; Larchen Costuchen & Dev, 2022). As a result of the historically significant studies on pedagogy (such as behaviorism, cognitivism, and constructivism) and different learning modalities (computer-assisted language learning (CALL), mobile-

assisted language learning (MALL) and game-based learning (GBL), a solid methodological base has been built (Ndibalema, 2021; Martinez, Gimenes & Lambert, 2022; Wang, Chen & Hwang, 2022; Marimon-Martí et al., 2022; Haleem et al., 2019; Carrió-Pastor, 2019). According to Marimon-Martí, Cabero, Castañeda, Coll et al (2022) ICT is an instrument that mediates between students and learning contents, between teachers and learning contents, and finally between teachers and students. Digital technologies became immensely popular inside and outside the classroom due to their flexibility, the ease with which they can be updated, and their lower price compared with traditional book-based materials (Shang, Sivaparthipan & Vadivel, 2022; Laufer et al., 2021; Shliakhovchuk, 2018; De Silva, Chigona & Adendorff, 2016). Their impact, which has been especially strong in today's pandemic epoch, has led to the emergence of digital natives, reinforcing the use of e-learning systems at the same time effecting their leisure activities (Wang, Chen & Hwang, 2022; Smith, Kahlke & Judd, 2020; Larchen Costuchen, 2020; Prensky & Gonzalez Calatayud, 2018).

Data from Spanish Video Game Association (AEVI) show that the video-game sector has expanded globally and has upgraded technological support applied to cloud gaming, instant games, and eSports, with an annual growth rate of 8.4%. Although video games have been associated with young and males, there is data indicating that gamers are a much more diverse community (Clement, 2022). In 2020, according to ISFE Europe´s Video Game Industry Key Facts report, 45% of all European video game players were female with 51% of those playing on hand-held devices with the average age of a video game player in EU being 31 years old. This has led us to pay attention on the European Commission's Creative Europe project, which takes another step forward, stimulating the development of video games with a high potential for wide distribution both within and beyond the European Union (European Commission, 2022) aimed at developing of new activities for mobile portable devices, PCs, and consoles. Positive effects from games on engagement, motivation, and memory have been mentioned by a number of academic practitioners (Kucher, 2021; Liu & Israel, 2022; Lei et al., 2022; Manzano-León, Rodríguez-Ferrer & Aguilar-Parra, 2022; Larchen Costuchen, Mollá Vayá & Dinkova Dimitrova) at the same time videogame exposure was disapproved and criticised by others (Greitemeyer, 2022; Rüth & Kaspar, 2021; De Pasquale el al., 2021; Novak, 2015).

P8.2 Homo Ludens: simulations and games

According to Huizinga (2014), human nature is that of a playful creature, a homo ludens. He sees play as a freely accepted action or occupation that is carried out within specific temporal and spatial limits, that is an end into itself, and is accompanied by feelings of tension and joy. Bruner (2003) adds to this the psychopedagogical role of play in thought, speech, and the development of intelligence. Saegesser (1991) relates play with simulation and distinguishes between social simulation, on the one hand, and simulation as a play, on the other, with the former being much less structured than the latter. The author also points out that play can be useful in the context of pedagogy because it trains players to tackle a hypothetical situation (to solve a problem).

The first use of simulation in game-based learning was in a military context, more specifically flight simulators employed by the American military. High-quality hardware and software were produced in the 1940s and, later on, in the 1960s (Valverde Berrocoso, 2010). The 1980s saw this technology being applied in ludic and commercial settings in the US and other countries since the launch of Breakout, The War of the Worlds, Star Wars, Space Invaders, and Super Mario Bros. Along the way, it has been demonstrated that many of those games whose initial purpose was purely amusing have served to upgrade a variety of players´ skills (Granic, Lobel & Engels, 2014; Dale & Shawn Green, 2017; Griffiths, 2019). In the late 1990s it was directed toward the development of materials for CALL (programs, tasks, contents, etc.) in the teaching of any language as a foreign language (FL). The same period also saw the emergence of commercial products for computer-assisted foreign-language teaching.

Malone (1981), Dempsey, Lucassen, Gilley, and Rasmussen (1993), Jenkins (2003), Habgood, Ainsworth and Benford (2005), and Prensky (2003) were the first to point out that games are a very efficient tool for creating learning environments that work with narratives. Gee (2003), Kress (2009), and Williamson (2022) compared games to multimodal texts or semiotic domains that employ strategies contributing to new forms of literacy with images and words, sounds, music, and movements. Malloy and Aarseth (1998) compared games and interactive fiction to ergodic texts with non-

linear, labyrinth-like structure in which most of decisions are attributed to the reader/player.

P8.3 Objectives

The preparatory stage of the study consisted in collecting preliminary information on population (obtaining numerical values for participants´ attitude to traditional homework, game-based activities, and device predilection) and offering them a suitable course in line with the findings. The main part of the chapter focuses on how to use the serious game Guadalingo (n.d.) and does so through a reflexive approach and using qualitative data. The study was aimed at promoting intrinsic motivation (Ebrahimzadeh & Alavi, 2017; Pereira, 2013; Chen & Yang, 2013; Garris, Ahlers & Driskell, 2002) among students via the use of Guadalingo as a substitute for conventional homework.

Graphic adventures, which developed from interactive fiction and graphic novels, are a good example of how game activities can be used to improve listening, vocabulary, and grammar (Hwang et al., 2016; Castillo-Cuesta, 2020; Wang & Han, 2021) reading and writing abilities (Bal, 2019) and to reinforce visual memory (Durso & Johnson, 1980; Dewhurst & Conway, 1994; Sheldon & El-Asmar, 2018). Harmonious with the dual-coding theory (Clark & Paivio, 1991), these types of games make extensive use of rich textual and imagery environment with a non-linear structure allowing the player to explore the game and decide what to do next at each stage.

P8.4 Obtaining preliminary data

Forty-one participants were reached via social-media platforms (Facebook, Twitter, Linkedin, and VK/Vkontakte by the research team. They were all were native speakers of Russian (68%), Belarusian (20%) or Ukrainian (13%), belonging to Indo-European language family, East Slavic language group with Cyrillic writing system. The participation condition was being over eighteen years old and having no previous knowledge of Spanish. All the participants had to provide informed written consent before taking part in the study. The first questionnaire (Microsoft Forms, Office 365 suite) collected information on the potential learners such as L1/L2 languages, course-related preferences, and goals in studying Spanish. Participation was anonymous and voluntary, with participants receiving remuneration in the form of a

30% discount on the total price of the online A1-level Spanish course. All the qualitative and numerical data obtained by the course tutors were anonymised by the main researcher. Thirty-eight valid answers were obtained after applying the inclusion criteria. The set of preliminary findings contains responses for ages between 27 and 43 with a vast majority (81%) of participants belonging to ages between 30 and 37, most of the latter being women (72%). Nearly 70% indicated knowledge of only one L2 (English) whereas a significantly fewer number of contestants mentioned previous knowledge of a language pair (English-German - 17%, English-French - 9%, and English-Italian - 4%). A 5-point-Likert scale was applied to collecting data on readiness to do an online course, eagerness to do exercise-based homework, availability to play a game as part of the course and device preference. An absolute majority (94.8% of contestants) confirmed their enthusiasm in course participation with answers reaching the same indicator in relation to game-based support (94.7%). The contestants´ availability for doing exercise-based home-work split between 41.1% of not-ready participant together with a more categorical sub-group of totally not ready (7.9%) against a total of 40.50% for ready (30%) and totally ready (10.5%) subgroups, with 10.5% of population staying neutral (Figure P8.F1).

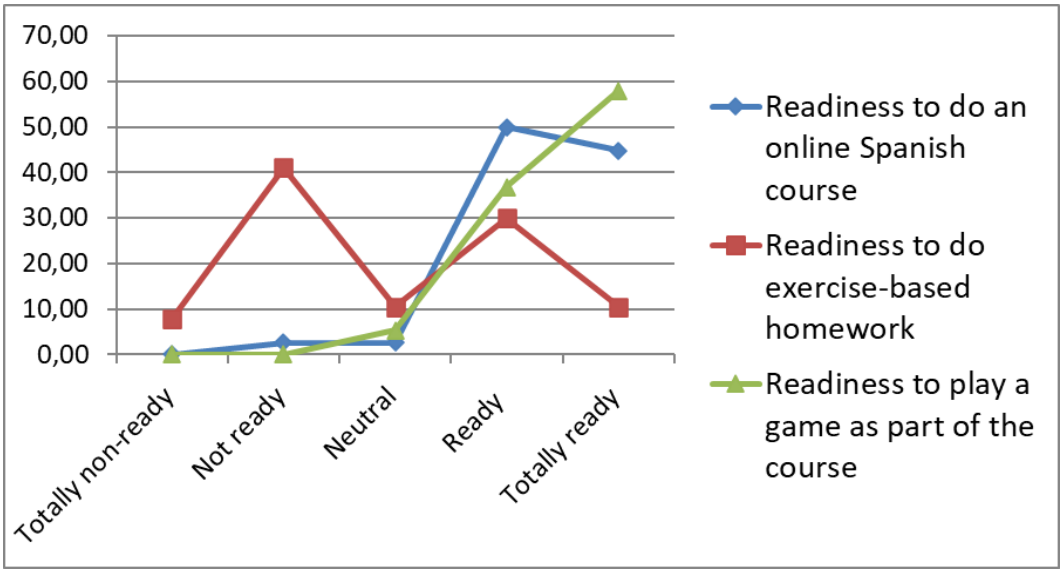


Figure P8.F1. Course-related expectations (distribution on a 5-point Likert)

The numbers almost equalled between Android-supported mobile devices (38%) and Windows-supported PC (41%) with a slight inclination towards the latter with macOS and iOS being similarly the least common choices (Figure P8.F2).

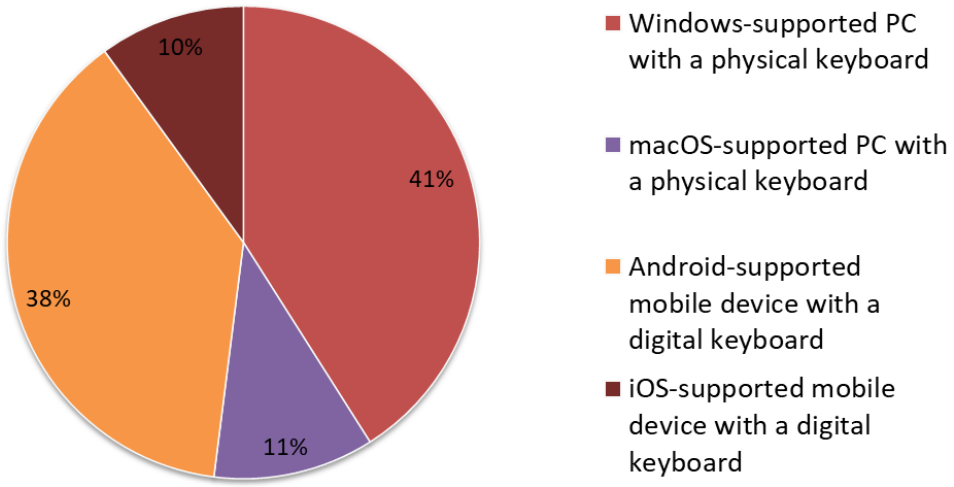


Figure P8.F2. Participants´ device choice

Studying Spanish at A1 level was associated among the contestants with three main goals: travel opportunities (frequency of related terms – 117 mentions among 38 contestants), job opportunities (frequency – 76 mentions among 38 contestants) and cultural aspects (frequency – 91 mentions among 38 contestants), among other, less frequent categories, which encompassed knowledge of a particular topic of interest or no specific answer. Taking into consideration all the findings, the game selected to substitute exercise-based home assignments for experimental group was Guadalingo by the publishing house Edinumen for basic (A1) level. It offers an action-based environment featuring situations similar to real life at the same time being the best fit for Spanish FL textbooks that follow the Cervantes Institute curriculum. The game's contents comprise of 25 missions (going to the language school, communicating in the airport, making gifts, decorating the character's home, going shopping, etc.) similar to real-life experiences in a foreign country (Figure P8.F3).

Figure P8.F3. Guadalingo map with areas

The in-game goal for the player consists in moving to a Spanish-speaking country (in Latin America) and gradually learning the language through practice in the virtual world. The individual missions contain specific challenges that the user´s character has to fulfil. Avatar personalization proposed in the game is presumably aimed at helping learners to identify more with their protagonists (Figure P8.F4).

Figure P8.F4. Personalizing the player´s avatar (in the home area at the start of the game)

When a mission is successfully completed, players obtain rewards (money, etc.) which could be used at other stages. Instant feedback is provided automatically which contributes to constant self-evaluation of their progress (formative in-game assessment).

P8.5 A three-months course (on Windows 10 for PC)

The study that this part is based on was a three-months study with a sample of 12 participants. Their ages ranged from 31 to 42 years, eight of them were women and four men; all were native speakers of Russian, four of them also spoke Belorussian and three of them were bilingual in Ukranian. The course was evaluated based on the end-of-course results and feedback obtained (online interviews, online survey forms, and group-chat interaction on Zoom). All the participants allowed their non-identifiable data to be used and asked to receive updates related to this study. None of the participants had any previous knowledge of Spanish, although all knew some English (between B1 and B2) and three students had some knowledge of other languages (German at A2-B1 or French at A2-B1). The participants were randomly distributed into two groups of six people each keeping numerical gender balance between both groups. Group EG (the experimental group) studied Spanish online with a tutor (one hour, two times per week) in combination with self-study through Guadalingo (the amount of time depended on each student's possibilities and interest with recommendation to dedicate between 3 to 5 hours' time per week on those activities). Group CG (the control group) only took online classes. The traditional didactic material that both groups used was the textbook Aula Internacional 1 Nueva Edición (Corpas Viñals, 2022).

P8.6 Results and discussion

Most students from the experimental group (83.3%) found Guadalingo to be a good and entertaining tool for self-study that presented useful situations. More than half (66.6%) did find the game repetitive and 16.6% felt the graphics could be changed. Guadalingo-integrated-games, such as ordering the words to make sentences, matching activities, definitions and crosswords were found mostly *appealing/ interesting/ motivating/ engaging/ fun*, etc. (data gathered from online interviews) in comparison to the control group exercise-based assignments that were predominantly described as *time-consuming/ demanding / burdensome, necessary*

but not easy and *all right*. The participants found listening comprehension to be one of the most challenging tasks at this level; this could be quickly improved by having the designers add the audio to the instructions in Spanish. All participants used dictionaries to better understand some tasks or expressions. In relation to the amount of time invested, this slightly varied: two students used the game 3 or more hours per week, three students used it between 2 and 3 hours per week, and one student said they used the game between 30 minutes and 2 hours per week. After the three-months study period, both groups did an exam (Table P8.T1, Table P8.T2) and evaluated the course (Figure P8.F5).

