# revista de

Nº 405 JULY-SEPTEMBER 2024









# N° 405 April-June 2024

Quarterly Journal Starting year: 1952



### MINISTRY OF EDUCATION, VOCATIONAL TRAINING AND SPORTS

SECRETARÍA DE ESTADO DE EDUCACIÓN

Instituto Nacional de Evaluación Educativa Paseo del Prado, 28, 4.ª planta 28014 Madrid España

Edita

© SECRETARÍA GENERAL TÉCNICA Subdirección General de Atención al Ciudadano, Documentación y Publicaciones

Catálogo de publicaciones del Ministerio: https://www.libreria.educacion.gob.es/ Catálogo general de publicaciones oficiales de la Administración General del Estado: https://cpage.mpr.gob.es/

Edición: 2024

NIPO pdf: 164-24-065-X

NIPO ibd: 164-24-064-4

NIPO html: 164-24-066-5

ISSN línea: 1988-592X

ISSN papel: 0034-8082

Depósito Legal: M-26966-2023

Cover Image: Annie Spratt in Unplash

Cover Design: Dinarte S.L.

Layout: Glaux Publicaciones Académicas S.L.U.

#### **BOARD OF DIRECTORS**

#### CHAIR

José Manuel Bar Cendón Secretario de Estado de Educación

Clara Sanz López Secretaria General de Formación Profesional

### **MEMBERS**

Santiago Antonio Roura Gómez Subsecretario de Educación, Formación Profesional y Deportes

Mónica Domínguez García Directora General de Evaluación y Cooperación Territorial

Carmen Tovar Sánchez Directora del Instituto Nacional de Evaluación Educativa

Clementa López Fernández Subdirectora General de Atención al Ciudadano, Documentación y Publicaciones

Francisco Javier Amaya Flores Subdirectora de Cooperación Territorial e Innovación Educativa

> Helena Ramos García Subdirector General de Ordenación Académica

#### **EDITORIAL BOARD**

#### DIRECTOR

Carmen Toyar Sánchez

#### **EDITOR IN CHIEF**

José Luis Gaviria Soto

#### **ASSISTANT EDITOR**

David Reyero García

#### **MEMBERS**

Antonio Cabrales Goitia (University College London); Caterina Casalmiglia (Universitat Autònoma de Barcelona); Antonio Lafuente García (Consejo Superior de Investigaciones Científicas); Leoncio López-Ocón Cabrera, (Consejo Superior de Investigaciones Científicas); Carlos Marcelo García (Universidad de Sevilla); Miquel Martínez Martín (Universitat de Barcelona); Francisco Michavila Pitarch; (Universidad Politécnica de Madrid); Juan Manuel Moreno Olmedilla (Banco Mundial); Clara Eugenia Núñez (Universidad Nacional de Educación a Distancia); Lucrecia Santibáñez (Claremont Graduate University); Denise Vaillant (Universidad ORT, Uruguay); Pablo Zoido (Banco Interamericano de Desarrollo).

#### **EDITORIAL TEAM**

Technical editors: Sabrina Gallego Verdi

Collaborator: Ruth Martín Escanilla and Alberto Díaz-Roncero Canales

#### **SCIENTIFIC ADVISERS**

#### International

Aaron Benavot (State University of New York, SUNY-Albany); Abdeljalilb Akkari (Universidad de Ginebra); Mark Bray (University of Hong Kong); José Joaquín Brunner (Universidad Diego Portales, Chile); Dirk Hastedt (Executive Director, International Association for the Evaluation of Educational Achievement, IEA); Andreas Schleicher (Director, Directorate for Education and Skills, OCDE).

#### National

Teresa Aguado Odina (Universidad Nacional de Educación a Distancia); Margarita Bartolomé (Universitat de Barcelona); Antonio Bolívar (Universidad de Granada); Josefina Cambra Giné (Colegio de Doctores y Licenciados); Anna Camps i Mundó (Universitat Autònoma de Barcelona); César Coll Salvador (Universitat de Barcelona); Agustín Dosil Maceira (Universidad LiberQuaré); Gerardo Echeita Sarrionandia (Universidad Autónoma de Madrid); Juan Manuel Escudero Muñoz (Universidad de Murcia); Mariano Fernández Enguita (Universidad Complutense de Madrid); Joaquín Gairín Sallán (Universitat Autònoma de Barcelona); José Luis García Garrido (Universidad Nacional de Educación a Distancia); Daniel Gil Pérez (Universitat. de València); Fuensanta Hernández Pina (Universidad de Murcia); Carmen Labrador Herraiz (Universidad Complutense de Madrid); Miguel López Melero (Universidad de Málaga); Elena Martín Ortega (Universidad Autónoma de Madrid); Rosario Martínez Arias (Universidad Complutense de Madrid); Inés Miret (Neturity S.L., Madrid); Juan Ignacio Pozo (Universidad Autónoma de Madrid); Joaquim Prats Cuevas (Universitat de Barcelona); Manuel de Puelles (Universidad Nacional de Educación a Distancia); Tomás Recio Muñiz (Universidad de Cantabria); Luis Rico Romero (Universidad de Granada); Juana M.ª Sancho Gil (Universitat de Barcelona); Mercedes Vico Monteoliva (Universidad de Málaga); Antonio Viñao Frago (Universidad de Murcia); Jesús García Laborda (Universidad de Alcalá)...

# Index

# **Editorial**

Manuel Jiménez López, Manuel Fernández Navas & Ana Yara Postigo Fuentes: Presentation: Gamification, videogames and eSports	1
Monographic section	
Alexandra Santamaría Urbieta & Sonsoles López-Pernas: Hint strategies in educational escape rooms: a process mining approach	13
LINDA CASTAÑEDA, SYLVESTER ARNAB, GEMMA TUR, FRIDE KLYKKEN, BARBARA WASSON, INMACULADA HABA-ORTUÑO, RUTH MALOSZEK & BARBARA DE BENITO-CROSETTI: Co-creating pedagogically informed games for data literacy.	37
Andrea Bueno-Baquero, Javier del Olmo-Muñoz, José Antonio González- Calero & Ramón Cózar-Guttérrez: Gamified approaches to computational thinking in teacher training	67
María Caridad Sierra-Daza, Marta Martín-del-Pozo & María Rosa Fernández-Sánchez: Videogames and learning in the university stage: a systematic review	97
Xavier García- Massó, Sergio Montalt-García & Luis-Millán González: Game-based learning in scientific literature: text mining analysis	127
ILUMINADA SÁNCHEZ-DOMÉNECH & BEATRIZ MARTÍN DEL CAMPO: Games and videogames for dyslexia rehabilitation: neurocognitive and psycholinguistic foundation	153
Jana María Gallardo Pérez, Iván Rivilla Arias, Amaia Ramírez Muñoz, Rosario Castro López, Bárbara San Juan Ferrer & Joel Manuel Prieto Andreu: Video games, educational implications	177
Jorge García Bastida, Guillermo Mendoza, Leandro Álvarez-Kurogi & Higinio González-García: Narrative review on factors related to health in video games and electronic sports	215

Laura Pérez Granados & Laura de la Concepción Muñoz Gonzái Gamification in education: challenges, potentialities and perspectiv for implementation	ves
Carmen Navarro-Mateos, Isaac José Pérez-López & Carmen Triguei Cervantes: Analysis of the teaching role in a gamification proposal the teacher's master's degree	in
RICARDO CASAÑ PITARCH: <i>The Engineer</i> : enhancing bachelor studer English technical engineering vocabulary proficiency with a serio video game	ous
Reviews	311



**Editorial** 

# Presentation Gamification, videogames and eSports

# Presentación Gamificación, videojuegos y eSports

### **Guest Editors**

# Manuel Jiménez López

https://orcid.org/0000-0002-5877-3482

Departamento de Didáctica de la Educación Física y Salud, Facultad de Educación, Universidad Internacional de La Rioja Cátedra de esports, Universidad de Málaga

### Manuel Fernández Navas

https://orcid.org/0000-0002-9445-2643
Departamento de Didáctica y Organización Escolar, Facultad de Educación, Universidad de Málaga
Cátedra de esports, Universidad de Málaga

# **Ana Yara Postigo Fuentes**

https://orcid.org/0000-0001-7965-1911 Institut für Romanistik, Heinrich-Heine Universität (University of Düsseldorf) Cátedra de esports, Universidad de Málaga

We would like to express our gratitude for the overwhelming amount of research work, academic reflections, and future directions submitted for this monograph. Due to space constraints, we had to select the papers with the greatest scientific impact, as determined by external reviewers, from over 40 submissions. The high quality of the manuscripts deserves special mention, and we are grateful for the trust and effort of the authors. This monograph will showcase the selected works and their contribution to the academic field. Recent research suggests that video games, often criticized for their supposed link to addiction and violence, do not directly correlate with aggressive behavior. This paper examines

how strategically incorporating video games into educational settings can serve as a powerful tool to facilitate learning and promote skills such as problem-solving, critical thinking, and cooperation.

# Video games, society, and verdicts

Video games have long been established as an integral part of popular culture. However, it contrasts the widespread social alarm and concern of many families with research findings that show a lack of direct correlation between video games and aggressive behaviours (Khün et al., 2019; Przybylski and Weinstein, 2019; Mathur and VanderWeele, 2019). Despite their popularity and recognition as the main entertainment industry in Spain, video games are often misinterpreted and stigmatized by society and the media. An issue that may have to do with what has been called by some "digital denialism" (Sánchez Vera and Adell, 2023).

This distance between established academic knowledge and social awareness makes us think of the words of Aguilera and Méndiz (2005, p.2):

To any dispassionate and rigorous observer, it must undoubtedly be curious - if not paradoxical - to contemplate the notable distance that in many of our societies exists between saying and doing in relation to different manifestations of popular culture - among others, made up of video games. Well, even though these manifestations represent a solid base on which various cultural practices that the vast majority of the population maintain on a daily basis are based, a good part of the scientific community, public authorities and members of other groups that show greater or lesser social leadership sustains a discourse that rejects these phenomena – when it does not disqualify them globally.

As we see, the debate about whether video games are good or bad is complex and cannot be resolved with a simple answer. However, technology is not neutral (all the more reason to educate about its use); like any other tool, video games' impact depends on how we use them.

The example of chess is revealing: if a boy or girl spends six hours playing chess, his or her family might feel proud and share it with others. However, if it were six hours playing video games, your parents would probably find it necessary to consult a psychologist. This

contrast highlights how the perception of what is good or bad, healthy or harmful, varies widely depending on the cultural perspective towards the activity in question. Both activities, playing chess or video games, can be considered equally healthy or problematic depending on how the social environment views them.

Another factor to consider is the shift in family dynamics and the challenges of balancing work and personal life. This has led to video games often becoming a solitary activity for children, with parents using this time for other tasks. It's crucial for parents to recognize the value of participating in and supervising their children's video game activities, just as they would with traditional games. While the industry has made efforts to promote video games as a family activity, this perspective is not yet widespread, perhaps awaiting the next generation of parents who have grown up with video games.

# Video games and education

The negative perception and prejudices about video games in society tend to ignore scientific evidence that does not demonize them but rather considers them as a modern evolution of traditional games driven by technological advancement. However, the central point we want to reach with this exhibition is related to formal education.

The experience that a young person has when playing video games clashes head-on with the structure and purpose of school classes, which in general can be described as colourless and unstimulating environments (Fernández Navas, 2015). The usefulness of the knowledge taught in these classrooms frequently does not transcend beyond what Pérez Gómez (2000) calls academic culture, putting them at a disadvantage compared to the attractive and vibrant world that video games offer.

Moreover, therefore, the closer we bring the classroom experience to this traditional way of living it where, as Santos Guerra (2001) explains to us, knowledge rarely has any use beyond serving to progress in school, what he calls "exchange value", the greater will be the shock of our students with the school reality and the more attractive will be the digital world in which they live outside of it. The ideal would be to promote the use of the value of knowledge as proposed from the vision of the curriculum that Wrigley (2017) calls Critical Realism.

This means that the more we turn classes into an environment without stimuli, without challenges, where knowledge is rarely useful beyond continuing to progress in school, the easier it will be for our boys and girls to feel attracted and dedicate more time to playing video games.

This has to do with what Aguilera and Méndiz (2005, pp. 3-4) propose:

In relation to the discourses that organize the meanings socially attributed to these technologies, several questions could still be raised. Among others, the public sphere of our societies does not pay due attention to some of the very important changes that young people go through and move through in their daily lives. Thus, as a consequence of this public inattention and abandonment, these types of experiences are rather confined to the private level, in which various industries linked to youth consumption have been able to detect many of the expectations and demands felt by consumers. Young people, as well as giving them a certain meaning - providing these segments of the population with consistent and coherent symbolic universes, supported above all by what can be called popular culture. Likewise, these discourses – which obey different logics - are spread throughout society as a whole and are assumed, to one extent or another, by its different members, among others, by its scientists -also participants in the "spirit of their time", as Edgar Morin would say-, who guide their work based on certain axiological, theoretical, and methodological assumptions.

Given these circumstances, we believe it is crucial to underscore the key factors that contribute to the negative view of video games in society, within many families, and even in educational institutions. This understanding is vital for initiating a shift in the perception of video games and their potential in education.

In the educational world, the idea predominates that learning involves reproducing information in order to memorize it. Schoolwork is fundamentally aimed at this: it focuses on students absorbing a large amount of content and then reciting it in a test.

This conception of education makes it difficult to consider video games as powerful tools for building knowledge since they do not follow a structured format of information, reproduction and verification of the fidelity of the reproduction of the initial information. Thus, video games tend to be seen more as forms of entertainment than as a means for learning and education (Quesada Bernaus and Tejedor Calvo, 2016).

Secondly, the interpretation of autonomy within the school environment takes a rather specific form. Although educational curricula and laws often emphasize the importance of autonomy in various modalities as a central element of education, the reality in classrooms frequently contradicts this principle. Generally, all students are expected to perform the same activities simultaneously and as uniformly as possible. It is rarely seen favourably that students engage in different tasks or learn at different rates or in different ways. The norm is that everyone follows the same educational itinerary in unison (Schmenk, 2010).

This situation causes video games to generate a perception of a lack of control over learning since each player can make decisions, follow paths and execute actions that completely differ from those of others.

A third factor that could be shaping the perception of video games in the educational field is what is known as school logic. According to Pérez Gómez (2000), this is related to "institutional culture", that is, the set of norms, meanings and procedures that have been developed and established within educational institutions over time. The prevalence of this school logic has an adverse effect in that any new tool or strategy introduced in the educational system, no matter how innovative, tends to be absorbed and adapted to existing practices and methodologies instead of causing a significant change in how knowledge is accessed and understood.

Finally, there is what we could call the generational problem. Most adults today, including family members and teachers, grew up in a time when video games were not common, causing many to view them as something strange and unknown. This lack of familiarity with video games as part of the culture (Aguilera and Méndiz, 2005) leads to a misunderstanding of the phenomenon, generating fear and social concern. For teachers, this generation gap can make it difficult to understand the potential educational applications of video games. This situation contributes to the media, both traditional and digital, finding a lucrative niche in promoting news that perpetuates these prejudices, which reinforces misinformation and widens the gap between public perception and the evidence presented by research and academic studies on the videogames.

# About the monograph

Free or spontaneous play is essential in early childhood education, allowing children to build knowledge through exploration and enjoyment. This type of game, which encourages cognitive, social and emotional development, should be a regular tool in teaching and not just a post-activity reward. Paniagua and Palacios (2005) highlight that play transforms with age, becoming more complex and collective, a crucial aspect for educators to maximize their educational potential. Vygotsky (2009) emphasizes that the game must retain its spontaneous and free character, this being a natural space where learning is built.

Vygotsky's (2009) theory suggests that play is a zone of proximal development where children are able to perform tasks beyond their ability when provided with appropriate assistance. This is reflected in how spontaneous games can foster essential social and cognitive skills without a formal structure. In this context, play is not only seen as an opportunity for direct learning but also as a tool for developing interpersonal and problem-solving skills that are crucial in the later stages of educational development.

Regarding Game-Based Learning (GBL), this bifurcates into the use of commercial games for teaching and the design of specific games to achieve educational objectives. The use of games not initially designed for educational purposes but adapted to teach certain concepts is an approach that can be considered a behavioural learning approach (Institute of Play, 2007). In contrast, the design of specific games for education allows educators to focus on particular learning objectives, creating educational experiences that directly integrate the content to be taught (Begg, Dewhurst, & Macleod, 2005).

In this monograph, we will find this approach in some articles. Thus, the article by Santamaría Urbieta et al., "Clue strategies in educational escape rooms: A process mining approach", examines how clues in escape rooms can be designed to optimize learning. Castañeda (Id.100713) explores the pedagogical co-creation of games for data literacy, while Bueno-Baquero et al. (Id.100691) discuss gamified approaches to computational thinking in teacher education, illustrating how game design can be applied in specific educational contexts in the article "Gamified approaches to computational thinking in teacher education."

Serious Games, specifically designed to educate about particular skills or concepts, are useful for effective learning and can be interactive and practical, as seen in games for learning languages or specific skills (Calvo-Ferrer & Belda-Medina, 2015). Casañ Pitarch, in his article "The Engineer: Improving Technical Engineering Vocabulary Mastery in English Among Undergraduate Students Through the Use of a Serious Video Game," illustrates the use of Serious Games in higher education for learning technical vocabulary.

The adoption of gamification in education, as described in the work of authors such as Kapp (2012) and Marczewski (2013), has transformed the way we understand student motivation and engagement. Applying game elements such as point systems, medals, and levels in the classroom can increase extrinsic motivation. However, these mechanics must be integrated in a way that also promotes intrinsic motivation. This is achieved by ensuring that game elements are intrinsically linked to educational objectives and that they encourage long-term engagement beyond immediate rewards.

Gamification, which transfers elements of game design to the educational field, seeks to motivate students and improve their participation through points, levels and medals systems. Kapp (2012), Jo Kim (2012) and Marczewski (2013) discuss how these elements can make learning more engaging and motivating. This approach is analyzed in the article by Pérez Granados et al. on "Gamification in the educational field: challenges, potential and perspectives for its implementation" as well as in the analysis by Navarro-Mateos et al. on the "Analysis of the teaching role in a gamification proposal in the teaching master's degree" (Id. 99871). These discussions underscore the promising benefits of gamification in education, instilling optimism and hope for its potential.

In addition, other articles in the monograph, such as Sierra-Daza et al.'s "Video games and learning in higher education: a systematic review" and Gallardo Pérez et al.'s "Video games: educational implications in Physical Education", discuss the benefits of video games in health and dyslexia rehabilitation, respectively, highlighting their potential in various educational areas.

The integration of playful elements in education can facilitate deeper and more meaningful learning. Educators must maintain a delicate balance between educational objectives and student autonomy, avoiding overstructuring that can limit the effectiveness of these playful methodologies (Pérez Gómez, 2000; 1991). This holistic approach to incorporating games into learning reflects the need to adapt educational practices to the changing needs and capabilities of students, ensuring that learning is relevant, interactive and motivating.

In summary, while gaming as an educational tool presents numerous benefits, its effective implementation requires a deep understanding of learning theories, as well as careful planning and adaptation according to specific student needs and curricular objectives. The evolution of play in educational contexts continues to be a fertile field for research and pedagogical practice, offering new opportunities to enrich and transform education in a significant and lasting way.

# Bibliographic references

- Begg, M., Dewhurst, D., & Macleod, H. (2005). Game-Informed Learning: Applying Computer Game Processes to Higher Education. *Innovate: Journal of Online Education*, 1(6). https://www.learntechlib.org/p/107268/
- Calvo-Ferrer, J. R., & Belda-Medina, J. R. (2015). Análisis de la satisfacción del alumnado de L2 con respecto a la adquisición de terminología especializada por medio de videojuegos: Estudio de caso. *Porta Linguarum*, 24, 179-190. http://digibug.ugr.es/handle/10481/53869
- De Aguilera, M., & Méndiz, A. (2005): "Un balance de la investigación sobre videojuegos: análisis de efectos y valoración de su capacidad educativa". *Texto abierto*, 6, 9-52.
- Fernández Navas, M. (2015). *Internet, organización en red y educ@ción: estudio de un caso de buenas prácticas en enseñanza superior.* Tesis Doctoral. Universidad de Málaga.
- Institute of Play. (2007). An introduction to games and learning: An Institute of Play reader.
- Jo Kim, A. (2012). Social engagement verbs. Amy Jo Kim. http://amyjokim. com/2012/09/19/social-engagement-whos-playing-how-do-they-like-to-engage/
- Kapp, K. M. (2012). The gamification of learning and instruction: Gamebased methods and strategies for training and education. John Wiley & Sons.

- Kühn, S., Kugler, D., Schmalen, K. et al. (2019). Does playing violent video games cause aggression? A longitudinal intervention study. *Mol Psychiatry*, *24*, 1220–1234. https://doi.org/10.1038/s41380-018-0031-7
- Marczewski, E. (2013). Gamified UK Blog. http://www.gamified.co.uk/
- Mathur, M. B., & VanderWeele, T. J. (2019). Finding Common Ground in Meta-Analysis "Wars" on Violent Video Games. *Perspectives on Psychological Science*, 14(4), 705–708. https://doi.org/10.1177/1745691619850104
- Paniagua, G., & Palacios, J. (2005). *Educación infantil: Respuesta educativa a la diversidad*. Alianza Editorial.
- Pérez Gómez, Á. (1991). Cultura escolar y aprendizaje relevante. *Educación y sociedad*, 8, 59-72. Recuperado de: https://issuu.com/enguita-eys/docs/educacion-y-sociedad-08
- Pérez Gómez, Á. (2000). La cultura escolar en la sociedad neolioberal. Morata.
- Przybylski A. K., & Weinstein N. (2019). Violent video game engagement is not associated with adolescents' aggressive behaviour: evidence from a registered report. *R. Soc. open sci*, 6, 171474. https://doi.org/10.1098/rsos.171474
- Quesada Bernaus, A., & Tejedor Calvo, S. (2016). Aplicaciones educativas de los videojuegos: El caso de World of Warcraft. *Pixel-Bit. Revista de Medios y Educación*, 48, 187-196. https://doi.org/10.12795/pixelbit.2016.i48.12
- Sánchez Vera, M. & Adell, J. (2023). El negacionismo digital. *El Diario de la Educación*. Recuperado de: https://eldiariodelaeducacion.com/2023/07/24/el-negacionismo-digital/
- Santos Guerra, M. Á. (2001). Dime cómo evalúas (en la universidad) y te diré qué tipo de profesional (y de persona) eres. *Tendencias pedagógicas*, 6, 89-100.
- Schmenk, B. (2010). Bildungsphilosophischer Idealismus, erfahrungsgesättigte Praxisorientierung, didaktischer Hiphop? Eine kleine Geschichte der Lernerautonomie. *Profil*, 2, 11-26.
- Vigotsky, L. (2009). *El desarrollo de los procesos psicológicos superiores* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.; 3a ed.). Crítica.
- Wrigley, T. (2017). 'Knowledge', curriculum and social justice, *The Curriculum Journal*, *29*(1), 1-21. https://doi.org/10.1080/09585176. 2017.1370381



**Monographic section** 

# Hint strategies in educational escape rooms: a process mining approach

# Estrategias de pistas en escape rooms educativas: un enfoque de minería de procesos

https://doi.org/10.4438/1988-592X-RE-2024-405-626

### Alexandra Santamaría Urbieta

https://orcid.org/0000-0003-0935-0616 Universidad Internacional de La Rioja

# Sonsoles López-Pernas

https://orcid.org/0000-0002-9621-1392 University of Eastern Finland

## Abstract

Educational escape rooms have become a useful tool for teachers who want to engage their students and attract their attention to the content taught. Also, they have been found to be valuable in improving learner outcomes, perceptions, and engagement in higher education. Although much attention has been placed on students' opinions when playing educational escape rooms, not much attention has been placed on the importance of the design process, and little research has investigated the effectiveness of hint strategies in optimizing participant experiences and learning outcomes. In this study, and through a process mining approach, the hints strategies of four online educational escape rooms at the university level are determined.

The games were designed with the software Escapp, which allows researchers to collect students' trace log data during the escape rooms. With this data, we calculated descriptive statistics for each escape room, studied the relationship between hints and performance, and to take into account the temporal aspect of students' actions, we employed process mining to investigate the transitions between actions and the role of hints in helping students solve the puzzles. Results show that the use of hints was generally low and that participants relied more on their own problem-solving skills. However, there were instances in

which hints were requested and correlated with longer gameplay duration and a higher number of failed attempts. In conclusion, the present study addresses a gap in the existing literature which highlights, after our analysis, the need for careful consideration of hint design and delivery strategies.

*Keywords:* educational escape rooms, hints, game-based learning, learning analytics, process mining.

#### Resumen

Los escape rooms educativos se han convertido en una herramienta útil para los profesores que quieren implicar a sus alumnos y atraer su atención hacia los contenidos impartidos. Además, se ha descubierto que son valiosas para mejorar los resultados, las percepciones y el compromiso de los alumnos en la enseñanza superior. Aunque se ha prestado mucha atención a las opiniones de los estudiantes acerca de estas metodologías educativas, no se ha atendido a la importancia del proceso de diseño, y se ha investigado poco sobre la eficacia de las estrategias de pistas que se deben diseñar para optimizar las experiencias de los participantes y los resultados de aprendizaje. En este estudio, y a través de un enfoque de minería de procesos, se determinaron las estrategias de pistas de cuatro escape rooms educativos online implementados a nivel universitario. Los resultados muestran que, en general, el uso de pistas fue escaso y que los participantes confiaron más en sus propias habilidades para resolver problemas. Sin embargo, hubo casos en los que se solicitaron pistas y esto se relacionó con una mayor duración del juego y un mayor número de intentos fallidos. En conclusión, el presente estudio aborda una laguna en la bibliografía existente que pone de relieve, tras nuestro análisis, la necesidad de considerar cuidadosamente el diseño de las pistas y las estrategias de diseño del juego. Los juegos se diseñaron con el software Escapp que permite a los investigadores recopilar los datos de registro de las pistas de los estudiantes durante el juego. Con estos datos, calculamos estadísticas descriptivas para cada escape room, investigamos la relación entre las pistas y el desempeño en el escape room y, para tener en cuenta el aspecto temporal de las acciones de los estudiantes, empleamos la técnica de minería de procesos con el objetivo de investigar las transiciones entre acciones y el papel de las pistas a la hora de ayudar a los estudiantes a resolver los desafíos.

*Palabras clave:* escape rooms educativos, pistas, aprendizaje basado en juegos, analíticas de aprendizaje, minería de procesos.

# Introduction

Game-based approaches in education are far from game-over by any stretch of the imagination but rather a sequel that has been replicated in academia in different formats among various levels of education, subjects, and groupings. From STEM education (Wang et al., 2022), pharmacy education (Abdul Rahim et al., 2022) or nursing (Chang et al., 2021) to sex education (von Kotzebue et al., 2022) and professional upskilling (Tay et al., 2022). An increasingly popular game-based technique is the use of educational escape rooms, which have experienced an evolution at different levels, not only from the point of view of their design and implementation but also from the perspective of research. What simply started as questionnaires that examined students' perceptions (Adams et al., 2018) after the implementation of an escape room in the classroom using qualitative analysis has now evolved to incorporate more complex quantitative analyses (López-Pernas et al., 2019a, 2022). Scholars use these in a bid to examine educational escape rooms' learning effectiveness (López-Pernas et al., 2019a) with the use of more complex research techniques such as those of sequence and process mining (Vartiainen et al., 2022), or the combination of pre-tests, post-tests, and learning analytics (López-Pernas et al., 2022). Numerous studies have delved into the efficacy of educational escape rooms as a tool for imparting knowledge to students. However, there has been insufficient investigation about students' actions, choices, and interactions with the game, which, as stated by these authors, calls for more complex methodological approaches for tracing patterns followed by players throughout the game (Vartiainen et al., 2022).

One of the main choices students have to make when playing educational escape rooms is whether or not to ask for help, which is often done by asking for hints. The hint strategy is paramount in educational escape rooms as it is quite "common for a team of students to get stuck while trying to solve a puzzle" (Gordillo et al., 2020, p. 225036). Thus, game designers should provide assistance or guidance to players throughout the game. By examining when and how players ask for hints, we can better understand how these influence their performance in the activity. Thus, the primary objective of our research is to bridge the existing knowledge gap regarding the efficacy of hints during gameplay. We endeavor to investigate various aspects, such as whether students who utilize hints extensively experience a greater level of success and if hints indeed aid students in succeeding in the educational escape room. Our research aims to fill a gap in the study of gaming by providing detailed insights into the significance of hints. We strongly believe that analyzing these strategies can assist game developers in creating better educational

escape rooms. Additionally, our study may also showcase how process mining techniques can be effective and contribute to more complex research in the field of educational escape rooms.

Based on the information gathered so far, the present study aims to analyze the hint strategy employed by 318 students from an online university when playing individually four different digital educational escape rooms (from four different study programs), and its relationship with performance. To do so, we take a descriptive approach through the methodology of process mining, which will enable us to examine gameplay data logs collected in the open-source web platform Escapp (López-Pernas et al., 2021) during the escape rooms to facilitate a better understanding of students' hint strategy. The Research Questions (RQs) of this study will be as follows:

**RQ1:** To what extent do students make use of hints during educational escape rooms?

**RQ2:** What is the relationship between hint usage and performance in educational escape rooms?

**RQ3:** What role do hints take in the puzzle-solving process during educational escape rooms?

# **Theoretical Framework**

# **Overview of Educational Escape Rooms**

According to Spira (2017), it is unclear where escape rooms originated, but the first documented reference to them dates back to 2007 in Japan (Sánchez-Martín et al., 2020). Prior to this, the idea of escape rooms was shaped in the form of video games and was featured on UK TV shows like The Adventure Game and The Crystal Maze. Over time, they have undergone various changes. Initially, they were just video games and recreational activities where participants had to escape from a room, but for some time now, they have also been used in educational settings to teach or review content using game-like methods. Educational escape rooms have transformed over the years and have become forms of recreation that "have drawn the attention of educators due to their ability to foster teamwork, leadership, creative thinking, and communication in a

way that is engaging for students" (López-Pernas et al., 2019b, p. 31723). Escape rooms have proliferated (Veldkamp et al., 2020b) in educational settings (both physical, virtual, and hybrid) and have been found to be valuable in improving learner outcomes, perceptions, and engagement, also in higher education (Morrell & Eukel, 2020; Morrell & Ball, 2020). Furthermore, the quests included in them have also evolved from solely escaping from a room (Veldkamp et al., 2020a; Santamaría Urbieta & Alcalde Peñalver, 2019) within a given time limit to including murder mysteries or helping create a cure (López-Pernas et al., 2019b).

# The Hint Strategy: How Important Is It?

As mentioned previously, hints in the educational escape room are meant to give players a little nudge or clue that can aid them in solving a particular challenge or puzzle (Clarke et al., 2017), maintaining at all times the appropriate level of balance within the game between being too straightforward or too difficult. Hints are there to help players learn and improve their problem-solving abilities by guiding them rather than providing the answers outright. Additionally, hints also can prevent students from feeling frustrated while playing the game. In 2015, Nicholson outlined the different methods that escape room facilities use to provide hints. After his study of 175 escape room facilities from around the world, he determined that the most common strategy was to offer hints as players request them (42%), and the second most popular method was to allow players to request a set number of hints, with a time penalty imposed if they did so (23%).