Table P8.T1 Summative evaluation in the experimental group

Evaluation on a 10-point scale for each part (EG)	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Reading comprehension	6	5	8	9	6	8
Writing skills	6	6	7	8	3	6
Spelling	7	6	9	8	5	6
Vocabulary	8	9	8	9	6	8
Grammar	8	7	8	7	6	5
Listening comprehension	6	6	5	6	4	5
Speaking skills	7	8	8	6	5	6
Pronunciation	8	7	8	7	6	7

Table P8.T2 Summative evaluation in the control group

Evaluation on a 10-point scale for each part (CG)	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**
Reading comprehension	9	5	3	7	6	6
Writing skills	8	5	4	6	5	6
Spelling	9	6	5	6	5	6
Vocabulary	9	6	7	6	7	7
Grammar	8	7	7	7	6	6
Listening comprehension	6	5	4	6	5	5
Speaking skills	8	6	5	7	5	6
Pronunciation	8	7	7	8	6	6

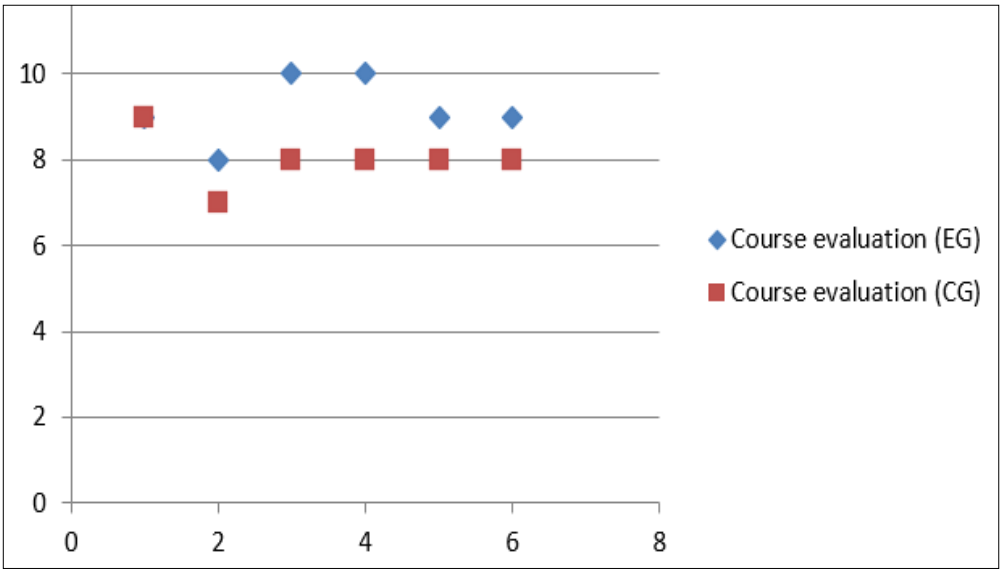


Figure P8.F5. Course evaluation on a 10-point scale

The experimental group outperformed the control group on reading comprehension, spelling, and vocabulary use during summative evaluation. The experimental group was also a little more motivated at the exam than the control group, whose members expressed slightly higher difficulties with some tasks. There were no significant differences in grammar, speaking or pronunciation between the two groups. The experimental course received slightly higher evaluation from the participants in comparison with its conventional alternative. The numerical data gathered were used to reflect on the study's context and subjective reality. Because of the low number of participants, however, no conclusions can be drawn regarding tendencies.

From the tutors´ perspective, one of the game's advantages was a platform which enabled them to not only supervise students' activities, but also to create tasks and incorporate contents (uploading writing tasks, sharing recordings, using a forum). Students eventually could check their progress on permanently visible tables, and thus to continuously self-evaluate. Guadalingo can be adapted to the structure and requirements of the DELE examinations (thus, in addition to the already integrated games, extra exercises can be added to practice reading, writing, listening, and speaking skills, and teachers can evaluate them through the platform).

Conclusively (research team perspective), the study received a high number of female contributors who actively demonstrated their readiness for playing a video

game to learn a new language. Due to the low number of research population, further (and more precise) work will be required in the study of motivational out-of-classroom tasks in teaching Spanish with focus on gender (male versus female), age (digital and/or not digital generations) and game graphics.

P8.7 Conclusion

The Web 2.0 and E-Learning 2.0 models gave rise to the concept of connectivism, shaped new experiences among a virtual community that, through technology and networks, allowed its users to learn by searching, learn by interacting, learn by doing, and learn by sharing (Corbett & Spinello, 2020). The year 2006 saw the birth of *Web 3.0*, which made a shift from a single-server location to decentralised networks with virtual assets and identities controlled by users. While serious games are excellent tools for self-learning, they can be even more motivating when contain tailor-made tasks or can be used non lineally. It would be good if in the near future Guadalingo (n.d.), Don Quijote (n.d.) and other retro-style graphic-walking games like Grim Fandango (n.d.) and Monkey Island series (n.d.) could offer different types of visuals (in line with the artistic preferences of the users), or maybe strive for virtual reality. Augmented reality programs which allow to traverse the physical world via a digital map could offer the generations of the digital era a stronger sense of immersion. Speech-recognition programs are also open to improvement and could offer a wider variety of phonetic exercises, and together with AI programs they could enhance various aspects of human/computer interaction, including Spanish/Spanish FL. Paper books for language teaching are already being supplemented or replaced with interactive educational platforms, and these may be adapted for multi-player use on the new digital devices and in Web 4.0 or get integrated into Metaverse virtual learning environments. This means that we will always have to design, upgrade, and apply new resources, and maybe we will have to do so very differently from what has been doing until now.

4. DISCUSSION OF RESULTS AND LIMITATIONS

The study described in Publication 1 belonged to the methodological framework development category and it was conducted to verify the efficiency in the use of spatial memory in combination with augmented reality for memorisation task (total N=62). Retention after the treatment in both the experimental and control groups was checked by a fifteen-minute and a 1 week delay test. A difference between the means in the two conditions after fifteen-minutes input was confirmed $t(60) = 5.22$, $p < .01$ with the Cohen´s d large effect size = 1.33, which indicated that vocabulary retention after fifteen minutes was higher with the 3D-models-in-the-familiar-environment method than with the software generated flashcards technique. After 1 week input in spite of the fact that statistical data indicated superior vocabulary retention in comparison with the control group, a higher forgetting rate after a week in the experimental technique was observed opposed to the 15-minite task. The method could still be used as an effective initial strategy for acquiring vocabulary in second-language learning with the results implying communication between cognitive systems involved in storing short-term memory for verbal and visual information alongside connections to and from knowledge held in long-term memory when the target information is shown in a familiar array, which were deployed during the AR task and which support enhanced vocabulary learning. Study described in Publication 3 belonged to serious game design and development category and it counted on memorisation of the 10 and 20 vocabulary items (pseudo-words created by a random word generator) in experimental (videogame) and control group (with list of words presented on mobile devices), (total N=48). The 10-word list yielded maximum test results (100 points) in a similar proportion (more than 50%) in both groups. The 20-item list yielded a notably lower test result in the control group (around 30%) compared with the experimental group (46%). On the other hand, the experimental group obtained similar proportions (80%) of high results (90 points or more) on both tests, almost doubling the proportions of high test results obtained by the control group on both tests. Finally, the only failing grades (<60) occurred among control-group participants on the 20-word test. A gender-based comparison of the results in the experimental group showed that 7.1% more women than men obtained the highest possible score (100%) on the 10-word test. In the 20-word test, however, this advantage increased to the point where twice as many women as men obtained

the highest possible score. Overall, however, the percentage of participants that obtained high scores (>80) was similar for both genders (80%). A gender-based comparison of the control group's results showed men obtaining higher scores on both tests. Significant differences were found in the 20-item test, with only half of the women scoring >80 and 21% failing, while no men failed the 20-word test. A comparison of the time needed to memorise the 10 and 20 vocabulary items using both methods shows that the traditional method proved to be the fastest one for the 10-item list, with an average of 6 minutes (7 minutes in the experimental group), but it was also the slowest one for the 20-item list, needing an average of 12 minutes compared with the experimental group's 10 minutes. Thus, as the grouping of the control group's participants around low time values shows, the control group generally needed less time to memorise the 10-item list than the experimental group. When it came to the 20 vocabulary items, however, the control group needed more time than their experimental counterparts, with 50% of the controls requiring more than 12 minutes, compared with only 25% of the experimental group. In both the control and experimental groups the women needed an average of between 12 and 24 more seconds to learn the 10 words. In the 20-item test the women in the control group show an even more marked gender difference, needing almost a minute more. The results are similar for the experimental group, although it is the only group where the men took slightly more than the women (6 seconds on average). There appeared to be no relation between age and time needed in the experimental group, while the control group showed a clear linear relation in both genders, i.e. the older the person, the more minutes needed. The numerical findings obtained in Publication 2, 6 and 8 demonstrated efficiency of the experimental method although due to the nature of the qualitative study we cannot make any conclusions based on numerical information and comparison between the groups. The findings also demonstrated that the use of the experimental technique was more appealing and motivating to participants than the control methods, however, it took the learners more time to set up the environment and to do the training. The qualitative perspective shared by the participants in Publication 2, 3, 7 revealed how they linked objects with the chains of associations and their opinion about the proposed system. The survey-based studies belonged to the category of customized training for 21st century students (Publication 5 and 6). The study in Publication 5 was aimed at obtaining the university students´

preferences and experiences related to the use of the new technologies in second-language vocabulary memorization (total N=62). The data obtained from a multiple-answer questionnaire show that most of the learners (almost 60%) preferred learning-by-seeing, more than 45% of the research population opted for learning-by-doing, and only 21% chose the option of learning-by-hearing. The study also reported that no more than 19.4% of the students were motivated to learn English as a Second Language by personal issues; many of the subjects (more than 72.6%) were driven by the need to pass exams and by motives related with their job future. The most common vocabulary-training choice among participants was the use of vocabulary lists in notebooks (61.3%), which is a traditional memorization method typical of Gen Xers. Surprisingly, students stated they had little experience with digital media for vocabulary memorization. Almost 80% had never used them and 14.5 % almost never. The same was the case with augmented reality on digital devices. More than 58% had never used it and 22.6 % almost never. However, the students explained this as a simple matter of habit carried over from their school days and eagerly accepted to try out new strategies and use digital media instead of paper and pencil. Another survey of population aged 22 to 55 years from the Valencian Autonomous Community in Spain (Publication 6) revealed that the new non-formal EFL course requirements present challenges in the context of lifelong learning (total N=72). In particular the participants referred to the transition from fixed-syllabus textbooks to tailor-made courses where students (as indicated by 69,4% of respondents) can determine the subject matter and the percentage distribution of the components of their language courses. The results obtained showed that formal education does not meet students' EFL needs, leading them to turn to non-formal training. Because of the limited sample size, quantitative conclusions could not be drawn, but some technology-related tendencies were observed that teachers should take into account at the beginning of every new term in order to motivate their students and make their classes more entertaining.

As for these studies limitations, several aspects need to be taken into consideration. Firstly, all the data should be paired for individual participants in order to allow a more complex analysis to be made between the test types, gender, language level and time conditions. Secondly, the learning input and post-tests took place remotely, which cannot be considered a controlled environment or representative of real-world

learning; it is, therefore, possible that the results may vary in other learning contexts. Thirdly, it would also be interesting to obtain results in additional age groups—e.g. from 18 to 22, from 22 to 45, from 45 to 65 and from 65 to 80—to see if there are any significant age-related differences in recall. Another way to contrast the groups could be to distribute the learners into digital natives and digital immigrants with generational subcategories as described in Publication 5, and to then divide the results into approximately four categories (late digital adopters, Gen X, Gen Y and hyper-connected generation) and compare these: e.g. digital-card input, paper-card input, notebook wordlist, and finally location-stimulated augmented reality and spatialised virtual reality. Including more time conditions (e.g. fifteen-minute delay, two-day delay, one-week delay and two-week delay) would be useful to more accurately track the changes in recall over time. In the sociodemographic, habits and preferences data analysis (Publication 5 and 6), a larger sample could allow a seven-point or nine-point Likert summative scale to be applied along with parametric statistical tests. Finally, publication 4, belongs to serious game and AMSTP-UE framework design, it forms part of a bigger project aimed at a first-person walking simulator development with VR technology. This proposal suggests using visuospatial recall of pseudowords at the pilot stage with further expansion to audio-visual input and output for Latin-script languages and deep learning APIs, with in-game data capture that will support learning analytics. One of the game's novelties is that it is not only meant for second-language learners of different ages, but also EFL teachers and game-design specialists. One of the game´s limitations is that the final test's multiple-choice structure may reduce the reliability of scores, which is why thorough pre- and postproduction analysis will be required to identify specific game-structure limitations and to guide updates.

5. CONCLUSION

Preparing this thesis has been demanding and complex. It required obtaining expertise in the field of spatial mnemonics, in outlining the 21st century learners' profile and in the application of qualitative and quantitative research methods together with data analysis and data visualisation techniques. Having done a literature- and a systematic review in line with the research questions and hypotheses provided a synthesised view on the previously conducted studies within the niche of the author´s interest. The opportunity to collaborate with psychology division and software developers gave a multidisciplinary vision to this research fitting with what applied linguistics aims to convey in relation to language learning, education, psychology, information science, and sociology. Finishing this thesis will eventually bring further work in this and in other areas, with the thesis author bearing in mind the challenges that interdisciplinary research brings, the advantages of team work and of double-blind peer reviews and the importance of continuous improvements and updates.

REFERENCES

Adobe Spark (n.d.) Web page and application. Available: https://www.adobe.com/

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review, 20*, 1–11. https://doi.org/10.1016/j.edurev.2016.11.002

Alfadil, M. (2020). Effectiveness of virtual reality game in foreign language vocabulary acquisition. Computers & Education, 153, 103893

Althoff, T., White, R. W., & Horvitz, E. (2016). Influence of Pokémon Go on Physical Activity: Study and Implications. *Journal of medical Internet research, 18*(12), e315. https://doi.org/10.2196/jmir.6759

Alva de la Selva, A. R. (2019): "EDUCAUSE Horizon Report Preview". *Revista Mexicana de Ciencias Políticas y Sociales, 60* (223), 265–85.

Amazing Space Journey (n.d.) Web page and application. Available: https://amazingspacejourney.com/

Amory, A. (2007). Game object model version II: A theoretical framework for educational game development. *Educational Technology Research and Development, 55*(1), 51–77. doi:10.1007/s11423-006-9001-x

Anatomy 3D Atlas (n.d.) Web page and Application. https:// anatomy3datlas.com/

Anatomy 4D (n.d.) Web page and Application. https://www.4danatomy.com/

Andarab, M. S. (2019). Learning vocabulary through collocating on Quizlet. *Universal Journal of Educational Research, 7*(4), 980– 985. https://doi.org/10.13189/ujer.2019.070409

Anderson, J. R. (1978). Arguments concerning representations for mental imagery. *Psychological Review, 85*(4), 249–277. https://doi.org/10.1037/0033-295X.85.4.249

AR Critic (n.d.) Web page and application. Available: https://arcritic.com/

AR Flashcards (n.d.) Web page and application. Available: https://arflashcards.com/

AR Translator (n.d.) Application for iOS. Available: https://apps.apple.com/us/app/ar-translator-translate-photo/id1465903782

Ardiny, H., & Khanmirza, E. (2019). The Role of AR and VR Technologies in Education Developments: Opportunities and Challenges. In *Proceedings of the 6th RSI International Conference on Robotics and Mechatronics, IcRoM 2018* (pp. 482–487). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICRoM.2018.8657615

Arloon Plants (n.d.) Application for iOS. Available: https://apps.apple.com/es/app/arloon-plants/id974606279

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., De Freitas, S., Louchart, S., Suttie, N., Berta, R., & De Gloria, A. (2015). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology*, *46*(2), 391–411. doi:10.1111/bjet.12113

Arzaluz Solano, S. (2005). La utilización del estudio de caso en el análisis local. *Región y sociedad*, 17 (32), 107-144

Ashcroft, R. J., Cvitkovic, R., & Praver, M. (2018). Digital flashcard L2 Vocabulary learning out-performs traditional flashcards at lower proficiency levels: A mixed-methods study of 139 Japanese university students. *The EuroCALL Review, 26*(1), 14. https://doi.org/10.4995/eurocall.2018.7881

Atkinson, R. C. (1975). Mnemotechnics in second language learning. *American Psychologist, 30*(8), 821-828.

Autry, A. J., & Berge, Z. (2011, October). Digital natives and digital immigrants: Getting to know each other. *Industrial and Commercial Training*. https://doi.org/10.1108/00197851111171890

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments 6,* 355-385. Cambridge, MA: The MIT Press

Babbel (n.d.) E-Learning Platform. Available: https://uk.babbel.com/

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented reality trends in education: A systematic review of research and applications. *Educational Technology and Society, 17*(4), 133–149.

Baddeley, A. (2000, November 1). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A., Hitch, G., & Allen, R. (2020). A Multicomponent Model of Working Memory. In *Working Memory: State of the Science* (pp. 10–43). Oxford University Press. https://doi.org/10.1093/oso/9780198842286.003.0002

Baddeley, A.D. (1999). *Essentials of Human Memory*. East Sussex: Psychology Press Ltd.