A common hint strategy involves providing gradual hints, that is, students request a first clue, which ought to be vague or subtle, the next hint includes more specific guidance, and, finally, the hints thereafter continually become more explicit, providing clearer and more direct instructions. Another common strategy is the multiple-level system, which offers, for instance, three levels of assistance: mild hints, moderate hints, and direct hints. Players would be the ones choosing the level of the hint they require, which strikes a balance between seeking guidance and maintaining a sense of accomplishment.

The scenario for which the educational escape room is designed also determines the hint strategy the gamemaster will employ, as it is not the

same to give students hints in a face-to-face classroom, in which they can give straightforward clues as students get stuck throughout the game (López-Pernas et al., 2021), as when the educational escape room has been designed for an online environment, where the hint strategy can highly determine whether students will continue and "escape the room", or just leave the room after feeling frustrated. In both scenarios, manually providing hints "can become overwhelming or even impossible if the student-teacher ratio is high" (p. 38063); the same happens when the educational escape room has been designed to be played asynchronously, that is, without the direct assistance of the gamemaster (a.k.a., the teacher).

To create a personalized hint system for both face-to-face and virtual scenarios, the web platform Escapp (López-Pernas et al., 2021) simplifies the process. This has been the digital tool where the four teachers of the present study have hosted their educational escape rooms. It enables teachers to decide if students are permitted to ask for hints during the escape room and if they can receive hints for free or by successfully completing a quiz. Additionally, Escapp allows teachers to set a minimum interval between hints to prevent students from frequently asking for help. The hint strategy utilized, whether gradual or multi-level, is at the teacher's discretion.

# **Process Mining and its Application in Education**

Educational process mining (EPM) is an emerging field in learning analytics and educational data mining (Bogarín et al., 2018; Ghazal et al., 2017; Sweta, 2021), which refers to the examination and identification of patterns and movements in the event records produced by educational settings (Romero et al., 2016). It originated in the field of business (van der Aalst et al., 2012) and has been demonstrated to be successfully applied to educational settings (Pechenizkiy et al., 2009) due to its ability to produce "clear visual representations of the whole process" studied (p. 280). Notably, several works have capitalized on process mining methods in the context of educational games since they enable researchers to account for the key role of temporality in educational games —as in any learning activity. For instance, Caballero-Hernández et al. (2023) used process mining for skill assessment according to students' actions

in an educational game about databases. Several works by Gómez et al. (2021a, 2021b) used sequence and process mining to investigate students' sequences of actions and errors in a geometry game. Schaedler Uhlmann et al. (2018) applied process mining to player interactions to analyze decision-making in remote educational games.

It is worth noting that further research in this area would undoubtedly contribute to a better understanding of how students learn and interact with educational games, leading to the development of more effective educational tools and strategies. In our study, we leverage "Player Experience Modeling" (PEM) as a pivotal framework for gathering and analyzing data about player behaviors and interactions within games. As defined by Nikitin (2020), PEM encompasses a comprehensive approach to understanding the multifaceted experiences of players by employing three distinct methodological groups: (1) subjective, (2) objective, and (3) gameplay-based methods. Each method serves a unique purpose in capturing different aspects of player experience, vital for our investigation into the hint strategies of educational escape rooms. Firstly, the subjective method allows to capture players' personal impressions and feedback, providing insight into the perceived difficulty and engagement levels of the hints. This method is instrumental in understanding the emotional and cognitive impact of hints on players, which is crucial for evaluating their effectiveness in educational contexts. Secondly, the objective method, which utilizes physiological parameters such as heart rate and eye tracking, offers a window into the players' unconscious responses to game hints. This data helps identify moments of heightened stress or confusion, indicating potential areas where the hint system may need adjustment to better support learning outcomes. Lastly, the gameplay-based method focuses on analyzing interactions with game objects and the game environment. By employing process mining techniques, as suggested by Nikitin (2020), we can systematically examine how players navigate hint strategies within the game, revealing patterns and strategies that contribute to effective learning through gameplay. Together, these methods provide a holistic view of the player experience, enabling us to tailor and optimize the hint strategy in educational escape rooms. The integration of subjective, objective, and gameplay-based data ensures a comprehensive analysis of game-player interaction, directly informing the design and implementation of more effective educational tools.

# **Methods**

# Context and participants

The context in which these escape rooms were designed and put into practice with students was within an Educational Innovation Project at Anonymized University. In this project, four teachers were selected to try out the Escapp platform (López-Pernas et al., 2021) during the years 2022/2023, not only as designers of the escape rooms but also as testers of the software. The teachers were chosen because of their prior experience designing escape rooms, though they had not used Escapp before, and because they covered a wide range of disciplines encompassing humanities, social sciences and scientific courses. Through an initial training workshop in which the project coordinator described how Escapp worked and how they could design their escape rooms with this software, teachers had to think about the narrative of their educational escape games, the missions and challenges they wanted to incorporate, and how and when they were going to launch their games with their students.

After a process of tutoring contemplated in the project and which allowed teachers to ask the coordinator any possible questions and doubts about the design process and execution, all four teachers were able to launch their escape games successfully asynchronously and synchronously among their students in the course year 2022/2023. As we have already mentioned, there were four teachers; two of them taught at the bachelor's degree level, and the other two at master's degree level. The table below summarizes the educational escape rooms' subjects, topics, numbers of missions, modality of the game, and hints created by each teacher. It's important to note that the teachers were not given any instructions on how to design the hint strategy for each game.

### **Data collection**

Students' trace log data collected during the escape rooms were downloaded from the Escapp platform for each of the four escape rooms. The log data records all the relevant actions that players perform within the Escapp platform during the activity. Each record contains an identifier for

TABLE I. Context and design of the educational escape rooms

Subject	Level	Study	Topic	Modality	Puzzles	Hints	Participants
Spanish	Bachelor's Degree	Bachelor's Translation and Degree Interpreting	Students need to find a potion to help the main character find a boyfriend who does not make many mistakes when writing in Spanish.	Synchronous & Asynchronous	∞	2 hints per puzzle	30
Consumers and their Behavior	Master's Degree	Neuromarketing	Students had to prepare for Synchronous a future job post.	Synchronous	10	2 hints per puzzle	41
Physics	Bachelor's Degree	Physics	Abstract (No narrative)	Asynchronous	11	1 hint per puzzle	65
Learning & Personality Development	Master's Degree	Teacher Education	Teacher Education A teacher who is working at a school for the first time is trapped inside a school and will not be able to escape until she can solve a number of problems related to the school, the students, the parents and other workmates.	Asynchronous	N	1 hint per puzzle	209

Source: Compiled by authors.

the player, a timestamp, an identifier of the current puzzle the player is working on, and the name of the action, namely;

- **Solve puzzle:** The player provides the right solution to a puzzle.
- **Fail puzzle:** The player provides an incorrect solution to a puzzle.
- **Obtain hint:** The player requests a hint (pooled from a preset set of hints created by the teacher).

# Data analysis

We conducted the analysis using the R programming language. As a first step of our analysis, we used the *psych* R package to calculate descriptive statistics for each escape room, including the total number of students who participated in the escape room and how many completed the escape room successfully (solved all the puzzles). We also calculated the mean duration to complete each puzzle per player, the mean number of failed attempts, and the mean hints per puzzle and player (RQ1).

To give answer to RQ2, we used the *rstatix* and *stats* R packages to conduct a series of statistical tests to investigate the relationship between the number of hints requested and students' performance in the escape room (whether they completed it and how long they took). We first conducted a Wilcoxon signed-rank test comparing the number of hints between those who completed the escape room and those who did not. Then, we computed Spearman's correlation between the number of hints requested and gameplay duration (for those who completed the escape room), as well as between the number of hints requested and the number of failed attempts to solve puzzles. We used the correlation coefficient (r) as a measure of effect size. According to Cohen's (1988) guidelines, the effect size is small when r is between 0.1 and 0.3; medium when r is between 0.3 and 0.5; and large when r is greater than or equal to 0.5.

To address our last RQ (RQ3), we took into account the temporal aspect of students' actions —since time is a key aspect of escape rooms—, using process mining to investigate the transitions between actions and the role of hints in helping students solve the puzzles. We relied on the R package *bupaverse* (Janssenswillen et al., 2019) to create

a process map of students' actions in each escape room and to compute the transition rates.

# Results

# **RQ1:** To what extent do students make use of hints during educational escape rooms?

Table II shows the descriptive statistics of the four escape rooms. The success rate of the escape rooms (number of participants who completed the activity over the total number of participants) varies greatly, ranging from 23.3% to 100%. The average time taken to solve the escape room puzzles revolves around 7-8 min., except for the Physics escape room, in which the average is remarkably low (1.30 min.). The average number of wrong solutions provided for the puzzles ranged from very low (0.58) to quite high (4.70), which may indicate trial-and-error behavior. The number of hints requested was very low, with less than one hint on average per puzzle.

### **TABLE II.** Descriptive statistics of the four escape rooms

N = Number of students who completed the escape room / number of participants (success rate). Duration = Time taken to solve each puzzle (mean and standard deviation). Failed attempts = Number of failed attempts to solve each puzzle (mean and standard deviation). Hints = Number of hints obtained (mean and standard deviation)

Escape room	N	Puzzle Duration (min.)	Failed attempts	Hints
Spanish	7/30 (23.3%)	M = 8.59 (SD = 7.56)	M = 4.70 (SD = 13.79)	M = 0.24 (SD = 0.54)
Marketing	14/14 (100%)	M = 7.73 (SD = 15.12)	M = 2.77 (SD = 7.04)	M = 0.23 (SD = 0.61)
Physics	58/65 (89.2%)	M = 1.30 (SD = 1.77)	M = 0.58 (SD = 1.21)	M = 0.02 (SD = 0.13)
Teacher Ed.	92/209 (44%)	M = 7.26 (SD = 6.85)	M = 5.13 (SD = 9.39)	M = 0.40 (SD = 0.57)

Source: Compiled by authors.

# RQ2: What is the relationship between hint usage and performance in educational escape rooms?

Table III shows the results of the statistical tests conducted to assess the relationship between hints and performance in the escape rooms. First, a Wilcoxon signed-rank test showed no statistically significant difference between the number of hints received for those who completed the escape room and those who did not, except for the Teacher Education escape room, in which there was a small albeit significant difference, where those who completed the escape room received on average more hints. For those who completed the escape room, there was a small although significant correlation between the number of hints and the time taken to complete the activity in two of the escape rooms (Physics and Teacher Education). Lastly, there was a medium to large and statistically significant correlation between the number of hints requested and the number of failed attempts to solve the escape room puzzles.

### TABLE III. Relationship between hints and performance:

(I. Hints vs. Completed) Wilcoxon signed-rank test comparing the number of hints between those who completed the escape room and those who did not (II. Hints vs. Duration) Spearman's correlation between hints requested and gameplay duration (for those who completed the escape room) and (III. Hints vs. Failed attempts) Spearman's correlation between hints requested and failed attempts to solve puzzles.

	Hints vs. Completed		Hints vs. Duration		Hints vs. Failed attempts	
	r	p-value	r	p-value	r	p-value
Spanish	-0.12	0.54	0.45	0.31	0.60	0.00*
Marketing †	-	-	0.05	0.87	0.57	0.03*
Physics	-0.09	0.48	0.37	0.00*	0.42	0.00*
Teacher Ed.	0.20	0.00*	0.27	0.01*	0.67	0.00*

Note: Since all participants completed the Marketing escape room, no comparison can be made. Source: Compiled by authors.

# RQ3: What role do hints take in the puzzle-solving process during educational escape rooms?

The process maps paint a clearer picture of the temporality and interplay of the recorded gameplay events. The "Start" node indicates a player starting to work on a puzzle, and the "End" node that they cease to work on a puzzle, be it because they have solved it correctly or because the time is up. The remaining nodes represent the three events recorded during students' gameplay and are annotated with the share of the total number of events they represent. An arrow between node A and node B represents a transition between event A and event B, and is annotated with the percentage that transition represents out of all the transitions with origin in node A.

Figure I shows the process map of the Spanish language escape room. In almost half of the cases, students (49.61%) are able to reach the correct solution of a puzzle directly whereas, 38.58% of the times, students start by providing a wrong solution. Only 11.81% of the times students ask for a hint before attempting to solve the puzzle. Failed puzzle attempts often come in a row, since a failed attempt leads to another one 87.05% of the times. Only 11.81% of the times students resort to asking for a hint after providing a wrong solution to the puzzle. Moreover, hints lead to reaching the correct solution 15.15% of the times, and a wrong solution 78.79% of the times.

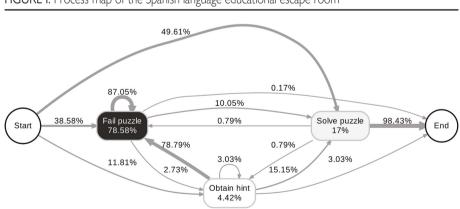


FIGURE I. Process map of the Spanish language educational escape room

The Marketing educational escape room presents a similar scenario as the previous one with few yet important differences. In this escape room, requesting a hint leads to providing a wrong puzzle solution 36% of the times (half as in the previous escape room). Instead, students ask for subsequent hints (20%) or figure out the right puzzle solution straight away (28%).

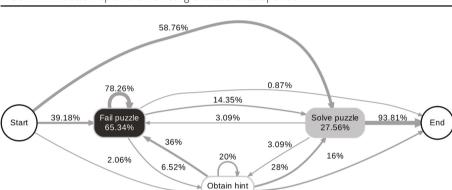
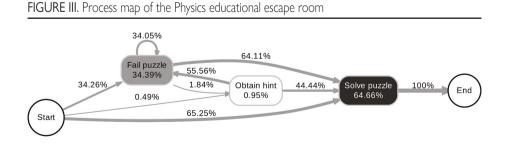


FIGURE II. Process map of the Marketing educational escape room

The Physics escape room seems to be the most straightforward, where students solve the puzzles on their first attempt 65.25% of the times. The role of hints in this escape room is almost non-existent (0.95% of all events) and their utility is not clear, as 55.56% of the occasions in which students ask for a hint, they are led to a wrong puzzle solution whereas 44.44% of the times they are led to the correct puzzle solution.

7.1%



Lastly, the process map of the Teacher Education escape room is very similar to the Spanish language one, where students make several failed attempts to solve the puzzles and hints do not seem to be very effective in helping them overcome their difficulties.

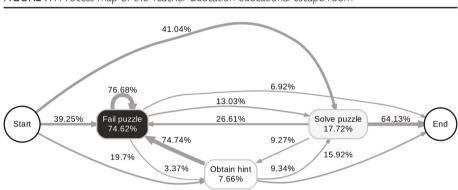


FIGURE IV. Process map of the Teacher Education educational escape room

# **Discussion and Conclusions**

The results obtained from the present study on hint strategies in educational escape rooms using a process mining approach reveal interesting insights into gameplay dynamics and the impact of hints on performance. In this section, we discuss the findings in relation to the research questions and highlight their implications for the design and implementation of educational escape rooms. Moreover, based on the results obtained, we suggest a hint strategy for the design of educational escape rooms.

The descriptive statistics presented in Table II provide a comprehensive overview of the four escape rooms analyzed in terms of success rate, puzzle duration, failed attempts, and hints obtained. One of the main conclusions obtained is that success rates vary significantly across the four escape rooms. The Spanish language escape room exhibits the lowest success rate, indicating that participants faced more challenges in this particular room. On the other hand, the Marketing escape room demonstrates the highest success rate, suggesting that it may have been relatively easier for participants to solve the puzzles. The average time taken to solve the puzzles aligns closely within the 7-8 minute range,

except for the Physics escape room where participants remarkably completed the puzzles in an average time of 1.30 minutes. This notable difference in duration may reflect the low level of complexity and difficulty associated with the Physics escape room puzzles compared to the others since, for instance, the Marketing escape room had a similar number of puzzles but the mean duration to solve each puzzle was substantially higher. Additionally, the average number of wrong solutions provided for the puzzles varied, ranging from low to relatively high values, which may indicate trial-and-error behavior in some instances. Interestingly, participants requested a very low number of hints, with less than one hint on average per puzzle across all escape rooms.

Table III presents the results of the statistical tests conducted to explore the relationship between hints and performance in the escape rooms. The Wilcoxon signed-rank test reveals that, except for the Teacher Education escape room, there was no significant difference in the number of hints received between participants who completed the escape room and those who did not. This finding suggests that the availability of hints did not strongly influence participants' completion rates, except in the case of the Teacher Education escape room, where those who completed the room received, on average, more hints compared to those who did not complete it.

Furthermore, the correlations between the number of hints and gameplay duration indicate a small but significant relationship in two escape rooms: Physics and Teacher Education. This suggests that participants who requested more hints tended to spend more time on the puzzles in these specific escape rooms. This could be attributed to the complexity or ambiguity of the puzzles, where additional hints were required to guide participants towards the correct solution. The correlation analysis also reveals a significant and medium to large positive correlation between the number of hints requested and the number of failed attempts to solve the puzzles across all escape rooms. This implies that participants who sought more hints generally struggled with solving the puzzles and made a higher number of unsuccessful attempts.

The process maps depicted in Figures I to IV visually represent the temporal flow and interaction of events during gameplay in each escape room. These maps offer valuable insights into the patterns of puzzle-solving behavior and the role of hints in guiding participants. In a Spanish escape room, most participants tried a different approach before seeking

help. Only a few asked for hints after giving a wrong answer, but the hints weren't very effective in leading to the correct solution. The Marketing escape room had a similar pattern to the Spanish language escape room, with some participants arriving at the correct solution and others starting with an incorrect solution. In this room, hints were slightly more effective, leading to the correct solution in 28% of cases. Interestingly, participants asked for subsequent hints more often than in the Spanish language escape room, indicating they relied more on hints when they faced challenges.

In contrast, the Physics escape room demonstrated a more straightforward puzzle-solving process, with participants achieving success on their first attempt in the majority of cases, probably due to the lack of difficulty of the puzzles designed. However, hints were not very helpful in this room and only accounted for 0.95% of all events. They seem to have caused more harm than good as they led to a wrong solution in the majority of cases instead of guiding participants to the correct solution.

Finally, the process map of the Teacher Education escape room resembled the pattern observed in the Spanish language escape room, with participants making multiple failed attempts to solve the puzzles. Hints were requested and utilized similarly to the Spanish language escape room, but their overall effectiveness in helping participants overcome challenges appeared limited.

The findings from the process maps highlight the importance of considering the sequence and impact of events in escape room gameplay. Understanding how participants approach puzzles, the timing of hint requests, and the outcomes of those hints can inform the design and delivery of educational escape rooms. These insights can be utilized to optimize the difficulty level and progression of puzzles, improve the efficacy of hints, and enhance the overall learning experience.

Data suggests that hint utilization in the educational escape rooms was generally low, with participants relying more on their own problem-solving abilities. However, there were instances where hints were requested and correlated with longer gameplay duration and a higher number of failed attempts. In fact, the process maps confirmed that, on many occasions, hints misled participants to the wrong puzzle solutions rather than helping them. This highlights the need for careful consideration of hint design and delivery strategies to optimize their effectiveness in facilitating successful puzzle-solving while maintaining an appropriate

level of challenge. The variations in success rates and puzzle durations across the escape rooms further emphasize the importance of aligning the difficulty levels of puzzles with the target audience and learning objectives.

Our analysis has provided us with valuable insights that we can use to create a hint strategy, which should be understood as an approximation to enhance the effectiveness of hints in guiding participants towards successful puzzle-solving, while maintaining an optimal level of challenge and engagement.

- 1. Gradual Hint Strategy. Implementing a gradual hint strategy that provides escalating levels of assistance is recommended. We encourage designers to start with subtle hints or clues that nudge participants in the right direction without explicitly giving away the solution. Following this approach, our results show that students needed few hints and therefore, disclosing too much information initially might prevent them from reaching the solution by themselves.
- **2. Contextualized Hints.** Tailor hints to the specific escape room theme and content, that is, incorporate hints that are relevant to the subject matter or concept being explored in the escape room.
- 3. Timely Availability of Hints. Based on our analysis, we can conclude that providing hints to players can be helpful if we monitor their progress and strategically offer hints to prevent frustration and encourage ongoing engagement. The software Escapp, used in this study, allows us to determine when students can request hints and the appropriate time interval between each. We should point out that if the escape room is conducted online, the use of time-limited hints may reduce interest in the game and lead to dropout.
- 4. Adaptive Hint System. This strategy would be interesting to integrate into a piece of software like Escapp, based on our results. As it has been observed, participants may consistently provide incorrect solutions or make many failed attempts. To avoid this, it would be interesting that the software incorporated an adaptive hint strategy to adjust the level of assistance based on participants' performance and request patterns. Conversely, if students were progressing without much assistance, the hint strategy could

adapt itself to that situation and maintain an appropriate level of challenge, avoiding boredom.

- **5. Hints as Learning Opportunities.** Designers should think of hints as key elements of the game because they should be considered promoters of active learning and problem-solving skills. We strongly advise against providing direct answers, as hints can prompt students to reflect on their approach, reconsider their assumptions, or provide alternative strategies to explore. This fosters critical thinking and promotes a deeper understanding of the concept being taught in the educational escape rooms.
- **6. Hint Accessibility.** Ensure that hints are easily accessible to participants. The software Escapp makes the inclusion of hints throughout the game very straightforward and does not interrupt the flow of the gameplay. This accessibility helps participants find hints more easily and faster, and it also helps designers to put all the hints in one single location, making it easier for the designer to also include them in the game.

In conclusion, this study used a process mining approach to examine hint strategies in educational escape rooms. The results provided valuable insights into the relationship between hints and performance, the dynamics of puzzle-solving behavior, and the effectiveness of hints across different escape rooms. The findings suggest that the availability of hints did not significantly impact completion rates, except in one escape room where completing participants received more hints. The correlation analysis revealed that the number of hints requested was positively associated with gameplay duration and the number of failed attempts. The process maps further illuminated the temporal flow and interaction of events during gameplay, highlighting the varying patterns of puzzle-solving behavior and the role of hints in facilitating or hindering progress.

These findings contribute to the broader field of educational escape rooms by providing empirical evidence on the impact of hints on game-play and offering insights into how hints can be effectively utilized to enhance the learning experience. Future research can build upon these findings by investigating additional factors that may influence hint utilization and examining the long-term effects of educational escape rooms on learning outcomes. Overall, this study sheds light on the importance

of understanding hint strategies in educational escape rooms, which can ultimately inform the design of more engaging and effective learning experiences.

#### Limitations

Our study is not without limitations. First, the data collected by Escapp is limited to what happens within the platform (i.e., puzzle resolution and hint requests) and therefore may not fully reflect all of the students' actions during the escape rooms (e.g., consulting learning materials, or talking to one another). Although the fact our data is unobtrusively and systematically collected provides an objective and non-invasive way of measuring students' performance, complementing the log data with video observations and/or interviews could provide a more detailed picture of each student's gameplay from a more qualitative perspective. More information about the study participants would also allow us to understand the factors that might cause some students to choose a certain hint strategy, for example, gender, degree, or a lack of sufficient prior knowledge to solve the escape room. Moreover, although our study encompasses escape rooms in a variety of academic disciplines, our sample is limited to a single institution and therefore the generalizability of our findings to other contexts needs further investigation. Nevertheless, our choice of process mining as an analytical tool frames our study as descriptive rather than making any inferences or generalizations.

# Bibliographical references

Abdul Rahim, A. S., Abd Wahab, M. S., Ali, A. A., & Hanafiah, N. H. M. (2022). Educational escape rooms in pharmacy education: A narrative review. *Pharmacy Education*, *22*(1), 540–557. https://doi.org/10.46542/pe.2022.221.540557

Adams, V., Burger, S., Crawford, K., & Setter, R. (2018). Can You Escape? Creating an Escape Room to Facilitate Active Learning. *Journal for Nurses in Professional Development*, *34*, E1–E5. https://doi.org/10.1097/NND.00000000000000433

- Bogarín, A., Cerezo, R., & Romero, C. (2018). A survey on educational process mining. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 8(1), e1230. https://doi.org/10.1002/widm.1230
- Caballero-Hernández, J.A., Palomo-Duarte, M., Dodero, J. M., & Gaševic, D. (2023). Supporting Skill Assessment in Learning Experiences Based on Serious Games Through Process Mining Techniques, *International Journal of Interactive Multimedia and Artificial Intelligence*, https://doi.org/10.9781/ijimai.2023.05.002
- Chang, C., Chung, M., & Yang, J. C. (2021). Facilitating nursing students' skill training in distance education via online game-based learning with the watch-summarize-question approach during the COVID-19 pandemic: A quasi-experimental study. *Nurse Education Today, 109*, 105256. https://doi.org/10.1016/j.nedt.2021.105256
- Clarke, S., Peel, D., Arnab, S., Morini, L., Keegan, H., & Wood, O. (2017). EscapED: A Framework for Creating Educational Escape Rooms and Interactive Games to For Higher/Further Education. *International Journal of Serious Games*, 4(3), 73-86. https://doi.org/10.17083/ijsg. v4i3.180
- Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences. Routledge. NY, USA. https://doi.org/10.4324/9780203771587
- Ghazal, M.A., Ibrahim, O., & Salama, M.A. (2017). Educational Process Mining: A Systematic Literature Review, 2017 European Conference on Electrical Engineering and Computer Science (EECS). https://doi.org/10.1109/EECS.2017.45
- Gómez, M. J., Ruipérez-Valiente, J. A., Martínez, P. A., & Y. J. Kim (2021a). Applying learning analytics to detect sequences of actions and common errors in a geometry game. *Sensors*, 21(4), 1025. https://doi.org/10.3390/s21041025
- Gómez, M. J., Ruipérez-Valiente, J. A., Martínez, P. A., & Y. J. Kim (2021b). Exploring the Affordances of Sequence Mining in Educational Games. *Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'20). Association for Computing Machinery*, New York, NY, USA, 648–654. https://doi.org/10.1145/3434780.3436562
- Gordillo, A., López-Fernández, D., López-Pernas, S., & Quemada, J. (2020). Evaluating an educational escape room conducted remotely for teaching software engineering. *IEEE*. 8, 225032–225051. https://doi.org/10.1109/ACCESS.2020.3044380

- Janssenswillen, G., Depaire, B., Swennen, M., Jans, M. J., & Vanhoof, K. (2019). bupaR: Enabling Reproducible Business Process Analysis. Knowledge-Based Systems, Vol. 163, p. 1857. https://doi.org/10.1016/j. knosys.2018.10.018
- López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019a). Analyzing Learning Effectiveness and Students' Perceptions of an Educational Escape Room in a Programming Course in Higher Education. *IEEE Access.* 7, 184221–184234. https://doi.org/10.1109/ACCESS.2019.2960312
- López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2019b). Examining the Use of an Educational Escape Room for Teaching Programming in a Higher Education Setting, in *IEEE Access*, vol. 7, 31723-31737. https://doi.org/10.1109/ACCESS.2019.2902976
- López-Pernas, S., Gordillo, A., Barra, E., & Quemada, J. (2021). Escapp: A web platform for conducting educational escape rooms. *IEEE Access*. 7, 184221–184234. https://doi.org/10.1109/ACCESS.2019.2960312
- López-Pernas, S., Saqr, M., Gordillo, A., & Barra, E. (2022) A learning analytics perspective on educational escape rooms, *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2022.2041045
- Morrell, B. L. M., & Ball, H. M. (2020). Can You Escape Nursing School? Educational Escape Room in Nursing Education. *Nursing Education Perspectives*, 41(3), 197–198. https://doi.org/10.1097/01. NEP.000000000000044
- Morrell, B. L. M., & Eukel, H. N. (2020). Escape The Generational Gap: A Cardiovascular Escape Room for Nursing Education. *The Journal of Nursing Education*, *59*(2), 111–115. https://doi.org/10.3928/01484834-20200122-11
- Nicholson, S. (2015). *Peeking behind the locked door: A survey of escape room facilities*. http://scottnicholson.com/pubs/erfacwhite.pdf
- Nikitin, K. (2020). Educational Game Analysis Using Intention and Process Mining. *Modeling and Analysis of Complex Systems and Processes MACSPro'2020, October 22–24, 2020, Venice, Italy & Moscow, Russia.*
- Pechenizkiy, M., Trcka, N., Vasilyeva, E., van de Aalst, W., & De Bra, Paul. (2009). Process Mining Online Assessment Data. *International Working Group on Educational Data Mining; International Working*

- Group on Educational Data Mining. Available from: International Educational Data Mining Society (EDM).
- Romero, C., Cerezo, R., Bogarín, A., & Sánchez-Santillán, M. (2016). Educational Process Mining. In S. ElAtia, D. Ipperciel & O.R. Zaïane (eds.), *Data Mining and Learning Analytics*. https://doi.org/10.1002/9781118998205.ch1
- Sánchez-Martín, J., Corrales-Serrano, M., Luque-Sendra, A., & Zamora-Polo, F. (2020). Exit for success. Gamifying science and technology for university students using escape-room. A preliminary approach. *Heliyon*, *6*(7), e04340. https://doi.org/10.1016/j.heliyon.2020.e04340
- Santamaría Urbieta, A., & Alcalde Peñalver, E. (2019). Escaping from the English Classroom. Who will get out first?, *Aloma Revista de Psicologia, Ciències de l'Eduació i de l'Esport, 37*(2), 83-92. https://doi.org/10.51698/aloma.2019.37.2.83-92
- Schaedler Uhlmann, T., Alves Portela Santos, E., & Mendes, L.A. (2018). Process Mining Applied to Player Interaction and Decision Taking Analysis in Educational Remote Games. In: Auer, M., Langmann, R. (eds) *Smart Industry & Smart Education. REV 2018. Lecture Notes in Networks and Systems, vol 47.* Springer, Cham. https://doi.org/10.1007/978-3-319-95678-7\_47
- Spira, D. (2017). A Quick History of Escape Rooms. *Room Escape Artist*. https://roomescapeartist.com/2017/01/15/a-quick-history-of-escaperooms/
- Sweta, S. (2021). *Modern Approach to Educational Data Mining and Its Applications*. Springer Nature.
- Tay, J., Goh, Y. M., Safiena, S., & Bound, H. (2022). Designing digital game-based learning for professional upskilling: A systematic literature review. *Computers & Education*, *184*, 104518. https://doi.org/10.1016/j.compedu.2022.104518
- Vartiainen, H., López-Pernas, S., Saqr, M., Kahila, J., Parkki, T., Tedre, M., & Valtonen, T. (2022). Mapping students' temporal pathways in a computational thinking escape room. *Proceedings of the Finnish Learning Analytics and Artificial Intelligence in Education Conference (FLAIEC22)* (pp. 77–88). CEUR.
- Veldkamp, A., Daemen, J., Teekens, S., Koelewijn, S., Knippels, M.-C.P.J., & van Joolingen, W.R. (2020a), Escape boxes: Bringing escape room

- experience into the classroom. *Br J Educ Technol*, *51*, 1220-1239. https://doi.org/10.1111/bjet.12935
- Veldkamp, A., van de Grint, L., Knippels, M.-C.P.J., & van Joolingen, W.R. (2020b). Escape Education: A Systematic Review on Escape Rooms in Education, *Educational Research Review*, *31*. https://doi.org/10.1016/j.edurev.2020.100364
- van der Aalst, W. *et al.* (2012). Process Mining Manifesto. In: Daniel, F., Barkaoui, K., Dustdar, S. (eds) *Business Process Management Workshops. BPM 2011. Lecture Notes in Business Information Processing*, vol 99. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-28108-2 19
- von Kotzebue, L., Zumbach, J., & Brandlmayr, A. (2022). Digital Escape Rooms as Game-Based Learning Environments: A Study in Sex Education. *Multimodal Technologies and Interaction*, *6*(2), 8. https://doi.org/10.3390/mti6020008
- Wang, L., Chen, B., Hwang, G., Guan, J., & Wang, Y. (2022). Effects of digital game-based STEM education on students' learning achievement: A meta-analysis. *International Journal of STEM Education*, 9(1), 1-13. https://doi.org/10.1186/s40594-022-00344-0

**Contact address:** Alexandra Santamaría Urbieta. Universidad Internacional de La Rioja, Área de Humanidades y Ciencias Sociales. Calle de García Martín 21, 28224, Pozuelo de Alarcón, Madrid. E-mail: alexandra.santamaria@unir.net

# Co-creating pedagogically informed games for data literacy

# Co-creación pedagógica de juegos para la alfabetización en datos

https://doi.org/10.4438/1988-592X-RE-2024-405-627

#### Linda Castañeda

https://orcid.org/0000-0002-1055-9241 Facultad de Educación. Universidad de Murcia

# **Sylvester Arnab**

https://orcid.org/0000-0002-4939-7382 Centre for Postdigital Cultures, Coventry University

#### Gemma Tur

https://orcid.org/0000-0003-4508-6808 Universitat de les Illes Balears

# Fride Klykken

https://orcid.org/0000-0003-4070-3782 Centre for the Science of Learning & Technology (SLATE). University of Bergen

#### Barbara Wasson

https://orcid.org/0000-0003-4897-1394 Centre for the Science of Learning & Technology (SLATE). University of Bergen

#### Inmaculada Haba-Ortuño

https://orcid.org/0000-0002-0712-8619 Universidad de Murcia

#### Ruth Maloszek

https://orcid.org/0009-0009-4457-216X FAU Chair of Educational Science

#### Barbara de Benito-Crosetti

https://orcid.org/0000-0002-5868-7920 Universitat de les Illes Balears

#### **Abstract**

This article explores the co-creation of educational games for data literacy in the framework of the DALI project. The games have been designed for the development of basic data literacy for citizenship and are aimed at young and older adults in non-formal contexts. The work presented here addresses the phases and strategies of co-design, highlighting their importance in the development of educational games, recognising playful learning methods as valuable tools in education that allow cultural expression, creativity, and exploration, while requiring a balance between playful and educational objectives. Co-creation in the framework of the DALI project follows a research-based design process with multidisciplinary teams (education, learning design and game science), and takes as fundamental conceptual elements of play-based learning and the principles of connected learning, combining them through the structure of the analysis framework and activity-centred design (ACAD framework). The paper details the five phases of work and highlights the importance of generating a solid pedagogical and conceptual base to scaffold the co-creation process, as well as a methodological superstructure that provides context and solidity to the playful proposal, in this case called Game Based Networked Learning Strategy (GBNLS). The paper emphasises the complexity of co-creation approaches, and the value of the tools and strategies used, highlighting the relevance of the ideas and methodologies used in this part of the DALI project for other teams working on similar strategies.