Bai, Z., Blackwell, A. F., & Coulouris, G. (2013). Through the looking glass: Pretend play for children with autism. *IEEE International Symposium on Mixed and Augmented Reality (ISMAR)*, 49-58. Adelaide.

Bal, M. (2019). Use of digital games in writing education: An action research on gamification. *Contemporary Educational Technology*, *10*(3), 246–271. https://doi.org/10.30935/cet.590005

Bauman, U., Shelley, M., Murphy, L., & White, C. (2008). New challenges, the role of the tutor in the teaching of languages at a distance. *Distances et Savoirs*, *6*(3), 365–392. doi:10.3166/ds.6.365-392

Becker HC (2000) Who's wired and who's not: Children's access to and use of computer technology. *The Future of Children 10*(2): 44–75

Bellezza, F. S. (1996). Mnemonic Methods to Enhance Storage and Retrieval. In *Memory* (pp. 345–380). Elsevier. https://doi.org/10.1016/b978-012102570-0/50012-4

Bellezza, F. S., Six, L. S., & Phillips, D. S. (1992). A mnemonic for remembering long strings of digits. *Bulletin of the Psychonomic Society*, *30*, 271-274.

Bencsik A., Horváth-Csikós G. & Juhás T. (2016). Y and Z Generations at Workplaces. *Journal of Competitiveness,* *8*(3), 90-106.https://doi.org/10.7441/joc.2016.03.06

Berge, Z. L. (1995). Facilitating computer conferencing: Recommendations from the field. *Educational Technology*, *35*(1), 22–30. https://www.jstor.org/stable/44428247?seq=1

Berjon, P., Nag, A., & Dev, S. (2021). Analysis of French phonetic idiosyncrasies for accent recognition. *Soft Computing Letters*, *3*, 100018. https://doi.org/10.1016/j.socl.2021.100018

Bernard, R. M. (1990). Using extended captions to improve learning from instructional illustrations. *British Journal of Education Technology*, 21, 215-225.

Bevan-Dye, A., Garnett, A. & De Klerk, N. (2012). Materialism, status consumption and consumer ethnocentrism amongst black generation Y students in South Africa, *African Journal of Business Management, 6*(16), 5578-5586

Billinghurst, M., Kato, H., & Poupyrev, I. (2001). The MagicBook - Moving seamlessly between reality and virtuality. *IEEE Computer Graphics and Applications*, *21*(3), 6–8. https://doi.org/10.1109/38.920621

Bower, G. H. (1970). Analysis of a Mnemonic Device: Modern psychology uncovers the powerful components of an ancient system for improving memory. *American Scientist, 58*(5), 496–510.

Bower, M., & Jong, M. S. Y. (2020). Immersive virtual reality in education. British Journal of Educational Technology, 51(6), 1981–1990. doi:10.1111/bjet.13038

Bower, M., Howe, K., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented reality in education: Cases, places and potentials. *Educational Media International, 51*(1), 1-15. Doi:10.1080/09523987.2014.889400

Briggs, G. G., Hawkins, S., & Crovitz, H. F. (1970). Bizarre images in artificial memory. *Psychonomic Science, 19*(6), 353–354. https://doi.org/10.3758/BF03328856

Bronack, S. C. (2011). The role of immersive media in online education. *Journal of Continuing Higher Education*, *59*(2), 113–117. Retrieved June 7, 2019 from: http://dx.doi.org/10.1080/07377363.2011.583186

Brown, H. D. (2000). *Principles of language teaching and learning*, (4th ed.). White Plains, NY: Longman.

Brown, J.A., Fishco, V.V., & Hanna, G. (1993). Nelson–Denny Reading Test: Manual for Scoring and Interpretation. *Forms G & H. Rolling Meadows*, IL: Riverside Publishing.

Brown, S. (2020) Best language learning apps of 2021. *CNET* Available: https://www.cnet.com/news/best-language-learning-apps-of-2021-update. [Accessed March 8, 2021].

Bruner, J. (2003). *Juego, pensamiento y lenguaje.* Barcelona: Associació de Mestres Rosa Sentat., pp. 4-10

Bruner, J. S. (2020). Going beyond the information given. In *In Search of Pedagogy* (Vol. I, pp. 17–33). Routledge. doi:10.4324/9780203088609-8

Bruno, L. E. (2018). Embracing Technology and Pop Culture Trends in Physical Education: Ready, Set, (Pokémon) Go! *Journal of Physical Education, Recreation and Dance*, *89*(4), 45–51. https://doi.org/10.1080/07303084.2018.1430627

Bush, M. & Roberts, T. (Eds.) (1997).Technology-enhanced language learning. National Textbook Company: Illinois.

Busuu (n.d.) Language learning platform on web, iOS and Android. Available: https://www.busuu.com/

Cabrera, J. (2019). How games made the transition from 2D to 3D. Retrieved from: https://en.softonic.com/articles/3d-video-game-history

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu). *European Journal of Education*, *54*(3), 356–369. doi:10.1111/ejed.12345

Calia C., S. Darling & J. Havelka et al. (2019). Visuospatial bootstrapping: Binding useful visuospatial information during verbal working memory encoding does not require set-shifting executive resources. *Quarterly Journal of Experimental Psy* Cambridge Assessment English. (2019). Test your English. General English. Retrieved March 7, 2019 from https://www.cambridgeenglish.org/test-your-english/general-english

Callaghan, M., McShane, N., Eguíluz, A. G., & Savin-Baden, M. (2018). Extending the activity theory-based model for serious games design in engineering to integrate analytics. *International Journal of Engineering Pedagogy*, *8*(1), 109–126. doi:10.3991/ijep.v8i1.8087

Callan, M. (2008). Review of Brabazon, T. (2007). The University of Google: education in the (post) information age. Aldershot: Ashgate Publishing. *Journal of Information Literacy, 2*(1), pp. 83 - 84. doi:10.11645/2.1.44

Cameron, K. (1999a). CALL: media, design and applications. Lisse: Swets and Zeitlinger

Canessa, E., & Tenze, L. (2021). Ideals and Virtual Realities. *International Journal of Emerging Technologies in Learning (iJET), 16*(21), pp. 201–209. https://doi.org/10.3991/ijet.v16i21.25493

Canva (n.d.) Platform to create social media graphics and presentations. Available: https://www.canva.com/es_es/

Carney, R. N., & Levin, J. R. (2013). Mnemonic strategies for adult learners. In *Adult Learning and Development: Perspectives From Educational Psychology* (pp. 159–176). Taylor and Francis. https://doi.org/10.4324/9781410603418-17

Carrió-Pastor, M. L. (2018). *Teaching language and teaching literature in virtual environments*. *Teaching Language and Teaching Literature in Virtual Environments* (pp. 1–293). Springer Singapore. https://doi.org/10.1007/978-981-13-1358-5

Carvalho, M. B., Bellotti, F., Berta, R., De Gloria, A., Sedano, C. I., Hauge, J. B., Hu, J., & Rauterberg, M. (2015). An activity theory-based model for serious games analysis and conceptual design. *Computers & Education*, *87*, 166–181. doi:10.1016/j.compedu.2015.03.023

Castellano, S. (2016). Welcome Generation Z to Work. *TD: Talent Development, 70*(2),18.https://www.td.org/Publications/Magazines/TD/TDArchive/2016/02/Intelligence-Welcome-Generation-Z-to-Work

Castillo-Cuesta, L. (2020). Using Digital Games for Enhancing EFL Grammar and Vocabulary in Higher Education. *International Journal of Emerging Technologies in Learning*, *15*(20), 116–129. https://doi.org/10.3991/ijet.v15i20.16159

Caudell, T. P. (1995). Introduction to augmented and virtual reality. *Proceedings of SPIE, 2351*(1994), 272–281.

Caudell, T.P. (1994). Introduction to Augmented Reality, *Proceedings of the Conference on Telemanipulator and Telepresence Technologies*, SPIE, Vol. 2351.

Chapelle, C. (2003). *English Language Learning and Technology*. John Benjamins. doi:10.1075/lllt.7

Chavan, S. R. (2016). Augmented Reality vs. Virtual Reality: Differences and Similarities. *International Journal of Advanced Research in Computer Engineering & Technology, 5*(6), 1947-1952

Chen, C. W. Y. (2020). Analyzing online comments: A language-awareness approach to cultivating digital literacies. *Computer Assisted Language Learning*, *33*(4), 435–454. doi:10.1080/09588221.2019.1569068

Chen, H. J. H., & Yang, T. Y. C. (2013). The impact of adventure video games on foreign language learning and the perceptions of learners. *Interactive Learning Environments*, *21*(2), 129–141. https://doi.org/10.1080/10494820.2012.705851

Chen, R. W., & Chan, K. K. (2019). Using Augmented Reality Flashcards to Learn Vocabulary in Early Childhood Education. *Journal of Educational Computing Research, 57*(7), 1812– 1831. https://doi.org/10.1177/0735633119854028

Chen, Y. (2008). Factors affecting the integration of information and communications technology in teaching English in Taiwan. *Asian EFL Journal*, *28*, 1-44. http://www.asian-efl-journal.com/pta_May_08.pdf

Cheng, C. H., & Su, C. H. (2012). A Game-based learning system for improving student's learning effectiveness in system analysis course. In *Procedia - Social and Behavioral Sciences, 31* (pp. 669–675). doi:10.1016/j.sbspro.2011.12.122

Chew, S. W., Jhu, J.-Y., & Chen, N.-S. (2018). The Effect of Learning English Idioms Using Scaffolding Strategy Through Situated Learning Supported by Augmented Reality. In 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT) (pp. 390–394). IEEE. https://doi.org/10.1109/ICALT.2018.00099

Chiang, T. H. C.; Yang, S. J. H. & Hwang, G. J. (2014). An AR-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Journal of Educational Technology and Society, 17*(4), 352– 365

Chicchi Giglioli, I. A., Pallavicini, F., Pedroli, E., Serino, S., & Riva, G. (2015). Augmented Reality: A Brand-New Challenge for the Assessment and Treatment of Psychological Disorders. *Computational and Mathematical Methods in Medicine*, 2015. Retrieved from: https://doi.org/10.1155/2015/862942

Cho, Y. (2018). How Spatial Presence in VR Affects Memory Retention and Motivation on Second Language Learning: A Comparison of Desktop and Immersive VR-Based Learning. *ProQuest Dissertations and Theses, (May).*

Chun, D. M., & Payne, J. S. (2004). What makes students click: Working memory and look-up behavior. *System, 32*, 481-503

Chun, D. M., & Plass, J. L. (1996a). Effects of multimedia annotations on vocabulary acquisition. *The Modern Language Journal, 80*, 183-198.

Civilizations AR (n.d.) https://play.google.com/store/apps/details?id=uk.co.bbc.civilisations&hl=en&gl=US

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, *3*(3), 149–210. https://doi.org/10.1007/BF01320076

Clement, C. (2021). Gaming - Statistics & Facts Statista [Online]. Retrieved from https://www.statista.com/statistics/232383/gender-split-of-us-computer-and-video-gamers/on June 1, 2022

Cobb, T., & Horst, M. (2011). Does word coach coach words? *CALICO Journal*, *28*(3), 639–661. doi:10.11139/cj.28.3.639-661

Cochrane, T., Farley, H., Jones, S., Narayan, V., & Kearney, M. (2016). Beyond Pokémon Go: Mobile AR & VR in education. In *ASCILITE 2016 - Conference Proceedings - 33rd International Conference of Innovation, Practice and Research in the Use of Educational Technologies in Tertiary Education: Show Me the Learning* (pp. 136–138). Australasian Society for Computers in Learning in Tertiary Education (ASCILITE).

Codrington, G., & Grant-Marshall, S. (2004). *Mind the gap*. Johannesburg, South Africa: Penguin Books

Comas-Quinn, A. (2011, September). Learning to teach online or learning to become an online teacher: An exploration of teachers' experiences in a blended learning course. *ReCALL*, *23*(3), 218–232. Advance online publication. doi:10.1017/S0958344011000152

Combes, B. (2009). Digital natives or digital refugees? Why we have failed Gen Y? Retrieved from https://ro.ecu.edu.au/ecuworks/662

Corbett, F., & Spinello, E. (2020, January 1). Connectivism and leadership: harnessing a learning theory for the digital age to redefine leadership in the twenty-first century. *Heliyon*. Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2020.e03250

Corpas Viñals, J. (2022). Aula Internacional 1. Barcelona: Difusión

Council of Europe. (2019). Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR). Retrieved March 11, 2019 from https://www.coe.int/en/web/portfolio/the-common-european-framework-of-reference-for-languages-learning-teaching-assessment-cefr-

Cowan, M. (2014). Generation Z - New Kids on the Block Have Arrived. London: Happen Group Dorman, S.M. (2000). Implications of Growing up Digital. Review of Tapscott´s Growing Up Digital. *The Journal of School Health,70*(10) pp.420-422

Cowan, N. (2010). The magical mystery four: How is working memory capacity limited, and why? *Current Directions in Psychological Science*, *19*(1), 51–57. https://doi.org/10.1177/0963721409359277

Cross, D., & James, C. V. (2001). *A practical handbook of language teaching*. London: Longman.

Crovitz, H. F. (1971). The capacity of memory loci in artificial memory. *Psychonomic Science, 24*(4), 187–188. https://doi.org/10.3758/BF03335561

Cunningham, K. (2000). Integrating CALL into the Writing Curriculum. *The Internet TESL Journal, 6*, 1–11. http://iteslj.org/Articles/Cunningham-CALLWriting/

Dale, G., & Shawn Green, C. (2017). The Changing Face of Video Games and Video Gamers: Future Directions in the Scientific Study of Video Game Play and Cognitive Performance. *Journal of Cognitive Enhancement*, *1*(3), 280–294. https://doi.org/10.1007/s41465-017-0015-6

Darling, S., & Havelka, J. (2010). Visuospatial bootstrapping: Evidence for binding of verbal and spatial information in working memory. *Quarterly Journal of Experimental Psychology*, *63*(2), 239–245. https://doi.org/10.1080/17470210903348605

Darling, S., Allen, R. J., & Havelka, J. (2017). Visuospatial Bootstrapping: When Visuospatial and Verbal Memory Work Together. *Current Directions in Psychological Science*, *26*(1), 3–9. doi:10.1177/0963721416665342 PMID:29713124

Das, J. P., Kirby, J., & Jarman, R. F. (1975). Simultaneous and successive synthesis: An alternative model for cognitive abilities. *Psychological Bulletin, 82*(1), 87–103. https://doi.org/10.1037/h0076163

Davis, E. A., & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34*(3), 3–14. https:// doi. org/ 10. 3102/ 00131 89x03 40030 03

Davis, E. A., Palinscar, A. S., Smith, P. S., Arias, A. M., & Kademian, S. M. (2017). Educative curriculum materials: Uptake, impact, and implications for research

and design. *Educational Researcher, 46*(6), 293–304. https://doi.org/10.3102/0013189X17727502

De Bra, P., Aerts, A., Berden, B., & Lange, B. D. (2003). Escape from the Tyranny of the Textbook : Adaptive Object Inclusion in AHA ! In *Proceedings of the AACE ELearn 2003 Conference* (pp. 65–71).

De Pasquale, C., Chiappedi, M., Sciacca, F., Martinelli, V., & Hichy, Z. (2021). Online videogames use and anxiety in children during the COVID-19 pandemic. *Children*, *8*(3). https://doi.org/10.3390/children8030205

De Silva, C. R., Chigona, A., & Adendorff, S. A. (2016). Technology integration: Exploring interactive whiteboards as dialogic spaces in the foundation phase classroom. *Turkish Online Journal of Educational Technology*, *15*(3), 141–150

Debarba, H. G., Bovet, S., Salomon, R., Blanke, O., Herbelin, B., & Boulic, R. (2017). Characterizing first and third person viewpoints and their alternation for embodied interaction in virtual reality. *PLoS One, 12*(12), e0190109. Advance online publication. doi:10.1371/journal.pone.0190109 PMID:29281736

Debarger, A. H., Penuel, W. R., Moorthy, S., Beauvineau, Y., Kennedy, C. A., & Boscardin, C. K. I. M. (2017). Investigating purposeful science curriculum adaptation as a strategy to improve teaching and learning. *Science Education, 101*(1), 66–98. https:// doi. org/10. 1002/ sce. 21249

DECRETO 61/2013, de 17 de mayo, del Consell, por el que se establece un sistema de reconocimiento de la competencia en lenguas extranjeras en la Comunitat Valenciana y se crea la Comisión de Acreditación de Niveles de Competencia en Lenguas Extranjeras

Dempsey, J., Lucassen, B., Gilley, W., & Rasmussen, K. (1993). Since Malone's Theory of Intrinsically Motivating Instruction: What's the Score in the Gaming Literature? *Journal of Educational Technology Systems*, *22*(2), 173–183. https://doi.org/10.2190/2th7-5txg-tar7-t4v2

Deng, X., & Yu, Z. (2022). A Systematic Review on the Influence of Virtual Reality on Language Learning Outcomes. *International Journal of Online Pedagogy and Course Design (IJOPCD), 12*(1), 1-18.

Denis, G., & Jouvelot, P. (2005). Motivation-Driven Educational Game Design: Applying Best Practices to Music Education Categories and Subject Descriptors. *ACE2005*, 462–465.

Derwinger, A., Neely, A. S., Persson, M., Hill, R. D., & Bäckman, L. (2003). Remembering Numbers in Old Age: Mnemonic Training Versus Self-Generated Strategy Training. *Aging, Neuropsychology, and Cognition, 10*(3), 202–214. https://doi.org/10.1076/anec.10.3.202.16452

Dewhurst, S. A., & Conway, M. A. (1994). Pictures, Images, and Recollective Experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(5), 1088–1098. https://doi.org/10.1037/0278-7393.20.5.1088

Diehl, L. (2019) Usage and Potential of Language Learning Apps. University of Trier. Available: https://www. grin.com/document/512898

Don Quijote (n.d.) Videogame for Amstrad CPC, Commodore 64, DOS, MSX, ZX Spectrum. https://www.mobygames.com/game/don-quijote

Dondlinger, M. (2007). Educational Video Game Design: A Review of the Literature. *Journal of Applied Educational Technology*, *4*(1), 21–31.

Duolingo (n.d.) Language-Learning platform. Available: https://es.duolingo.com/

Durso, F. T., & Johnson, M. K. (1980). The effects of orienting tasks on recognition, recall, and modality confusion of pictures and words. *Journal of Verbal Learning and Verbal Behavior*, *19*(4), 416–429. https://doi.org/10.1016/s0022-5371(80)90294-7

Ebrahimzadeh, M., & Alavi, S. (2017). The effect of digital video games on efl students' language learning motivation. *Teaching English with Technology*, *17*(2), 87–112

Edler, D., Kersten, T.P. Virtual and Augmented Reality in Spatial Visualization. KN J. Cartogr. Geogr. Inf. 71, 221–222 (2021). https://doi.org/10.1007/s42489-021-00094-z T.P. Virtual and Augmented Reality in Spatial Visualization. KN *J. Cartogr. Geogr. Inf. 71*, 221–222 (2021). https://doi.org/10.1007/s42489-021-00094-z

Eklund, J., & Brusilovsky, P. (1999). InterBook: An Adaptive Tutoring System. *Universe Science News, 12,* 8-13.

Elements 4D(n.d.) Application to illustrate chemical elements and reactions. Available: https://www.educationalappstore.com/app/elements-4d

Elgort, I. (2010). *Deliberate Learning and Vocabulary Acquisition in a Second Language. Language Learning*, *61*(2), 367-413. Retrieved June 17, 2019 from: doi: 10.1111/j.1467-9922.2010.00613.x

Engeström, Y. (2014). Learning by expanding: An activity-theoretical approach to developmental research, second edition. Cambridge University Press. doi:10.1017/CBO9781139814744

Ermi, L., & Mäyrä, F. (2005). Fundamental components of the gameplay experience: Analysing immersion. In *Proceedings of DiGRA 2005 Conference: Changing Views - Worlds in Play.*

European Commission (2020). EACEA National Policies Platform. Lifelong Learning. Portal oficial https://ec.europa.eu/education/policies/european-policycooperation/et2020framework_en

European Commission (n.d.) [Online]. Available: https://ec.europa.eu/programmes/creative-europe/media/video-game-development_en [Accessed: Jan 8, 2022].

European Council. (2018). Council recommendation of 22 May 2018 on key competences for lifelong learning. *Official Journal of the European Union*, 1–13. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&rid=7

Experience Real History (n.d.) Web page and application. Available: https://www.experiencerealhistory.com/

Explain Everything (n.d.) Interactive whiteboard platform for teams, classrooms and businesses. Available: https://explaineverything.com/

Fernández-Gutiérrez, M., Gimenez, G., & Calero, J. (2020). Is the use of ICT in education leading to higher student outcomes? Analysis from the Spanish Autonomous Communities. *Computers and Education*, *157*. https://doi.org/10.1016/j.compedu.2020.103969

Fleming, M. L. (1977). The picture in your mind. *Educational Communication & Technology, 25*(1), 43–62.

Fortunati, L., Taipale, S., & de Luca, F. (2019). Digital generations, but not as we know them. *Convergence, 25(*1), 95–112. https://doi.org/10.1177/1354856517692309

Freitas, S. D., & Staalduinen, J.-P. V. (2009). A Game Based Learning Framework Linking Game Design and Learning Outcomes. *Learning to Play: Exploring the Future of Education with Video Games*, 1–37. http://sgiwiki.cueltd.co.uk/papers/Chapter_Staalduinen_Freitas_-_Final.pdf

Freitas, S., & Jarvis, S. (2006). A framework for developing serious games to meet learner needs. *Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), (2742),* 1–11. http://ntsa.metapress.com/index/8C0WLMJV4UHQ1WVH.pdf

Frohberg, D., Göth, C., & Schwabe, G. (2009). Mobile Learning projects - a critical analysis of the state of the art: Original article. *Journal of Computer Assisted Learning, 25*(4), 307–331. https://doi.org/10.1111/j.1365-2729.2009.00315.x

Fuhrman, O., Eckerling, A., Friedmann, N., Tarrasch, R., & Raz, G. (2021). The moving learner: Object manipulation in virtual reality improves vocabulary learning. *Journal of Computer Assisted Learning, 37*(3), 672–683. doi:10.1111/jcal.12515

Fuhrman, O., Eckerling, A., Friedmann, N., Tarrasch, R., & Raz, G. (2021). The moving learner: Object manipulation in virtual reality improves vocabulary learning. Journal of Computer Assisted Learning, 37(3), 672–683. https://doi.org/10.1111/jcal.12515

Fullan, M., & Langworthy, M. (2011). A rich seam how new pedagogies find deep learning. *Journal of Bodywork and Movement Therapies* (Vol. 15, p. 129). g/10.1080/09588221.2019.1569068

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation and Gaming*, *33*(4), 441–467. https://doi.org/10.1177/1046878102238607

Garzón, J., Pavón, J., & Baldiris, S. (2019). Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality, 23*(4), 447–459. https://doi.org/10.1007/s10055-019-00379-9

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment, 1*(1), 20–20. https://doi.org/10.1145/950566.950595

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment*, *1*(1), 20–20. https://doi.org/10.1145/950566.950595

Gee, J. P. (2005). Learning by Design: good video games as learning machines. *ELearning, 2*(1), 5. doi:10.2304/elea.2005.2.1.5

Gelsomini, F., Kanev, K., Barneva, R. P., & Walters, L. (2020). Technological Enhancements of the Method of Loci for Facilitating Logographic Language Learning. *Journal of Educational Technology Systems*, *48*(3), 440–459. https://doi.org/10.1177/0047239519881758

Gerard, L. F., Spitulnik, M., & Linn, M. C. (2010). Teacher use of evidence to customize inquiry science instruction. *Journal of Research in Science Teaching, 47*(9), 1037–1063.

Gerard, L., Bradford, A. & Linn, M.C. Supporting Teachers to Customize Curriculum for Self-Directed Learning. *J Sci Educ Technol 31,* 660–679 (2022). https://doi.org/10.1007/s10956-022-09985-w

Giglioli Chicchi, I. A., Pallavicini, F., Pedroli, E., Serino, S., & Riva, G. (2015). Augmented Reality: A Brand-New Challenge for the Assessment and Treatment of Psychological Disorders. *Computational and Mathematical Methods in Medicine, article ID 862942*. Retrieved June 1, 2019 from: https://doi.org/10.1155/2015/862942.

Glenberg, A.M. & Langston, W. E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language, 26*, 129-151.

Glum, J. (2015). Marketing to Generation Z: Millennials Move Aside as Brands Shift Focus to Under-18 Customers. Retrieved from http://www.ibtimes.com/marketing-generation-z-millennials-move-asidebrands-shift-focus-under-18-customers-1782220

Godwin-Jones, R. (2010). Emerging technologies from memory palaces to spacing algorithms: Approaches to second-language vocabulary learning. *Language Learning and Technology, 14*(2), 4–11.

Granic, I., Lobel, A., & Engels, R. C. M. E. (2014). The benefits of playing video games. *American Psychologist*, *69*(1), 66–78. https://doi.org/10.1037/a0034857

Greitemeyer, T. (2022, August 1). The dark and bright side of video game consumption: Effects of violent and prosocial video games. *Current Opinion in Psychology*. Elsevier B.V. https://doi.org/10.1016/j.copsyc.2022.101326

Greitzer, F. L., Kuchar, O. A., & Huston, K. (2007). Cognitive science implications for enhancing training effectiveness in a serious gaming context. *ACM Journal on*

Educational Resources in Computing, *7*(3), 2. Advance online publication. doi:10.1145/1281320.1281322

Grier, R. A., Thiruvengada, H., Ellis, S. R., Havig, P., Hale, K.S., & Hollands, J. G. (2016). Augmented Reality – Implications toward Virtual Reality, Human Perception and Performance. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *56*(1), 1351-1355.

Griffiths, M. D. (2019) *The Oxford Handbook of Cyberpsychology.* Oxford University Press, pp. 484–505.

Grim Fandango (n.d.) Video game. Available: https://es.ign.com/grim-fandango-remastered/

Gross, A. L., Parisi, J. M., Spira, A. P., Kueider, A. M., Ko, J. Y., Saczynski, J. S., et al (2012). Memory training interventions for older adults: A meta-analysis. *Aging & Mental Health*, *16*(6), 722-734.

Guadalingo (n.d.) Learning platform to study Spanish. Available: https://edinumen.es/guadalingo/

Guida, A., Leroux, A., Lavielle-Guida, M., & Noël, Y. (2016). A SPoARC in the dark: Spatialization in verbal immediate memory. *Cognitive Science, 40*(8), 2108–2121. https://doi.org/10.1111/cogs.12316

Gupta, S. (2016). OGMA: language acquisition system using immersive virtual reality. Dissertação de Mestrado em Computer Science. The University of Texas at Arlington, Arlington.

Habgood, M. P. J., Ainsworth, S. E., & Benford, S. (2005). Endogenous fantasy and learning in digital games. *Simulation and Gaming*, *36*(4), 483–498. https://doi.org/10.1177/1046878105282276

Hagström, J., & Winman, A. (2018). Virtually overcoming grammar learning with 3D application of Loci mnemonics? Applied Cognitive Psychology, 32(4), 450–462. https://doi.org/10.1002/acp.3418

Haleem, A., Javaid, M., Qadri, A. & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, vol. 3*, pp. 275-285, 2022

Hamzi, A., Echantoufi, N., Khouna, J., & Ajana, L. (2021). Effects of Using Digital Tools on the Process of Memorization. *International Journal of Emerging*

Technologies in Learning (iJET), 16(04), pp. 278–295. https://doi.org/10.3991/ijet.v16i04.18285

Harben, P. (1999). An exercise in applying pedagogical principles to multimedia CALL materials design. *ReCALL, 11*(3), 25-33.

Hartmann, A., & Gommer, L. (2021). To play or not to play: On the motivational effects of games in engineering education. *European Journal of Engineering Education*, *46*(3), 319–343. doi:10.1080/03043797.2019.1690430

Hashim, N. C., Majid, N. A. A., Arshad, H., & Obeidy, W. K. (2018). User Satisfaction for an Augmented Reality Application to Support Productive Vocabulary Using Speech Recognition. *Advances in Multimedia*, 2018, 1-10. https://doi.org/10.1155/2018/9753979

Heilig, M. (1962). Sensorama simulator. U.S. Patent No 3050870A. Virginia: United States Patent and Trade Office. Available: https://patents.google.com/patent/US3050870A/en

Helsper, E. J., & Eynon, R. (2010). Digital natives: Where is the evidence? *British Educational Research Journal, 36*(3), 503-520. https://doi.org/10.1080/01411920902989227

Herrera Sierra, G., & Prendes Espinosa, M. P. (2019). Implementación y análisis del método de aula invertida: un estudio de caso en Bachillerato. *Innoeduca. International Journal of Technology and Educational Innovation*, *5*(1), 24–33. https://doi.org/10.24310/innoeduca.2019.v5i1.3091

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly: Management Information Systems*, *28*(1), 75–105. https://doi.org/10.2307/25148625

Higbee, K. L. (2001). *Your memory: How it works and how to improve it*. New York, NY: Marlowe & Company.

Holloway, S. L., & Valentine, G. (2003). Cyberkids: Children in the Information Age. *Education and Information Technologies, 8*, 383-386.https://doi.org/10.1023/B:EAIT.0000008698.37757.ee

Holmes D (1999) Adolescent CIT Use: Paradigm shifts for educational and cultural practices? *British Journal of Sociology of Education 20*(1): 69–78

Horváth, I. (2007). Comparison of three methodological approaches of design research. In *Proceedings of ICED 2007, the 16th International Conference on Engineering Design* (Vol. DS 42).

Huang, T.C., Chen, C.C., & Chou, Y.W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality-based experiential learning environment. *Computers & Education, 96*, 72-82

Huang, X., Zou, D., Cheng, G., & Xie, H. (2021, May 1). A systematic review of AR and VR enhanced language learning. *Sustainability (Switzerland).* MDPI AG. https://doi.org/10.3390/su13094639

Huizinga, J. (2014). *Homo Ludens: A study of the play-element in culture*. *Homo Ludens: A Study of the Play-Element in Culture* (pp. 1–220). Taylor and Francis. https://doi.org/10.4324/9781315824161

Hunicke, R., Leblanc, M., & Zubek, R. (2004). MDA: A formal approach to game design and game research. In *AAAI Workshop – Technical Report* (Vol. WS-04-04, pp. 1–5). Academic Press.

Huttner, J. P., & Robra-Bissantz, S. (2017). An immersive memory palace: supporting the method of loci with virtual reality. In *AMCIS 2017 - America's Conference on Information Systems: A Tradition of Innovation* (Vol. 2017-August). Americas Conference on Information Systems.