*Keywords:* co-creation, educational games, data literacy, DALI project, pedagogical principles, multidisciplinary collaboration.

#### Resumen

Este artículo explora la cocreación de juegos educativos para la alfabetización en datos, en el marco del proyecto DALI. Los juegos han sido diseñados para el desarrollo de la competencia básica en datos para la ciudadanía y están dirigidos a adultos jóvenes y mayores, en contextos no-formales. El trabajo que

se presenta aborda las fases y estrategias de codiseño, destacando su importancia en el desarrollo de juegos educativos, reconociendo a los métodos de aprendizaje lúdico como herramientas valiosas en la educación que permiten la expresión cultural, la creatividad y la exploración, al tiempo que requieren un equilibrio entre los objetivos lúdicos y educativos. La cocreación en el marco del proyecto DALI sigue un proceso de investigación basada en el diseño con equipos multidisciplinares (educación, diseño del aprendizaje y ciencia de juegos), y toma como elementos conceptuales fundamentales los propios del aprendizaje basado en el juego y los principios del aprendizaje conectado, combinándolos a través de la estructura del marco de análisis y el diseño centrado en la actividad (marco ACAD). Se detallan en el trabajo las cinco fases de trabajo y se destaca la importancia de la generación de una base pedagógica y conceptual sólida que sirva de andamiaje al proceso de cocreación, además de una supraestructura metodológica que proporciona contexto y solidez a la propuesta lúdica, en este caso llamada Estrategia Didáctica Conectada Basada en el Juego (GBNLS Game Based Networked Learning Strategy). El documento hace hincapié en la complejidad de los enfoques de cocreación y el valor de las herramientas y estrategias utilizadas, destacando la relevancia de las ideas y metodologías utilizadas en esta parte del proyecto DALI para otros equipos que trabajan en estrategias similares.

*Palabras clave*: co-creación, juegos educativos, alfabetización en datos, proyecto DALI, principios pedagógicos, colaboración multidisciplinar.

# Introduction

In the current educational landscape, there is a growing need for innovative approaches that cater to the changing competencies needed from adults today. Researchers and educational designers are facing the challenge of developing pedagogically engaging solutions that not only address educational goals but also tap into the subjects that highly motivate the intended learners. It is within this complex educational environment that games and playful learning approaches emerge as pivotal tools (Arnab et al., 2019; Whitton, 2018).

Games have become an increasingly pertinent medium for cultural expression and artistic creativity, serving as imaginative systems that facilitate both playfulness and exploration (Arnab et al., 2019). Designing and creating games for learning is a complex challenge as it demands the balancing of the playful aspects of games and the educational outcomes they are expected to enable. There thus needs to be an intentional

mapping of the game design aspects to the pedagogical aspects to ensure that the gameplay process will facilitate the learning process, enable adaptation of the games, leading to their reusability.

Recognizing the intricacy of this design challenge, this paper aims to explore the co-creation of educational games for adults, specifically targeting the development of data competencies. This endeavour unfolds within the ambit of the Data Literacy for Citizenship (DALI) project, executed under a participatory-based research approach (Gros, 2019; Gros & Durall, 2020). DALI entails collaborative endeavours in developing, testing, and evaluating learning strategies, co-creating games, and engaging adult learners with game-based resources. The project endeavours to kindle heightened interest and participation in learning through effective outreach, guidance, and motivational strategies.

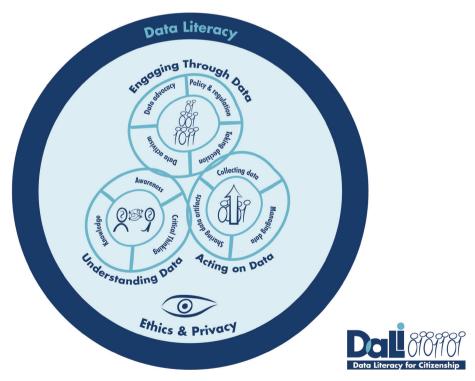
This paper elucidates five distinct design phases and elucidates the strategies and tools employed during this process. It underscores their value in the framework of educational game development and emphasizes their significance within the unique context of DALI's experience. Comprehending the complexity of this approach is crucial, and delineating the value of each tool and strategy used in the process is pivotal. This insight is not only pertinent to the present context but also holds relevance for other teams embarking on the development of analogous strategies in the future.

# The DALI project, Data Literacy, and Game-Based Learning

Data Literacy for Citizenship (DALI) is an Erasmus+ project (Strategic Partnership 2020-1-NO01-KA204-076492), aimed at empowering adults to become responsible citizens and actively engage in civic activities in a world shaped by digital advancements through the development of their data literacy. DALI focuses on adults, considering that, in addition to the impact of data on their own lives, these adults have the responsibility of overseeing how young people interact with data both at home and in educational settings. The primary target groups include young adults, general adults, and senior citizens across four countries: Germany, Norway, Spain, and the UK. External stakeholders, including non-formal learning institutions and facilitators, acted as associated partners in the project.

The project started with the development of a Conceptual Framework of Data Literacy (Figure I), the DALI Framework for Data Literacy for Citizenry (Castañeda et al., 2024). The process of creating this framework involved a three-and-a-half round Delphi study that engaged experts from diverse fields such as data, education, and literacy, across four countries. The DALI Data Literacy framework encompasses four primary elements, three of which are interconnected and sometimes overlapping: (1) Understanding Data, (2) Acting on Data, and (3) Engaging Through Data. Additionally, there is a cross-cutting element, (4) Ethics & Privacy, which permeates the other three. The DALI framework is flexible and scalable, making it suitable for adaptation across various international, organizational, and educational contexts (Castañeda et al., 2024).

# FIGURE I. DALI Data literacy framework



Source: Castañeda et al., 2024.

Pursuing the learning outcomes in this framework, the DALI project developed a set of ten game-based networked learning strategies (GBNLS) that cover the basic Data Literacy spectrum for each target group. Each of the ten learning strategies was designed to meet one specific learning goal. This means that the ten games addressed different learning goals and the collection altogether covered the basic Data Literacy spectrum for each target group of adult learners.

# The Study: A Research-Based Design

The research-based design is a participatory design process which has been defined in four steps, that can occur as a sequence or in parallel (Gros, 2019): the context analysis, the participatory design, the product design and the prototype as hypothesis. Adapting these steps, the consortium started a process of cocreation of the GBNLS that follow five main phases:

- Firstly, in phase 1, the consortium started defining the Pedagogical approach that served as a learning design framework for the project. This approach included the data literacy framework developed within the project along with the playful approach and the networked learning background to develop the game-based pedagogical strategies. In this step, the target participants were also selected, which were mainly members of the associated partners within the project as well as target adults from these institutions and organizations.
- In phase 2, the consortium was onboarded into this pedagogical approach, where they were trained in workshops within the project. Usage scenarios were introduced mainly with the development of persona cases, informed by stakeholder mapping carried out in the project, which were then used to create the narratives of the target profiles of adult players. The content analysis of the first designs allows observing the diversity of sources, along with the awareness about designing a game for adult participants for data literacy skills.
- In Phase 3, collaborative workshops were conducted with partner teams and associate partners to co-create game-based networked

learning strategies (GBNLS). During this stage, target users actively engaged in discussions about games, contributing to the development process. Initial versions of both games and GBNLS were conceptualized and tested through interactive sessions. Data collection in this phase involved distributing questionnaires to researchers, who provided insights into their co-creation experiences with others.

- In phase 4, the consortium created the game prototypes and the adaptations of the prototypes. These prototypes were viewed as hypotheses, which were tested in the field trials.
- Phase 5, which was specifically included in this process as an adaptation, encompassed the visual and material design of GBNLS (Game-Based Networked Learning Strategies) to be presented to trainers and educators.

A summary of this part of the project is detailed in the following figure (Figure II).

# Phase 1. Context: Definition of the Learning Approach and target participants

According to Wasson and Kirschner (2020), the contemporary technological and educational landscape has shifted the emphasis in learning design "from just the learning materials and their sequence... ... to the learning environment as a whole" (Wasson & Kirschner, 2020, p. 816). This underscores the significance of moving beyond a sole focus on content or artifacts, highlighting the transformation of learning design into the crafting of a comprehensive learning experience within a specific learning environment. Therefore, the formulation of DALI learning strategies, while directed at non-formal educational contexts, must exhibit coherence on their formulation and a clearly defined pedagogical approach. This approach should prioritize the objectives of Data Literacy, as outlined by the DALI Data Literacy framework, aligning with an innovative perspective that places the adult learning vision at the forefront.

Consequently, the initial project phase focused on structuring a pedagogical approach that reconciles and structures the learning design behind the GBNLS. Recognizing the significance of expertise in education,

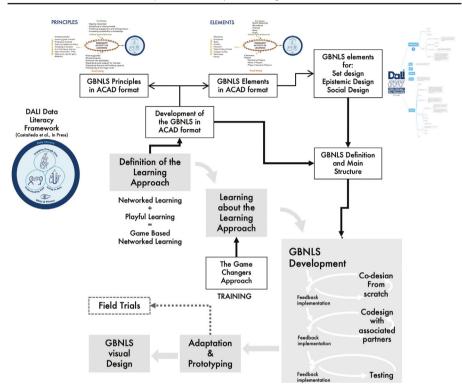


FIGURE II. DALI GBNLS development- Global process diagram

Source: Compiled by the authors.

learning design, and the science of game-based learning, a multidisciplinary approach was adopted. Two specialized teams, one from the University of Murcia (UM) specializing in education and learning design, and the other from Coventry University (CU) specializing in game science, collaborated to define the learning design elements and principles (Castañeda et al., 2022). This collaboration ensures a shared pedagogical direction within the partnership, emphasizing both overarching features and essential requirements of the project's learning strategies.

Subsequently, the DALI pedagogical approach was formulated on the foundation of Networked Learning (NL). Adhering to the principles of NL involves viewing competence development as an emergent activity that

prioritizes "foregrounding learner agency." This perspective emphasizes expansive learning, reflexivity, and shared engagement among participants, fostering a "distinctive dynamic potential" (Networked Learning Editorial Collective (NLEC), 2020). The Activity-Centred Analysis and Design (ACAD) framework (Goodyear et al., 2021) was employed to organize the design components. Additionally, the learning approach incorporates principles from Connected Learning (CL) to create new scenarios that consider the social and material realities of the target participants, encompassing their needs, interests, and cultures (Ito et al., 2020).

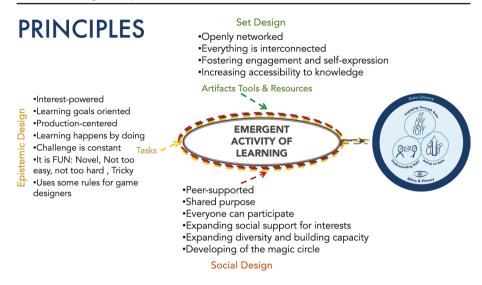
The DALI pedagogical approach also integrates the concept of playful learning, leveraging games as valuable tools to observe and facilitate play in a structured manner. This approach promotes purposeful and meaningful engagement, along with actionable feedback. According to Whitton (2018) and Tekinbaş & Zimmerman (2003), three key aspects of game use in non-formal adult learning contexts are relevant to DALI: (1) The creation of a learning environment that allows learners to embrace failure; (2) the possibility of stimulating learners' imagination enabling them to approach real-life problems from fresh perspectives and (3) the possibility of voluntary and intrinsically motivating activities through playfulness, enabling participants to enact their agency in shaping the rules, actions, and boundaries of the game space. The gaming experience itself provides a compelling context for learning and reflection (Arnab et al., 2019; Postigo Fuentes, 2021).

Grounded in playful learning, game-based learning, natural language (NL), and collaborative learning (CL), the DALI learning principles were intricately crafted utilizing the ACAD framework (refer to Goodyear et al., 2021). The primary objective was to anchor the DALI pedagogical approach in a streamlined structure, enabling the tangible embodiment of abstract project principles in physical (Set Design in ACAD), social (Social Design), and epistemic (Epistemic Design) dimensions (see Figure III).

Additionally, focusing on the essential elements of game design (Arnab, 2020; Fullerton, 2019; Schell, 2008) that align with our proposed principles, we aimed to explicitly outline the design components in each category within the ACAD framework, as illustrated in Figure IV.

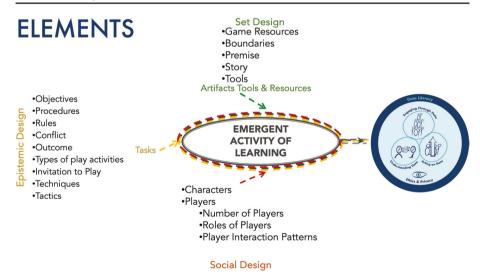
Furthermore, to facilitate the co-creation of the 10 game-based networked learning strategies (GBNLS) proposals and designs, we mapped each ACAD design element, encompassing all possible game design elements (refer to Figure V).

# FIGURE III. Design Principles of DALI GBNLS in the ACAD Framework Structure



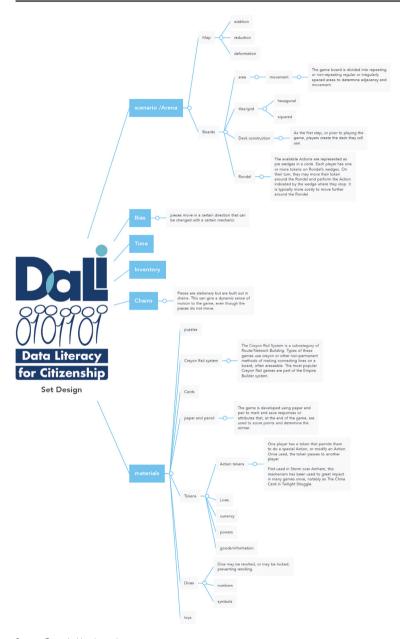
Source: Own Elaboration.

# FIGURE IV. Design Elements of DALI GBNLS in the ACAD Framework Structure



Source: Own Elaboration.

# FIGURE V. Detail on the DALI ACAD Set Design Elements Mapping



Source: Compiled by the authors.

These three maps (Set Design, Epistemic Design, and Social Design) were developed, with complete Epistemic Design and Social Design maps available in the Appendix and distributed to the entire design team.

Building on these developments, the structure of GBNLS was established. GBNLS represents the manifestation of games from a pedagogical perspective, concretizing the primary learning design elements that constitute DALI games. The final elements integrated into the GBNLS structure encompass:

The final elements included in the GBNLS structure were:

- Name of this Game-based Networked Learning Strategy
- Learning goal
  - DALI framework
  - Element
- Subelement
  - Skill
  - Ethics & Privacy
- Game inspiration
  - What game?
  - Rules or mechanics taken.
  - Elements and materials taken.
- Name of the game (different from the GBNLS one, this is the brand name of the game)
- Epistemic Design
  - The objective of the game
  - Premise (story)
  - Rules
  - Defining objects and concepts
  - Mechanics
  - Indicator of learning
  - Other aspects (Conflict, Tactics)
- Set Design
  - Estimated time.
  - Physically situation
  - Scenario/Arena
  - Materials
  - Other aspects

## Social Design

- Number of players
- Concrete characteristics of the different target groups (Young adults, General adults, Workers, and Seniors).

# Other aspects

This comprehensive list not only streamlines the design process but also ensures the effective integration of pedagogical principles into the fabric of DALI games.

# Phase 2. Training strategy for the learning approach

After the completion of the GBNLS materials and finalization of its structure, the next crucial step involved training the entire design team, comprising representatives from each partner organization, in the game co-creation. A workshop was organized for this purpose, with participation from at least two members of each partner, and was facilitated by Coventry University (CU). The workshop adhered to the Game Design Thinking strategy, a co-creation technique established by CU's Game Changers initiative (https://gchangers.org), as illustrated in Figure VI. This methodology (The Game Changers' methodology), detailed by Arnab et al. (2017), played a pivotal role in shaping the DALI learning strategies.

The integration of design thinking with game design in the field of education has led to a unique approach known as game design thinking. This approach, as proposed by Arnab et al. (Arnab et al., 2017), facilitates the development of empathy through the game co-creation process, providing a meaningful framework for the design of game-based learning (GBL) resources. The approach follows an iterative design process (see Figure VI), drawing upon the principles of design thinking as outlined by Plattner (2011), encompassing phases such as needs assessment, ideation, prototyping, and testing. It draws inspiration from the "Game Jam Movement" (Fowler et al., 2013).

Games, with their structured rules, clear objectives, and multiple possible solutions to problems, provide an ideal context for embracing design thinking principles (Arnab et al., 2017). Partners in DALI were trained, where they practiced with the ideation and design of games that respond to the data competency framework using the mechanics, dynamics, and aesthetics of existing games. The process was guided by

EMPATHISE

Step 1: Understand the need and the target audience

• What specific topic? corrindom?

• What specific topic? corrindom?

• What soutcomes need to be arbitived – learning, behavioral, competioning of suitive discontinuity of the content of learning, such as where and when?

• What are the assessment / reflection criteria?

• What a content content of learning, such as where and when?

• What are the season of which the content of learning, such as where and when?

• What are the season of which the content of learning, such as where and when?

• What are the season of which the content of learning, such as where and when?

• What are the season of which the content of learning is the content of learning. Such as where and when?

• What are the season of which the content of learning is the content of learning is the content of learning is the content of learning.

• What are the season of which the content of learning is the content of learning is the content of learning is the content of learning.

• What are the season of which the content of learning is the content of l

PROTOTYPE

Step 5: Create your game

rhat platform/medium is your game? e you leveraging available resources - what can you TEST

Step 6: Implement your game with

players

How are you deploying the game?

what is the learning assessment instrument What is the game evaluation instrument? What feedback will be looped back to impri fow flexible is your design — can it adapt gra can others adapt the solution?

FIGURE VI. An extended Game Design Thinking Protocol based on the Game Changers approach

Source: Arnab et al., 2017.

IDEATE (Part 2)

Step 4: Design your game

What is the concept of your game and gameplay?

How many players per game?

How do the game rules and gameplay map to the learning ctivities/tasks?

What are the aesthetics of your game i.e., game elements, into ook and feel, etc.? Is you design flexible – can it be easily adapted to work with different environments / resources?

What are the rules of your game?

relevant prompts under each stage (refer to Figure VI). Through exploring multiple creative solutions based on this approach, partners can then engage their teams and stakeholders in the game design process in Phase 3.

# Phase 3. Codesigning the DALI GBNLS

The primary aim of this phase was to formulate a set of engaging and adaptable learning strategies explicitly designed to promote the advancement of adult data literacy across various non-formal contexts. To achieve this, the project embraced a co-design methodology, involving the collaborative creation of GBNLS through a multidisciplinary approach (Prior et al., 2022) that harnessed combined creativity during the design process (Sanders & Stappers, 2008).

New workshops within partner teams were conducted to co-create games, employing a double strategy of cooperative inquiry and informant design (De Jans et al., 2017). The cooperative inquiry involved

partners working in specialized groups, each dedicated to a specific target audience (Young adults, General adults, Workers, and Seniors). Simultaneously, an informant design strategy was implemented to incorporate external stakeholders, such as non-formal learning institutions and facilitators acting as project-associated partners, maximizing the value of their contributions (De Jans et al., 2017; Lanezki et al., 2020).

Considering these aspects, the co-design of GBNLS unfolded across three key moments:

- a) GBNLS co-design from inception: International co-design teams, comprising one partner per country, utilized the Game Design Thinking strategy to develop the initial game idea.
- b) Second Co-Design moment: The developed game ideas were tested in each country, with at least one partner providing feedback and suggesting improvements to the game.
- c) Third Co-Design moment: In a large group setting, all members of the game design teams collaborated to design adaptations for broader applicability across different target groups.

Throughout these instances, instruments were devised to collect data on the co-created games' quality. The first two instruments were derived from a condensed version of the UNE (Spanish Association for Standardization) 71362:2020 instrument, which evaluates the quality of digital educational materials (UNE, 2020). Surveys included questions related to criteria such as general instructions, learning impact, fun and motivation, visual design, and textual content accessibility. Initially, a quantitative approach offered a general overview of the co-creation process. Subsequently, a qualitative instrument provided detailed feedback, identifying optimal gameplay requirements. Two qualitative questions gauged partner satisfaction and gathered suggestions for necessary changes in previously defined criteria.

The three key moments are described below:

# a) The GBNLS co-design from inception

Each team was given the task to design two GBNLS. Each GBNLS included as a learning objective, at least, one Data Literacy Framework sub element that was indicated in advance. The teams could include more than

one sub element or level in the game but to ensure coverage of the data literacy spectrum, the one specified was compulsory and had to be the principal one. All the games created in DALI aimed to develop the basic level (level A) of the DALI Data Literacy Framework (Table I).

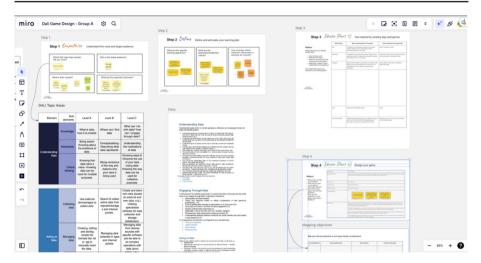
TABLE I. DALI Data Literacy Framework, Level A: elements and subelements

Element	Sub-elements	Level A
Understanding Data	Knowledge	(Know) what is data and how it is created
	Awareness	Be aware / Know about the existence of data
	Critical thinking	Know that data have a value / Know data can be used for multiple purposes
Acting on Data	Collecting data	Use external devices/apps to collect data
	Managing data	Create, edit, and store simple file formats like .txt or .xsl to manually insert the data
	Sharing data artifacts	Share and communicating data sets that already exist under ethical considerations
Engaging through Data	Policy and regulation	Understand how society shapes data use or influences policy making
	Taking decision	Understand civil action / Understand individual potential to use data
	Data activism	Understand data activism movements and how these can change the use of that data that stakeholders do
	Data advocacy	Understand your influence on peers or stakeholders to help them understand the potential and applications of data

Source: Castañeda et al. 2024.

Collaborative understanding among stakeholders relies on the exchange of knowledge. Furthermore, the initial stage of designing a game holds significant importance as stakeholders must align on the project's objectives, expectations from the involved parties, and the requirements of the intended audience (Prior et al., 2022).

Materials with all the elements of the Educational Approach, as well as guides and exercises, were organized in a folder, available for each team. Additionally, a MIRO board was created for each group to follow the Game Design Thinking Strategy (Figure VII).



# FIGURE VII. Miro Board used for Design Group A

Source: Compiled by the authors.

In total, they were 5 teams of cocreation (4, one for each target group, and one team targeting intergenerational groups), that worked online using videoconference sessions (via Zoom), shared documents (via Google Drive), and email. Some of the groups centralised their work in the MIRO Boards, as can be seen in Figure VIII.

In this phase, the collaborative teams within the partnership actively engaged in playing the games, contributing to a holistic understanding of the gaming experience. Feedback was gathered through a Likert scale, featuring seven degrees of agreement. Notably, the visual aspects received consistently high ratings for quality and clarity from the participating partners, indicating a positive reception from the outset. Nevertheless, challenges surfaced concerning the overall gameplay experience, particularly in relation to written elements found in both the instructions and game components. This insight points to areas where improvements and refinements can enhance the overall gaming experience.

# General Adults - Coup (Needs Title) - CU-URE © Q | Course classes | Cours

# FIGURE VIII. MIRO Board for "Coup"

Source: Compiled by the authors.

# b) Co-design with associated partners

In the second round of GBNLS codesign, associated partners were actively engaged in validating the games. Initial game concepts underwent testing in each participating country, involving at least one partner per country. These partners provided valuable feedback on the games and contributed by suggesting improvements, fostering a collaborative refinement process for the game designs. Validation sessions were predominantly conducted face-to-face, although some were held online for convenience.

Following the game testing with associated partners, certain games underwent readjustments, while others underwent a complete restructuring based on the insights and recommendations gathered during the validation process.

Suggestions from associated partners were related to a broad range of issues. One recurring topic was addressing challenges relating to balancing the gameplay with educational purposes. Each GBNLS should be fun and easy to play, but also promote Data Literacy and address the learning goals. A crucial aspect of each game is that it promotes play, imagination, voluntary engagement, and intrinsic motivation when they are introduced in the learning contexts. Useability, game dynamics and game mechanics were also discussed, as well as issues relating to design choices affecting the games accessibility. For instance, the final design needed to accommodate that the GNBLS were to be freely available as print-and-plays, and therefore easy to download and print. The size of the game materials and wordings of the instructions also needed to be adapted to accommodate the needs among diverse target groups. The team-based collaborative testing and evaluation processes were vital in this iterative process of continuous improvement and refinement of the functionality and overall experience of each game.

In this instance, the quality control approach was deliberately qualitative, providing teams with specific feedback to enhance subsequent stages of development. Evaluations encompassed key aspects such as the fun factor, clarity in understanding and playing, functionality of game rules and dynamics, usability and clarity of materials, visuals, texts, and instructional layout, and the appropriateness of content. The feedback, presented in open comments, was meticulously compiled into a spreadsheet. Each team received comprehensive comments pertaining to the games in which they were actively engaged. Due to space limitations, a singular comment was showcased for each dimension below:

#### Fun:

- "It is fun! One improvement (which I can write more about under) is that instead of having a moderator the cards could be bigger with the Q & A on the back and then the person on the right of the one whose turn it is, reads the Q and checks the answer. This way all could be involved!"

#### **Easiness:**

"Overall, the game was easy to play. Some suggestions: the D-A-L-I letters don't match with the subjects on the cards (data, context, person, activity). We think icons that suit the different categories might be better, and for clarity it is nice to print the icons on both sides of the cards. Some of the context / person cards can be activities as well, so therefore it's easy to mix them up".

#### Functionality:

- "I think mostly they are clear, but there was some confusion on deciding the end of the game (and if we would have one, or potentially multiple winners). The rules stated first that the game ends when someone has a perfect week (implying one person will be the winner), but then it said the person that fulfils the week should notify the rest of the players so they know it is the last round (implying the round goes on until the last round is finished, which may imply several people can be the winner)".

# Learning:

"Yes. The game did makes us think about data".

## Usability:

- "It was also time-consuming to cut around each card. Suggestion: Make cards straight edged, and place cards next to each other. (So that one 'cut' cuts between two cards)".

#### Content:

"The language of the instruction was not so clear. I think it is because multiple steps are explained single sentences, which are really long with many commas. This confused me. Suggestion: Make short sentences. No commas. Each sentence should explain one step only".

# c) Testing

Following the integration of codesigned changes with associated partners, a brief testing phase was initiated. Each team commenced testing their respective games with individuals from their specific contexts, utilizing homemade prototypes. During these testing sessions, the games were deployed, and feedback was gathered. The associated partners were queried about their overall satisfaction with the games, and input was sought regarding recommended changes for the final version. These recommendations focused on the previously mentioned criteria, encompassing factors such as game satisfaction, usability, and suggested modifications to enhance the game experience. The following are examples of the feedback:

#### Satisfaction.

- "They liked the game and had fun. Also, the fact of talking and reflecting on the data is something they valued".

## Changes

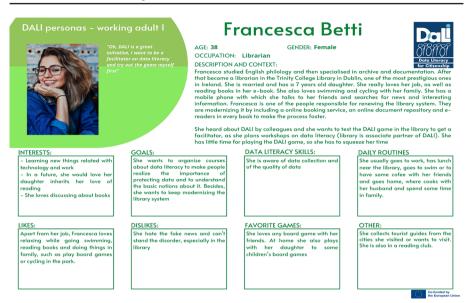
- "We found that the rules and the game dynamics are clear in general and made only some suggestions for the instructions and cards in detail:
  - explain the idea of the personal board before it is mentioned in ""Game Play"" as the ""right place""
  - name examples for "data" in the introduction to make it clearer what is meant by data
  - wording: personal player board (board) or personal game board (instructions), it should be called the same in all places.
  - clarify the role of the jokers: what does ""you can keep the joker"" mean? mention that the jokers don't count in the end.
  - suggest in "end of the game" to check together if pairs are placed rightly, so that all players can learn from that.
  - card about parking not clear, makes sense if a parking app is meant, app should be mentioned then in the card text".

# Phase 4. Adaptation and Prototyping

During Phase 4, the entire consortium engaged in the creation of game prototypes. This conclusive stage involved refining the visual design, game mechanics, and content of the games, culminating in presentations to trainers and educators. The cocreation teams collaborated on developing the visual design of the game material of each GBNLS. The visual interface of each game was also created through a reiterative co-creation process. Whilst placing data literacy and adult learning at the forefront, some practical criteria were also agreed upon. For instance, the games' illustrations needed to be under creative commons license, and the final game-based resources had to be easy to share and print-and-play. These refined prototypes were perceived as hypotheses, subsequently subjected to field trials for validation.

After confirming the readiness of all games for their initial release, we commenced the customization process to tailor each game for diverse target groups. In a collaborative face-to-face meeting that included all design group members, the consortium introduced a dynamic needs

# FIGURE IX. Persona: Working Adult N.1



Source: Compiled by the authors.

analysis framework employing design tools known as "personas" (Jansen et al., 2020). Two personas were meticulously crafted for each target group, providing a clearer understanding of the ultimate end-users of the games (see Figure IX for an example of the personas).

Utilizing these personas during the meeting, the consortium organized into teams to deliberate and analyse the needs of these personas concerning games (see Figure X). Subsequently, the teams shared their conclusions in a collaborative session focused on Data Literacy.

In the shared session, based on the insights gathered, the entire group collaborated on proposals for adapting each game to the different DALI target groups.

# Phase 5. GBNLS Visual Design

After finalizing the games, primed for extensive testing by end-users in the subsequent project phase, the concluding element of this design



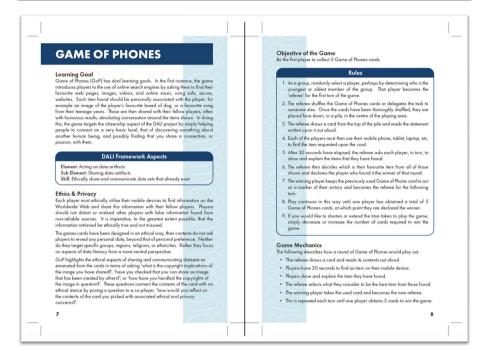


Source: Compiled by the authors.

phase focuses on the visual design of the GBNLS. As emphasised earlier, while games play a crucial role in the DALI approach, the development of GBNLS has the capacity to underscore the pedagogical and educational foundations of these games. This emphasis on learning design informs educators and trainers, offering valuable insights to integrate games into meaningful learning experiences (Castañeda et al., 2022).

Drawing on the prototyped versions of the games, the GBNLS underwent refinement, and the visual design was meticulously curated by CU (refer to Figure XI). These refined GBNLS were then organized into a handbook tailored for facilitators. Furthermore, a guide for facilitators was created, with indications and recommendations for carrying out play sessions.

# FIGURE XI. Game of Phones GBNLS design



Source: Game of Phones GBNLS in DALI Handbook (https://toolkit.dalicitizens.eu/for-facilitators).

# **Conclusions**

Acknowledging the inherent complexity of designing educational games for adults, this paper seeks to delve into the co-creation process within the context of the Data Literacy for Citizenship (DALI) project for the design of educational games for adults. Addressing the intricate processes of designing learning games, a participatory approach is adopted, which is aligned with current trends for game design (Arnab et al., 2019; Gros, 2019; Prior et al., 2022).

The DALI project, conducted as participatory research, encourages collaborative development, testing and evaluation of learning strategies, the co-creation of games and the engagement of adult learners with game-based resources, and the process of development outlined in the previous sections highlights several characteristic features that emerge as particularly interesting:

- Multidisciplinary approach: The project adopts a multidisciplinary approach, with specialized teams in education and learning design as well as game learning science working together. This collaborative effort ensures a comprehensive understanding and integration of expertise from different fields, which can lead to a well-rounded and effective learning approach (Prior et al., 2022).
- Pedagogical direction: The partnership ensures that everyone involved in the project follows the same pedagogical direction by defining the learning design elements and principles. This alignment promotes consistency and coherence in the development of learning strategies and educational experiences (Bartolomé et al., 2018; Castañeda & Selwyn, 2018).
- Networked Learning and Connected Learning: The DALI approach is based on principles of networked learning and connected learning. These approaches emphasize learner agency, reflexivity, shared engagement, and consideration of social and material realities. By incorporating these principles, the project aims to create learning experiences that are relevant, engaging, and culturally sensitive (Ito et al., 2020; Networked Learning Editorial Collective (NLEC), 2020).
- Value of games in learning: The text highlights the value of games to promote play, imagination, voluntary engagement, and intrinsic motivation in learning contexts. Games provide a structured environment that allows learners to embrace failure, approach real-life problems from fresh perspectives, and actively shape the game space. The use of games can enhance learning experiences and provide actionable feedback (Agbo et al., 2021; Paraskeva et al., 2010).
- Game Design Thinking: The project utilizes the Game Design Thinking strategy, which integrates design thinking principles with game design. This approach facilitates empathy, ideation, prototyping, and testing in the development of game-based learning resources. It provides a meaningful framework for the

- design of engaging and effective learning experiences (Arnab et al., 2019, 2019; Lanezki et al., 2020).
- Co-design and collaboration: The project adopts a co-design approach, involving multiple partners and stakeholders in the design process. Through cooperative inquiry and informant design strategies, the project maximizes the value of contributions from diverse perspectives. This collaborative work approach enhances creativity and ensures the development of playful and flexible learning strategies (Gros & Durall, 2020; Sanders & Stappers, 2008).
- Iterative design process: The project follows an iterative design process, involving multiple phases such as needs assessment, ideation, prototyping, and testing. This iterative approach allows for continuous improvement and refinement of the game-based networked learning strategies (Agbo et al., 2021; Lanezki et al., 2020) The quality control and criteria based on the 71362:2020 UNE norm (UNE, 2020) allowed obtaining concrete and efficient feedback for further improvement within the iterative design process.
- Participatory design: from game concept ideation through to the design of the gameplay mechanics, dynamics, and aesthetics. Building on the preceding contemplation of co-design and collaboration, a key emphasis on participatory design throughout all stages of game development underscores the potential for participants as co-creators to enrich the game concept from its inception. Additionally, their inclusion in the later phases proves instrumental in refining and enhancing the game's mechanisms and functional aspects. This dual approach ensures a comprehensive engagement of co-creators, optimizing both the conceptual foundation and the fine-tuning of the game's operational elements. (Destyanto et al., 2019)
- Adaptation and prototyping: The project recognize the importance of adapting the games to different target groups. By conducting need analysis and developing personas, the consortium ensures that the games meet the specific needs and preferences of each target group. This adaptation process enhances the relevance and effectiveness of the games.

■ Visual design: The project considers the visual design of the gamebased networked learning strategies. Attention to visual elements can enhance user engagement, aesthetics, and overall user experience. Overall, the text highlights the comprehensive and collaborative approach taken in the project, the value of games in learning, and the iterative design process employed to create engaging and effective game-based networked learning strategies.

## Aknowledgement

The authorship team extend their heartfelt gratitude to all consortium members for their invaluable contributions to the development of the framework. This research has been supported by the Project DALI "Data Literacy for Citizenship, an ERASMUS+ Strategic Partnership (KA204-076492) funded by the European Union.

## Bibliographical references

- Agbo, F. J., Oyelere, S. S., Suhonen, J., & Laine, T. H. (2021). Co-design of mini games for learning computational thinking in an online environment. *Education and Information Technologies*, *26*(5), 5815–5849. https://doi.org/10.1007/s10639-021-10515-1
- Arnab, S. (2020). *Game Science in Hybrid Learning Spaces*. Routledge. https://doi.org/10.4324/9781315295053
- Arnab, S., Clarke, S., & Morini, L. (2019). Co-Creativity through Play and Game Design Thinking. *Electronic Journal of E-Learning*, *17*(3), Article 3. https://doi.org/10.34190/JEL.17.3.002
- Arnab, S., Morini, L., Green, K., Masters, A., & Bellamy-Woods, T. (2017). We are the Game Changers: An Open Gaming Literacy Programme. *International Journal of Game-Based Learning (IJGBL)*, 7(3), 51–62. https://doi.org/10.4018/IJGBL.2017070105
- Bartolomé, A., Castañeda, L., & Adell, J. (2018). Personalisation in educational technology: The absence of underlying pedagogies. *International Journal of Educational Technology in Higher Education*, *15*, 14. https://doi.org/10.1186/s41239-018-0095-0

- Castañeda, L., Haba-Ortuño, I., Villar-Onrubia, D., Marín, V. I., Tur, G., Ruipérez-Valiente, J. A., & Wasson, B. (2024). Developing the DALI Data Literacy Framework for critical citizenry. *RIED-Revista Iberoamericana de Educación a Distancia*, *27*(1), Article 1. https://doi.org/10.5944/ried.27.1.37773
- Castañeda, L., & Selwyn, N. (2018). More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education*, *15*, 22. https://doi.org/10.1186/s41239-018-0109-y
- Castañeda, L., Villar-Onrubia, D., Haba-Ortuño, I., Postigo-Fuentes, A. Y., & Arnab, S. (2022). Game-based Networked Learning. *Proceedings For The Thirteenth International Conference On Networked Learning*, 273–277. https://prod-aaudxp-cms-001-app.azurewebsites.net/media/ebadergh/1274674\_proceedings-for-the-thirteenth-international-conference-on-networked-learning\_.pdf
- De Jans, S., Van Geit, K., Cauberghe, V., Hudders, L., & De Veirman, M. (2017). Using games to raise awareness: How to co-design serious mini-games? *Computers & Education*, 110, 77–87. https://doi.org/10.1016/j.compedu.2017.03.009
- Destyanto, A. R., Hidayatno, A., Moeis, A. O., & Iman, M. R. N. (2019). Co-creating Prototype Improvement Using Participatory Design on the Development of a Serious Game in Financial Literacy Skills. In R. Hamada, S. Soranastaporn, H. Kanegae, P. Dumrongrojwatthana, S. Chaisanit, P. Rizzi, & V. Dumblekar (Eds.), *Neo-Simulation and Gaming Toward Active Learning* (pp. 111–122). Springer Nature. https://doi.org/10.1007/978-981-13-8039-6\_10
- Fowler, A., Khosmood, F., Arya, A., & Lai, G. (2013, October 6). The Global Game Jam for Teaching and Learning. *Proceedings of the 4th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ2013)*. 4th Annual Conference of Computing and Information Technology Research and Education New Zealand (CITRENZ2013), Hamilton, New Zealand.
- Fullerton, T. (2019). Game Design Workshop. CRC Press.
- Goodyear, P., Carvalho, L., & Yeoman, P. (2021). Activity-Centred Analysis and Design (ACAD): Core purposes, distinctive qualities and current developments. *Educational Technology Research and Development*, 69(2), 445–464. https://doi.org/10.1007/s11423-020-09926-7

- Gros, B. (2019). *La investigación sobre el diseño participativo de entornos digitales de aprendizaje*. Universitat de Barcelona. https://diposit.ub.edu/dspace/handle/2445/144898
- Gros, B., & Durall, E. (2020). Retos y oportunidades del diseño participativo en tecnología educativa. *Edutec. Revista Electrónica de Tecnología Educativa*, 74, Article 74. https://doi.org/10.21556/edutec.2020.74.1761
- Ito, M., Richard Arum, Dalton Conley, Kris Gutiérrez, Ben Kirshner, Sonia Livingstone, Vera Michalchik, William Penuel, Kylie Peppler, Nichole Pinkard, Jean Rhodes, Katie Salen Tekinbaş, Juliet Schor, Julian Sefton-Green, & S. Craig Watkins. (2020). *The Connected Learning Research Network: Reflections on a Decade of Engaged Scholarship*. Connected Learning Alliance. https://clalliance.org/wp-content/uploads/2020/02/CLRN\_Report.pdf
- Jansen, B. J., Salminen, J. O., & Jung, S.-G. (2020). Data-Driven Personas for Enhanced User Understanding: Combining Empathy with Rationality for Better Insights to Analytics. *Data and Information Management*, *4*(1), 1–17. https://doi.org/10.2478/dim-2020-0005
- Lanezki, M., Siemer, C., & Wehkamp, S. (2020). "Changing the Game—Neighbourhood": An Energy Transition Board Game, Developed in a Co-Design Process: A Case Study. Sustainability, 12(24), Article 24. https://doi.org/10.3390/su122410509
- Networked Learning Editorial Collective (NLEC). (2020). Networked Learning: Inviting Redefinition. *Postdigital Science and Education*. https://doi.org/10.1007/s42438-020-00167-8
- Plattner, H. (2011). *An Introduction to Design Thinking PROCESS GUIDE*. Institute of Design at Stanford. https://web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf
- Paraskeva, F., Mysirlaki, S., & Papagianni, A. (2010). Multiplayer online games as educational tools: Facing new challenges in learning. *Computers and Education*, *54*(2), 498–505. Scopus. https://doi.org/10.1016/j.compedu.2009.09.001
- Postigo Fuentes, A. Y. (2021). *Aprendizaje de una lengua extranjera en una liga de esports amateur. Un estudio de caso*. [Universidad de Málaga]. https://hdl.handle.net/10630/22920
- Prior, E., Sanchez, E., & Mandran, N. (2022). Supporting Knowledge Sharing for the Co-design of Digital Learning Games. In K. Kiili, K. Antti,

- F. de Rosa, M. Dindar, M. Kickmeier-Rust, & F. Bellotti (Eds.), *Games and Learning Alliance* (pp. 32–42). Springer International Publishing. https://doi.org/10.1007/978-3-031-22124-8\_4
- Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, 4(1), 5–18. https://doi.org/10.1080/15710880701875068
- Schell, J. (2008). *The art of game design: A book of lenses*. Elsevier/Morgan Kaufmann.
- Tekinbaş, K. S., & Zimmerman, E. (2003). Rules of Play: Game Design Fundamentals. MIT Press.
- UNE. (2020). *Norma UNE 71362:2020 de calidad de los materiales educativos digitales* (71362:2020). https://www.une.org/encuentra-tu-norma/busca-tu-norma/norma?c=N0063263
- Wasson, B., & Kirschner, P. A. (2020). Learning Design: European Approaches. *TechTrends*, 64(6), 815–827. https://doi.org/10.1007/s11528-020-00498-0
- Whitton, N. (2018). Playful learning: Tools, techniques, and tactics. *Research in Learning Technology*, 26. https://doi.org/10.25304/rlt. v26.2035

Contact address: Linda Castañeda. Universidad de Murcia. Facultad de Educación. Campus Universitario de Espinardo. 30100 Murcia. E-mail: lindacq@um.es

# Gamified approaches to computational thinking in teacher training

# Enfoques gamificados de pensamiento computacional en formación docente

https://doi.org/10.4438/1988-592X-RE-2024-405-628

### Andrea Bueno-Baquero

https://orcid.org/0000-0001-5567-7535 Universidad de Castilla-La Mancha

### Javier del Olmo-Muñoz

https://orcid.org/0000-0001-8754-0648 Universidad de Castilla-La Mancha

## José Antonio González-Calero

https://orcid.org/0000-0003-0842-8151 Universidad de Castilla-La Mancha

#### Ramón Cózar-Gutiérrez

https://orcid.org/0000-0001-8255-6376 Universidad de Castilla-La Mancha

#### **Abstract**

This study explores the integration of computational thinking (CT) and gamification in teacher training. In the digital age, technology plays an essential role in all fields, including education. CT is already a fundamental skill in compulsory education, which implies a critical evolution in the contemporary educational landscape. Gamification has emerged as a powerful tool in education, revolutionising traditional teaching methods. By integrating game elements into the learning environment, gamification can increase student engagement and

motivation, which are essential for effective learning. The study focused on the integration of gamification for CT promotion and training with 99 prospective teachers, using two types of gamification: shallow and deep gamification. Shallow gamification focuses on external components such as points, levels and badges, while deep gamification incorporates elements beyond the points that are considered meaningful to participants, such as personalised avatars, narratives, unexpected events and alternative activities. Results indicated improvements in self-perceived CT skills, particularly with deep gamification, but a decrease in the problem-solving dimension. In addition, higher motivation was observed in the shallow gamification group. These results have significant implications for teacher education. Overall, the integration of gamification into CT instruction represents a promising strategy for improving the training of future teachers in an increasingly digitised world. However, the implementation of gamification must be carefully considered to ensure that all CT skills are developed effectively. Ultimately, more research is needed to unravel the underlying causes of the results obtained and to explore the application of CT and gamification in various educational settings and levels.

*Keywords:* computational thinking, gamification, intrinsic motivation, extrinsic motivation, pre-service teachers, higher education.

#### Resumen

Este estudio aborda la integración del pensamiento computacional (PC) y la gamificación en la formación del profesorado. En la era digital, la tecnología desempeña un papel esencial en todos los ámbitos, incluida la educación. El PC constituye ya una habilidad fundamental en la educación obligatoria, lo que implica una evolución crítica en el panorama educativo contemporáneo. La gamificación, por su parte, ha surgido como una herramienta poderosa en la educación, revolucionando los métodos de enseñanza tradicionales. Al integrar elementos de juego en el entorno de aprendizaje, la gamificación puede aumentar el compromiso y la motivación de los estudiantes, fundamentales para un aprendizaje eficaz. El estudio se centró en la integración de la gamificación para la promoción y capacitación en PC con 99 futuros docentes, utilizando dos tipos de gamificación: superficial y profunda. La gamificación superficial se centra en componentes externos como puntos, niveles y medallas, mientras que la gamificación profunda incorpora elementos más allá de los puntos que se consideran significativos para los participantes, como avatares personalizados, narrativas, eventos inesperados y actividades alternativas. Los resultados indicaron mejoras en habilidades auto percibidas de PC, particularmente con gamificación profunda, pero una disminución en la dimensión de resolución de problemas. Además, se observó mayor motivación en el grupo con gamificación superficial. Estos resultados tienen implicaciones significativas para la formación

del profesorado. En conjunto, la integración de la gamificación en la instrucción de PC representa una estrategia prometedora para mejorar la capacitación de futuros docentes en un mundo cada vez más digitalizado. Sin embargo, la implementación de la gamificación debe ser cuidadosamente estudiada para garantizar que todas las habilidades de PC se desarrollen eficazmente. En definitiva, se necesita más investigación para desentrañar las causas subyacentes de los resultados obtenidos y explorar la aplicación del PC y la gamificación en diversos entornos y niveles educativos.

Palabras clave: pensamiento computacional, gamificación, motivación intrínseca, motivación extrínseca, docentes en formación, educación superior.

### Introduction

Today, in the digital era in which we are immersed, technology has an essential role in every field, including education. In this domain, computational thinking (CT) is acquiring a key role in recent years, receiving increasing interest of different countries which are including it as a necessary skill in compulsory education (Bocconi et al., 2022). This shift implies a critical evolution in the contemporary educational landscape, aligning it with the dynamic needs of the digital world.

Similarly, in this technology-driven era, gamification has emerged as a fundamental tool in education, revolutionising traditional teaching methods. By integrating gaming elements into the learning environment, gamification can increase student engagement and motivation. As educational institutions strive to prepare students for a rapidly changing world, gamification offers a dynamic and adaptive approach to teaching that resonates with today's digital natives. This has led to increased adoption of gamification strategies in educational settings around the world, as educators and policymakers recognise its potential in fostering critical skills and competencies in students (van Roy & Zaman, 2017).

The intersection between CT and games has already been explored both at pre-university levels (e.g., Madariaga et al., 2023) and in future teacher training (Tankiz & Atman Uslu, 2023). Moreover, the inclusion of CT and gamification into teacher education programmes is therefore essential to prepare educators to effectively navigate the contemporary educational landscape (Dong et al., 2023). By incorporating CT in teacher training, pre-service teachers can develop CT knowledge and pedagogical

skills associated with teaching CT (Ottenbreit-Leftwich et al., 2021). At the same time, exposure to gamification can equip them with innovative strategies to engage and motivate their future students (Cózar-Gutiérrez & Sáez-López, 2016). As teachers are central to the learning experience, it is imperative that they are well versed in CT and gamification to foster a generation of technology literate, motivated and well-prepared learners. This integration into teacher training can ultimately contribute to a more adaptive and future-oriented education system.

Although there are existing studies which have used gamification as a method to teach CT, further research is necessary (Altaie & Jawawi, 2021). Because of that reason, this study aims to focus on the abilities developed by pre-service teachers using this type of thinking and gamification as part of the instruction. Within this study, we will examine the effect of a gamified CT instruction on pre-service teachers' abilities as well as their motivational outcomes. Concretely, we are especially interested in how shallow and deep gamification affect self-reported CT skills and intrinsic and extrinsic motivation.

#### Literature review

## Computational thinking

The concept of CT emerged from the ideas of Seymour Papert (1980) who started talking about the relationship between programming and thinking abilities. However, it was years later when the concept became popular in education. Since then, different interpretations have attempted to reflect on the essence of this type of thinking. The most spread definition is the one of Wing (2006) who claims that CT involves: "solving problems, designing systems and understanding human behaviour by drawing on the fundamental concepts to computer science" (p.33). The author adds that this ability is essential for everyone, not only for scientists, comparing it with other abilities such as reading, writing or arithmetic. From this definition, two fundamental aspects can be drawn in the field of education according to a report published by INTEF (2017): the first aspect is that CT is independent of technology; the second is that this concept encompasses several different abilities to formulate problems and solutions. These two aspects will be discussed in

the next sections. The last report published by the Joint Research Centre (Bocconi et al., 2022), also highlights the idea that CT is a fundamental skill that everybody should manage. Merino-Armero et al. (2021) see on CT an opportunity to change the role of pupils from simple consumers to creators of content, including all the skills that this latter role implies. For this reason, in recent years concern has increased in regards to the introduction of this concept in compulsory education.

There are multiple ways of including CT in Primary Education. In this study we consider the distinction between plugged-in activities and unplugged activities. On the one hand, plugged-in activities are those which normally use technological devices for the development of CT skills such as computers or robots. Inside this field, it has been shown that educational robotics can promote students' active participation in their learning process promoting meaningful learning and better academic achievement (Merino-Armero, 2021). Xia and Zhong (2018) also highlighted that educational robotics creates learning environments that promote interest and motivation reinforcing positive relationships between pupils. On the other hand, unplugged activities are used for teaching computational science without the need of using technological devices. This latter method is especially recommended in Primary Education as it has been demonstrated that it helps pupils to better comprehend the main concepts of CT. Different studies have shown that conducting blended approaches introducing unplugged activities before plugged-in ones can be an effective method for CT instruction (Del Olmo-Muñoz et al., 2020; Tsarava et al., 2019).

One of the areas which needs to be highlighted is programming, as it is closely related to CT. In the field of education, it was in the 1960s when the programming language called LOGO was developed, primarily aimed at helping children learn mathematical concepts (Papert, 1980). At present, there are several intuitive models that can be used to teach programming in Primary Education. Some examples are platforms that use block-based programming environments such as Scratch and Code. org, which allow users who have not programmed before to do so in an intuitive way, arranging blocks together. The present study also included Ozoblockly, a platform used for programming the movements and instructions that the Ozobot robot will then follow. The visual format that these platforms use is known as block-based programming, a method which different studies have shown to contribute to the improvement of CT skills (see e.g., Tsarava et al., 2019).

Various authors emphasise that CT encompasses diverse skills such as arithmetic, visual-spatial reasoning, creativity, critical thinking, systems thinking, and problem solving (e.g., Zapata-Ros, 2015). To assess these multifaceted skills, the Computational Thinking Scale (CTS) developed by Korkmaz et al. (2017) is the choice for the present study involving preservice teachers. The CTS has not only undergone rigorous validity and reliability testing with university students, but also measures perceptions and attitudes towards CT (Román-González et al., 2019). This is crucial for teachers, as their perceptions and attitudes will determine how they will integrate CT into their future classrooms (Dong et al., 2023; Rich et al., 2020; Román-González et al., 2019).

The CT skills measured with the CTS are: creativity, algorithmic thinking, critical thinking, problem solving and cooperativity. For this reason, a better explanation of them is necessary to understand this study. Table I shows brief definitions of these skills in terms of CT.

## Teachers' training

Considering all the advantages found in including CT in Primary Education, the importance of training teachers to introduce this ability in class has increased in recent years. However, although teachers can appreciate the benefits of incorporating thinking abilities such as CT into compulsory education, many are uncomfortable with technology

TABLE I. Abilities associated to CT
-------------------------------------

Creativity	Life-long ability necessary for finding different solutions for the same problem.
Algorithmic thinking	Skill required for finding the solution of a proposed problem turning daily life language into programming one.
Critical thinking	Use of cognitive skills to justify and assess a problem considering consistency and soundness.
Problem solving	Ability to overcome the obstacles that may arise when solving a problem.
Cooperativity	The ability to help each other in accordance with a common purpose.

Source: Korkmaz et al. (2017).

use (Xia & Zhong, 2018), and the scarcity of trained teachers presents a current challenge in these stages (Bocconi et al., 2022). This challenge is even more important when their decisive role in changing education and schools in terms of the computational science field. Some studies have demonstrated that when teachers are involved in computational science courses, workshops or conferences, their confidence using technology and applying CT concepts increase (e.g., Rich et al., 2020). For this reason, pre-service teachers' and teachers' training is extremely necessary to give them enough tools so that they can implement it in class, taking advantage of the benefits that it brings.

Teacher training at university level should be the starting point for introducing CT in Primary Education, one of the main objectives being that teachers are capable of finding new ways of linking pedagogy with CT. To this end, Ottenbreit-Leftwich et al. (2021) propose that the challenge lies in strengthening teachers' skills to promote this learning. Above all, teachers are ultimately the ones who determine the use of technology in the classroom through their attitudes and thoughts among other things. Because of that, focusing on their training from the university stage is necessary (Bocconi, 2022).

#### Gamification

In order to integrate CT skills in Primary Education different educational methods have been proposed. Altaie and Jawawi (2021) suggested that one of the most powerful methods to learn CT is gamification. One of the main reasons to justify its implementation with CT is that it has been shown that its implementation in education increases motivation. Motivation plays a key role in educational settings as it can significantly influence learning outcomes. Self-Determination Theory (SDT) is a psychological framework that explains different types of motivation, focusing mainly on intrinsic and extrinsic motivation (Deci & Ryan, 1985).

According to SDT, intrinsic motivation refers to engaging in an activity for its inherent satisfaction or interest. In contrast, extrinsic motivation involves engaging in an activity for external rewards or to avoid negative consequences. According to Ryan and Deci (2000), SDT distinguishes between different regulations within extrinsic motivation, such as identified regulation and external regulation. Identified regulation is a

form of extrinsic motivation in which individuals engage in an activity because they identify with its value and consider it personally important, becoming identified regulations (Guay et al., 2000). External regulation, also a form of extrinsic motivation, involves behaviour that is driven by external control, such as rewards or pressures, where internalisation does not occur. In addition to these, SDT also recognises amotivation as a lack of motivation or intention to act, as a result of a sense of lack of competence or a belief that one's actions will not lead to the desired outcome. Researchers have concluded that autonomous motivation, which encompasses intrinsic motivation and identified regulation, is the desired type of motivation for positive outcomes, whereas external regulation is considered the least desired type as it represents an unstable determinant of behaviour that can lead to amotivation when external regulations are removed (van Roy & Zaman, 2017). Understanding these facets of motivation through the lens of SDT can be critical in designing gamification strategies to improve student engagement and learning outcomes.

Moreover, it is demonstrated that gamification have positive effects not only on motivation, but also on cognitive and behavioural aspects in education (Sailer & Homner, 2020). Deterding et al. (2011) define gamification as the use of game elements in contexts that do not directly involve playing, to generate motivation and interest in participants. Other studies have gone one step further, arguing that two types of gamification exist: shallow and deep gamification (Gurjanow et al., 2019).

On the one hand, shallow gamification focuses on external components like the use of points, levels and badges, what is known by some authors as "pointification" (Huang et al., 2020). In general, shallow gamification makes use of pre-defined systems that provide these aspects. Moreover, this type of gamification is associated with extrinsic motivation as it just focuses on external aspects (Gurjanow et al., 2019). This is where the SDT becomes particularly relevant. Shallow gamification, with its predefined systems and external rewards, is closely related to the external regulation described in SDT, actions are influenced by external rewards or penalties (van Roy & Zaman, 2017).

On the other hand, deep gamification incorporates elements beyond points, which are meaningful for the participants (Mozelius, 2021). Some examples are: personalized avatars, narratives, unexpected events and alternative activities. These elements increase students'

sense of autonomy like the capacity to choose the activities developed to promote their own learning and the identification of the implied participants with avatars chosen or designed by themselves. In this latter type of gamification, special attention is paid to create a narrative so that students feel identified in the teaching-learning process. Such elements of deep gamification resonate with intrinsic motivation, a central concept in SDT. When students are intrinsically motivated, they are driven by internal satisfaction and personal interest, which are fundamental for deep learning and better academic performance (Alsawaier, 2018).

### Method

The problem in which this research is framed is the lack of knowledge about how to integrate CT in Primary Education as well as developing the skills which are related with it. Considering the possible problems that teachers may find when using it in class, either due to lack of training or not being comfortable with technology, the motivation of this study is to know the perception that pre-service teachers have about CT and its associated skills. In addition, the gamified instruction applied aims to discover the motivation that participants experience considering two types of gamification: shallow and deep.

## Research questions

The study was guided by the following research questions:

- RQ1. Do pre-service teachers' self-perceived CT skills improve after the implementation of a gamified CT short instruction?
- RQ2. Do pre-service teachers' self-perceived CT skills differ depending on the type of gamification (deep or shallow) applied to a short CT instruction?
- RQ3. Do pre-service teachers' intrinsic and extrinsic motivation towards gamified CT instruction differ depending on the type of gamification (deep or shallow) applied?

## Design

Based on the main research questions of this study, a quasi-experimental design with two groups (control and experimental) was proposed. Both groups carried out a CT gamified instruction but they used different types of gamification. Specifically, the control group experienced shallow gamification for that instruction, whereas the experimental group experienced the same instruction by applying deep gamification to it. The differences between both groups are better explained in the procedure section.

#### Instruments

For this study, two validated existing questionnaires were used to measure pre-service teachers' attitudes towards CT and their motivation during the experience.

The first questionnaire (Korkmaz et al., 2017) measures different skills that have been demonstrated to be associated with CT which, are: creativity, algorithmic thinking, cooperativity, critical thinking and problem solving. The questionnaire consisted of 29 items that were answered by the participants on a scale from 1 to 5, being 1 "totally disagree" and 5 "totally agree". These items were classified into the different skills named before, following the original questionnaire guidelines. The test was administered before and after the gamified instruction to see the possible gains that pre-service teachers may have.