Huttner, J. P., Qian, Z., & Robra-Bissantz, S. (2020). A virtual memory palace and the user's awareness of the method of loci. In *27th European Conference on Information Systems - Information Systems for a Sharing Society, ECIS 2019*. Association for Information Systems

Hwang, G. J., & Tsai, C. C. (2011). Research Trends in Mobile and Ubiquitous Learning: A Review of Publications in Selected Journals from 2001 to 2010. *British Journal of Educational Technology, 42,* E65-E70. https://doi.org/10.1111/j.1467-8535.2011.01183.x

Hwang, W. Y., Shih, T. K., Ma, Z. H., Shadiev, R., & Chen, S. Y. (2016). Evaluating listening and speaking skills in a mobile game-based learning environment with situational contexts. *Computer Assisted Language Learning*, *29*(4), 639–657. https://doi.org/10.1080/09588221.2015.1016438

Ibáñez, M. B., Di Serio, Á., Villarán, D., & Delgado, K. C. (2014). Experimenting with electromagnetism using AR: impact on flow student experience and educational effectiveness. *Computers & Education, 71*, 1-13

IBM's SPSS V24 (n.d.) Statistical software suite. Available: https://www.ibm.com

Ibrahim, A., Huynh, B., Downey, J., Hollerer, T., Chun, D., & O'donovan, J. (2018). Arbis Pictus: A Study of Vocabulary Learning with Augmented Reality. IEEE Transactions on Visualization and Computer Graphics, 24(11), 2867–2874. https://doi.org/10.1109/TVCG.2018.2868568

Igel, C., & Urquhart, V. (2012). Generation Z meet cooperative learning. *Middle School Journal, 43*(4), 16-21. doi:10.1080/00940771.2012.11461816

ImmerseMe (n.d.). Language-learning platform. Available: https://immerseme.co

Jarvinen, H., Bernardet, U., & Verschure, P. F. M. J. (2011). Interaction mapping affects spatial memory and the sense of presence when navigating in a virtual environment. In *Proceedings of the 5th International Conference on Tangible Embedded and Embodied Interaction, TEI'11* (pp. 321–324). https://doi.org/10.1145/1935701.1935776

Jenkins, H. (2003). Game Design as Narrative Architecture. *Response*, *44*(3), 118–130. Retrieved from http://web.mit.edu/cms/People/henry3/games&narrative.html

Jenkins, H., Klopfer, E., Squire, K., & Tan, P. (2003). Entering the education arcade. *Computers in Entertainment*, *1*(1), 1–11.doi:10.1145/950566.950591

Jiang, Y., Zhao, Y., He, Y., Jiao, L., & Qu, X. (2019). A study on acceptance of educational games for the students in the stage of compulsory education. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 11546, pp. 316–326). Springer Verlag. doi:10.1007/978-3-030-21562-0_26

Jiménez, R. M. (1994). Estrategias mnemotécnicas para la enseñanza y el aprendizaje del vocabulario del inglés. *Comunicación, Lenguaje y Educación, 6*(4), 79–88. https://doi.org/10.1174/021470394321341150

JISC online survey tool (n.d.) Digital resources in support of further and higher education institutions. Available: https://www.jisc.ac.uk

Johnston, K. A. (2013). A guide to educating different generations in South Africa, *Issues in Informing Science and Information Technology, 10*, 36, 261-273

Kahneman, D. (2011). *Thinking fast, thinking slow. In Interpretation*. Tavistock.

Kahoot (n.d.) Learning platform. Available: https://kahoot.com/

Kalmpourtzis, G. (2018). *Educational Game Design Fundamentals: A Journey to Creating Intrinsically Motivating Learning Experiences*. Educational Game Design Fundamentals. doi:10.1201/9781315208794

Kaufmann, H., & Schmalstieg, D. (2003). Mathematics and geometry education with collaborative augmented reality. In *Computers and Graphics (Pergamon)* (Vol. 27, pp. 339–345). Elsevier Ltd. https://doi.org/10.1016/S0097-8493(03)00028-1

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A Systematic Review of Virtual Reality in Education. *Themes in Science and Technology Education, 10*(2), 85–119.

Kerr, K. A., Marsh, J. A., Ikemoto, G. S., Darilek, H., & Barney, H. (2006). Strategies to promote data use for instructional improvement: Actions, outcomes, and lessons from three urban districts. *American Journal of Education, 112*, 496–520. https:// doi. org/10. 1086/ 505057

Khan, T., Johnston, K., & Ophoff, J. (2019). The Impact of an Augmented Reality Application on Learning Motivation of Students. *Advances in Human-Computer Interaction*, *2019*. https://doi.org/10.1155/2019/7208494

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, *8*(1), 13–24. doi:10.1016/j.iheduc.2004.12.001

Kinash, S., Wood, K., & Knight, D. (2013). Digital immigrant teachers and digital native students: What happens to teaching? *Educational Technology Solutions, 54*, 56-58

Kliegl, R., Smith, J., & Baltes, P. B. (1990). On the Locus and Process of Magnification of Age Differences During Mnemonic Training. *Developmental Psychology, 26*(6), 894–904. https://doi.org/10.1037/0012-1649.26.6.894

Klopfer, E., & Squire, K. (2008). Environmental detectives: the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development, 56*(2), 203–228. Retrieved June 10, 2019 from: http://dx.doi.org/10.1007/s11423-007-9037-6.

Klopfer, E., Osterweil, S., & Salen, K. (2009). Moving Learning Games Forward. Massachusetts Institute of Technology, USA: The Education Arcade.

Knauff, M. (2013). Space to reason: A spatial theory of human thought. The MIT Press.

Kosslyn, S. M. (2006). You can play 20 questions with nature and win: Categorical versus coordinate spatial relations as a case study. *Neuropsychologia, 44*(9), 1519–1523. https://doi.org/10.1016/j.neuropsychologia.2006.01.022

Krathwohl, D. R. (2002). A revision of bloom's taxonomy: An overview. *Theory into Practice*. Ohio State University Press. https://doi.org/10.1207/s15430421tip4104_2

Kress, G. (2009). *Multimodality: A social semiotic approach to contemporary communication*. *Multimodality: A Social Semiotic Approach to Contemporary Communication* (pp. 1–212). Routledge Taylor & Francis Group. https://doi.org/10.4324/9780203970034

Krokos, E., Plaisant, C., & Varshney, A. (2019). Virtual memory palaces: immersion aids recall. *Virtual Reality, 23*(1). https://doi.org/10.1007/s10055-018-0346-3

Krueger, M. W, (1977). Responsive Environments. Proc. National Computer Conference 1977. p. 423-433.

Krueger, M. W., Gionfriddo, T. and Hinrichsen, K. (1985) Videoplace—an artificial reality. In *Proceedings of the ACM SIGCHI Bulletin*, *16*(4) Available: https://doi.org/10.1145/317456.317463

Krueger, M. W., Gionfriddo, T., & Hinrichsen, K. (1985). Videoplace - an Artificial Reality. ACM SIGGHI *Bulletin, 16*(4), 35-40

Krumsvik, R. J. (2008). Situated learning and teachers' digital competence. *Education and Information Technologies*, *13*(4), 279–290.doi:10.1007/s10639-008-9069-5

Kucher, T. (2021). Principles and Best Practices of Designing Digital Game-Based Learning Environments. *International Journal of Technology in Education and Science*, *5*(2), 213–223. https://doi.org/10.46328/ijtes.190

Kukulska-Hulme, A. (2000). WorldCALL: Global Perspectives on Computer-Assisted Language Learning. *Computers & Education*, *35*(4), 330–332. https://doi.org/10.1016/s0360-1315(00)00040-3

Kukulska-Hulme, A. (2005). Mobile usability and user experience. In *Mobile Learning: A Handbook for Educators and Trainers* (pp. 45–56). Routledge., doi:10.4324/9780203003428

Kupperschmidt, B.R. (2000). Multigeneration Employees: Strategies for Effective Management. Health Care Manager, 19(1), 65-76. DOI: 10.1097/00126450200019010-00011

Kurt, W. (2007). An Interview with Jaron Lanier. *Serials Review*, *33*(3), 190–195. https://doi.org/10.1016/j.serrev.2007.05.009

Lai, K.-W. K., & Chen, H.-J. H. (2021). A comparative study on the effects of a VR and PC visual novel game on vocabulary learning. Computer Assisted Language Learning, 1–34. https://doi.org/10.1080/09588221.2021.1928226

Lam, Y. (2000). Technophilia vs. technophobia: A preliminary look at why second-language teachers do or do not use technology in their classrooms. *Canadian Modern Language Review*, *56*(3), 389–420. doi:10.3138/cmlr.56.3.389

Lanier, J. (1988). A Vintage Virtual Reality Interview. Whole Earth Review 1988.

Larchen Costuchen, A. & Dev. S. (2022) Confronting challenges of non-formal education: A shift from book-based EFL to tailor-made, experimental syllabi, in *The 2022 5th International Conference on Big Data and Education (ICBDE'22)*, Shanghai, China. ACM, New York, NY, USA, 2022, pp. 248–254 https://dl.acm.org/doi/10.1145/3524383.3524450

Larchen Costuchen, A. (2019). Gamified Curriculum and Open-Structured Syllabus in Second-Language Teaching (pp. 35–55). https://doi.org/10.4018/978-1-5225-9775-9.ch003

Larchen Costuchen, A. (2020). Adaptación curricular: gamificación, el aula invertida y la aplicación de métodos mnemotécnicos. *Estudios Interlingüísticos*, *8*, 111–123.

Larchen Costuchen, A. (2020). From Generation Gap to Generation Lap: Gen Z Subcultures (p. 113-130). In *Estudios de lingüística aplicada IV* / coord. por María Luisa Carrió Pastor, Carlos Periñán-Pascual, Francesca Romero Forteza, Françoise Olmo Cazevieille, ISBN 978-84-9048-927-7

Larchen Costuchen, A., Darling, S., & Uytman, C. (2021). Augmented reality and visuospatial bootstrapping for second-language vocabulary recall. *Innovation in Language Learning and Teaching,* *15*(4), 352–363. https://doi.org/10.1080/17501229.2020.1806848

Larchen Costuchen, A., Darling, S., & Uytman, C. (2021). Augmented reality and visuospatial bootstrapping for second-language vocabulary recall. *Innovation in Language Learning and Teaching*, *15*(4), 352–363. doi:10.1080/17501229.2020.1806848

Larchen Costuchen, A., Mollá Vayá, R. P., & Dinkova Dimitrova, D. (2022). Roman Palace: A Videogame for Foreign-Language Vocabulary Retention. *International Journal of Emerging Technologies in Learning*, *17*(5), 87–102. https://doi.org/10.3991/ijet.v17i05.27621

Latham-Koenig, C. (2014) English File. B2. Oxford University Press

Latham-Koenig, C., Oxenden C., & Lambert J. (2019) English File. B1. Oxford University Press

Laufer, M., Leiser, A., Deacon, B., Perrin de Brichambaut, P., Fecher, B., Kobsda, C., & Hesse, F. (2021). Digital higher education: a divider or bridge builder? Leadership perspectives on edtech in a COVID-19 reality. *International Journal of Educational Technology in Higher Education*, *18*(1). https://doi.org/10.1186/s41239-021-00287-6

Learn click (n.d.) Quiz creator. Available: https://www.learnclick.com/

Lee, L. K., Chau, C. H., Chau, C. H., & Ng, C. T. (2017). Using Augmented Reality to Teach Kindergarten Students English Vocabulary. *Proceedings - 2017 International Symposium on Educational Technology, Iset 2017*, 53-57.Https://Doi.Org/10.1109/Iset.2017.20

Lee, L.-K., Chau, C.-P., Tsoi, K.-N., Yang, N. L., & Wu, N.-I. (2019). A Mobile Game for Learning English Vocabulary with Augmented Reality Block Builder. In S. K. S. Cheung, J. Jiao, L.-K. Lee, X. Zhang, K. C. Li, & Z. Zhan (Eds.), Communications in Computer and Information Science. Technology in Education: Pedagogical Innovations (Vol. 1048, pp. 116–128). Springer Singapore. https://doi.org/10.1007/978-981-13-9895-7_11

Legault, J., Zhao, J., Chi, Y.-A., Chen, W., Klippel, A., & Li, P. (2019). Immersive Virtual Reality as an Effective Tool for Second Language Vocabulary Learning. Languages, 4(1), 13. https://doi.org/10.3390/languages4010013

Legault, J., Zhao, J., Chi, Y.-A., Chen, W., Klippel, A., and Li, P. (2019). Immersive virtual reality as an effective tool for second language vocabulary learning. *Languages, 4*(1):13.

Legge, E. L. G., Madan, C. R., Ng, E. T., & Caplan, J. B. (2012). Building a memory palace in minutes: Equivalent memory performance using virtual versus conventional environments with the Method of Loci. *Acta Psychologica, 141*(3), 380–390. https://doi.org/10.1016/j.actpsy.2012.09.002

Lei, H., Chiu, M. M., Wang, D., Wang, C., & Xie, T. (2022). Effects of Game-Based Learning on Students' Achievement in Science: A Meta-Analysis. *Journal of Educational Computing Research*, *60*(6), 1373–1398. https://doi.org/10.1177/07356331211064543

Leontiev, A. N. (1978). *Activity, consciousness, and personality.* Prentice-Hall.

Levin, M. E., & Levin, J. R. (1990). Scientific Mnemonomies: Methods for Maximizing More Than Memory. *American Educational Research Journal*, *27*(2), 301. https://doi.org/10.2307/1163011

Levy, M. (1997). Computer-assisted language learning: Context and conceptualization. Oxford University Press

Ley orgánica de educación 2/2006, de 3 de mayo. (LOE). BOE, 4 de mayo de 2006, núm. 106, p.17158-17207 Consellería de Educación, Cultura y Deporte

Li, Q. (2012). Understanding enactivism: A study of affordances and constraints of engaging practicing teachers as digital game designers. *Educational Technology Research and Development*, *60*(5), 785–806. doi:10.1007/s11423-012-9255-4

Li, Y., Ying, S., Chen, Q., & Guan, J. (2022). An Experiential Learning-Based Virtual Reality Approach to Foster Students' Vocabulary Acquisition and Learning Engagement in English for Geography. Sustainability, 14(22), 15359. https://doi.org/10.3390/su142215359

Littenberg-Tobias, J., Beheshti, E., & Staudt, C. (2016). To customize or not to customize? Exploring science teacher customization in an online lesson portal. *Journal of Research in Science Teaching, 53*(3), 349–367. https://doi.org/10.1002/tea.21300

Liu, T., & Israel, M. (2022). Uncovering students' problem-solving processes in game-based learning environments. *Computers and Education*, *182*. https://doi.org/10.1016/j.compedu.2022.104462

Loci Memory Palace (n.d.) Learning platform. Create your personalised palace. Available: https://www.memorypalace.com/palaces

Lu, A. S. (2013). Video Games and Learning: Teaching and Participatory Culture in the Digital Age. *Journal of Children and Media*, *7*(2), 277–280. doi:10.1080/17482798.2012.724596

Ma, B. D., Ng, S. L., Schwanen, T., Zacharias, J., Zhou, M., Kawachi, I., & Sun, G. (2018). Pokémon GO and Physical Activity in Asia: Multilevel Study. *Journal of medical Internet research, 20*(6)

Madan, C. R., & Singhal, A. (2012, August). Motor imagery and higher-level cognition: Four hurdles before research can sprint forward. *Cognitive Processing.* https://doi.org/10.1007/s10339-012-0438-z

Maguire, E. A., Valentine, E. R., Wilding, J. M., & Kapur, N. (2003). Routes to remembering: The brains behind superior memory. *Nature Neuroscience, 6*(1), 90–95. https://doi.org/10.1038/nn988

Malaquias, R. F., Malaquias, F. F. O., & Hwang, Y. (2018). Understanding technology acceptance features in learning through a serious game. *Computers in Human Behavior*, *87*, 395–402. doi:10.1016/j.chb.2018.06.008

Malloy, J., & Aarseth, E. J. (1998). Cybertext, Perspectives on Ergodic Literature. *Leonardo Music Journal*, *8*, 77. https://doi.org/10.2307/1513408

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science*, *5*(4), 333–369. https://doi.org/10.1016/S0364-0213(81)80017-1

Mann, S. (1997) Wearable computing: a first step toward personal imaging. *Computer, 30*(2) pp. 25-32. Available: https://doi.org/10.1109/2.566147

Mann, S. (1997). Wearable computing: a first step toward personal imaging. *IEEE Computer, 30*(2)

Mannheim, K. (1952). The sociological problem of generation. *Essays on the Sociology of Knowledge*, 163-195

Manzano-León, A., Rodríguez-Ferrer, J. M., Aguilar-Parra, J. M., Fernández-Campoy, J. M., Trigueros, R., & Martínez-Martínez, A. M. (2022). Play and learn: Influence of gamification and game-based learning in the reading processes of secondary school students. *Revista de Psicodidactica*, *27*(1), 38–46. https://doi.org/10.1016/j.psicod.2021.07.001

Marimon-Martí, M., Cabero, J., Castañeda, L., Coll, C., De Oliveira, J. M., & Rodríguez-Triana, M. J. (2022). Construir el conocimiento en la era digital: retos y reflexiones. *Revista de Educación a Distancia (RED)*, *22*(69). https://doi.org/10.6018/red.505661

Marne, B., Wisdom, J., Huynh-Kim-Bang, B., & Labat, J.-M. (2012). The Six Facets of Serious Game Design: A Methodology Enhanced by Our Design Pattern Library. 21st Century Learning for 21st Century Skills. doi:10.1007/978-3-642-33263-0_17

Marqués Andrés, M. (2016). Qué hay detrás de la clase al revés (flipped classroom). *ReVisión*, *9*(3), 2

Martinez, L., Gimenes, M., & Lambert, E. (2022). Entertainment Video Games for Academic Learning: A Systematic Review. *Journal of Educational Computing Research*, *60*(5), 1083–1109. https://doi.org/10.1177/07356331211053848

Matuk, C. F., Linn, M. C., & Eylon, B.-S. (2015). Technology to support teachers using evidence from student work to customize technology-technology-enhanced inquiry units. *Instructional Science, 43,* 229–257.