The second questionnaire (Guay et al., 2000) aims to measure participants' motivation towards the instruction. The authors developed this questionnaire from the stance of the SDT. The scale refers to the individual motivations that human beings experience when they are participating in a determined activity. Specifically, the authors distinguish four motivational constructs: intrinsic motivation, identified regulation, external regulation and amotivation. According to them, on the one hand, intrinsic motivation and identified regulation are said to be experienced when one behaviour is performed for self-choice reasons. On the other hand, external regulation is thought to be experienced because of

external factors that are not directly related to the main activity. Finally, amotivation is defined as the feeling which is experienced when there is no motivation towards the activity itself, nor to the possible reward obtained.

This latter questionnaire was administered only after the gamified experience was applied to determine the motivation that pre-service teachers had towards the instruction. Consistent with this view, one of the main objectives of this questionnaire was to test the possible differences between both groups controlling the type of gamification as a variable. The questionnaire consisted of 16 items which were rated on a 7-point Likert scale being 1 "not at all in agreement" and 7 "completely in agreement".

### **Context**

The present research was conducted with a total of 99 students from a Faculty of Education. All of whom were studying to obtain the Primary Education Degree. The proposal was specifically developed on the subject of History and Social Science in the University of Castilla-La Mancha. The control and the experimental group consisted of 49 and 50 students respectively. Both groups were in the second course of the degree on Primary Education teaching. The proposal was developed during weekly hours that are normally booked for seminars. At the beginning of the intervention, in response to an explicit inquiry, the students expressed that they had no knowledge of CT and had not worked on it in any previous course. In Table II there is a representation of the participants of this research:

TABLE II. Participants

Group	Students	Gender		
Control	49	Males: 18; Females: 31		
Experimental	50	Males: 11; Females: 39		

Source: Compiled by the authors.

#### **Procedure**

For the instruction design, as it has been explained previously, gamification was used to involve students and to provide the sessions with a common thread that would encourage the implementation of CT in Primary Education subjects. In this case, the instruction was held in the subject of Social Science: History and Didactics, in the second grade of the Degree on Primary Education. All the activities were designed around this subject to get as close as possible to the interests of the participants, but without modifying the contents of CT.

Firstly, concerning the instruction it is necessary to explain the differences between both groups in terms of gamification. Regarding the control group (in which shallow gamification was applied), the gamification elements were, mainly, points and leader boards. Students from this group also used avatars from historical characters to represent themselves that were randomly assigned to each participant. The experimental group, however, carried out an instruction using deep gamification. Therefore, in addition to the points and leader boards, they used avatars created by themselves and the gamification had a narrative related to History that tried to link the whole experience together. This way, the activities developed were not perceived isolated as in the control group, but they were seen as a group of activities that had a specific goal. The "MyClassGame" platform was used to track the progress of both groups. This platform allows students and teachers to identify themselves with a character, reflecting the points and advancements that they carry out. Figure I shows an illustration of this platform with the students' names anonymized.

Regarding the gamified instruction, it was composed of four sixtyminute sessions in which a variety of unplugged and plugged-in activities were presented to the participants. The method followed was based on a blended perspective: two sessions consisted of unplugged activities and two sessions consisted of plugged-in activities, which were the same for both groups. The only difference between control and experimental group lies in the gamification elements mentioned before.

Unplugged activities were selected from the website Code.org and adapted to our specific research objectives. This website counts with a wide variety of activities that can be used at different educational levels to learn CT. Because of it, as we were working with pre-service teachers,

we wanted them to have real experiences that they could apply in their future classes. Regarding plugged-in activities, they were planned using the platforms Scratch and OzoBlockly. This last one was introduced to work with robotics.

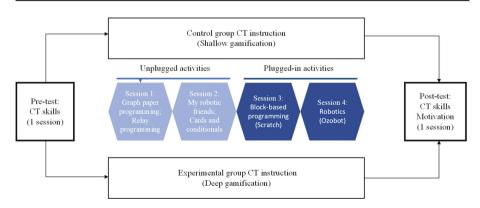
Figure II provides a detailed overview of the structured sessions, covering both the questionnaires and the diverse range of activities that constituted the instruction for both experimental conditions. It is

FIGURE I. MyClassGame platform



Source: Compiled by the authors.

FIGURE II. Study design and session procedure



Source: Compiled by the authors.

necessary to mention that in the post-test phase, both questionnaires were administered in the same session, with a brief pause between them to minimize participant fatigue. The layout and progression of these sessions were influenced by existing research (Ottenbreit-Leftwich et al., 2021; Tsarava et al., 2019), which advocates the integration of unplugged activities as precursors, plugged activities and simulation or fieldwork with robotics, as an effective approach in CT instruction.

#### Sessions

Within this section a detailed explanation of the sessions that were developed during the gamified instruction on CT in both groups is shown.

The first unplugged session consisted of two activities whose objective was to introduce pre-service teachers to programming concepts. The first activity was called "Graph Paper Programming" and it was adapted from the website Code.org. The aim of this activity was to work on basic concepts such as sequences and algorithms. The abilities developed with this activity were problem solving and algorithmic and critical thinking and the objectives pursued were:

- To organise sequences in a logical order.
- To communicate ideas through codes and symbols.

In this activity participants had to write down individually the necessary instructions that a programme would theoretically follow to colour a grid. Figure III shows an example of this activity.

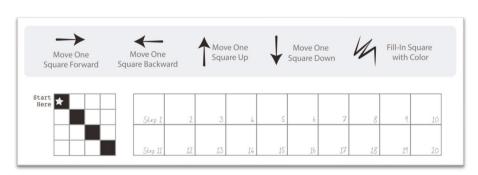


FIGURE III. Graph paper programming example

Source: Code.org (2018).

The second activity was called "Relay Programming". This activity followed the same dynamics as the previous one but in this case, it was necessary to work in teams so that we introduced participants to cooperativity skills. Participants were divided into groups of five and organised in a queue up relay-style. On one side of the room there was a queue of participants and on the other side a grid paper like the one which is shown in Figure IV. In turns, each participant needed to set a single instruction, run back and tag the next person in line so that they could write the following instruction. If a participant noticed that one of their partner's instructions was wrong, he or she would cross it out and write a new one. We wanted participants to work on the concept of "debugging" which means identifying and correcting possible mistakes that may arise in programming. The objectives pursued of this activity were:

- Define ideas using codes and symbols.
- Become familiar with the concept "debugging" by checking the work done by their teammates.

The abilities developed with this activity were mainly cooperativity and critical thinking. To link the activity with the History and Social Science subject, the participants needed to answer a few questions that were proposed, as can be seen in Figure IV. In this way, the colouring option was replaced by the correct letter which stands for the answer expressed below. Figure IV shows an example in which two answers were correct.

The second unplugged session consisted of two activities. The first activity was called "My robotic friends" and it was also adapted from Code.

#### Programme 1 Which object did Egyptians in the past use to write? Step 1 5 6 Choose the correct option. 10 11 12 13 14 16 17 18 21 22 19 20 Options: A) Papyrus. B) Clay tablet. C) Metal. D) Paper.

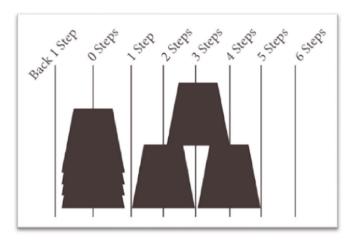
FIGURE IV. Relay Programming

Source: Adapted from Code.org (2018).

org. During this activity the participants needed to give the necessary instructions (turning the steps into programming language) to build up a tower of cups. This tower was built following a template which was provided by the researchers (Figure V).

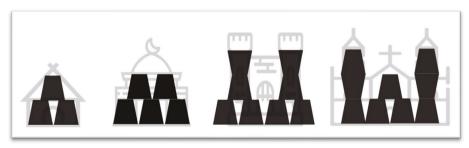
Similar to the first session we continued working with simple algorithms. The activity was developed in pairs: one student was assigned the writing of the instructions while the other carried out those instructions as if he/she was an "imaginary robot". Figure VI shows ideas for cup constructions related to History that were provided to the students.

FIGURE V. Tower of cups template example



Source: Code.org (2018).

FIGURE VI. Ideas for cup constructions related to History



Source: Compiled by the authors.

Regarding the abilities associated with CT, this activity developed critical thinking and cooperative work. The objectives pursued were:

- To trace a sequence of steps as a coded program.
- To recognise and correct possible errors in the instructions of a sequence (internalising the concept of debugging).

The second activity of this second session aimed to work the concept of "conditionals" in programming. For that purpose, a card game related with history concepts was designed. The participants needed to create their own rules with the cards given. However, the instruction should be written using blocks programming language. The objectives that this activity followed were:

- Define the requirements that a programme must meet to be executed or not.
- Determine whether a conditional is fulfilled according to the requirements given.

Within this activity the abilities cooperativity and critical thinking were developed. Figure VII shows an example extract of the instructions that were given by the participants for a card game:

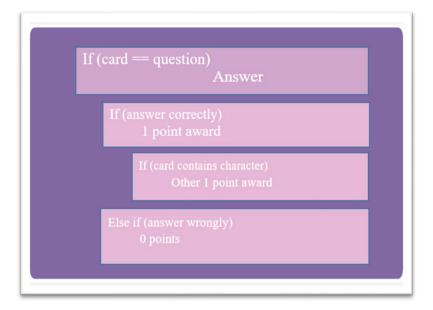
In the third session plugged-in activities were introduced. For that purpose, the educational platform Scratch was used. This platform allows programming by blocks to create activities and games. Thus, the participants needed to create their own programmes thinking about how they would develop this activity in the subject of History and Social Science. The abilities associated with CT that are developed with this activity are mainly creativity and critical thinking. The objectives of this activity were:

- To transfer the knowledge acquired in the unplugged activities to the plugged-in ones.
- To work on conditionals in programming.
- To be able to write a programme, and in case of making mistakes, to know how to correct them.

An example of these programmes is presented in Figure VIII.

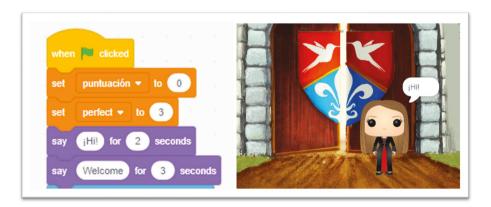
In the fourth session, following the line of plugged-in activities, educational robotics was introduced. In this case we worked with

## FIGURE VII. Conditionals example



Source: Compiled by the authors.

## FIGURE VIII. Scratch programme example



Source: Scratch (2023).

Ozobot, a robot the size of an eyeball that can be used as an introduction to programming in educational environments. This robot is programmed through block-based programming in the website "Ozoblockly". Once the instructions are made, the robot needs to be loaded with them and it will be ready to execute the programme. Concretely, we used its "follow-lines" mode. Within this session we provided participants with a board that contained some objects and inventors' names. Using the board presented, the students needed to program the robot in groups (using Ozoblockly platform) to link the two elements that were related together. The abilities associated with this session were cooperativity, creativity and problem solving. The objectives pursued with this activity were:

- To program by blocks to make the "Ozobot" follow the instructions.
- To be able to correct mistakes in case the "Ozobot" does not follow the instructions correctly.
- To encourage creativity by adding different options and trying out alternatives.

## **Results**

To answer the objectives of this study, two validated existing questionnaires were used: one questionnaire was aimed to evaluate pre-service teachers' skills associated with CT (Korkmaz et al., 2017) and the other one was held to measure participants' intrinsic and extrinsic motivation (Guay et al., 2000) towards the gamification experience implemented. Cronbach alpha reliability coefficient was used to evaluate the internal reliability of the questionnaires. The scores for the CT instrument by dimensions in the pre-test and post-test, respectively, were: creativity ( $\alpha_{pre}$ =.72;  $\alpha_{pos}$ =.79), algorithmic thinking ( $\alpha_{pre}$ =.80;  $\alpha_{pos}$ =.86), cooperativity ( $\alpha_{pre}$ =.91;  $\alpha_{pos}$ =.91), critical thinking ( $\alpha_{pre}$ =.75;  $\alpha_{pos}$ =.77), and problem solving ( $\alpha_{pre}$ =.75;  $\alpha_{pos}$ =.73). In the case of motivation, the alphas for each dimension were: intrinsic motivation ( $\alpha$ =.86), identified regulation ( $\alpha$ =.76), external regulation ( $\alpha$ =.80), and amotivation ( $\alpha$ =.86). In all cases, the values are within intervals considered respectable (.70-.80) or very good (.80-.90) (DeVellis & Thorpe, 2022).

Following the guidelines of the original questionnaire by Korkmaz et al. (2017), to analyse the results, we considered the different dimensions

in which it is divided: creativity, algorithmic thinking, cooperativity, critical thinking and problem solving. Table III shows the results obtained broken into these dimensions, considering pre-test and post-test data of both groups separately and together (Total).

In regards to self-perceived CT skills, an independent samples t-test was performed on pre-test scores to ensure that the control and experimental groups were comparable before the intervention. The test revealed no statistically significant differences (t(73) = -0.54, p = 0.5940, d = -0.12), indicating that both groups had similar baseline levels.

TABLE III. Pre-service teachers self-perceived CT skills

Dimension	n	Group	Pre-test	Post-test	Comparison
Creativity	42	Control	4.02 (0.39)	4.09 (0.44)	<b>t</b> (41)=1.23, <b>p</b> = .2258, <b>d</b> = 0.19
	39	Exp.	4.09 (0.45)	4.11 (0.48)	<b>t</b> (38)=0.49, <b>p</b> = .6302, <b>d</b> = 0.08
	81	Total	4.05 (0.42)	4.10 (0.46)	<b>t</b> (80)=1.24, <b>p</b> = .2175, <b>d</b> = 0.14
Algorithmic thinking	42	Control	3.00 (0.74)	3.13 (0.74)	<b>t</b> (41)=1.45, <b>p</b> = .1537, <b>d</b> = 0.22
	39	Exp.	2.78 (0.63)	3.00 (0.81)	<b>t</b> (38)=2.78, <b>p</b> = .0085, <b>d</b> = 0.45
	81	Total	2.90 (0.70)	3.06 (0.77)	<b>t</b> (80)=2.91, <b>p</b> = .0047, <b>d</b> = 0.32
Cooperativity	42	Control	4.15 (0.80)	4.33 (0.69)	<b>t</b> (41)=1.90, <b>p</b> = .0639, <b>d</b> = 0.29
	39	Exp.	4.38 (0.65)	4.38 (0.62)	<b>t</b> (38)=0.08, <b>p</b> = .9364, <b>d</b> = 0.13
	81	Total	4.26 (0.74)	4.36 (0.65)	<b>t</b> (80)=1.38, <b>p</b> = .1715, <b>d</b> = 0.15
Critical thinking	42	Control	3.64 (0.54)	3.79 (0.61)	<b>t</b> (41)=1.60, <b>p</b> = .1170, <b>d</b> = 0.25
	39	Exp.	3.47 (0.62)	3.67 (0.63)	<b>t</b> (38)=3.26, <b>p</b> = .0024, <b>d</b> = 0.52
	81	Total	3.56 (0.58)	3.73 (0.62)	<b>t</b> (80)=3.14, <b>p</b> = .0024, <b>d</b> = 0.35
Problem solving	42	Control	2.27 (0.58)	2.07 (0.48)	<b>t</b> (41)=2.51, <b>p</b> = .0163, <b>d</b> = -0.39
	39	Exp.	2.28 (0.56)	2.25 (0.58)	<b>t</b> (38)=0.49, <b>p</b> = .6272, <b>d</b> = -0.08
	81	Total	2.28 (0.57)	2.16 (0.53)	<b>t</b> (80)=2.27, <b>p</b> = .0259, <b>d</b> = 0.25
Total	42	Control	3.38 (0.26)	3.42 (0.26)	<b>t</b> (41)=1.07, <b>p</b> = .2909, <b>d</b> = 0,17
	39	Ехр.	3.34 (0.32)	3.43 (0.33)	<b>t</b> (38)=2.71, <b>p</b> = .0100, <b>d</b> = 0,43
	81	Total	3.36 (0.29)	3.42 (0.29)	<b>t</b> (80)=2.38, <b>p</b> = .0198, <b>d</b> = 0.26

Source: Compiled by the authors.

While the intervention did not lead to statistically significant improvements in all individual dimensions, the aggregate analysis of the total scores of self-perceived CT skills indicates a statistically significant improvement in the participants as a whole across the combined dimensions, with a small effect size according to Cohen (1988). This suggests a generalized improvement in the broader CT construct measured by the instrument, regardless of the experimental condition. When examining the overall results considering the experimental conditions, only the experimental group demonstrated a statistically significant improvement in the post-test total scores, with a small-intermediate effect size according to Cohen (1988), suggesting that the effect of the intervention is noticeable and potentially meaningful for this group.

Shifting focus to a more granular analysis of the results on the different dimensions, irrespective of the experimental condition, the participants collectively showed significant gains in the algorithmic thinking and critical thinking dimensions. In contrast, there was a significant decline in the problem-solving dimension. When examining the results by experimental condition, the most pronounced gains were observed in algorithmic and critical thinking for the experimental group, with small-intermediate and intermediate effect sizes, respectively, according to Cohen (1988). An intriguing exception to this trend of improvement was the dimension of problem-solving skills, where a significant decrease in scores was observed for the control group.

In addition to self-perceived CT skills, we measured the type of motivation that the participants experienced. To do so, the questionnaire validated in Guay et al. (2000) was used. As explained in the instruments section, this questionnaire distinguishes different motivational constructs: intrinsic motivation and identified regulation (which are related to participants self-choice), external regulation (in which participants perform the activities to obtain a reward) and amotivation (involving neither intrinsic nor extrinsic motivation). Table IV shows the results obtained distinguishing these constructs considering both, experimental and control group.

From the standpoint of descriptive analysis, the results indicate favourable motivational outcomes across all dimensions for both groups, particularly noteworthy on a 1 to 7 scale, where external regulation is the closest to a neutral midpoint (value 4). This is significant, especially since intrinsic motivation and identified regulation are esteemed as the most

TABLE IV Motivation results

Motivation type	Experimental group	Control group	Comparison
Intrinsic motivation	5.63 (1.10)	6.06 (0.74)	$\mathbf{t}(67.3)$ =-2.09, $\mathbf{p}$ = .0408, $\mathbf{d}$ = -0.46
Identified regulation	5.14 (1.00)	5.35 (1.02)	<b>t</b> (83)=-0.95, <b>p</b> =3440, <b>d</b> = -0.21
External regulation	3.39 (1.21)	2.99 (1.25)	<b>t</b> (83)=1.52, <b>p</b> = .1330, <b>d</b> = 0.33
Amotivation	2.16 (1.13)	1.58 (0.52)	<b>t</b> (53.2)=2.94, <b>p</b> = .0048, <b>d</b> = 0.65

Source: Compiled by the authors.

advantageous forms of motivation. Considering the differences between experimental conditions, it can be seen that the control group obtained higher results in intrinsic motivation than the experimental group. Considering that external regulation and amotivation are areas in which lower scores are desired due to their negative implications, the control group also excelled, showing significant lower levels of amotivation compared to the experimental group. According to Cohen (1988), the effect sizes indicate small differences for identified and external regulations, small-intermediate differences for intrinsic motivation and intermediate differences for amotivation.

#### Discussion

This study aimed to explore the impact of gamified CT teaching on the skills and motivation (intrinsic and extrinsic) of CT pre-service teachers through the lens of three research questions. In doing so, differences in outcomes attributed to the use of deep gamification techniques for the experimental group and shallow gamification techniques for the control group were critically examined.

Regarding the first research question (RQ1), which asked whether pre-service teachers' self-perceived CT skills would improve after a brief gamified CT instruction, the results indicated a positive trend in the overall score of self-perceived CT skills among the participants, irrespective of the experimental condition. This is in line with the results of previous studies (Del Olmo-Muñoz et al., 2023), but at a different educational level. When dissecting the results according to the different dimensions of self-

perceived CT skills, a lack of uniformity emerges: while there is evident progress in algorithmic thinking and critical thinking, perceptions related to problem solving have experienced a decline. This variability suggests several underlying factors at play and opens new avenues for further research. In order to properly interpret these results, it is important to note that this study did not include a control group without any form of gamification, so improvements cannot be attributed solely to the gamified elements of instruction.

Moving on to the second research question (RQ2), which sought to investigate the differences in self-perceived CT skills depending on the type of gamification implemented, the results showed that the experimental group, subjected to deep gamification techniques, showed statistically significant improvements in self-perceived CT skills overall. Improvements were most prominent in the dimensions of algorithmic thinking and critical thinking. These results are consistent with previous research claiming that immersive gamified experiences can foster engagement and learning outcomes (Altaie & Jawawi, 2021; Sailer & Homner, 2020; van Roy & Zaman, 2017). However, there is a notable exception in the problem-solving dimension for the control group. Contrary to expectations, this group exhibited a decrease in their results after the implementation of the gamified CT instruction. This is unexpected as other studies have shown improvements in problem solving following CT instruction (e.g., Cakır et al., 2021). One of the possible reasons of this fact, could be the fact that the shallow gamification techniques used in the control group may not have been sufficiently engaging or motivating for participants to become deeply attached to problem solving. Deep gamification, with its immersive elements, might be more conducive to developing a problem-solving mindset by stimulating sustained critical thinking and engagement (Alsawaier, 2018).

Considering the third research question (RQ3) related to motivation, the findings from the results section reveal that the control group, which was exposed to shallow gamification, scored higher on intrinsic motivation, a key type of motivation linked to positive outcomes. Although the difference in identified regulation between groups was not statistically significant, it is noteworthy to mention that there was a small effect size that leaned in favour of the control group too. Conversely, the experimental group, engaged in deep gamification, showed higher scores in external regulation. Although these differences did not reach statistical significance, there was a small effect size observed, slightly

favouring the experimental group. This would have negative implications, being external motivation not desired as it can lead to amotivation when external regulations are removed (van Roy & Zaman, 2017). In fact, the experimental group obtained a higher value also in terms of amotivation. All of these results expressed a contrast with literature findings, in which some authors have demonstrated a correlation between on the one hand, intrinsic motivation and deep gamification and on the other hand, extrinsic motivation and shallow gamification (Gurjanow et al., 2019; Mozelius et al., 2021). These unexpected results could be due to a confluence of factors. One possible explanation could be the length of the gamified experience. Being implemented across only four sessions, deep gamification may not have worked so well in the short term (Alsawaier, 2018). This suggests that more extended engagement with CT instruction might be necessary for substantial impact on motivation.

In addition, the context and environment in which the study was conducted might have interacted with the gamification strategies, leading to divergent results from the literature. Taking these aspects into account, it is essential to interpret the results with caution and to consider further research to unravel the underlying causes of such results. Because of that, as some authors like Altaie and Jawawi (2021) have suggested, we adhere to the demand for more research in this field to prove not only the integration of gamification into CT, but also the correlation between the type of motivation that participants experience considering shallow and deep gamification.

#### Limitations and future research

This study, while providing insights into the integration of CT and gamification, has certain limitations that warrant consideration for future research. Firstly, the sample size was modest, with 99 participants from the same age group. To increase the generalisability of the results, future research should consider using a larger and more diverse sample, considering demographic variables such as age, gender and educational level, as recommended by Dong et al. (2023).

Another noticeable limitation is the duration of the gamified instruction, which comprised only four sessions. Although these sessions were designed to be representative of core CT teaching methods, including unplugged and plugged-in activities and robotics, the brevity of the intervention might have

impeded participants' ability to fully engage and assimilate the content. In addition, the short time frame may not have been conducive for the deep gamification approach to manifest its alleged effects on intrinsic motivation. A design with a longer duration and more comprehensive gamification elements should allow for a more in-depth investigation of the effectiveness of different gamification strategies. It is also important to analyse the application of gamification methodologies. Although deep gamification was structured with a cohesive narrative, it did not produce the intended impact on intrinsic motivation. This calls for more complex designs, which could include different levels of gamification, to unravel the nuances of the relationship between different types of gamification and motivation.

Furthermore, the transferability of the results to different contexts is vital. Exploring the application of CT and gamification in diverse educational settings, such as different universities or K-12 schools, can elucidate the adaptability and effectiveness of these approaches across diverse educational landscapes. For example, Del Olmo-Muñoz et al. (2023) provide an example of the application of gamified CT instruction in primary school. This article highlights how gamified approaches can foster engagement and computational thinking skills among young learners, highlighting the potential for these approaches to be adapted and applied across diverse age groups and educational settings. In light of this, education practitioners and policy makers should consider integrating gamified CT teaching tailored to the specific needs and contexts of their learners.

Finally, the interdisciplinarity of CT has been suggested in this study, with its application demonstrated in subjects such as History and Social Sciences. However, it's noteworthy that no significant improvement was observed in dimensions such as creativity and problem solving, which warrants careful consideration. Future studies could design interventions that integrate CT into a wider range of subjects in Primary Education, exploring how gamification can be effectively employed in these contexts to foster holistic development of CT skills and competences.

## Conclusion and implications of the study

Technology has acquired great importance in the last few years, especially in terms of promoting abilities such as CT. Within this study we have addressed the relevance of introducing CT in pre-service teachers training at university. In line with some emerging studies (Altaie & Jawawi, 2021; Del Olmo-Muñoz et al., 2023), this study has demonstrated that blending CT and gamification is a good model to do so, as it can motivate participants and offer them a different vision to incorporate it in their future classrooms.

Analysing the results obtained, it can be noted that, after applying a CT instruction, pre-service teachers improved their self-perceived CT skills considering the different areas that Korkmaz et al. (2017) suggested such as critical thinking and algorithmic thinking. However, in this study it was appreciated that there was an exception in the problemsolving skill, where the results decreased after developing the gamified CT instruction, instead of increasing as was expected. Moreover, it has been demonstrated that it is possible to introduce CT concepts in diverse subjects, in this case History and Social Science. Regarding gamification, the results have shown that there is no clear relationship between deep gamification and intrinsic motivation on the one hand, and shallow gamification and extrinsic motivation on the other hand. Nevertheless, it seems that presenting pre-service teachers CT activities together with a gamification methodology had a positive effect in motivational aspects in both groups, irrespective of the type of gamification applied. Thus, we encourage future researchers to explore combinations of CT and gamification to provide pre-service teachers with the necessary background to teach CT in primary education, as it has been shown to be an essential skill that helps learners in different aspects of their lives. Education depends to a large extent on teachers. For this reason, investing in initial teacher training is a key point for introducing CT at primary education schools.

## **Funding**

This work has been supported by project 2022-GRIN-34039, funded by the University of Castilla-La Mancha and the European Regional Development Funds; project TED2021-131557B-I00, funded by MCIN/AEI/10.13039/501100011033 and European Union NextGenerationEU/PRTR; and grant FPU19/03857, funded by the Spanish Ministry of Science, Innovation and Universities.

## Bibliographic references

- Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology*, 35(1), 56–79. https://doi.org/10.1108/IJILT-02-2017-0009
- Altaie, M.A., & Jawawi, D.N.A. (2021). Adaptive gamification framework to promote computational thinking in 8-13 year olds. *Journal of e-Learning and Knowledge Society, 17*(3), 89-100. https://doi.org/10.20368/1971-8829/1135552
- Bocconi, S., Chioccariello, A., Kampylis, P., Dagienè, V., Wastiau, P., Engelhardt, K., Earp, J., Horvath, M., Jasuté, E., Malagoli, C., Masiulionytė-Dagienė, V., & Stupurienė, G. (2022). *Reviewing computational thinking in compulsory education*. In A. Inamorato dos Santos, R. Cachia, N. Giannoutsou, & Y. Punie (Eds.). Joint Research Centre.
- Çakır, R., Şahin, H., Balci, H., & Vergili, M. (2021). The effect of basic robotic coding in-service training on teachers' acceptance of technology, self-development, and computational thinking skills in technology use. *Journal of Computers in Education*, 8(2), 237-265. https://doi.org/10.1007/s40692-020-00178-1
- Code.org. (2018). *Instructor handbook: Code studio lesson plans for courses one, two, and three.* [PDF]. Retrieved from: https://code.org/curriculum/docs/k-5/complete.pdf
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.
- Cózar-Gutiérrez, R., & Sáez-López, J. M. (2016). Game-based learning and gamification in initial teacher training in the social sciences: an experiment with MinecraftEdu. *International Journal of Educational Technology in Higher Education*, *13*(1), 1–11. https://doi.org/10.1186/s41239-016-0003-4
- Deci, E. L., & Ryan, R. M. (1985). Conceptualizations of Intrinsic Motivation and Self-Determination. In *Intrinsic Motivation and Self-Determination in Human Behavior* (pp. 11–40). Springer US. https://doi.org/10.1007/978-1-4899-2271-7\_2
- Del Olmo-Muñoz, J., Bueno-Baquero, A., Cózar-Gutiérrez, R., & González-Calero, J. A. (2023). Exploring Gamification Approaches for Enhancing Computational Thinking in Young Learners. *Education Sciences*, *13*(5), 487. https://doi.org/10.3390/educsci13050487

- Del Olmo-Muñoz, J., Cózar-Gutiérrez, R., & González-Calero, J.A. (2020). Computational thinking through unplugged activities in early years of Primary Education. *Computers & Education*, *150*. https://doi.org/10.1016/j.compedu.2020.103832
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9–15. https://doi.org/10.1145/2181037.2181040
- DeVellis, R. F., & Thorpe, C. T. (2022). *Scale development: theory and applications* (Fifth edit). Sage publications.
- Dong, W., Li, Y., Sun, L., & Liu, Y. (2023). Developing pre-service teachers' computational thinking: a systematic literature review. *International Journal of Technology and Design Education*, 1–37. https://doi.org/10.1007/s10798-023-09811-3
- Guay, F., Vallerand, R.J., & Blanchard, C. (2000). On the Assessment of Situational Intrinsic and Extrinsic Motivation: The Situational Motivation Scale (SIMS). *Motivation and Emotion*, *24*(3), 175-213. https://doi.org/10.1023/A:1005614228250
- Gurjanow, I., Oliveira, M., Zender, J., Santos, P. A., & Ludwig, M. (2019). Mathematics Trails: Shallow and Deep Gamification. *International Journal of Serious Games*, 6(3), 65-79. https://doi.org/10.17083/ijsg. v6i3.306
- Huang, R., Ritzhaupt, A.D., Sommer, M., Zhu, J., Stephen, A., Valle, N., Hampton, J., & Li, J. (2020). The impact of gamification in educational settings on student learning outcomes: a meta-analysis. *Education Tech Research*, *68*(1), 1875-1901. https://doi.org/10.1007/s11423-020-09807-z
- INTEF (2017). El Pensamiento Computacional en la Enseñanza Obligatoria (Computhink) Implicaciones para la política y la práctica. https://doi.org/10.2791/792158
- Korkmaz, Ö., Çakir, R., & Özden, M. Y. (2017). A validity and reliability study of the Computational thinking scales (CTS). *Computers in Human Behavior*, 72. https://doi.org/10.1016/j.chb.2017.01.005
- Madariaga, L., Allendes, C., Nussbaum, M., Barrios, G., & Acevedo, N. (2023). Offline and online user experience of gamified robotics for introducing computational thinking: Comparing engagement, game mechanics and coding motivation. *Computers & Education*, 193, 104664. https://doi.org/10.1016/j.compedu.2022.104664

- Merino-Armero, J.M., González-Calero, J.A., & Cózar-Gutiérrez, R. (2021). Computational thinking in K-12 education. An insight through meta-analysis. *Journal of Research on Technology in Education*. https://doi.org/10.1080/15391523.2020.1870250
- Mozelius, P. (8<sup>th</sup>- 9<sup>th</sup> March 2021). *Deep and shallow gamification in higher education, what is the difference?* Proceedings of INTED 2021 Conference.
- Ottenbreit-Leftwich, A., Yadav, A., & Mouza, C. (2021). Preparing the next generation of teachers. In A. Yadav & U. Dalvad Berthelsen (Eds.), *Computational Thinking in Education: A Pedagogical Perspective* (1 st ed., Vol. 1, pp. 151-171). Routledge.
- Papert, S. (1980). *Mindstorms: Children, computers and powerful ideas*. Basic Books, Inc.
- Rich, P.J., Larsen, R.A., & Mason, S.L. (2020). Measuring teacher beliefs about coding and computational thinking. *Journal of Research on Technology in Education*, *53*(3), 296-316. https://doi.org/10.1080/153 91523.2020.1771232
- Román-González, M., Moreno-León, J., & Robles, G. (2019). Combining Assessment Tools for a Comprehensive Evaluation of Computational Thinking Interventions. In S.-C. Kong & H. Abelson (Eds.), *Computational Thinking Education* (pp. 79–98). Springer Singapore. https://doi.org/10.1007/978-981-13-6528-7\_6
- Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68
- Sailer, M., & Homner, L. (2020). The Gamification of Learning: a Metaanalysis. *Educational Psychology Review*, *32*, 77-112. https://doi. org/10.1007/s10648-019-09498-w
- Tankiz, E., & Atman Uslu, N. (2023). Preparing Pre-Service Teachers for Computational Thinking Skills and its Teaching: A Convergent Mixed-Method Study. *Technology, Knowledge and Learning*, 28(4), 1515– 1537. https://doi.org/10.1007/s10758-022-09593-y
- Tsarava, K., Leifheit, L., Ninaus, M., Román-González, M., Butz, M.V., Golle, J., Trautwein, U., & Moeller, K. (2019). *Cognitive Correlates of Computational Thinking: Evaluation of a Blended Unplugged/Plugged-In Course.* [sesión de conferencia]. 14th Workshop in Primary

- and Secondary Computing Education, Glasgow, Scotland. https://doi.org/10.1145/3361721.3361729
- Van Roy, R., & Zaman, B. (2017). Why Gamification Fails in Education and How to Make It Successful: Introducing Nine Gamification Heuristics Based on Self-Determination Theory. In *Serious Games and Edutainment Applications: Vol. II* (pp. 485–509). Springer International Publishing. https://doi.org/10.1007/978-3-319-51645-5 22
- Wing, J.M. (2006). Computational Thinking. *Communications of the ACM* 49(3), 33-35. https://doi.org/10.1145/1118178.1118215
- Xia, L., & Zhong, B. (2018). A systematic review on teaching and learning robotics content knowledge in K-12. *Computers & Education*, 127, 267-282. https://doi.org/10.1016/j.compedu.2018.09.007
- Zapata-Ros, M. (2015). Pensamiento computacional: Una nueva alfabetización digital. *Revista de Educación a Distancia (RED)*, 46(46). https://doi.org/10.6018/red/46/4

**Contact address:** Javier del Olmo-Muñoz. Facultad de Educación, Dpto. Matemáticas. Universidad de Castilla-La Mancha. Plaza de la Universidad, 3, 02071 Albacete. E-mail: javier.olmo@uclm.es

# Video games and learning in university education: a systematic review

# Videojuegos y aprendizaje en la etapa universitaria: una revisión sistemática

https://doi.org/10.4438/1988-592X-RE-2024-405-629

#### María Caridad Sierra-Daza

https://orcid/0000-0003-3474-3841 Universidad de Extremadura

#### Marta Martín-del-Pozo

https://orcid/0000-0002-1971-7904 Universidad de Salamanca

#### María Rosa Fernández-Sánchez

https://orcid/0000-0001-6889-5806 Universidad de Extremadura

#### **Abstract**

Video games offer interactive educational opportunities in the sphere of university education that contribute to acquiring knowledge and developing skills. In this regard, this study aims to identify supporting evidence from research papers on the pedagogical use of video games at this educational stage. To this end, the procedure for a systematic literature review was followed rigorously, with full adherence to the standards of the PRISMA 2020 protocol. Specifically, this review involves the selection and analysis of scientific papers on studies that investigate the use and impact of video games in higher education over the last seven years. The final study sample comprised 64 papers found in the Science Direct, Dialnet, Springer Link and Scopus databases, which were published during 2016–2022. The findings gathered encompass learning outcomes generated with the use of video games – especially serious games – in the context of

university education, with the majority of these findings coming from studies conducted with students in the academic domain of the Social Sciences and Law. These learning outcomes are evidenced in relation to knowledge acquisition, increased motivation and student engagement with the learning process. Moreover, the promotion of other learnings generated with the use of video games in university education is noteworthy, with relatively fewer studies focusing on behaviour change, cognitive and perceptual skills, social and soft skills and physiological skills. Although there has been a significant increase in research on this subject, there are only a few such studies within certain academic domains, and there is a dearth of research on the use of video games in the university setting that investigate its impact on improvements in knowledge assimilation –in the sphere of specific subjects – and improvements in the development of fundamental skills for the proper practice of the profession for which the students are being trained.

*Keywords:* video games, game-based learning, learning, higher education, learning outcomes.

#### Resumen

Los videojuegos ofrecen oportunidades educativas interactivas en el ámbito de la Universidad, contribuyendo a la adquisición de conocimientos y al desarrollo de destrezas. En este sentido, este estudio pretende identificar evidencias de artículos basados en el uso didáctico de videojuegos en esta etapa educativa. Para ello, se ha seguido rigurosamente el proceso de una revisión sistemática de literatura, siguiendo los estándares del protocolo PRISMA 2020. En concreto, esta revisión se apoya en el análisis y selección de artículos científicos que abordan el impacto y uso de videojuegos en Educación Superior en los últimos siete años, contando con una muestra final de 64 artículos publicados en las bases de datos Science Direct, Dialnet, Springer Link y Scopus, durante el período comprendido entre 2016 y 2022. Los hallazgos obtenidos recogen resultados de aprendizaje generados con el uso de videojuegos, y, en especial, con serious game, en el ámbito de la etapa universitaria, siendo la mayoría procedentes de estudios planteados con estudiantes de la rama de Ciencias Sociales y Jurídicas. A su vez, se evidencian resultados de aprendizaje relacionados con la adquisición de conocimientos, seguido del fomento de la motivación e implicación del alumnado con su proceso de aprendizaje. Por su parte, es destacable la promoción de otros aprendizajes generados con el uso de videojuegos en la etapa universitaria, siendo inferiores los estudios donde se trabaja el cambio de comportamiento, las habilidades cognitivas y perceptuales, las habilidades fisiológicas y las habilidades sociales y blandas. Aunque existe un incremento significativo de investigaciones sobre la temática, hay pocos estudios en algunas ramas de conocimiento y una falta de investigaciones sobre uso de videojuegos en el contexto universitario, que aborden las mejoras que se producen en la

asimilación de conocimientos de materias específicas y en el desarrollo de habilidades fundamentales para el adecuado ejercicio de la profesión.

*Palabras clave:* videojuegos, aprendizaje basado en juegos, aprendizaje, educación superior, resultados de aprendizaje.

### Introduction

Video games are tools with educational potential and are one of the main entertainment options for youth (Herder & Rau, 2022; Martí-Parreño *et al.*, 2018; Martín-Martín *et al.*, 2022; Sierra-Daza *et al.*, 2023). In this context, video games can be used as an educational resource at different educational stages (Amores-Valencia & De Casas-Moreno, 2019; Cantó, 2020; Herrero *et al.*, 2020; Martín, 2015, 2019; Martínez *et al.*, 2022), and several studies highlight the need to utilise these media in teaching-learning processes (Adedoyin & Soykan, 2020; Rapanta *et al.*, 2020; Zhu & Liu, 2020).

In the context of university education, the utilisation of game-based learning (GBL) is outstanding at fostering student engagement with the learning process (Chung-Shing et al., 2020; Corsi et al., 2019). GBL involves the use, creation and/or adaptation of games - including digital games, video games and apps for educational purposes – in a classroom context, such that the games become facilitators of learning (Del Moral, 2020). Several studies present evidence of the potential of GBL in educational settings, with reports of a positive correlation between gaming activities and learning (Backlund & Hendrix, 2013; Vandercruysse et al., 2012). Specifically, the methodological strategy underpinning GBL entails constant feedback, which allows students to understand their progress in light of preset goals, bringing the approach closer to a reflective assessment of what the students need to achieve the preset objectives and how the activity guides them by turning them into players. The effectiveness of GBL is facilitated by the integration of five key elements - (1) motivation: the game affects the will to learn, (2) fun learning: the game promotes learning through enjoyment, (3) autonomy: the game encourages independent exploration, (4) authenticity: the game fosters a concern for learning, and (5) experiential learning: learning by doing through play (Pérez-Manzano & Almeda-Baeza, 2018; Perrotta et al., 2013). In this regard, several studies highlight the benefits of GBL for improving student participation in the

learning process and for acquiring transversal competencies (Fernández-Sánchez *et al.*, 2020; González-González, 2014).

Furthermore, the incorporation of video games into education holds significant potential as teaching material in higher education, as it would facilitate the assimilation of content from various curricular areas and promote the development of the skills in the syllabi of university courses (Corsi *et al.*, 2019; Guenaga *et al.*, 2013; Muñoz *et al.*, 2021a, 2021b), which are relevant resources for acquiring and developing competencies necessary for the 21st century (Fernández *et al.*, 2017; García Varela *et al.*, 2014; Romero & Turpo, 2015). Regarding this educational stage, four lines of research on video games can be found in the literature: (1) the use of video games for content learning (De Castro *et al.*, 2018; Smith & Chan, 2017); (2) the design and development of serious games (educational games) or their use in classrooms (González & Martín, 2016); (3) the use of commercial video games in education (Rama *et al.*, 2012); and (4) analysis of the educational possibilities inherent in video games and their introduction to the classroom (Cantó, 2020).

Among video games, those categorised as serious games are some of the most widespread pedagogical resources in educational contexts, including the university, acting as a relatable medium that encourages student involvement and commitment, through which they can work on challenges that can be approached systematically and train in professional and transversal competencies via experimentation (Alonso & Navazo, 2019; Erhel & Jamet, 2019; Hallinger et al., 2020). Several studies on the use of serious games in the classroom have reported results that point to increased student motivation regarding the learning process, which contributes positively to improvement in their academic performance (Lamb et al., 2018; Molina-Carmona & Llorens-Largo, 2020; Nazry et al., 2017). In particular, serious games (e.g., digital games) simulate scenarios that bring players into close approximations of real-world problems and situations, with the objective of developing a deep understanding of the processes and factors in play in those situations (Zhonggen, 2019). All of this is linked to natural learning, which extends beyond the formal education environment, thus providing opportunities to connect and transfer what is learned to real situations (Goldberg & Cannon-Bowers, 2015). In this sense, serious games, via simulated environments, facilitate the development of social skills such as empathy and assertiveness and contribute to collaborative learning while promoting the acquisition of key

competencies for proper professional practice, such as problem-solving, decision-making and cooperation (Cuenca & Martín, 2010) – in addition to serving as suitable means for developing soft skills and/or essential knowledge (Zabala-Vargas *et al.*, 2020).

In recent years, some literature review studies have identified very specific aspects of the relationship between the use of video games or digital games in university contexts and certain learning outcomes. Agudelo-Londoño, González *et al.* (2019) focus on the relationship between learning effectiveness and the design criteria for serious games in medicine. Zabala-Vargas *et al.* (2020) examine the dimensions of student behaviour in relation to the types of games and teaching methodology employed in teaching mathematics. In addition, a particular review focuses on the effect of simulators and highlights the achievement of learning objectives (De Smale *et al.*, 2016). Furthermore, a study by Vlachopoulos and Makri (2017) presents evidence of affective, cognitive and behavioural learning using digital games and simulators.

This systematic literature review (SLR) builds on a previous study by Boyle *et al.* (2016), which addresses the educational use of video games and collates data on the impact and primary learning outcomes reported in studies published during 2009–2016 without focusing on any specific particular stage of education. Specifically, this research aims to provide a current review of the impact of the educational use of video games on learning – in this case – among university students from the time of completion of the Boyle *et al.* (2016) study to the present.

## **Methods**

This study adopts the approach of an SLR, with the objective of analysing the educational use of video games and the learning outcomes achieved in university settings. To this end, we apply the standards of the PRISMA 2020 protocol (Page *et al.*, 2021) in our research, including the following elements, in sequential order: research questions; eligibility criteria; database search strategies; selection of research papers; and the collection, extraction and analysis of potential papers on the research topic. To mitigate methodological bias, our review uses the study by Boyle *et al.* (2016) as a reference and has well-defined inclusion and exclusion criteria for selecting the most relevant papers.

# Research questions and coding

Beginning with the primary objective, this review aims to answer the four research questions presented in Figure I, following the indicated coding.

#### FIGURE I. Research questions and coding

#### Research questions

P1. What video games have been used the most in Higher Education considering its main objective in its original design?

P2. What academic domains of university degrees have developed experiences with video games?

P3. What are the learning and behaviour outcomes generated with video games in Higher Education?

P4. What are the learning and behavioural outcomes depending on the academic domains of the university degrees?

Source: Compiled by authors.

#### Coding

Main objective of the video game: 1=Serious game; 2= Game for entertainment

Academic domains of university degrees: 1=Arts and Humanities; 2=Sciences; 3=Health Sciences; 4=Social Sciences and Law; 5=Engineering and Architecture

Learning and behaviour outcomes (Boyle et al., 2016): Knowledge acquisition or comprehension of content; affective and motivational; cognitive and perceptual skills; behaviour change; physiological skills; social and soft skills. 1=yes, there are improvements; 2=No, there are no improvements; 3=Not indicated in this regard.

Learning and behavioural outcomes and academic domains (the previous coding is adopted)

# Eligibility criteria

As inclusion criteria, the studies considered had to be scientific journal articles published in the last seven years (2016–2022) in Spanish, English and Portuguese. In particular, papers that provide empirical evidence on the impact and outcomes of the use of video games in higher education

were included. Furthermore, references to all types of video games or digital games (e.g., serious games, video games, digital games) were considered, and studies conducted with university students (undergraduate, master's, and doctoral students) were also inclusion criteria. Finally, a full-text version of the paper must be available for perusal and extraction of the necessary data for analysis.

Regarding the exclusion criteria, theses, books, book chapters, conference papers, research reports and studies published before 2016 were excluded. In addition, papers published in languages other than those indicated were not included. Furthermore, theoretical studies and didactic proposals in which no empirical evidence is presented and systematic reviews were excluded. Research papers that refer to board games or non-digital games, as well as studies conducted on educational stages other than university (e.g., early childhood education, primary education, secondary education), were not included. Finally, studies aimed at training university faculty were not considered.

# **Search strategies**

The four international databases searched for this SLR are those most relevant to the fields of education, educational technology and higher education: Science Direct, Dialnet, Springer Link and Scopus. Specifically, multiple searches were conducted in each database using combinations of terms in English, Spanish and Portuguese, with each concept associated with digital games or video games looked up alongside another term related to university education.

Due to the extensive volume of papers on the use of video games in education, Boolean operators were used to filter searches, incorporate terms with quotes and use the AND and OR operators. Specifically, the search terms for video games or digital games in English, Spanish and Portuguese were: «serious game» or «digital game» or «videogame» or «video game» or «game-based learning» or «educational game» or «computer games»; «serious game» or «juego digital» or «videojuego» or «juego serio» or «game-based learning» or «juego educativo» or «juegos de ordenador»; «serious game» or «jogo digital» or videojogo» or «jogo sério» or «game-based learning» or «jogo educativo» or «jogo educacional» or «jogo de computadora». These concepts were searched together with

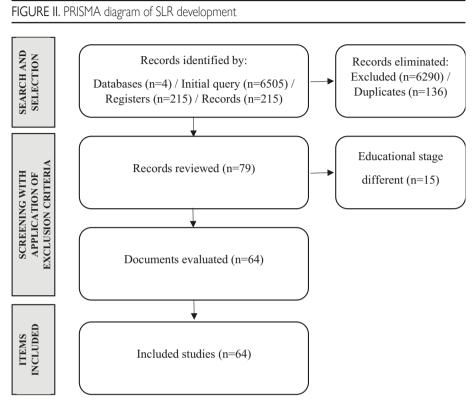
the following terms related to university education (depending on the language): «higher education» or «undergraduate» or «postgraduate»; «educación superior» or «universitario» or «postgrado» or «posgrado»; «educação superior» or «universitário» or «mestrado» or «pós-graduação».

# **Selection process**

This SLR was conducted for a period of one year between 2021 and 2022, and the procedure followed comprised four phases. The first phase was an initial planning phase in which the inclusion and exclusion criteria for the study were formulated. The second phase involved searching the selected databases using various search term combinations. In this second phase, the papers in the search results were filtered, with the application of inclusion criteria such as the year of publication (2016-2022), document type (scientific paper), language (English, Spanish and Portuguese), content (empirical study) and availability of full-text papers. In general, a total of 6,505 results were obtained from the searches conducted in the Science Direct (n = 1960), Dialnet (n = 261), Springer Link (n = 2970) and Scopus (n = 1314) databases. Subsequently, the papers were reviewed as a function of their titles and abstracts, and 215 papers that met the review criteria were selected (Figure II). The selected papers are, therefore, on the use of video games and learning outcomes generated with video games, with university education as the setting.

In the third phase, screening was performed through independent peer evaluation of the studies, which eliminated 136 duplicates, leaving 79 papers. In the fourth phase, a review of each collated full-text paper was conducted after assessing the possibility of excluding or including them in the study sample, depending on whether they met the determined inclusion criteria and were supported by the exclusion criteria, resulting in 64 papers comprising the final study sample of the SLR.

Overall, the final sample of papers primarily addresses the use of serious games applied individually and collaboratively in the classroom with students from various university degree programmes. Regarding the origin of the papers as a function of searched databases: 13 papers were obtained from Science Direct, 13 from Dialnet, 5 from Springer Link and 33 from Scopus. Pertaining to the language of the papers, 7 are in Spanish and 57 are in English (with 3 also available in Portuguese). As for the year of publication, 11 papers were published in 2016, 13 were



Source: Compiled by authors.

published in 2017, 12 were published in 2018, 12 were published in 2019, 12 were published in 2020, 2 papers were published in 2021, and 2 papers were published in 2022.

# Data collection, extraction and analysis

Data collection, extraction and analysis in this SLR are based on the coding of relevant aspects of studies on the use of video games in university education with which the assessed papers were aggregated in a database created specifically for this research. In the research database, the papers were indexed according to the source database and search keywords in a folder containing the full-text papers. Thus, specific information could be

pulled from the papers, such as source database, language, author's full name, year of publication, scientific journal and author's reference data. The complete coding of the final sample of papers can be downloaded via the following link: https://doi.org/10.5281/zenodo.10656904

Subsequently, relevant aspects of the studies regarding the use of video games in university education were analysed, allowing us to answer the research questions of the study. These relevant aspects include the following: the original design purpose of the video games, which comprised serious games (Michael & Chen, 2006) and entertainment games (Meyer & Sørensen, 2009); specific degrees pursued by students in the study sample; the academic domain of the degree (per the classification of the Registry of Universities, Centres, and Titles of the Spanish Ministry of Science, Innovation and Universities); and learning outcomes. The coding is presented in Figure I.

Descriptive analyses of the data were performed to yield frequencies and percentages. Furthermore, the dependent variables related to the learning outcomes were analysed together with the independent variable of the academic domain of the studies pursued by the study participants. Overall, the analysis of the papers was performed by assigning codes and values to information associated with the data pulled from the collated papers.

### **Results**

The results of the data collection, extraction and analysis obtained allow for achieving the central research objective: analysing the scientific literature on learning and skills acquired using video games in university education. The main findings are presented in relation to the relevant research questions.

# Types of video games used – considering the primary objective of their original design

Almost all the reviewed papers in the final study sample employ what are known as serious games (n = 63, 98.4%). A chronological view of the distribution of the publishing of these papers on serious games across the research period is presented in Figure III. As can be seen, the publication

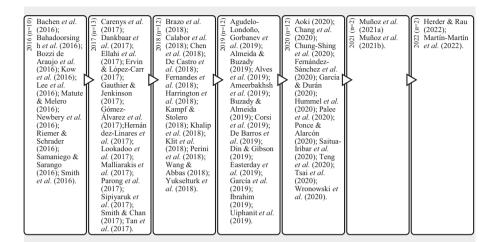


FIGURE III. Studies using serious games by year of publication

Source: Compiled by authors.

trend was constant over the years until the last two years, during which there has been a decline in the number of publications on the subject. In addition, only a single study is identified in which entertainment video games or games for entertainment are utilised – specifically, the study by Peng et al. (2016). This aligns with the findings of the study by Martín (2015), which highlights the trend towards the use of serious games in educational contexts vis-à-vis entertainment video games, regardless of the educational stage at which they are utilised.

# Academic domains of university degree programmes with video game learning experiences

As seen in Figure IV, the majority of the papers in our final study sample fall under the following domains: the Social Sciences and Law (n = 25, 39.1%), Engineering and Architecture (n = 18, 28.1%), and the Health Sciences (n = 12, 18.8%). Conversely, the smallest number of these studies fall under the Sciences (n = 6, 9.4%) and the Arts and Humanities (n = 7, 10.9%) domains. Most of the reviewed studies focus on students pursuing

#### FIGURE IV. Academic domains of the degrees pursued by the students in the study sample

Arts and Humanities (n=7; 10,9%)

• Brazo et al. (2018); De Castro et al. (2018); Ervin & López-Carr (2017); Ibrahim (2019); Muñoz et al. (2021a); Muñoz et al. (2021b); Ponce & Alarcón (2020).

Sciences (n=6; 9,4%)

Ameerbakhsha et al. (2019);
 Gauthier & Jenkinson (2017);
 Herder & Rau (2022);
 Lee et al. (2016);
 Lookadoo et al. (2017);
 Teng et al. (2020).

Health Sciences (n=12; 18,8%)

Agudelo-Londoño et al. (2019); Alves et al. (2019); Bozzi et al. (2016); Chen et al. (2018); Dankbaar et al. (2018); Kow et al. (2018); Kow et al. (2022); Palee et al. (2022); Palee et al. (2017); Smith et al. (2016); Tan et al. (2016); Tan et al. (2017).

Social Sciences and Law (n=25; 39,1%)

 Almeida & Buzady (2019); Aoki Bachen et al. (2016); Brazo et al. (2018); Brazo et al. (2018); Buzady & Almeida (2019); Calabor et al. (2018); Carenys et al. Almeida (2017); Chung-Shing et al. (2020); De Castro et al. (2018); Easterday et al. (2019); Ellahi et al. (2017); Fernandes et al. (2018); Fernández-Sánchez et al. (2020); Hummel et al. (2020); Kampf & (2018); Ma Stolero Matute Melero (2016); Muñoz et al. (2021a); Muñoz et al. (2021b); Newbery et al. (2016); Parong et al. (2017); Peng et al. (2016); Riemer & Riemer & Schrader (2016); Saitua-Iribar et al. (2020); Wronowski et al. (2020); Yükseltürk et al. (2018).

Engineering and Architecture (n=18; 28,1%)

· Bahadoorsingh et al. (2016); Chang et al. (2020); Corsi et al. (2019); De Barros & Gama (2019); Din & Gibson (2019); & García Durán (2020); García et al. (2019): Gómez-Álvarez *et al.* (2017); Hernández-Linares ét al. (2017); Khalip et Malliarakis et al. (2017); Møller Klit et al. (2018); Perinia et (2018);Samaniego Sarango (2016); & (2017); Tsai et al. (2020); Uiphanit et al. (2019); Wang & Abbas (2018).

Source: Compiled by authors.

degrees within a single academic domain; however, four studies (Brazo et al., 2018; De Castro et al., 2018; Muñoz et al., 2021a, 2021b) span two different academic domains. Similar to the conclusions drawn by Boyle et al. (2016), these reviewed studies conclude that games facilitate learning across different themes and various fields.

# Learning outcomes linked to video game use in higher education

Notably, a single research study can contribute to the improvement of several different types of learning outcomes. In this regard, the majority of the studies in our study sample report knowledge acquisition or comprehension of content (n = 57, 89.1%) associated with curricular areas and/or basic knowledge areas within a profession (Figure V) that is facilitated by video games. Another noteworthy observation is the reported

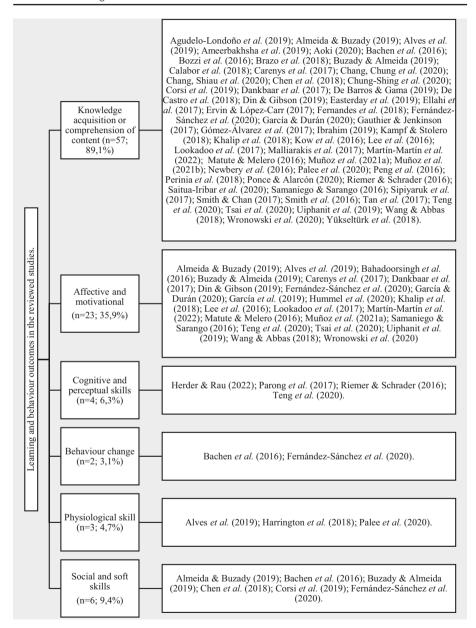
increase in motivation and student engagement with the learning process mediated by video games (n = 23, 35.9%). However, there are relatively fewer studies related to the acquisition of social and soft skills (n = 6, 9.4%) and cognitive and perceptual skills (n = 4, 6.3%). Specifically, the studies among the reviewed papers that investigate the development of cognitive and perceptual skills via video games fall within the domains of the Sciences and the Social Sciences and Law - predominantly psychology (Parong et al., 2017; Riemer & Schrader, 2016; Teng et al., 2020). In addition, physiological skills (n = 3, 4.7%) were among the least investigated skill sets, along with behaviour change (n = 2, 3.1%). These findings align with those of Boyle et al. (2016), in that serious games are primarily employed for knowledge acquisition and the promotion of student motivation regarding the learning process. There is also a significant similarity to the Molina-Carmona and Llorens-Largo (2020) study, which highlights the motivational potential of these resources (i.e., video games) in the educational sphere. Generally, the acquisition of physiological and social skills is seldom attempted using commercial video games (Boyle et al., 2016).

# Learning outcomes by academic domains

Overall, the majority of the studies analysed investigate knowledge acquisition. This trend is also reflected at the level of the academic domains under which the degrees fall, as this learning outcome (knowledge acquisition) is the most predominant among the reviewed studies across all domains (Figure VI): 23 studies out of a total of 25 in the Social Sciences and Law domain (92%), 15 out of 18 in Engineering and Architecture (83.3%), 11 out of 12 in Health Sciences (91.6%), 5 out of 6 in the Sciences (83.3%), and 7 out of 7 in the Arts and Humanities (100%). In addition, the next most investigated learning outcome across the different academic domains is motivation: 8 studies out of 25 in the Social Sciences and Law, 8 out of 18 in Engineering and Architecture, 3 out of 6 in the Sciences, and 1 in the Arts and Humanities.

Furthermore, there are studies with other learning outcomes in each academic domain. In the case of the Sciences, there are 2 studies with learning outcomes related to cognitive and perceptual skills (33.3%). Under the Social Sciences and Law, a variety of learning outcomes are investigated in addition to those already mentioned. In this sense, there

FIGURE V. Learning and behaviour outcomes in the reviewed studies



Source: Compiled by authors.

# FIGURE VI. Academic domains of the degrees in the study sample and researched learning outcomes generated via video games in university education

#### Knowledge acquisition or comprehension of contents (n=7: 100%): Brazo et al. (2018); De Castro *et al.* (2018); Ervin & López-Carr (2017); Ibrahim (2019); Muñoz *et al.* (2021a); Muñoz *et al.* (2021b); Ponce & Alarcón (2020). Arts and • Affective and motivational (n=1; 14,3%): Muñoz et al. (2021a). Humanities Cognitive and perceptual skills (n=0; 0%). (n=7) Behaviour change (n=0; 0%). Physiological skills (n=0; 0%). Social and soft skills (0; 0%). •Knowledge acquisition or comprehension of contents (n=5; 83,3%): Ameerbaksha et al. (2019); Gauthier & Jenkinson (2017); Lee et al. (2016); Lookadoo et al. (2017); Teng et al. (2020). • Affective and motivational (n=3; 50%): Lee et al. (2016); Lookadoo et al. (2017); Teng et al. (2020). Sciences (n=6) • Cognitive and perceptual skills (n=2; 33,3%): Herder & Rau (2022); Teng et al. • Behaviour change (n=0: 0%). Physiological skills (n=0; 0%). Social and soft skills (n=0; 0%). • Knowledge acquisition or comprehension of contents (n=11; 91,6%): Agudelo-Londoño et al. (2019); Alves et al. (2019); Bozzi et al. (2016); Chen et al. (2018); Dankbaar et al. (2017); Kow et al. (2016); Martín-Martín et al. (2022); Palee et al. (2020); Sipiyaruk et al. (2017). • Affective and motivational (n=3; 25%): Alves et al. (2019); Dankbaar et al. Health Sciences (2017); Martin-Martin et al. (2022) (n=12) Cognitive and perceptual skills (n=0; 0%) • Behaviour change (n=0; 0%). Physiological skills (n=3; 25%): Alves et al. (2019); Harrington et al. (2018); Palee et al. (2020) Social and soft skills (n=0; 0%). • Knowledge acquisition or comprehension of contents (n=23; 92%): Almeida & Buzady (2019); Aoki (2020); Bachen et al. (2016); Brazo et al. (2018); Buzady & Buzady (2019); Calabor et al. (2018); Carenys et al. (2016); Brazzo et al. (2016); Brazzo et al. (2018); Calabor et al. (2018); Carenys et al. (2017); Chung-Shin et al. (2020); De Castro et al. (2018); Easterday et al. (2018); Elahi et al. (2017); Fernandes et al. (2018); Fernández-Sánchez et al. (2020); Kampf & Stolero (2018); Matute & Melero (2016); Muñoz et al. (2021); Muñoz et al. (2021); Muñoz et al. (2021); Muñoz et al. (2020); Valselutira et al. (2020); Winnowski et al. (2020); Yükseltürk et al. (2018). Affective and motivational (n=8; 32%): Almeida & Buzady (2019); Carenys et Social Sciences al. (2017); Buzady & Almeida (2019); Fernández-Sánchez et al. (2020); Hummel et al. (2020); Matute & Melero (2016); Muñoz et al. (2021a); Wronowski et al. and Law (n=25) (2020)• Cognitive and perceptual skills (n=2; 8%): Parong et al. (2017); Riemer & Schrader (2016). · Behaviour change (n=2; 8%): Bachen et al. (2016); Fernández-Sánchez et al. (2020). Physiological skills (n=0; 0%). • Social and soft skills (n=4; 16%): Almeida & Buzady (2019); Bachen et al. (2016); Buzady & Almeida (2019); Fernández-Sánchez et al. (2020). • Knowledge acquisition or comprehension of contents (n=15; 83,3%): Chang, Chung et al. (2020); Corsi et al. (2019); De Barros & Gama (2019); Din & Gibson (2019); Garcia & Durán (2020); Gómez-Álvarez et al. (2017); Herniandez-Linares et al. (2017); Khalip et al. (2018); Malliarakis et al. (2017); Pernia et al. (2018); Samaniego & Sarango (2016); Smith & Chan (2017); Tsai et al. (2020); Uiphanit et al. (2019); Wang & Abbas (2018). Engineering • Affective and motivational (n=8; 44,4%): Bahadoorsingh et al. (2016); Din & Gibson (2019); García & Durán (2020); García et al. (2019); Khalip et al. (2018); and Architecture (n=18) Samaniego & Sarango (2016); Tsai et al. (2020); Uiphanit et al. (2019) Cognitive and perceptual skills (n=0; 0%) Behaviour change (n=1; 5,5%): Hernández-Linares et al. (2017)

Source: Compiled by authors.