McCarthy, M., & O´Dell, F. (2017). *English Idioms in Use. Intermediate. Book with Answers, Vocabulary, Reference and Practice*. 2nd Edition. ISBN 9781316629888

McCrindle, M., & Wolfinger, E. (2010). Generations defined. *Ethos, 18*(1), 8-13

McMahan, A. (2013). Immersion, engagement, and presence: A method for analyzing 3-d video games. In *The Video Game Theory Reader* (pp. 67–86). Taylor and Francis. https://doi.org/10.4324/9780203700457-10

McMahon, D. D., Cihak, D. F., Wright, R. E., & Bell, S. M. (2016). Augmented reality for teaching science vocabulary to postsecondary education students with intellectual disabilities and autism. *Journal of Research on Technology in Education*, *48*(1), 38–56. https://doi.org/10.1080/15391523.2015.1103149

McMahon, M. (2009). The DODDEL model: A flexible document-oriented model for the design of serious games. In Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices (pp. 98–118). IGI Global. doi:10.4018/978-1-60566-360-9.ch007

Microsoft Excel 365 (n.d.) Spreadsheet software. https://www.microsoft.com/

Milgram, P., & Kishino, F. (1994). Taxonomy of mixed reality visual displays. *IEICE Transactions on Information and Systems*, *E77-D*(12), 1321–1329.

Mind Meister (n.d.) Mind-mapping software. Available: https://www.mindmeister.com/

Mishra, P., & Koehler, M. J. (2008). *Introducing technological pedagogical content knowledge* [Paper presentation]. The Annual Meeting of the American Educational Research Association, New York, NY

Moè, A., & De Beni, R. (2005). Stressing the efficacy of the Loci method: oral presentation and the subject-generation of the Loci pathway with expository passages: Loci method in the study of passages. *Applied Cognitive Psychology,*

Mondly (n.d.). Language-learning application. https://www.mondly.com

Monkey Island series (n.d.) The Secret of Monkey Island. Return to Monkey Island. https://www.mobygames.com/game/secret-of-monkey-island

Montaner-Villalba, S. (2019). The use of Quizlet to enhance vocabulary in the English language classroom. In *CALL and complexity – short papers from EUROCALL 2019* (pp. 304–309). Research-publishing.net. https://doi.org/10.14705/rpnet.2019.38.1027

Morton, J. (1979). Facilitation in word recognition: Experiments causing change in the logogen model. In P. A. Kolers, M. Wrolstead, & H. Bouma (Eds.), *Processing of visible language, 1*, 59– 268. New York: Plenum Press.

Motion Sickness Symptomatology and Origins. (2014). *Handbook of Virtual Environments*. CRC Press. doi:10.1201/b17360-33

Moulton, D. (2015). Generation Z steps up to the workplace. *Bottom Line, 31*(12), 7.http://search.proquest.com.ezp.waldenulibrary.org

Mozelius, P., Bergström-Eriksson, S., & Jaldemark, J. (2017). Learning by Walking - Pokémon Go and Mobile Technology in Formal Education. In *ICERI2017 Proceedings* (Vol. 1, pp. 1172–1179). IATED. https://doi.org/10.21125/iceri.2017.0394

Mungello, D. E., & Spence, J. D. (1986). The Memory Palace of Matteo Ricci. *The American Historical Review, 91*(2), 444. https://doi.org/10.2307/1858259

Murray, J. B. (1997). Hamlet on the holodeck: The future of narrative in cyberspace. New York, NY, USA: Free Press.

Nakata, T. (2011). Computer-assisted second language vocabulary learning in a paired-associate paradigm: A critical investigation of flashcard software. *Computer Assisted Language Learning, 24*, 17-38. doi:10.1080/09588221.2010.520675

Narrator AR (n.d.) AR application for kids. Available: https://www.narratorar.com.au/

NASA (2016). Virtual Reality: Definition and Requirements. Available from: http://www.nas.nasa.gov/Software/VWT/vr.html

Nation, I. (2005). Language education: Vocabulary. In I. C. Brown (Ed.), Encyclopaedia of language and linguistics (2nd ed., Vol. 6, pp. 494-499). Oxford: Elsevier.

Nation, I. S. P. (2001). *Learning vocabulary in another language.* Cambridge: Cambridge University Press.

Nation, I. S. P. (2003). Effective ways of building vocabulary knowledge. *ESL Magazine*, *6*(4), 14–15

Nation, I. S. P. (2015). Principles guiding vocabulary learning through extensive reading. *Reading in a Foreign Language, 27*, 136–145.

Nation, I. S., & Webb, S. A. (2011). *Researching and analyzing vocabulary*. Boston, MA: Heinle, Cengage Learning.

Nazry, N. N (2017). Mood and learning in navigation-based serious games. *Computers in Human Behavior, 73,* 596–604. https://doi.org/10.1016/j.chb.2017.03.040

Ndibalema, P. (2021). Online Assessment in the Era of Digital Natives in Higher Education Institutions. *International Journal of Technology in Education*, 443–463. https://doi.org/10.46328/ijte.89

Neville, D. O., Shelton, B. E., & McInnis, B. (2009). Cybertext redux: Using digital game-based learning to teach L2 vocabulary, reading, and culture. *Computer Assisted Language Learning*, *22*(5), 409–424. doi:10.1080/09588220903345168

Nicolaidou, I., Pissas, P., & Boglou, D. (2021). Comparing immersive Virtual Reality to mobile applications in foreign language learning in higher education: A quasi-experiment. *Interactive Learning Environments*, 1–15. Advance online publication. doi:10.1080/10494820.2020.1870504

Nicolaidou, I., Pissas, P., & Boglou, D. (2021). Comparing immersive Virtual Reality to mobile applications in foreign language learning in higher education: a quasi-experiment. *Interactive Learning Environments*, 1–15. https://doi.org/10.1080/10494820.2020.1870504

Nigg, C. R., Mateo, D. J., & An, J. (2017). Pokémon GO May Increase Physical Activity and Decrease Sedentary Behaviors. *American journal of public health, 107*(1), 37-38. Doi:10.2105/AJPH.2016.303532

Nikoopour, Jahanbakhsh and Kazemi, Azin. 2014. Vocabulary Learning through Digitized & Non-digitized Flashcards Delivery. *Procedia – Social and Behavioral Sciences 98*: 1366-1373.

Novak, E. (2015). A critical review of digital storyline-enhanced learning. *Educational Technology Research and Development*, *63*(3), 431–453. https://doi.org/10.1007/s11423-015-9372-y

Number of active users of Pokémon Go worldwide from 2016 to 2020, by region in millions. (2019, October 12) Retrieved from https://www.statista.com/statistics/665640/pokemon-go-global-android-appleusers/

Nurkhamimi Zainuddin, Muhammad Sabri Sahrir, Rozhan M. Idrus, & Mohammad Najib Jaffar (2018). Scaffolding a Conceptual Support for Personalized Arabic Vocabulary Learning Using Augmented Reality (AR) Enhanced Flashcards. Journal of Personalized Learning, 2(1), 95–103. http://spaj.ukm.my/jplearning/index.php/jplearning/article/view/36

Nyberg, L., Sandblom, J., Jones, S., Neely, A. S., Petersson, K. M., Ingvar, M., & Bäckman, L. (2003). Neural correlates of training-related memory improvement in adulthood and aging. *Proceedings of the National Academy of Sciences of the United States of America, 100*(23), 13728–13733. https://doi.org/10.1073/pnas.1735487100

O'keefe, J., & Nadel, L. (1979). Précis of O'Keefe & Nadel's The hippocampus as a cognitive map. *Behavioral and Brain Sciences*, *2*(4), 487–494. https://doi.org/10.1017/S0140525X00063949

Oblinger, D., & Oblinger, J. (2005). Is It Age or IT: First Steps Toward Understanding the Net Generation? In D. G. Oblinger & J. L. Oblinger (Eds.), *Educating the Net Generation*, 1-20 Parry, E., & Urwin, P.J. (2011). Generational differences in

work values: a review of theory and evidence. International Journal of Management Reviews. 13(1), 79-96. Doi:10.1111/j.1468-2370.2010.00285.x

Oculus Rift (n.d.) Desktop application for PC. Available: https://www.oculus.com

OECD. (2014). The Future of Education and Skills: Education 2030: The future we want. *OECD Education Working Papers*, 23. Retrieved from http://www.oecd.org/education/2030/E2030 Position Paper (05.04.2018).pdf

Osma-Ruiz, V. J., Sáenz-Lechon, N., Gutiérrez-Arriola, J. M., Argüelles-Álvarez, I., Fraile, R., & Marcano-Ganzo, R. (2015). Learning English is fun! Increasing motivation through video games. *Iceri2015*, 10. https://oa.upm.es/44606/1/INVE_MEM_2015_241732.pdf

Ouchaouka, L., Omari, K., Talbi, M., Moussetad, M., El Amrani, N., & Labriji, L. (2020). Flipped classroom and serious games as a new learning model in experimental sciences at the university. In *Advances in Intelligent Systems and Computing* (Vol. 1134 AISC, pp. 731–739).Springer. doi:10.1007/978-3-030-40274-7_69

Padlet (n.d.) Collaboration tool. Available: https://padlet.com/

Paivio, A. (1965). Abstractness, imagery, and meaningfulness in paired-associate learning. *Journal of Verbal Learning and Verbal Behavior*, *4*(1), 32–38. https://doi.org/10.1016/S0022-5371(65)80064-0

Paivio, A. (1971). *Imagery and verbal processes.* New York: Holt, Rinehart, and Winston.

Paivio, A. (1978). *The relationship between verbal and perceptual codes.* In E. C. Carterette & M. P. Friedman (Eds.), Handbook of perception. Vol. IX: Perceptual processing, 113– 131. New York: Academic Press.

Paivio, A. (1986). *Mental representations: A dual coding approach.* New York: Oxford University press.

Paivio, A., & Lambert, W. (1981). Dual coding and bilingual memory. *Journal of Verbal Learning and Verbal Behavior*, *20*(5), 532–539. https://doi.org/10.1016/S0022-5371(81)90156-0

Papin, K., & Kaplan-Rakowski, R. (2022). A study of vocabulary learning using annotated 360° pictures. Computer Assisted Language Learning, 1–28. https://doi.org/10.1080/09588221.2022.2068613

Parmaxi, A. (2020). Virtual reality in language learning: a systematic review and implications for research and practice. *Interactive Learning Environments.* https://doi.org/10.1080/10494820.2020.1765392

Parmaxi, A., & Demetriou, A. A. (2020, December 1). Augmented reality in language learning: A state-of-the-art review of 2014–2019. *Journal of Computer Assisted Learning.* Blackwell Publishing Ltd. https://doi.org/10.1111/jcal.12486

Paulsen, M. (1993). The hexagon of cooperative freedom: A distance education theory attuned to computer conferencing. *DEOS News*, *3*, 1–9. Retrieved from http://nettskolen.nki.no/forskning/21/hexagon.html

Pearltrees (n.d.) Content management system. Available: https://www.pearltrees.com/

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302

Pegler, K., Kollewyn, J. & Crichton, S. (2010). Generational attitudes and teacher ICT use, *Journal of Technology and Teacher Education, 18*(3), 443-458

Penuel, W. R. (2017). Research–practice partnerships as a strategy for promoting equitable science teaching and learning through leveraging everyday science. *Science Education, 101*(4), 520–525.

Pereira, J. (2013). Video Game Meets Literature: Language Learning with Interactive Fiction. *E-Teals: An e-Journal of Teacher Education & Applied Language Studies*, *4*(4), 19–45

Pettersson, F., & Olofsson, A. D. (2019). Learning to Teach in a Remote School Context: Exploring the Organisation of Teachers' Professional Development of Digital Competence Through Networked Learning. doi:10.1007/978-3-030-18030-0_10

Pokemon Go (n.d.) Location-based game for mobile devices. https://www.pokemongo.com

Popplet (n.d.) Former Popplet and current ClickUp. Project management software. Available: https://clickup.com/compare

Prensky M (2001a) Digital natives, digital immigrants. *On the Horizon 9*(5): 1–6.

Prensky, M. (2001). *Digital game-based learning*. McGraw-Hill.

Prensky, M. (2001b). Digital Natives, Digital Immigrants Part 2: Do They Really Think Differently? *On the Horizon*, *9*(6), 1–6. https://doi.org/10.1108/10748120110424843

Prensky, M. (2003). Digital Game-based Learning Prensky. *Games2train*, *1*(1), 1–4.

Prensky, M., & Gonzalez Calatayud, V. (2018). Entrevista a Marc Prensky. *Revista Interuniversitaria de Investigación En Tecnología Educativa*, 12–21. https://doi.org/10.6018/riite/2018/354791

Pressley, G. M., Levin, J. R., & Delaney, H. D. (1982). The mnemonic keyword method. *Review of Educational Research, 52*, 61–91. Retrieved June 23, 2019 from: http://dx.doi .org/10.3102/00346543052001061

Prieto Martín, A. (2017). *Flipped learning. Aplicar el modelo de aprendizaje inverso*. Madrid: Narcea

Putnam, A. L. (2015). Mnemonics in education: Current research and applications. Translational Issues in *Psychological Science, 1*(2), 130–139. https://doi.org/10.1037/tps0000023

Quick, Draw! (n.d.). *Doodles processing to text.* Available: https://quickdraw.withgoogle.com/data

Quiver (n.d.) Education dashboard. Available: https://quivervision.com/

Quiz It: Multiple Choice Game (n.d.) Former Quiz It: Multiple Choice Game and current Quizizz. Platform to make gamified quizzes, lessons and presentations. https://quizizz.com/admin/quiz/56f036fd4e5bedee162e7104/multiple-choice

Quiz Maker Offline (n.d.) Available: https://www.9apps.com/android-apps/Simple-Quiz-Maker/

Quizlet (n.d.) Learning tool to make digital flashcard and practice tests. Available: http://www.quizlet.com/

Qureshi, A., Rizvi, F., Syed, A., Shahid, A., & Manzoor, H. (2015). The method of loci as a mnemonic device to facilitate learning in endocrinology leads to improvement in student performance as measured by assessments. *Advances in Physiology Education, 38*(2), 140–144. https://doi.org/10.1152/advan.00092.2013

Race, E., Palombo, D. J., Cadden, M., Burke, K., & Verfaellie, M. (2015). Memory integration in amnesia: Prior knowledge supports verbal short-term memory.

Neuropsychologia, *70*, 272–280.Retrieved May 23, 2020 from: https://doi.org/10.1016/j.neuropsychologia.2015.02.004.

Rakes, G. C., & Casey, H. B. (2002). An analysis of teacher concerns toward instructional technology. *International Journal of Educational Technology*, *3*(1).

Random Word Generator (n.d.) Create a list of random words. Available: https://randomwordgenerator.com/

Rasche, P., Schlomann, A., & Mertens, A. (2017). Who Is Still Playing Pokémon Go? A Web-Based Survey. *JMIR serious games,* 5(2), e7. Doi:10.2196/games.7197

Rawendy, D., Ying, Y., Arifin, Y., & Rosalin, K. (2017). Design and Development Game Chinese Language Learning with Gamification and Using Mnemonic Method. In *Procedia Computer Science* (Vol. 116, pp. 61–67). Elsevier B.V. https://doi.org/10.1016/j.procs.2017.10.009

Real Decreto 1041/2017, de 22 de diciembre, por el que se fijan las exigencias mínimas del nivel básico a efectos de certificación, se establece el currículo básico de los niveles Intermedio B1, Intermedio B2, Avanzado C1, y Avanzado C2, de las Enseñanzas de idiomas de régimen especial reguladas por la Ley Orgánica 2/2006, de 3 de mayo, de Educación, y se establecen las equivalencias entre las Enseñanzas de idiomas de régimen especial reguladas en diversos planes de estudios y las de este real decreto. BOE, 24 de diciembre de 2017, núm. 311, p. 3-64. Referencia: BOE-A-2017-153678] Spain.