Physiological skills (n=0: 0%)

(2017).

Social and soft skills (n=2: 11.1%): Corsi et al. (2019): Hernández-Linares et al.

are 4 studies with outcomes related to social skills and soft skills (16% of the studies within the Social Sciences and Law domain), as well as 2 related to cognitive and perceptual skills and 2 on behaviour change in each case (8% of the studies in the Social Sciences). However, none of the reviewed studies investigate physiological skills. Finally, in Engineering and Architecture, in addition to what has been mentioned, there are also two studies with learning and behaviour outcomes associated with social skills and soft skills and one on behaviour change (11.1% and 5.5%, respectively). In general, this coincides with the findings of Boyle *et al.* (2016) regarding the achievement of positive learning outcomes through the pedagogical application of video games in education; however, our study focuses on university education.

### Discussion and conclusions

As observed in this study, video games can be utilised in the university setting as teaching material across a variety of academic domains with diverse learning objectives (Martín, 2019). Regarding the question related to the type of video games employed, there is a predominance of studies on serious games over entertainment games, as has been reported in previous studies (Martín, 2015). Furthermore, as Martí-Parreño *et al.* (2018) report, educational video games are considered a tool for motivating and engaging university-level students.

In terms of the academic domains of the degrees pursued by study participants, the majority of the studies in our study sample fall under the Social Sciences and Law, Engineering and Architecture. This aligns with the observation by Cuenca and Martín (2010) that, based on their analysis of different video games on the physically-sold video games market and on the Internet for integration into the educational processes in the Social Sciences, video games can be used for economic and commercial activities and for analysing the problems or social relations of citizens.

Concerning learning outcomes, the studies investigate the acquisition of knowledge and comprehension of content and the motivation of students regarding the learning process. In this sense, fostering motivation using video games aligns with the notion that the appropriate pedagogical use of technologies generates motivation in students (Amores-Valencia & De Casas-Moreno, 2019). Notably, motivation is a fundamental element of the teaching–learning process, being a driving force of learning

(Molina-Carmona & Llorens-Largo, 2020). However, the adoption of video games as teaching tools in university education should be complemented with the added objective of developing competencies and fundamental skills among university students that equip them to respond to social needs and their subsequent insertion into the labour market (Fernández *et al.*, 2017; Fernández-Sánchez *et al.*, 2020; Guenaga *et al.*, 2013).

In conclusion, this study represents an update and contribution to the body of knowledge on video games and education from an interdisciplinary perspective, with broad coverage of studies that investigate the impact of video games in university education. We understand that including only scientific papers in this SLR leaves out other types of research, such as theoretical studies - which would allow for a broader view of the subject – could be a limitation of our study. Emerging voices propose taking advantage of the opportunity offered by video games to transform university education, with advocation for mixed, combined, integrated and flexible teaching and learning processes more characteristic of this new era (Adedoyin & Soykan, 2020; Rapanta et al., 2020; Zhu & Liu, 2020). In this regard, the development of studies on learning outcomes achieved via commercial video games in the university setting and other educational stages is imperative. Similarly, given the low number of studies that have sought to contribute to the development of relevant capacities such as social and soft skills, it would be interesting to see more research that addresses the use of video games for the development of competencies related to conflict resolution and ethical issues among future education professionals. Finally, video games are tools that can support change processes in the university context; they facilitate highly student-centric learning methodologies and foster ubiquitous learning in an active and collaborative environment.

# **Bibliographic references**

Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: the challenges and opportunities. *Interactive Learning Environments*, *28*(6), 1-13. https://doi.org/10.1080/10494820.2020.1813180

Agudelo-Londoño, S., González, R. A., Pomares, A., Delgadillo, V., Muñoz, O., Cortes, A., & Gorbanev, I. (2019). Revisión sistemática de juegos serios para la educación médica. Rol del diseño en la efectividad. *Educación Médica Superior*, *33*(2), 1-16. http://bit.ly/3OsjCuw

- Agudelo-Londoño, S., Gorbanev, I., Delgadillo, V., Muñoz, O., Cortés, A., González, R. A., & Pomares-Quimbaya, A. (2019). Development and Evaluation of a Serious Game for Teaching ICD-10 Diagnosis Coding to Medical Students. *Games for health journal*, 8(5), 349-356. https://doi.org/10.1089/g4h.2018.0101
- Almeida, F., & Buzady, Z. (2019). Assessment of Entrepreneurship Competencies Through the Use of FLIGBY. *Digital Education Review*, *35*, 151-169. https://doi.org/10.1344/der.2019.35.151-169
- Alonso, D., & Navazo, P. (2019). Juegos y simulaciones en la educación actual. *Revista Prisma Social*, *25*, 537-548. https://revistaprismasocial. es/article/view/2702
- Alves, R., Freitas, F., Gelain, M. A., de Oliveira, M. M. C., Figueiredo, A. E., Dahmer, A., & Bresolin, M. E. (2019). Serious game is an effective learning method for primary health care education of medical students: A randomized controlled trial. *International Journal of Medical Informatics*, 130, 103-944. https://doi.org/10.1016/j.ijmedinf.2019.08.004
- Ameerbakhsh, O., Maharaj, S., Hussain, A., & McAdam, B. (2019). A comparison of two methods of using a serious game for teaching marine ecology in a university setting. *International Journal of Human-Computer Studies*, 127, 181-189. https://doi.org/10.1016/j.ijhcs.2018.07.004
- Amores-Valencia, A. J., & De Casas-Moreno, P. (2019). El uso de las TIC como herramienta de motivación para alumnos de enseñanza secundaria obligatoria. Estudio de caso español. *Hamut'ay*, 6(3), 37-49. http://dx.doi.org/10.21503/hamu.v6i3.1845
- Aoki, R. (2020). Aprendizagem Baseada em Jogos Digitais aplicada ao ensino de Redação Jornalística. *Media & Jornalismo, 20*(36), 109-128. https://doi.org/10.14195/2183-5462\_36\_6
- Bachen, C. M., Hernández-Ramos, P., Raphael, C., & Waldron, A. (2016). How do presence, flow, and character identification affect players' empathy and interest in learning from a serious computer game? *Computers in Human Behavior*, 64, 77-87. https://doi.org/10.1016/j. chb.2016.06.043
- Backlund, P., & Hendrix, M. (2013). Educational games are they worth the effort? A literature survey of the effectiveness of serious games. En 2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES) (pp.1-8). IEEE. https://doi.org/10.1109/VS-GAMES.2013.6624226

- Bahadoorsingh, S., Dyer, R., & Sharma, C. (2016). Integrating serious games into the engineering curriculum-a game-based learning approach to power systems analysis. *International Journal of Computational Vision and Robotics*, *6*(3), 276-289. https://doi.org/10.1504/IJCVR.2016.077372
- Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, *94*, 178-192. https://doi.org/10.1016/j.compedu.2015.11.003
- Bozzi, T. B., Silveira, F. R., Souza, D. L. S., Strey, Y. T. M., Flores, C. D., & Webster, R. S. (2016). Impact of video game genre on surgical skills development: a feasibility study. *Journal of Surgical Research*, *201*(1), 235-243. https://doi.org/10.1016/j.jss.2015.07.035
- Brazo, A. I., Muñoz, J. M., & De Castro, C. (2018). Aprendiendo léxico y ortografía francesa en la universidad mediante el videojuego SCRIB-BLENAUTS. *EDMETIC*, 7(2), 18-36. https://doi.org/10.21071/edmetic. v7i2.7201
- Buzady, Z., & Almeida, F. (2019). FLIGBY-A Serious Game Tool to Enhance Motivation and Competencies in Entrepreneurship. *Informatics*, 6(3), 1-27. https://doi.org/10.3390/informatics6030027
- Calabor, M. S., Mora, A., & Moya, S. (2018). Acquisition of competencies with serious games in the accounting field: an empirical analysis. *Revista de Contabilidad-Spanish Accounting Review*, *21*(1), 38-47. https://doi.org/10.1016/j.rcsar.2016.11.001
- Cantó, T. (2020). Enseñando Historia Moderna en las aulas: didáctica con videojuegos. En F. García, C.J. Gómez, R. Cózar, & P. Martínez (Coords.). *La Historia Moderna en la Enseñanza Secundaria: Contenidos, métodos y representaciones* (pp.707-714). Universidad de Castilla La Mancha.
- Carenys, J., Moya, S., & Perramon, J. (2017). Is it worth it to consider videogames in accounting education? A comparison of a simulation and a videogame in attributes, motivation and learning outcomes. *Revista de Contabilidad-Spanish Accounting Review*, *20*(2), 118-130. https://doi.org/10.1016/j.rcsar.2016.07.003
- Chang, C. S., Chung, C. H., & Chang, J. A. (2020). Influence of problem-based learning games on effective computer programming learning

- in higher education. *Educational Technology Research and Development*, 68(5), 2615-2634. https://doi.org/10.1007/s11423-020-09784-3
- Chen, A., Hanna, J. J., Manohar, A., y Tobia, A. (2018). Teaching Empathy: the Implementation of a Video Game into a Psychiatry Clerkship Curriculum. *Academic Psychiatry*, *42*, 362-365. https://doi.org/10.1007/s40596-017-0862-6
- Chung-Shing, C., Yat-hang, C., & Agnes, F. T. H. (2020). The effectiveness of online scenario game for ecotourism education from knowledge-attitude-usability dimensions. *Journal of Hospitality, Leisure, Sport & Tourism Education, 27*, 100-264. https://doi.org/10.1016/j. jhlste.2020.100264
- Corsi, D., Revuelta, F. I., & Pedrera, M. I. (2019). Adquisición de competencias emocionales mediante el desarrollo y uso de Serious Games en Educación Superior. *Pixel-Bit: Revista de Medios y Educación*, *56*, 95-112. https://doi.org/10.12795/pixelbit.2019.i56.05
- Cuenca, J. M., & Martín, M. J. (2010). La resolución de problemas en la enseñanza de las ciencias sociales a través de videojuegos. *Íber. Didáctica de las Ciencias Sociales, Geografía e Historia, 63*, 32-42. http://hdl.handle.net/11162/86839
- Dankbaar, M. E., Richters, O., Kalkman, C. J., Prins, G., Ten Cate, O. T., Van Merrienboer, J. J., & Schuit, S. C. (2017). Comparative effectiveness of a serious game and an e-module to support patient safety knowledge and awareness. *BMC Medical Education*, *17*(1), 1-30. https://doi.org/10.1186/s12909-016-0836-5
- De Barros, H. B., Gama, L. R., & De Souza, W. (2019). Avaliação da usabilidade do Game Líder Sim-um jogo digital para estimular o planejamento e liderança. *Obra digital: Revista de Comunicación, 16*, 119-134. http://bit.ly/3XoV7SW
- De Castro, C., Muñoz, J. M., & Brazo, A. I. (2018). El uso de videojuegos serios en el aprendizaje de francés en educación superior. *Revista mexicana de investigación educativa*, 23(76), 157-177. https://www.scielo.org.mx/scielo.php?pid=S1405-66662018000100157&script=sci abstract
- De Smale, S., Overmans T., Jeuring J., & Van, L. (2016). The Effect of Simulations and Games on Learning Objectives in Tertiary Education: A Systematic Review. En A. De Gloria, & R. Veltkamp (Eds.), *Games and Learning Alliance. Lecture Notes in Computer Science* (pp.97-124). Springer.

- Del Moral, E. (2020). Aprendizaje basado en juegos digitales. Claves para implementar una metodología innovadora en el aula. *Comunicación y Pedagogía*, *321-322*, 7-10. https://dialnet.unirioja.es/servlet/articulo?codigo=7612802
- Din, Z. U., & Gibson, G. E. (2019). Serious games for learning prevention through design concepts: An experimental study. *Safety science*, *115*, 176-187. https://doi.org/10.1016/j.ssci.2019.02.005
- Easterday, M. W., Krupnikov, Y., Fitzpatrick, C., Barhumi, S., & Hope, A. (2019). Political Agenda: Designing a Cognitive Game for Political Perspective Taking. En *Civic Engagement and Politics: Concepts, Methodologies, Tools, and Applications* (pp.361-390). IGI Global.
- Ellahi, A., Zaka, B., & Sultan, F. (2017). A study of supplementing conventional business education with digital games. *Journal of Educational Technology & Society, 20*(3), 195-206. https://www.jstor.org/stable/26196130
- Erhel, S., & Jamet, E. (2019). Improving instructions in educational computer games: Exploring the relations between goal specificity, flow experience and learning outcomes. *Computers in Human Behavior*, *91*, 106–114. https://doi.org/10.1016/j.chb.2018.09.020
- Ervin, D., & Lopez-Carr, D. (2017). An evaluation of serious games and computer-based learning on student outcomes in university level geographic education. *European Journal of Geography*, *8*(4), 64-81. http://bit.ly/3EU3Jty
- Fernandes, R., De Oliveira, F. F., Borges, J., & Zambra, P. (2018). The use of a Serious Game and Academic Performance of Undergraduate Accounting Students: An Empirical Analysis. *Turkish Online Journal of Distance Education*, 19(2), 117-127. https://doi.org/10.17718/tojde.415825
- Fernández, E., Leiva, J. J., & López, E. J. (2017). Formación en competencias digitales en la universidad. Percepciones del alumnado. *Campus Virtuales*, *6*(2), 79-89. https://dialnet.unirioja.es/servlet/articulo?codigo=6170315
- Fernández-Sánchez, M. R., Sierra-Daza, M. C., & Valverde-Berrocoso, J. (2020). Serious Games para la adquisición de competencias profesionales para el desarrollo social y comunitario. *Revista Prisma Social*, *30*, 141–160. https://revistaprismasocial.es/article/view/3746
- García, I., & Durán, A. D. (2020). Uso de videojuegos de simulación empresarial como complemento de aprendizaje en el área de Ingeniería

- de Organización. *Dirección y Organización*, 70, 19-27. https://doi.org/10.37610/dyo.v0i70.566
- García, A. B., Del Castillo, H., Herrero, D., Monjelat, N., & Checa, M. (2014). Video games in educational settings: developing skills for new media learning. En M. C. Angelides & H. Agius (Eds.), *Handbook of Digital Games* (pp.502-522). IEEE Press & Wiley.
- García, I., Pacheco, C., León, A., & Calvo-Manzano, J. A. (2019). Experiences of using a game for improving learning in software requirements elicitation. *Computer Applications in Engineering Education*, 27(1), 249-265. https://doi.org/10.1002/cae.22072
- Gauthier, A., & Jenkinson, J. (2017). Serious game leverages productive negativity to facilitate conceptual change in undergraduate molecular biology: A mixed-methods randomized controlled trial. *International Journal of Game-Based Learning (IJGBL)*, 7(2), 20-34. http://dx.doi.org/10.4018/IJGBL.2017040102
- Goldberg, B., & Cannon-Bowers, J. (2015). Feedback source modality effects on training outcomes in a serious game: Pedagogical agents make a difference. *Computers in Human Behavior*, *52*, 1-11. https://doi.org/10.1016/j.chb.2015.05.008
- Gómez-Álvarez, M. C., Echeverri, J. A., & González-Palacio, L. (2017). Games-based assessment strategy: Case systems engineer of Universidad de Medellín. *Ingeniare*, *25*(4), 633-642. http://dx.doi.org/10.4067/S0718-33052017000400633
- González-González, C. S. (2014). Estrategias para trabajar la creatividad en la Educación Superior: pensamiento de diseño, aprendizaje basado en juegos y en proyectos. *RED*, *Revista de Educación a Distancia*, 40, 2-15. https://www.um.es/ead/red/40/
- González, L., & Martín, M. (2016). Creación de videojuegos en la asignatura "TIC aplicadas a la Educación" por estudiantes del Grado de Maestro de Educación Infantil. En M. Merinhos, A. García-Valcárcel, V. Gonçalves, L. González, M. R. Patrício, & J. S. Sousa (Coords.), *Livro de atas da Conferència Ibérica em Inovação na Educação com TIC* (pp.219-234). Instituto Politécnico de Bragança.
- Guenaga, M., Arranz, S., Rubio, I., Aguilar, E., Ortiz, A., Rayón, A., Bezanilla, M. J., & Menchaca, I. (2013). Serious Games for the Development of Employment Oriented Competences. *IEEE-Revista Iberoamericana de Tecnologías del Aprendizaje*, 8(4), 176-183, https://doi.org/10.1109/RITA.2013.2285024

- Hallinger, P., Wang, R., Chatpinyakoop, C., Nguyen, V., & Nguyen, U. (2020). A bibliometric review of research on simulations and serious games used in educating for sustainability. *Journal of Cleaner Production*, 256, 120-358. https://doi.org/10.1016/j.jclepro.2020.120358
- Harrington, C. M., Chaitanya, V., Dicker, P., Traynor, O., & Kavanagh, D. O. (2018). Playing to your skills: a randomised controlled trial evaluating a dedicated video game for minimally invasive surgery. *Surgical endoscopy*, 32(9), 3813-3821. https://doi.org/10.1007/s00464-018-6107-2
- Herder, T., & Rau, M. A. (2022). Representational-competency supports in the context of an educational video game for undergraduate astronomy. *Computers & Education*, 190, 1-13. https://doi.org/10.1016/j.compedu.2022.104602
- Hernández-Linares, R., Sánchez, H., Agudo, J. E., & Rico, M. (2017). Chronos: A tool to develop the time management competence among engineering students. *Computer Applications in Engineering Education*, *25*(1), 79-89. https://doi.org/10.1002/cae.21780
- Herrero, M., Torralba-Burrial, A., & Del Moral Pérez, M. E. (2020). Revisión de investigaciones sobre el uso de juegos digitales en la enseñanza de las ciencias de la vida en Primaria y Secundaria. *Enseñanza de las Ciencias*, 38(2), 103-119. https://doi.org/10.5565/rev/ensciencias.2806
- Hummel, H. G., Nadolski, R. J., Eshuis, J., Slootmaker, A., & Storm, J. (2020). Serious game in introductory psychology for professional awareness: Optimal learner control and authenticity. *British Journal of Educational Technology*, *52*(1), 125-141. https://doi.org/10.1111/bjet.12960
- Ibrahim, K. (2019). Foreign language practice in simulation video games: An analysis of game-based FL use dynamics. *Foreign Language Annals*, 52(2), 335-357. https://doi.org/10.1111/flan.12388
- Kampf, R., & Stolero, N. (2018). Learning About the Israeli–Palestinian Conflict Through Computerized Simulations: The Case of Global Conflicts. *Social Science Computer Review*, *36*(1), 125-134. https://doi.org/10.1177/0894439316683641
- Khalip, S., Amirul, M., & Irsyad, M. (2018). A Historical Educational Game for Learning Support: Design and Evaluation of Pre-Mortem. *Computer Applications in Engineering Education*, *27*(1), 94-99. http://bit.ly/3gwuATm
- Klit, K. J. M., Pedersen, K. S., & Stege, H. (2018). A prospective cohort study of game-based learning by digital simulation of a pig farm to

- train agriculture students to reduce piglet mortality. *Porcine Health Management*, 4(28), 1-8. https://doi.org/10.1186/s40813-018-0105-6
- Kow, A. W. C., Ang, B. L. S., Chong, C. S., Tan, W. B., & Menon, K. R. (2016). Innovative patient safety curriculum using iPAD game (passed) improved patient safety concepts in undergraduate medical students. World journal of surgery, 40(11), 2571-2580. https://doi.org/10.1007/s00268-016-3623-x
- Lamb, R. L., Annetta, L., Firestone, J., & Etopio, E. (2018). A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations. *Computers in Human Behavior*, 80, 158-167. https://doi.org/10.1016/j.chb.2017.10.040
- Lee, Y. H., Dunbar, N., Kornelson, K., Wilson, S. N., Ralston, R., Savic, M., Stewart, S., Lennox, E., Thompson, W., & Elizondo, J. (2016). Digital game-based learning for undergraduate calculus education: Immersion, calculation, and conceptual understanding. *International Journal of Gaming and Computer-Mediated Simulations*, 8(1), 13-27. https://doi.org/10.4018/IJGCMS.2016010102
- Lookadoo, K. L., Bostwick, E. N., Ralston, R., Elizondo, F. J., Wilson, S., Shaw, T. J., & Jensen, M. L. (2017). "I Forgot I Wasn't Saving the World": the Use of Formative and Summative Assessment in Instructional Video Games for Undergraduate Biology. *Journal of Science Education and Technology*, 26(6), 597-612. https://doi.org/10.1007/s10956-017-9701-5
- Malliarakis, C., Satratzemi, M., & Xinogalos, S. (2017). CMX: The effects of an educational MMORPG on learning and teaching computer programming. *IEEE Transactions on Learning Technologies*, *10*(2), 219-235. https://doi.org/10.1109/TLT.2016.2556666
- Martí-Parreño, J., Galbis-Córdoba, A., & Miquel-Romero, M. J. (2018). Students' attitude towards the use of educational video games to develop competencies. *Computers in Human Behavior*, *81*, 366-377. https://doi.org/10.1016/j.chb.2017.12.017
- Martín, M. (2015). Videojuegos y aprendizaje colaborativo. Experiencias en torno a la etapa de Educación Primaria. *Education in the Knowledge Society (EKS)*, 16(2), 69-89. https://doi.org/10.14201/eks20151626989
- Martín, M. (2019). Videojuegos como recurso y material didáctico en la docencia universitaria. *Comunicación y Pedagogía, 313-314*, 84-90. https://dialnet.unirioja.es/ejemplar/518898

- Martín-Martín, O., Manero, B., & Romero-Hernández, A. (2022). El videojuego como herramienta de alfabetización informacional en estudiantes universitarios. *Profesional de la información*, *31*(4), 1-13. https://doi.org/10.3145/epi.2022.jul.02
- Martínez, 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
- Matute, J., & Melero, I. (2016). Game-based learning: using business simulators in the university classroom. *Universia Business Review*, *51*, 106-154. https://doi.org/10.3232/UBR.2016.V13.N3.03
- Meyer, B., & Sørensen, B. H. (2009). Designing serious games for computer assisted language learning a framework for development and analysis. En M. Kankaanranta & P. Neittaanmäki (Eds.), *Design and use of serious games. Intelligent Systems, Control, and Automation: Science and Engireering (Vol. 37)* (pp.69-82). Springer Netherlands.
- Michael, D., & Chen, S. (2006). *Serious Games: Games that Educate, Train and Inform.* Thomson Course Technology
- Molina-Carmona, R., & Llorens-Largo, F. (2020). Gamification and Advanced Technology to Enhance Motivation in Education. *Informatics*, 7(2), 1-20. https://doi.org/10.3390/informatics7020020
- Muñoz, J. M., De Castro, C., & Brazo, A. I. (2021a). Aprendizaje de francés a través de videojuegos cooperativos: Portal 2. *Çédille, Revista de Estudios Franceses*, 19, 575-594. https://doi.org/10.25145/j.cedille
- Muñoz, J. M., De Castro, C., & Brazo, A. I. (2021b). The adventure of an adventure videogame in French. *Digital Education Review, 39*, 257-269. https://revistes.ub.edu/index.php/der/article/view/27923
- Nazry, N., Nazrina, M., & Romano, D. M. (2017). Mood and learning in navigation-based serious games. *Computers in Human Behavior*, 73, 596–604. http://dx.doi.org/10.1016/j.chb.2017.03.040
- Newbery, R., Lean, J., & Moizer, J. (2016). Evaluating the impact of serious games: the effect of gaming on entrepreneurial intent. *Information Technology & People*, 29(4), 733-749. https://doi.org/10.1108/ITP-05-2015-0111
- Page, M. J., Mckenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., Mcdonald, S., & Moher, D. (2021).

- The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*(71), 1-9. https://doi.org/10.1136/bmj.n71
- Palee, P., Wongta, N., Khwanngern, K., Jitmun, W., & Choosri, N. (2020). Serious Game for Teaching Undergraduate Medical Students in Cleft lip and Palate Treatment Protocol. *International Journal of Medical Informatics*, 141, 104-166. https://doi.org/10.1016/j.ijmedinf.2020.104166
- Parong, J., Mayer, R. E., Fiorella, L., MacNamara, A., Homer, B. D., & Plass, J. L. (2017). Learning executive function skills by playing focused video games. *Contemporary Educational Psychology*, *51*, 141-151. https://doi.org/10.1016/j.cedpsych.2017.07.002
- Peng, W., Song, H., Kim, J., & Day, T. (2016). The influence of task demand and social categorization diversity on performance and enjoyment in a language learning game. *Computers & Education*, *95*, 285-295. https://doi.org/10.1016/j.compedu.2016.01.004
- Pérez-Manzano, A., & Almela-Baeza, J. (2018). Gamificación transmedia para la divulgación científica y el fomento de vocaciones procientíficas en adolescentes. *Comunicar*, *55*(26), 93-103. https://doi.org/10.3916/C55-2018-09
- Perini, S., Luglietti, R., Margoudi, M., Oliveira, M., & Taisch, M. (2018). Learning and motivational effects of digital game-based learning (DGBL) for manufacturing education—The Life Cycle Assessment (LCA) game. *Computers in Industry*, *102*, 40-49. https://doi.org/10.1016/j.compind.2018.08.005
- Perrotta, C., Featherstone, G., Aston, H., & Houghton, E. (2013). *Gamebased learning: Latest evidence and future directions*. NFER.
- Ponce, R., & Alarcón, L. M. (2020). Entornos virtuales para la escritura académica. Un modelo en Minecraft. *Alteridad. Revista de Educación, 15*(1), 76-87. https://doi.org//10.17163/alt.v15n1.2020.06
- Rama, P. S., Black, R. W., Van Es, E., & Warschauer, M. (2012). Affordances for second language learning in World of Warcraft. *ReCALL: the Journal of EUROCALL*, *24*(3), 322-338. https://doi.org/10.1017/S0958344012000171
- Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L., & Koole, M. (2020). Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity. *Postdigital Science and Education*, *2*, 923-945. https://doi.org/10.1007/s42438-020-00155-y
- Riemer, V., & Schrader, C. (2016). Impacts of behavioral engagement and self-monitoring on the development of mental models through serious

- games: Inferences from in-game measures. *Computers in Human Behavior*, 64, 264-273. https://doi.org/10.1016/j.chb.2016.06.057
- Romero, M., & Turpo Gebera, O. (2015). Serious Games para el desarrollo de las competencias del siglo XXI. *Revista de Educación a Distancia*, *34*, 1-22. https://revistas.um.es/red/article/view/233511
- Saitua-Iribar, A., Corral-Lage, J., & Peña-Miguel, N. (2020). Improving Knowledge about the Sustainable Development Goals through a Collaborative Learning Methodology and Serious Game. *Sustainability*, *12*(15), 61-69. https://doi.org/10.3390/su12156169
- Samaniego, R., & Sarango, E. (2016). Aplicación de juegos digitales en educación superior. *Revista San Gregorio*, *11*, 82-91. http://dx.doi.org/10.36097/rsan.v1i11.81
- Sierra-Daza, M. C., Martín-del-Pozo, M., & Fernández-Sánchez, M. R. (2023). Videojuegos para el desarrollo de competencias en educación superior. *Revista Fuentes*, *25*(2), 228-241. https://doi.org/10.12795/revistafuentes.2023.22687
- Sipiyaruk, K., Gallagher, J. E., Hatzipanagos, S., & Reynolds, P. A. (2017). Acquiring Critical Thinking and Decision-Making Skills: An Evaluation of a Serious Game Used by Undergraduate Dental Students in Dental Public Health. *Technology, Knowledge and Learning, 22*(2), 209-218. https://doi.org/10.1007/s10758-016-9296-6
- Smith, S., & Chan, S. (2017). Collaborative and competitive video games for teaching computing in higher education. *Journal of Science Education and Technology*, *26*(4), 438-457. https://doi.org/10.1007/s10956-017-9690-4
- Smith, C. E. R., Ryder, P., Bilodeau, A., & Schultz, M. (2016). Use of an Online Game to Evaluate Health Professions Students' Attitudes toward People in Poverty. *American Journal of Pharmaceutical Education*, 80(8), 121-139. https://doi.org/10.5688/ajpe808139
- Tan, A. J. Q., Lee, C. C. S., Lin, P. Y., Cooper, S., Lau, L. S. T., Chua, W. L., & Liaw, S. Y. (2017). Designing and evaluating the effectiveness of a serious game for safe administration of blood transfusion: A randomized controlled trial. *Nurse education today*, *55*, 38-44. https://doi.org/10.1016/j.nedt.2017.04.027
- Teng, Y. Y., Chou, W. C., & Cheng, M. T. (2020). Learning immunology in a game: Learning outcomes, the use of player characters, immersion experiences and visual attention distributions. *Journal of Computer Assisted Learning*, 0, 1-12. https://doi.org/10.1111/jcal.12501

- Tsai, M. H., Chang, Y. L., Shiau, J. S., & Wang, S. M. (2020). Exploring the effects of a serious game-based learning package for disaster prevention education: The case of Battle of Flooding Protection. *International Journal of Disaster Risk Reduction*, *43*, 101-393. https://doi.org/10.1016/j.ijdrr.2019.101393
- Uiphanit, T., Bhattarakosol, P., Suanpong, K., & Iamsupasit, S. (2019). Packet Warriors: An Academic Mobile Action Game for Promoting OSI Model Concepts to Learners. *International Association of Online Engineering*, *13*(6), 41-51. https://doi.org/10.3991/ijim. v13i06.10469
- Vandercruysse, S., Vandewaetere, M., & Clarebout, G. (2012). Game-based learning: A review on the effectiveness of educational games. En M. M. Cruz-Cunha (Ed.), *Handbook of research on serious games as educational, business, and research tools* (pp.628–647). IGI Global.
- Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education, 14*, 1-22. https://doi.org/10.1186/s41239-017-0062-1
- Wang, Q., & Abbas, M. (2018). Designing web-games for transportation engineering education. *Computer Applications in Engineering Education*, 26(5), 1699-1710. https://doi.org/10.1002/cae.22031
- Wronowski, M., Urick, A., Wilson, A. S., Thompson, W., Thomas, D., Wilson, S., Elizondo, F. J., & Ralston, R. (2020). Effect of a serious educational game on academic and affective outcomes for statistics instruction. *Journal of Educational Computing Research*, *57*(8), 2053-2084. https://doi.org/10.1177/0735633118824693
- Yukselturk, E., Altıok, S., & Başer, Z. (2018). Using game-based learning with kinect technology in foreign language education course. *Journal of Educational Technology & Society, 21*(3), 159-173. http://bit.ly/3EUbjEP
- Zabala-Vargas, S. A., Ardila-Segovia, D. A., García-Mora, L. H., & Benito-Crosetti, B. L. D. (2020). Aprendizaje Basado en Juegos (GBL) aplicado a la enseñanza de la matemática en educación superior. una revisión sistemática de literatura. *Formación universitaria*, *13*(1), 13-26. https://doi.org/10.4067/S0718-50062020000100013
- Zhonggen, Y. (2019). A Meta-analysis of use of serious games in education over a decade. *International Journal of Computer Games Technology, 1*, 1-8. https://doi.org/10.1155/2019/4797032

Zhu, X., & Liu, J. (2020). Education in and After Covid-19: Immediate Responses and Long-Term Visions. *Postdigital Science and Education*, *0*, 1-5. https://doi.org/10.1007/s42438-020-00126-3

**Contact address:** María Caridad Sierra-Daza. Universidad de Extremadura, Facultad de Formación del Profesorado, Departamento de Ciencias de la Educación. Avenida de la Universidad, 10004, Cáceres (Spain). E-mail: caridadsierra@unex.es

# Game-based learning in the scientific literature: text mining analysis

# Pedagogía basada en el juego en la literatura científica: análisis de minería de textos

https://doi.org/10.4438/1988-592X-RE-2024-405-630

#### Xavier García-Massó

https://orcid.org/0000-0002-5925-4537 Universidad de Valencia

# Sergio Montalt-García

Universidad de Valencia

### Luis-Millán González

https://orcid.org/0000-0002-6478-4014 Universidad de Valencia

#### **Abstract**

Game-based learning has increased its influence in different fields (e.g., education or marketing) in recent years. However, it is difficult to have an overall landscape of the scientific approach that has been carried out to date around this term. The objective of this study is to identify, analyze, and provide a comprehensive map of the emerging concepts published in the scientific literature related to game-based learning, as well as to establish the most studied topics around these concepts. Method: A search was conducted in the Web of Science (WOS) database for all articles related to this topic, and they were analyzed through data mining techniques using both titles and keywords, as well as abstracts. The frequency of occurrence of unigrams, bigrams, and trigrams was calculated, as well as the investigated topics within the subject through latent Dirichlet analysis. Results: Some of the most frequent unigrams, bigrams, and trigrams were 'student', 'education', 'virtual reality', 'video

game', 'learning environment', 'autism spectrum disorder', 'design methodology approach', and 'information communication technology'. From the model based on latent Dirichlet analysis, 15 research topics related to game-based pedagogy emerged, focusing on new tools for implementing gamification in different contexts (e.g., marketing or economics), as well as the application of game-based learning in the university environment to enhance learning and motivation, which has increased their scientific presence in recent years. Conclusions: According to the results of this study, there is an overall understanding of the scientific approach that has been carried out around play-based pedagogy.