Reed, D. J., & Beveridge, M. (1986). Effect of text illustration on children's learning of a school science topic. *British Journal of Educational Psychology, 56,* 294-303.

Reggente, N., Essoe, J.K., Baek, H.Y. et al. (2020). The Method of Loci in Virtual Reality: Explicit Binding of Objects to Spatial Contexts Enhances Subsequent Memory Recall. *J Cogn Enhanc 4*, 12–30 https://doi.org/10.1007/s41465-019-00141-8

Rickes, P. C. (2016). Generations in flux: How Gen Z will continue to transform higher education space. *Planning for Higher Education, 44*(4), 21. www.scup.org/phe

Robertson, D. (2009). The Games in Schools - Community of Practice. European Schoolnet.

Roediger, H. L. (1980). The effectiveness of four mnemonics in ordering recall. *Journal of Experimental Psychology: Human Learning and Memory, 6*(5), 558–567. https://doi.org/10.1037/0278-7393.6.5.558

Rogler, L.H. (2002). Historical generations and psychology: The case of the Great Depression and World War II. *American Psychologist, 57*(12), 1013-1023

Romero, D., Molina, A., & Chirino, V. (2010, November). Editorial especial aprendizaje móvil: Tendencias, cuestiones y retos. *Revista Iberoamericana de Tecnologias Del Aprendizaje*.

Ruiz-Ariza, A., Casuso, R. A., Suarez-Manzano, S., & Martínez-López, E. J. (2018). Effect of augmented reality game Pokémon GO on cognitive performance and emotional intelligence in adolescent young. *Computers and Education*, *116*, 49–63. https://doi.org/10.1016/j.compedu.2017.09.002

Rüth, M., & Kaspar, K. (2021). Commercial Video Games in School Teaching: Two Mixed Methods Case Studies on Students' Reflection Processes. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.594013

Ryan, M. L. (2003). Narrative as virtual reality: Immersion and interactivity in literature and electronic media. Baltimore, MD, USA: The Johns Hopkins University Press.

Sadoski, M., & Paivio, A. (2001). *Imagery and text: A dual coding theory of reading and writing.* Mahwah, NJ: Lawrence Erlbaum Associates.

Saegesser, F. (1991). *Los juegos de simulación en la escuela.* Madrid: Editorial Visor Distribuciones S. A., pp. 5-14

Salmi, H., Sotiriou, S., & Bogner, F. (2009). Visualising the invisible in science centres and science museums: Augmented reality (AR) technology application and science teaching. In *Web-Based Learning Solutions for Communities of Practice: Developing Virtual Environments for Social and Pedagogical Advancement* (pp. 185-208). IGI Global. https://doi.org/10.4018/978-1-60566-711-9.ch014

Sandeen, C. (2008). Boomers, Xers, and Millennials: Who are They and What Do They Really Want from Continuing Higher Education? Continuing Higher Education Review, 72, 11-31. Retrieved from http://files.eric.ed.gov/fulltext/EJ903434.pdf

Sanosi, A. B. (2018). The effect of Quizlet on vocabulary acquisition. *Asian Journal of Education and e-Learning, 6*(4), 71-77

Santos, M. E. C., Chen, A., Taketomi, T., Yamamoto, G., Miyazaki, J., & Kato, H. (2014). Augmented reality learning experiences: Survey of prototype design and evaluation. *IEEE Transactions on Learning Technologies, 7*, 38-56.

Santos, M. E. C., Lubke, A. W., Taketomi, T., Yamamoto, G., Rodrigo, M. M. T., Sandor, C., & Kato, H. (2016). Augmented reality as multimedia: The case for situated vocabulary learning. *Research and Practice in Technology Enhanced Learning, 11*(4).

Sawyer, B (2002). Serious Games: Improving Public Policy Through Game-based Learning and Simulation. Woodrow Wilson International Center for Scholars.

Sawyer, B., & Rejeski, D. (2002). Serious Games: Improving Public Policy Through Game-based Learning and Simulation. Woodrow Wilson International Center for Scholars

Schell, J. (2019). The art of game design: A book of lenses (3rd ed.). CRC Press. doi:10.1201/b22101

Schewe, C. D., & Meredith, G. (1994). The power of cohorts. *American Demographics,16*(22)

Schmitt, N. (2008). Review article: Instructed second language vocabulary learning. *Language Teaching Research, 12*, 329–363. https://doi.org/10.1177/1362168808089921

Schmitt, N., & Schmitt, D. (2014, October 17). A reassessment of frequency and vocabulary size in L2 vocabulary teaching. *Language Teaching*. Cambridge University Press. https://doi.org/10.1017/S0261444812000018

Scribbling Speech (n.d.). *Turn real time free speech into animated drawings.* Available: https://experiments.withgoogle.com/scribbling-speech

Selwyn N, Bullon K (2000) Primary school children's use of ICT. *British Journal of Educational Technology 31*(4): 321–332

Shang, H., Sivaparthipan, C. B., & ThanjaiVadivel. (2022). Interactive teaching using human-machine interaction for higher education systems. *Computers and Electrical Engineering*, *100*. https://doi.org/10.1016/j.compeleceng.2022.107811

Sharples, M., Taylor, J., & Vavoula, G. (2007) A Theory of Learning for the Mobile Age. In R. Andrews and C. Haythornthwaite (eds.) The Sage Handbook of Elearning Research. London: Sage, pp. 221-4

Sheldon, S., & El-Asmar, N. (2018). The cognitive tools that support mentally constructing event and scene representations. *Memory*, *26*(6), 858–868. https://doi.org/10.1080/09658211.2017.1417440

Shepard, R. N. (1978). The mental image. *American Psychologist, 33*(2), 125–137. https://doi.org/10.1037/0003-066X.33.2.125

Shield, L., & Kukulska-Hulme, A. (2008). Editorial *ReCALL, 20*(3), 249-252. doi:10.1017/S095834400800013X

Shliakhovchuk, E. (2018) Using video games in intercultural, diversity and inclusive education, in *ICERI2018 Proceedings* (IATED), Seville, Spain, vol. 1, pp. 10326–10336

Silva, F. G. M. (2020). Practical methodology for the design of educational serious games. *Information (Switzerland)*, *11*(1), 14. Advance online publication. doi:10.3390/info11010014

Siriborvornratanakul, T. (2018). Enhancing User Experiences of Mobile-Based Augmented Reality via Spatial Augmented Reality: Designs and Architectures of Projector-Camera Devices. *Advances in Multimedia, article ID 8194726.* Retrieved June 12, 2019 from: https://doi.org/10.1155/2018/8194726.

Sistema de Formación Para el Empleo (2020): *Fundación Estatal para la Formación en el Empleo (FUNDAE)*. [en línea], disponible en https://www.fundae.es/formacion

Skiba, D. J., & Barton, A. J. (2006). Adapting your teaching to accommodate the net generation of learners. *Online Journal of Issues in Nursing*. American Nurses Association

Sky Map (n.d.) Interactive sky chart. Available: https://apps.apple.com/us/app/classic-sky-map-2/id1137455038?l=es

Smith, E. E., Kahlke, R., & Judd, T. (2020). Not just digital natives: Integrating technologies in professional education contexts. *Australasian Journal of Educational Technology*, 1–14. https://doi.org/10.14742/ajet.5689

Solso, R. L. (1995). *Cognitive Psychology* (4th Ed.). Boston: Allyn and Bacon.

Squire, K. (2003). Video Games in Education. International Journal of Intelligent Simulations and Gaming. *International Journal of Intelligent Simulations and Gaming*, *2*(1), 49–62

Squire, K. (2005). Game-based learning: An X-learn perspective paper. *MASIE Center: E-Learning Consortium*

Staalduinen, J.-P., & de Freitas, S. (2011). A Game-based Learning Framework: Linking Game Design and Learning Outcomes. In M. S. Khine (Ed.), *Learning to Play: Exploring the Future of Education with VIdeo Games* (pp. 29–54). Peter Lang

Stake, R.(1994). Case studies, in Norman Denzin and Yvonna Lincoln (eds.): *Handbook of qualitative research*. Washington: Sage Publications, 236–247

Star Walk (n.d.) Real-time interactive sky map on screen. Available: https://starwalk.space/en

Stengel, E. (1971). Image Formation and Cognition. By Mardi J. Horowitz. Butterworths. 1970. Pp. 351. Price £5.80. *British Journal of Psychiatry, 119*(552), 573–573. https://doi.org/10.1192/bjp.119.552.573-a

Strauss, W., & Howe, N. (1991). Generations: the history of America's future, 1584 to Tapscott, D. (1999). Growing up digital: The rise of the net generation. NASSP *Bulletin, 83*(607), 86-88. https://doi.org/10.1177/019263659908360714206 9. New York: William Morrow and Company Inc

Sung, H. Y., Hwang, G. J., & Chang, Y. C. (2016). Development of a mobile learning system based on a collaborative problem-posing strategy. *Interactive Learning Environments, 24*(3), 456 - 471.

Super Mario World (n.d.) Two-dimensional, side-scrolling platform game. Available: https://www.miniplay.com/game/super-mario-world-online

Sutherland I. E. (1968). A head-mounted three-dimensional display, in *Proceedings of the December 9-11, 1968,* Fall Joint Computer Conference, Part I, (ACM), 757–764. 10.1145/1476589.1476686

Tai, T. Y., & Chen, H. H. J. (2021). The Impact of Immersive Virtual Reality on EFL Learners' Listening Comprehension. *Journal of Educational Computing Research*, *59*(7), 1272–1293. doi:10.1177/0735633121994291

Theodosiou, S., & Karasavvidis, I. (2015, September 1). Serious games design: A mapping of the problems novice game designers experience in designing games. *Journal of E-Learning and Knowledge Society.* 10.20368/1971-8829/1071

Thomas, M. (2011). Editorial: Digital games and second language acquisition in Asia. *Digital Culture & Education*, *3*(1), 1–3

Thompson, V. A., & Paivio, A. (1994). Memory for pictures and sounds: independence of auditory and visual codes. *Canadian Journal of Experimental Psychology = Revue Canadienne de Psychologie Expérimentale*, *48*(3), 380–398. https://doi.org/10.1037/1196-1961.48.3.380

Tversky, B. (1969). Pictorial and verbal encoding in a short-term memory task. *Perception & Psychophysics, 6*(4), 225–233. https://doi.org/10.3758/BF03207022

Tzima, S., Styliaras, G., & Bassounas, A. (2019) Augmented Reality Applications in Education: Teachers Point of View. *Education Sciences, 9*(2). Retrieved June 10, 2019 from: https://doi.org/10.3390/educsci9020099

UNESCO (2014): *UNESCO Education Strategy 2014-2021*. [en línea], disponible en https://unesdoc.unesco.org/ark:/48223/pf0000231288

Unreal Engine 4 (n.d.) Video game creation tool. Available: https://www.unrealengine.com

Valimont, R. B., Gangadharan, S. N., Vincenzi, D. A., & Majoros, A. E. (2007). The Effectiveness of Augmented Reality as a Facilitator of Information Acquisition in Aviation Maintenance Applications. *Journal of Aviation/Aerospace Education & Research, 16*(2).

Valverde Berrocoso, J. (2010). The Learning of History and Educational Simulation. *Tejuelo: Didáctica de La Lengua y La Literatura. Educación*, *9*(9), 83–99

Vazquez, C., Xia, L., Aikawa, T., & Maes, P. (2018). Words in motion: Kinesthetic language learning in virtual reality. In *Proceedings - IEEE 18th International Conference on Advanced Learning Technologies, ICALT 2018* (pp. 272–276). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICALT.2018.00069

Vindenes, J., de Gortari, A. O., & Wasson, B. (2018). Mnemosyne: Adapting the method of loci to immersive virtual reality. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 10850 LNCS, pp. 205–213). Springer Verlag. https://doi.org/10.1007/978-3-319-95270-3_16

Vocabulary AR (n.d.) Vocabulary teaching with augmented reality. Available: https://apps.apple.com/us/app/vocabulary-ar/id1597643859

Voorveld, H. A., & van der Goot, M. (2013). Age differences in media multitasking. A diary study. *Journal of Broadcasting & Electronic Media, 57*(3), 392-408. doi:10.1080/08838151.2013.816709

Vygotsky, L. (1978). *Mind in society*. Harvard University Press

Walker, Z., McMahon, D. M., Rosenblatt, K., & Arner, T. (2017). Beyond Pokémon: Augmented Reality Is a Universal Design for Learning Tool. *SAGE Open* 7(4):215824401773781

Wang, L. H., Chen, B., Hwang, G. J., Guan, J. Q., & Wang, Y. Q. (2022, December 1). Effects of digital game-based STEM education on students' learning achievement: a meta-analysis. *International Journal of STEM Education*. Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1186/s40594-022-00344-0

Wang, Z., & Han, F. (2021). Developing English language learners' oral production with a digital game-based mobile application. *PLoS ONE*, *16*(1 January). https://doi.org/10.1371/journal.pone.0232671

Warschauer, M. (2002). A developmental perspective on technology in language education. *TESOL Quarterly*, *36*(3), 453–475. doi:10.2307/3588421

Warschauer, M. (2008). Whither the digital divide? In D. L. Kleinman, K. A. Cloud-Hansen, C. Matta, & J. Handesman (Eds.), *Controversies in science and technology: From chromosomes to cosmos* (pp. 140–151). Liebert

Wharton, W. P. (1980). High-imagery words and the readability of college history texts, *Journal of Mental Imagery, 4*, 129-14 7.

Wharton, W. P. (1988). Imagery and the Comprehension of College History Texts: Free Response Measure. *Imagination, Cognition and Personality*, *7*(4), 323–333. https://doi.org/10.2190/cy49-cclu-eyn9-nhnm

White, K., Sheehan, P. W., & Ashton, R. (1977). Imagery assessment: A survey of self-report measures. *Journal of Mental Imagery, 1*(1), 145–169.

Williamson, B. (2022). Review of Gee's 'What Videogames Can Teach us About Learning and Literacy'. Retrieved from www.futurelab.org.uk/research/book_reviews.htm

Winn, B. M. (2011). The Design, Play, and Experience Framework. In *Handbook of Research on Effective Electronic Gaming in Education* (pp. 1010–1024). IGI Global. doi:10.4018/978-1-59904-808-6.ch058

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments, 7*(3), 225–240. https://doi.org/10.1162/105474698565686

Wong, M. C., Turner, P., Macintyre, K. & Yee, K. C. (2017). Pokémon-Go: Why Augmented Reality Games Offer Insights for Enhancing Public Health Interventions on Obesity-Related Diseases. *Studies in Health Technology and Informatics, 241,* 128-133

WordPress (n.d.) Content management system. Available: https://wordpress.com/es/

Worthen, J. B., & Hunt, R. R. (2011). *Mnemonology: Mnemonics for the 21st century*. New York, NY: Taylor & Francis.

Yacuzzi, E. (2005). El Estudio de Caso como Metodología de Investigación: Teoría, Mecanismos Causales, Validación. *Universidad Del CEMA*, 1–37. https://doi.org/Article

Yamani, H. A. (2021). A Conceptual Framework for Integrating Gamification in eLearning Systems Based on Instructional Design Model. *International Journal of Emerging Technologies in Learning (iJET), 16*(04), pp. 14–33. https://doi.org/10.3991/ijet.v16i04.15693

Yang, C. L., Perfetti, C. A., Tan, L. H., & Jiang, Y. (2018). ERP indicators of L2 proficiency in word-to-text integration processes. *Neuropsychologia, 117*, 287–301. https://doi.org/10.1016/j.neuropsychologia.2018.06.001

Yang, F., Qian, J., Novotny, J., Badre, D., Jackson, C. D., & Laidlaw, D. H. (2020). A virtual reality memory palace variant aids knowledge retrieval from scholarly articles. *IEEE Transactions on Visualization and Computer Graphics, 27*(12), 4359-4373.

Yates, F. A. (1966). *The art of memory.* London: Routledge & Kegan Paul.

Yates, F. A. (1999). *The art of memory.* New York: Routledge.

Yates, F. A. (2013). Selected works: Volume III: Art of memory. Selected Works: Volume III: Art of Memory (Vol. 2, pp. 1–400). Taylor and Francis. https://doi.org/10.4324/9781315010960

Ye, L., Recker, M., Walker, A., Leary, H., & Yuan, M. (2015). Expanding approaches for understanding impact: Integrating technology, curriculum, and open educational resources in science education. Educational Technology Research and Development, 63(3), 355–380.

Zhan, T., Yin, K., Xiong, J., He, Z., & Wu, S. T. (2020, August 21). Augmented Reality and Virtual Reality Displays: Perspectives and Challenges. *IScience.* Elsevier Inc. https://doi.org/10.1016/j.isci.2020.101397

Zhang, S., Xia, Z., Wang, T., Williams, B. K., Szaro, R. C., Shapiro, C. D., & Ross, L. et al. (2013). Serious games: Improving public policy through game-based learning and simulation. *Environmental Modelling & Software*, *39*(1), 70–76

Zhonggen, Y. (2019). A Meta-Analysis of Use of Serious Games in Education over a Decade. *International Journal of Computer Games Technology.* Hindawi Limited. https://doi.org/10.1155/2019/4797032

Zhou, F., Duh, H. B. L. & Billinghurst, M. (2008). Trends in augmented reality tracking, interaction and display: A review of ten years of ISMAR. *IEEE International Symposium on Mixed and Augmented Reality, 15-18.* Cambridge, UK.

Zooburst (n.d.) AR program to create 3D pop-up books. Available: http://www.zooburst.com

Zou, D., Huang, Y., & Xie, H. (2021). Digital game-based vocabulary learning: where are we and where are we going? In *Computer Assisted Language Learning*. Routledge. doi:10.1080/09588221.2019.1640745

APPENDICES

Appendix 1: Records included in the review (n=12)

Author	L1	L2	Language domain	Technology	Country of study
(Lee et al., 2019)	NA	English	Vocabulary acquisition	AR	Hong Kong
(Chew et al., 2018)	Mandarin Chinese	English	Vocabulary acquisition (idioms)	AR	Taiwan
(Ibrahim et al., 2018).	Multiple but most were proficient in English	Basque	Vocabulary acquisition, recognition and retention	AR	USA
(Nurkhamimi Zainuddin et al., 2018)	Not specified but most likely Malay	Arabic	Vocabulary acquisition satisfaction with the technology	AR	Malaysia
(Papin & Kaplan-Rakowski, 2022).	Multiple but proficient in English	French	Vocabulary acquisition	VR	Canada
(Lai & Chen, 2021)	Mandarin Chinese	English	Vocabulary acquisition	VR	China
(Li et al., 2022)	Chinese	English	Vocabulary acquisition for geography	VR	China
(Nicolaidou et al., 2021)	Greek	Italian	Vocabulary acquisition Engagement and immersion	VR	Cyprus
(Fuhrman et al., 2021)	Hebrew	Finnish	Vocabulary acquisition	VR	Israel
(Alfadil, 2020)	Arabic	English	Vocabulary acquisition	VR	Saudi Arabia
(Hagström & Winman, 2018)	Swedish	German	Grammar learning+ vocabulary acquisition	VR	Sweden
(Legault et al., 2019)	English	Chinese	Vocabulary acquisition	VR	USA

Appendix 2: Idioms in Q41, Q38, Q45, Q80, Q95, Q50, Q54, Q63, Q90, Q35 selected for the trial as the least known vocabulary out of a 100-itemed test

Q41. Match the beginning of the idiom with its ending: be panic

	Frequency	%	Valid %	Cumulative %
limb	7	11.3	11.3	11.3
alone	19	30.6	30.6	41.9
escape	15	24.2	24.2	66.1
stations	3	4.8	4.8	71.0
astray	4	6.5	6.5	77.4
napping	8	12.9	12.9	90.3
teeth	6	9.7	9.7	100.0
Total	100.0	100.0		

Q38. Match the beginning of the idiom with its ending: be led

	Frequency	%	Valid %	Cumulative %
limb	6	9.7	9.7	9.7
alone	23	37.1	37.1	46.8
escape	5	8.1	8.1	54.8
stations	12	19.4	19.4	74.2
astray	6	9.7	9.7	83.9
napping	5	8.1	8.1	91.9
teeth	5	8.1	8.1	100.0
Total	62	100.0	100.0	

Q45. Choose the correct definition for the idiom: be toffee-nosed

	Frequency	%	Valid %	Cumulative %

make an attempt	9	14.5	14.5	14.5
be difficult or tiresome	19	30.6	30.6	45.2
do your fair share	8	12.9	12.9	58.1
do something without enthusiasm or effort	9	14.5	14.5	72.6
make a lot of effort	7	11.3	11.3	83.9
be very easy to do	4	6.5	6.5	90.3
to look down on people	6	9.7	9.7	100.0
Total	62	100.0	100.0	

Q80. Choose the correct definition for the idiom: be under someone´s feet

	Frequency	**%**	**Valid %**	**Cumulative %**
be very busy	12	19.4	19.4	19.4
start off in a bad way	7	11.3	11.3	30.6
feel familiar with something	8	12.9	12.9	43.5
regret a decision	14	22.6	22.6	66.1
remain connected to the real world	7	11.3	11.3	77.4
be constantly in the way	6	9.7	9.7	87.1
be lucky/ successful	8	12.9	12.9	100.0
Total	62	100.0	100.0	

Q95. Match the idiom with the situation: within living memory

	Frequency	**%**	**Valid %**	**Cumulative %**
someone shows you a car which is driven by solar energy	6	9.7	9.7	9.7
you tell someone about a very ancient tradition	22	35.5	35.5	45.2
a scientist claims to be on the point	14	22.6	22.6	67.7

discovering a cure from cancer				
someone asks you if you like an english course after only one day	4	6.5	6.5	74.2
someone is spending all their savings carelessly	6	9.7	9.7	83.9
never, for as long as anyone can remember, has there been so much rain	7	11.3	11.3	95.2
someone tells you this before stating a very important idea or fact	3	4.8	4.8	100.0
Total	62	100.0	100.0	

Q50. Choose the correct definition for the idiom: have a bash

	Frequency	**%**	**Valid %**	**Cumulative %**
make an attempt	7	11.3	11.3	11.3
be difficult or tiresome to do	3	4.8	4.8	16.1
do your fair share	9	14.5	14.5	30.6
do something without enthusiasm or effort	10	16.1	16.1	46.8
make a lot of effort	10	16.1	16.1	62.9
be very easy to do	10	16.1	16.1	79.0
to look down on people	13	21.0	21.0	100.0
Total	62	100.0	100.0	

Q54. Choose the correct definition for the idiom: on hold

	Frequency	**%**	**Valid %**	**Cumulative %**
be very busy	9	14.5	14.5	14.5
make an effort	4	6.5	6.5	21.0

promising	18	29.0	29.0	50.0
hidden	9	14.5	14.5	64.5
unofficially	2	3.2	3.2	67.7
delayed	9	14.5	14.5	82.3
without prospects	11	17.7	17.7	100.0
Total	62	100.0	100.0	

Q63. Match the beginning of the idiom with its ending: The film is about two men on

	Frequency	**%**	**Valid %**	**Cumulative %**
a joke	8	12.9	12.9	12.9
step	5	8.1	8.1	21.0
the run	9	14.5	14.5	35.5
fever pitch	10	16.1	16.1	51.6
the spot	7	11.3	11.3	62.9
a flying start	14	22.6	22.6	85.5
leaps and bounds	9	14.5	14.5	100.0
Total	62	100.0	100.0	

Q90. Match the beginning of the sentence with its ending: He tries not to think about it, but it´s always

	Frequency	**%**	**Valid %**	**Cumulative %**
his mind at rest	7	11.3	11.3	11.3
at the back of his mind	20	32.3	32.3	43.5
pick his brains	4	6.5	6.5	50.0
in his mind´s eye	12	19.4	19.4	69.4

getting blood out of a stone	6	9.7	9.7	79.0
his guts out	2	3.2	3.2	82.3
on the brain	11	17.7	17.7	100.0
Total	62	100.0	100.0	

Q35. Match the beginning of the idiom with its ending: won´t give a(n)

	Frequency	**%**	**Valid %**	**Cumulative %**
nutshell	1	1.6	1.6	1.6
coin	5	8.1	8.1	9.7
inch*	16	25.8	25.8	35.5
circle	4	6.5	6.5	41.9
knots	4	6.5	6.5	48.4
test	3	4.8	4.8	53.2
account	29	46.8	46.8	100.0
Total	62	100.0	100.0	

* The students did not actively demonstrate their knowledge of the indicated idiom at the moment of being asking to translate it or to explain the set expression during the classroom-based session. However, the diagnostic-test design contained the possibility of choosing the right option by applying the grammar rule of "an before vowel sounds" (e.g. match the beginning of the idiom to its ending: won´t give an – nutshell/coin/inch/circle/knots/test/account). The idiom was included in the list of the ten least-known vocabulary items).

Appendix 3: Quantified data for student survey

	Frequency	**%**	**Cumulative %**
Q1: Could you please indicate your gender?			
Male	28	45.2	45.2
Female	34	54.8	100.0
Total	62	100.0	
Q2: What is your native (first) language?			

Spanish	46	74.2	74.2
Valencian	15	24.2	98.4
Other	1	1.6	100.0
Total	62	1.0	
Q3: What are your learning objectives related to English?			
To fulfil department requirements	23	37.1	37.1
To pass official examinations	33	53.2	53.2
To get employed in a specific multinational company	15	24.2	24.2
To improve employment possibilities in general	45	72.6	72.6
To communicate with family and friends	2	3.2	3.2
To go on an internship abroad	11	17.7	17.7
A possibility of a job abroad	12	19.4	19.4
I enjoy studying languages	12	19.4	19.4
Total	62		
Q4: Which of these do you use to memorise vocabulary?			
Vocabulary notebooks	38	61.3	61.3
Looking at words within periods of time	14	22.6	22.6
Reading	31	50.0	50.0
Using new words	5	8.1	8.1
Word games (puzzles, crosswords, word searches	14	22.6	22.6

etc)			
Paper flashcards	6	9.7	9.7
Digital flashcards	3	4.8	4.8
Other	4	6.5	6.5
Total	62		
Q5: How often do you use flashcards to memorise new vocabulary?			
Never	19	30.6	30.6
Almost never	20	32.3	62.9
Sometimes	21	33.9	96.8
Often	2	3.2	100.0
Very often	0	0	100.0
Total	62		
Q6: How often do you use software apps for vocabulary memorisation?			
Never	48	77.4	77.4
Almost never	9	14.5	91.9
Sometimes	4	6.5	98.4
Often	1	1.6	100.0
Very often	0	0.0	100.0
Total	62		
Q7: How often do you use augmented reality on digital devices?			
Never	36	58.1	58.1
Almost never	14	22.6	80.6
Sometimes	8	12.9	93.5
Often	1	1.6	95.2
Very often	3	4.8	100.0
Total	62	100.0	
Q8: How often do you use bilingual dictionaries (with words translated into your native language)?			
Never	6	9.7	9.7
Almost never	6	9.7	19.4
Sometimes	21	33.9	53.2
Often	18	29.0	82.3
Very often	11	17.7	
Total	62		
Q9: How often do you use monolingual dictionaries (with words explained in the			

foreign language through synonyms, antonyms, examples etc.)?			
Never	11	17.7	17.7
Almost never	20	32.3	50.0
Sometimes	25	40.3	90.3
Often	5	8.1	98.4
Very often	1	1.6	100.0
Total	62		
Q10: What is your preferable way to perceive information?			
By seeing	36	58.1	58.1
By hearing	13	21.0	21.0
By doing	28	45.2	45.2

Appendix 4: Language, Birth Rates, Education, and Employment

Native language		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Spanish	54	75.0	75.0	75.0
	Valencian (local language in the Autonomous Community of Valencia)	18	25.0	25.0	100.0
	Total	72	100.0	100.0	
Birth rates		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Between 1965 and 1980	22	30.6	30.6	30.6
	Between 1981 and 1996	31	43.1	43.1	73.6
	Between 1995 and 2000	17	23.6	23.6	97.2
	Other	2	2.8	2.8	100.0
	Total	72	100.0	100.0	
Education		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal education	1	1.4	1.4	1.4
	High school	1	1.4	1.4	2.8
	Vocational	6	8.2	8.3	11.1

	training				
	Bachelor´s Degree	27	37.0	37.5	48.6
	Master´s Degree	32	43.8	44.4	93.1
	Doctorate / Ph. D.	5	6.8	6.9	100.0
	Total	72	98.6	100.0	
Employment		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Full time employment	37	51.4	51.4	51.4
	Other	1	1.4	1.4	52.8
	Part-time employment	11	15.3	15.3	68.1
	Retired	1	1.4	1.4	69.4
	Student	6	8.3	8.3	77.8
	Unemployed (looking for work)	14	19.4	19.4	97.2
	Unemployed (not looking for work)	2	2.8	2.8	100.0
	Total	72	100.0	100.0	

Appendix 5: EFL- related Data

English at School		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	8	11.1	11.1	11.1
	Yes	64	88.9	88.9	100.0
	Total	72	100.0	100.0	
English at University		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	22	30.6	30.6	30.6
	Yes	50	69.4	69.4	100.0
	Total	72	100.0	100.0	
Private tutor		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	26	36.1	36.1	36.1

	Yes	46	63.9	63.9	100.0
	Total	72	100.0	100.0	
Corporate training		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	53	73.6	73.6	73.6
	Yes	19	26.4	26.4	100.0
	Total	72	100.0	100.0	
English abroad		Frequency	Percent	Valid Percent	Cumulative Percent
	No	50	70.4	70.4	70.4
	Yes	21	29.6	29.6	100.0
	Total	71	100.0	100.0	
English abroad duration		Frequency	Percent	Valid Percent	Cumulative Percent
	< 1 month	14	66.7	66.7	66.7
	1-3months	2	9.5	9.5	76.2
	3-9 months	5	23.8	23.8	100.0
	Total	21	100.0	100.0	
Level of English		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Basic (A1)	1	1.4	1.4	1.4
	Elementary (A2)	0	0.0	0.0	1.4
	Pre-Intermediate (B1)	26	36.6	36.6	38.0
	Intermediate (B2)	27	38.0	38.0	76.1
	Advanced (C1)	12	16.9	16.9	93.0
	Proficiency (C2)	5	7.0	7.0	100.0
	Total	71	100.0	100.0	
English Certification		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	23	31.9	31.9	31.9
	Yes	49	68.1	68.1	100.0
	Total	72	100.0	100.0	
Certification type		Frequency	Percent	Valid Percent	Cumulative Percent

	ACLES / CertAcles	5	10.2	10.2	10.2
	Cambridge ESOL	11	22.4	22.4	32.7
	EOI	15	30.6	30.6	63.3
	IELTS	2	4.1	4.1	67.3
	Other	2	4.1	4.1	71.4
	TOEFL	3	6.1	6.1	77.6
	Trinity GESE	4	8.2	8.2	85.7
	Trinity ISE	7	14.3	14.3	100.0
	Total	49	100.0	100.0	
Studying English now		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	25	34.7	34.7	34.7
	Yes	47	65.3	65.3	100.0
	Total	72	100.0	100.0	
Mode of studying		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Corporate course at the workplace	2	2.8	2.8	2.8
	Course in a language school	22	30.6	30.6	33.3
	Informal learning	21	29.2	29.2	62.5
	Self-study courses	16	22.2	22.2	84.7
	Other	3	4.2	4.2	88.9
	With a private tutor	8	11.1	11.1	100.0
	Total	72	100.0	100.0	