Keywords: games, game design, learning, students, software, motivation.

#### Resumen

La pedagogía basada en el juego ha aumentado su influencia en diferentes ámbitos (p. ej. educativo o márquetin) durante los últimos años sin embargo es difícil tener una visión general del abordaje científico que se ha realizado hasta la fecha alrededor de este término. El objetivo de este trabajo es identificar, analizar y proporcionar un mapa completo de los conceptos emergentes publicados en la literatura científica relacionada con la pedagogía basada en juegos, así como establecer los tópicos más estudiados alrededor de dichos conceptos. Método: se realizó una búsqueda en la base de datos Web of Science (WOS) de todos los artículos relacionados con esta temática y se analizaron utilizando tanto el título como las palabras clave y los resúmenes mediante técnicas de minería de datos. Se calcularon la frecuencia de aparición de los unigramas, bigramas y trigramas así como los tópicos investigados dentro de la materia a través del análisis latente de Dirichlet. Resultados: algunos de los unigramas, bigramas y trigramas más frecuentes son: 'student', 'education', 'virtual reality', 'video game', 'learning environment', 'autism spectrum disorder', 'design methodology approach' y 'information communication technology'. Del modelo basado en análisis latente de Dirichlet emergieron 15 tópicos de investigación relacionados con la pedagogía basada en el juego siendo aquel que se centra en nuevas herramientas para la implementación de gamificaciones en diferentes contextos (p. ej. marketing o economía) así como la aplicación de pedagogía basada en el juego en el entorno universitario para favorecer el aprendizaje y la motivación los que han aumentado su presencia científica en los últimos años. Conclusiones: gracias a los resultados de este trabajo se dispone de una visión general del abordaje científico que se ha realizado alrededor de la pedagogía basada en el juego hasta la fecha.

Palabras clave: juegos, diseño de juegos, aprendizaje, alumnado, software, motivación.

## Introduction

Game-based pedagogy (GBP) has recently emerged as a topic of great interest in various academic and practical fields. It seeks to integrate games or their elements into the design of learning activities, whether through digital games, adapted board games, simulations or the use of game mechanics in traditional activities (Deterding et al., 2011).

The use of GBP is intended to enhance students' intrinsic motivation, improve their engagement with content, encourage problem-solving, promote critical thinking, and provide a more meaningful and memorable learning experience (Brangier & Marache-Francisco, 2020; Nadolny et al., 2020; Osipovskaya & Miakotnikova, 2020; Tundjungsari, 2020). Furthermore, it is important to note that GBP does not simply involve the act of "playing" in the classroom; rather, it requires the careful design and appropriate integration of game elements to support the achievement of educational goals and the students' learning process (Pan et al., 2021).

GBP can be implemented through a combination of different strategies, including gamification and serious games. Gamification is the process of applying game elements and mechanics in nongame contexts (Deterding et al., 2011), such as education, work or marketing. It involves the use of game-like techniques and dynamics to motivate and engage people in activities that might otherwise be less appealing. Elements such as rewards, challenges, competition and progression are employed to encourage participation and engagement (Toda et al., 2019). For instance, the Kaboot! tool (http://kahoot.com/) permits assessment processes in the classroom (it is not a game) while implementing gamelike elements such as progress bars, rankings or immediate feedback. In contrast, serious games are interactive applications designed with a primary purpose beyond entertainment (Apt, 1970). Although they are games in themselves, their main purpose is to provide learning, training, simulation or problem-solving in specific areas (Ritterfeld et al., 2009). These games are often used in fields such as education, health, business training or research (Pan et al., 2021). One example of such a game is Foldit (https://fold.it/). This is a protein folding game in which players attempt to solve online puzzles to determine the three-dimensional structure of proteins.

Both gamification and serious games have recently emerged as topics of great interest in various academic and practical fields. This innovative approach has captured the attention of researchers, practitioners and educators seeking to harness the potential of games to foster engagement and learning in different contexts. Its application in areas such as education (İlhan, 2021; Pando Cerra et al., 2022), marketing (Korn & Schmidt, 2015; Rodrigues et al., 2016), health (Edwards et al., 2016; Sardi et al., 2017) and personal development (Gaonkar et al., 2022) has generated a growing body of research and a wide variety of theoretical and practical approaches.

The objective of this article is to conduct a comprehensive review of the literature on GBP and then perform a text mining analysis. This will enable a comprehensive understanding and interpretation of how GBP is being approached, developed and implemented. It will also facilitate the establishment of key terms and relationships between them, as well as the most studied topics to date related to this pedagogy and its evolution over the years. This can provide valuable guidance for future research on gamification and offer a comprehensive and up-to-date understanding of the key areas of interest concerning GBP.

To date, several papers have been published that have conducted a text mining analysis on articles related to gamification in different contexts. Rodrigues et al., (2019) conducted their analysis on a selection of papers (i.e., 50 articles) related to gamification. Furthermore, in this paper, they analyzed only the conclusions and future lines of research in their text mining. In their conclusions, they identify eight topics of interest related to this term: gamification, games, use, users, business, points, engagement and learning. Martí-Parreño et al., (2016) conducted a study based on social networks and text mining of 139 articles published between 2010 and 2014. These authors found that interest in GBP at the scientific level increased progressively during those five years. Moreover, the researchers identified four themes that have been investigated to date: effectiveness, acceptance, social interactions and engagement. However, it should be noted that the majority of these papers only analyze a small proportion of the available literature on GBP. Likewise, a significant period of time has elapsed since the completion of these works, and a current analysis could provide an updated and present overview of the state of the art.

The objective of this paper is therefore to identify, analyze and provide a comprehensive mapping of the emerging concepts published

in the scientific literature related to GBP, as well as to establish the most studied topics around these concepts. To achieve this objective, a search was conducted in the *Web of Science* (WOS) database of all articles related to this topic. These were then analyzed using both the title and the keywords and abstracts through the application of text mining techniques.

## Method

# **Data Recovery**

This study focuses on the analysis of titles, abstracts, and keywords published in the WOS database. A group of experts in Physical Education convened to define the study's topic and design a structured search.

The search was conducted in the *Web of Science database (Advanced Search Query Builder)*, utilizing the title, abstract, and author keywords fields. The following search equation was employed, considering the theme and the keywords of interest for the present special issue: "gamif\*" OR "gameful des\*" OR "gam\* bas\* learn\*" OR "serious gam\*". No document type filters were applied, and multiple databases within the WOS main collection were considered, such as SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.

The search had no time or language restrictions and was conducted on May 19, 2023. A total of 23,603 documents were downloaded. For each obtained record, the title, abstract, author keywords, publication year, and DOI were collected and stored in a CSV file for further analysis.

# Data pre-processing

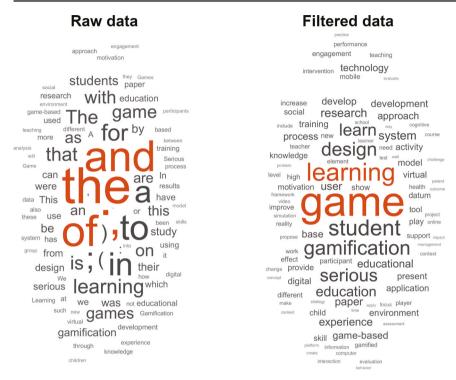
To prepare the text of the documents for further analysis, we followed the standard recommendations used in similar studies (Rajman & Besançon, 1998). As a first step, duplicate documents, in our case 138, were removed, leaving a total of 23,465 documents. These documents were converted into tokens (tokenisation) and the following actions were performed in the following order:

- All hyperlinks ('http://url') were removed.
- Punctuation marks and special characters were also removed.
- All characters were converted to lowercase.
- Words that did not contribute significant content to the documents and could introduce noise in the text (e.g. 'a', 'and', 'to') were removed, using a list of stopwords provided by the Matlab text analysis toolbox.
- As the abstracts of articles sometimes include copyright information and the name of the publisher and sometimes not meaningful content (e.g. 'aim' or 'methods'), these parts were removed as they do not provide relevant information about the content of the articles.
- The words were standardised through a process of lemmatisation, which involves analysing the morphology of the words and reducing them to their roots using a predefined dictionary. In addition, details were added about the grammatical function of the words, such as whether they were nouns, verbs, adjectives, etc.
- Finally, words that were less than two characters or more than 20 characters in length, as well as words that appeared less than two times in the corpus of documents, were removed. This procedure has been employed by research applying this same methodology (Pans et al., 2021). Figure I shows the effect of preprocessing on the most repeated words in the analyzed bibliography. The resulting tokens were then grouped into sets of words (unigrams), as well as two sets of frames (bigrams and trigrams).

# Descriptive analysis of the documents

The document analysis commenced with a description of the retrieved documents, using only the text and the date of creation. The number of articles per year was counted, and a frequency analysis of the principal n-grams was performed. An n-gram is defined as a contiguous sequence of n elements within a given sequence of words. The frequency values of the principal unigrams, bigrams and trigrams are presented in frequency tables.

FIGURE I. The principal terms identified in the documents prior to and subsequent to data processin



Source: own elaboration.

# **LDA Topic Analysis**

To identify the present topics in our data corpus (i.e., the collection of papers), we applied a latent Dirichlet assignment (LDA) model. This model assumes that there are a fixed number of latent topics appearing in various documents (in our case, the 23,465 papers). Each paper is characterized by a mixture of topics, and each topic is characterized by a probability distribution of words. The presence of a word in a document indicates the potential presence of a latent topic.

The LDA model serves two functions: first, it extracts the main topics from the corpus studied by different research groups over the years; second, it serves as a method for selecting documents related to topics of interest. The analysis was performed using the 'filtlda.m' function from the MAT-LAB text analysis toolbox, utilizing the previously preprocessed unigrams. Before proceeding, it was essential to determine the optimal number of subjects. To assess the quality of the LDA model, the perplexity was calculated, which indicates the model's ability to describe a set of documents. A lower perplexity value indicates a superior fit. A total of 5, 10, 15, 20, 30, 40, 50, and 60 topics were tested, with the lowest perplexity value obtained with 15 topics. Once the appropriate number of topics was fixed, an LDA model based on a Gibbs sampling algorithm was implemented.

The 15 topics were then subjected to further analysis, with the most representative words being selected based on their highest probabilities of occurrence in the topic. Additionally, topic mixtures were calculated for each document, and the most representative documents for each selected topic were identified.

Finally, an analysis of the dynamics of the topics was conducted. To this end, the words that belonged to each topic were searched year by year, and the frequency of occurrence in the documents published was calculated. With the frequency values for each year, Z scores were calculated for each of the topics. The Z score, also known as the Z score, is a statistical measure that indicates the number of standard deviations a particular data point is above or below the mean in a normal distribution. A positive Z score indicates that the value is above the mean, while a negative Z score indicates that it is below the mean. The Z score is used to standardize and compare different datasets.

#### **Results and Discussion**

This study represents a pioneering effort to analyze all articles published to date and indexed in WOS that explore different applications, effects, or conceptualizations of GBP-related terms. The results derived from these text mining analyzes are presented in the following sections.

### **General Data of Published Articles**

Before preprocessing, a total of 23,465 documents published in WOS were included once duplicates were removed. Figure II presents a

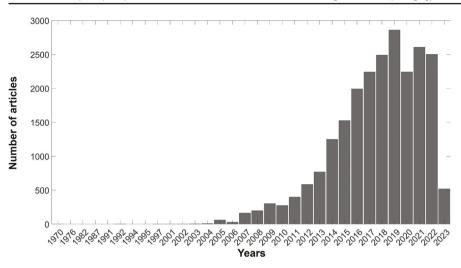


FIGURE II. Frequency of published articles indexed in WOS related to game-based pedagogy

Source: Compiled by the authors.

histogram of the frequency of publication of the articles included in the study over the years. There was an increase that followed a practically linear trend from 2012 to 2019. The number of journals and, therefore, the number of articles published each year are increasing (Peset et al., 2020). Nevertheless, it is evident that the research topic is garnering increasing attention from the scientific community, as previously posited by certain authors (Martí-Parreño et al., 2016). However, since 2019, the number of publications has remained relatively constant. It is possible that this was due to the impact of the COVID-19 pandemic for two different reasons. The first is that following the pandemic, restrictions were imposed that included educational institutions, which hindered the possibility of conducting research studies in classrooms, in our case, related to GBP. Second, the emergence of the pandemic prompted a shift in focus among researchers, with an increased emphasis on analysing the effects of the pandemic on various aspects, including educational aspects (Cretu & Ho. 2023). This shift in focus resulted in a reduction in the number of GBP-based studies conducted.

# **Description of the Most Frequently Used N-Grams**

A total of 21,791 words emerged independently from all the documents analyzed. Table I shows the twenty most repeated unigrams, bigrams, and trigrams in the documents used. As expected, those combinations that were used as a search strategy appear at the top of this list (e.g., 'serious game' or 'game-based learning').

Upon examination of the most frequently occurring unigrams, excluding those explicitly included in the search strategy, it becomes evident that 'student' and 'education' are the two most prevalent terms. This suggests that despite the multitude of contexts in which GBP-related strategies have been employed and investigated, the educational setting has received the greatest degree of attention.

Concerning the most frequently occurring bigrams (again, with the exclusion of those directly included in the search), we find the terms 'video game', 'virtual reality', 'educational game', or 'learning environment'. Upon examination of these bigrams, two primary trends related to GBP can be identified. The first, as with unigrams, is the application of this pedagogical strategy in the educational environment to promote learning. The second trend is related to the use of technological means (virtual reality or video games) to implement this type of pedagogy.

Finally, concerning the trigrams, the most representative terms in the field of study could be 'autism spectrum disorder', 'design methodology approach', and 'information communication technology'. In some ways, the trends identified in the bigrams are reinforced, both in terms of technological media (e.g., 'information communication technology' or 'immersive virtual reality') and in terms of the application of this pedagogy in the educational environment (e.g., 'autism spectrum disorder' or 'high school student'). Nevertheless, a novel line of concepts emerges that can be related to the design of methodologies and games to implement this pedagogy in different environments (e.g., 'design methodology approach').

# Main topics found in the LDA model

The identified words were classified into fifteen broad topic groups according to the LDA model. These topics are ordered from most to least

TABLE I. Unigrams, bigrams and trigrams most frequently repeated in the analyzed documents

Count	1401	1133	1017	859	540	504	409	409	379	348	325	322	314	312	304	304	265	261	246	233
	learning	design	game	learning	game	environment	technology	element	disorder	game	game	game	approach	student	virtual	game	environment	game	reality	reality
Trigram	base	game	serious	game-based	serions	learning	communication	design	spectrum	serious	serious	serious	methodology	school	game	serious	learning	video	virtual	virtual
	game	serious	game	digital	gamification	game-based	information	game	autism	development	learning	develop	design	high	serious	reality	virtual	educational	immersive	game
Count	20093	7429	4569	3678	3584	3019	2606	2483	2390	2374	2227	1847	1784	1738	1595	1497	1286	1275	1204	1118
Bigram	game	learning	design	game	reality	game	present	game	environment	game	education	base	game	element	activity	process	experience	learning	experience	environment
Bigi	serious	game-based	game	video	virtual	educational	paper	play	learning	digital	high	game	computer	game	physical	learning	learning	base	user	virtual
Count	82.773	36.884	30.906	26.703	24.775	22793	20283	16523	13382	12569	12214	12022	11805	11561	11165	10572	10537	10443	10442	10386
Unigram	game	learning	student	gamification	design	serious	learn	education	research	system	educational	paper	user	experience	approach	process	base	game-based	develop	technology

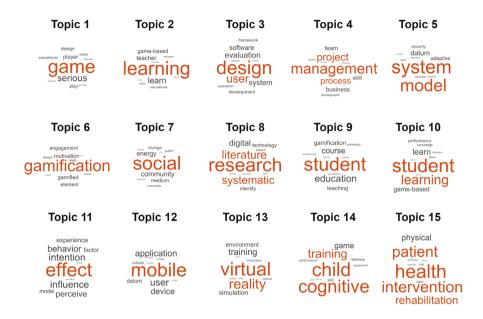
Source: Compiled by the authors.

likely to appear in the complete body of knowledge. That is, topic 1 is more likely to appear in articles published about GBP than topic 8 or 15. Additionally, the model provides a percentage of probability that the concepts are part of a given topic and ranks them from most to least important for the topic according to that percentage. This approach enables the determination of the significance of individual topics and the occurrence of combinations of key concepts. The number of topics identified differs from the four proposed by Martí-Parreño et al., (2016) and the eight proposed by Rodrigues et al., (2019). It is important to note that by including a larger number of papers in this study than in the two previously published studies (i.e., 23,603 versus 50 and 139 of the previous studies), it is to be expected that the number of topics that emerge from text mining will be greater and that they will cover different aspects.

Although it may be somewhat complex to express this concept, visualizing Figure III and proposing illustrative examples will facilitate a clear understanding of this analysis and the results it provides. The first topic is represented by terms such as 'game', 'serious', 'player', 'design', 'video', and 'educational'. Therefore, this topic appears to pertain to documents that have focused on the design of serious games, which are likely to be applied, above all, in the educational context. Upon examination of the literature on this topic, it becomes evident that several authors have advocated the inclusion of user enjoyment as a crucial element in the design of serious games. For instance, Read, (2016) proposed that user engagement should be a primary consideration in the development of these games. Similarly, Fiadotau et al., (2022) recommended striking a balance between player preferences and design considerations, such as the educational value or practicality of the game, when designing serious games. Additionally, Dormann & Biddle, (2009) proposed that humor should be incorporated into the design of serious games, as it influences social, emotional, and cognitive aspects of player behavior. These works collectively provide a framework for the design of serious games, with a focus on the educational environment.

The following section describes those topics that are most relevant to the learning environment and learning. In particular, we selected topics 2, 6, 9 and 10 for an in-depth description and discussion. However, if readers would like to know which documents are most closely associated with each of the topics and to read them, they can consult the supplementary material.

FIGURE III. Topics included in the documents analyzed using the LDA model



Source: Compiled by the authors.

Topic 2 is composed of terms such as 'learning', 'game-based', 'teacher', 'language', 'digital' or 'school'. This suggests that this theme is based on the use of serious games in teaching-learning processes for students at early levels of schooling. Furthermore, it seems that language teaching may have a special relevance to this topic. To elaborate on this in more detail, let us look at the main contributions made in this area. Hsu et al., (2008) propose a system for analysing GBPs and digital GBPs and raise questions about the design of these strategies for use in the classroom. Fu et al., (2022) conducted a study in which they applied a proposal for collaborative digital game design by students. They found that students who designed collaboratively performed the task more effectively and from a more constructivist point of view. Another study on this topic applied an intervention for teaching mathematics at the primary school stage using serious games in a digital context. They found that children who completed sessions using this methodology increased their

mathematics knowledge to a greater extent than did those in a traditional teaching group (Hwa, 2018). School teachers believe that educational games such as Minecraft can help foster collaboration among students, encourage creativity, and foster active learning and can be useful in fostering inclusive education (Slattery et al., 2023). Finally, Hayak & Avidov-Ungar, (2023) conducted a qualitative study in which they reported that primary schoolteachers use four types of knowledge to integrate digital GBPs in the classroom. These four categories were knowledge of games (e.g., type of game, difficulty levels), technological knowledge associated with games (e.g., familiarity with digital systems and technical skills to operate them), pedagogical knowledge associated with games (e.g., how to use digital games to contribute to teaching-learning objectives) and pedagogical knowledge of content associated with games (e.g., ability to integrate knowledge of using games to implement teaching methods for any content and learning-centred pedagogy). As previously stated, this topic concerns the implementation and design of GBP (especially serious games) in primary and secondary education and the analysis of its effects on variables of educational interest. It also includes works that analyze strategies for incorporating this pedagogy into the educational environment. This topic is related to the theme identified by Martí-Parreño et al., (2016) on the effectiveness of gamification in the educational process and to the themes of 'gamification' and 'game' identified by Rodrigues et al., (2019).

Topic 6 encompasses words such as 'gamification', 'element', 'engagement', 'design', 'motivation', 'reward', 'online' or 'system'. This suggests that the topic is focused on gamification, its design and implementation through various systems and elements, and its effect on user motivation and engagement. One of the most representative works on this topic is that published by Chan et al., (2018), in which the influence of gamification based on different elements (e.g., points and rankings) on intrinsic motivation is determined. The results of this study indicated that students who are already motivated do not require gamified environments. Furthermore, the authors suggest that the use of gamification decreases intrinsic motivation, particularly in cases where the point system is not proposed as a way of providing feedback. However, Kim et al., (2020) found that the application of gamification to engineering students led to improvements in intrinsic and extrinsic motivation while simultaneously reducing demotivation. Hamari et al., (2014) suggest that gamification

has the potential to promote positive effects on motivation, although these effects depend on the context in which it is implemented and the users who participate in the experience. In a similar vein, Mekler et al., (2017) examined the impact of points, rankings and levels on intrinsic motivation. Their findings indicate that none of the three elements of the games resulted in greater intrinsic motivation compared to a control group. However, they elicited a greater number of positive responses in the task, which may be attributed to the increase in extrinsic motivation. Another study on this topic has also been interested in analysing the differential effects of certain elements included in gamification. This review concluded that elements such as stories or narratives and badges are useful for increasing students' cognitive engagement with lessons (Abu-Dawood, 2016). It seems that a key aspect to consider when developing educational programmes is the elements that are included in gamification, as different groups of elements can generate specific changes in student motivation and other educational variables. This research topic is still ongoing today, and there is a need for further articles to be published to establish which types of elements are the most suitable for creating gamification in educational environments. Upon examination of the works included in this topic, it becomes evident that a significant proportion of them are not from the educational field and instead belong to the domains of marketing and economics (e.g., Eisingerich et al., 2019; Morschheuser et al., 2016). Upon attempting to correlate this topic with those previously identified by other researchers, a degree of concurrence was observed with the theme of 'engagement' proposed by Martí-Parreño et al., (2016), which encompasses terms such as enjoyment and task retention. Additionally, it is also related to the themes 'engagement' (e.g., context, mechanics), 'game' (e.g., elements, design), and 'gamification' found by Rodrigues et al., (2019).

Topic 9 encompasses terms such as 'student', 'university', 'learning', 'course', or 'education'. Consequently, it appears to be more oriented towards the application of this pedagogical approach to university students, with the objective of facilitating learning. A further investigation of this topic revealed works such as that of Sánchez-Martín et al., (2020), who demonstrated the efficacy of escape game experiences in science, technology, engineering and mathematics (STEM) subjects in enhancing student motivation. These experiences were well received by students, irrespective of their degree or gender, and the experiences they had were

predominantly positive. Gómez-Urquiza et al., (2022) conducted a study to assess the opinions of nursing students regarding educational escape games. The findings indicated that the students perceived these games as fun, dynamic, and motivating strategies for studying and learning. In contrast, Martínez-Jiménez et al., (2021) conducted a study demonstrating that the utilization of Kaboot! in student assessment is conducive to enhancing learning efficiency and reducing the number of students who fail the subject. Additionally, numerous papers in this field have examined the utilization of this assessment tool in university settings (e.g., Cruz et al., 2021; Esteves et al., 2018; Pertegal-Felices et al., 2020). Other works present compendiums of applications that can be used for gamification and propose the creation of different resources, such as role-playing games (RPGs), to be applied in the educational environment (Batista & Vaz de Carvalho, 2008; Mikic-Fonte et al., 2020; Rocha et al., 2020). Consequently, this topic is linked to the application of GBP in the university environment. Among the most commonly employed strategies are educational escape games and the utilization of Kahoot! in assessment processes.

Finally, topic 10 included words such as 'student', 'learning', 'gamebased', 'performance' or 'motivation'. When contrasting some of the papers associated with this topic, we found works such as Lei et al., (2022). These authors conducted a meta-analysis to determine the effects of GBP on the academic performance of students from primary school to university in science fields. Their results showed that GBP helps students achieve educational goals to a greater extent than more traditional forms of instruction. Lin et al., (2017) conducted a study comparing the effectiveness of digital GBP on student learning and motivation when used in a competitive or cooperative manner. Their findings indicate that both strategies vielded comparable results in terms of effectiveness and motivation. However, they observed that participants in the competitive mode exhibited greater levels of satisfaction than did those in the cooperative mode. In a study conducted by Hung et al., (2014), the application of GBP in primary school mathematics was found to have a positive impact on students' performance, self-efficacy and motivation towards the subject. Consequently, the focus of this topic is on the effects that GBP has on the outcome (in terms of efficiency) of the educational process. Additionally, different proposals, competitive or cooperative, and their impact on the variables of educational interest are analyzed. It is important to

note that the cooperative or competitive orientation of GBP may be related to the differentiated effects that gamification elements may have on motivation. This is because the character of the game is dependent on the elements that predominate in the game. Therefore, both topics 9 and 10 seem to focus on how GBP can promote learning in the educational environment. These findings may be related to the 'learning' theme identified by Rodrigues et al., (2019) or the 'effectiveness' theme identified by Martí-Parreño et al., (2016).

To conclude, this section, Figure IV illustrates the evolution of the various topics in terms of the number of related papers published over time. Upon analysis of this figure, it becomes evident that there has been a notable increase in interest in topics 6 and 9 in recent years. Consequently, over recent years, there has been a surge in interest among the scientific community in developing novel systems to implement gamification in diverse settings with the aim of enhancing motivation and user engagement. Similarly, there has been a notable increase in the application of GBP in the university environment, with the objective of facilitating learning and boosting student motivation. Conversely, topics 1 and 2 have experienced a decline in relevance over the same period. It is important to recall that the first topic is focused on the design of serious games for application, above all, in the educational context. The second topic is based on the use of serious games in teaching-learning processes for students at the initial levels of schooling and the analysis of their effects on variables of educational interest (e.g., motivation or effectiveness).

## Limitations and future lines of research

This work is subject to certain limitations pertaining to the type of analysis employed. While text mining enables the analysis of a significantly larger corpus of texts than would be possible through manual means, it does have certain limitations in terms of the depth of analysis that can be conducted on the texts themselves. Consequently, the methodology employed yields results that provide a valuable overview of the research conducted thus far in the field of GBP. To gain a deeper understanding of the texts and to present the current knowledge of each topic in a narrative form, it would be necessary to carry out a qualitative and manual

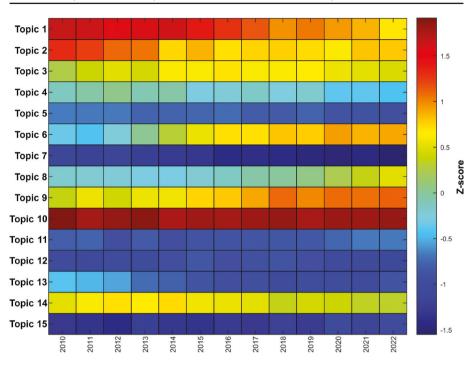


FIGURE IV. Dynamics of the topics found in the LDA model over the years

Source: Compiled by the authors.

review of the complete texts. As a second limitation, it would have been beneficial to include more databases. However, due to the large number of papers available, we considered that using WOS (the database with the greatest impact at present) was sufficient.

This work paves the way for comprehensive narrative reviews of the topics under consideration, which will enable us to ascertain the current state of knowledge about each topic with precision. This will result in a comprehensive description of the current knowledge about GBP in all areas of application. Furthermore, while there are some topics that seem to have lost interest in specialist journals, it is recommended that researchers continue to carry out studies proposing new systems that allow the implementation of gamification in various environments to increase user motivation and engagement, as well as the application of GBP in the university environment to promote learning and increase

student motivation. This is because the number of papers published on these topics in recent years has been increasing.

## **Conclusions**

In recent years, the number of published works on GBP has increased significantly. An overview of the existing knowledge on this subject is therefore essential. This work makes a significant contribution to this overview by identifying the unigrams, bigrams and trigrams most closely related to GBP. The most relevant terms identified as the most common topics covered in GBP-related research are 'student', 'education', 'virtual reality', 'video game', 'learning environment', 'autism spectrum disorder', 'design methodology approach' and 'information communication technology'. Nevertheless, for a more comprehensive analysis, the 15 most pertinent research topics related to this subject have been provided. These include the investigation of novel tools for the implementation of gamification in diverse settings, as well as the utilization of GBP to enhance learning and increase the motivation of university students. Additionally, the research topics that have witnessed a surge in scientific prominence in recent years have been included.

# **Bibliographical references**

- Abu-Dawood, S. (2016). The Cognitive and Social Motivational Affordances of Gamification in E-Learning Environment. 2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT), 373-375. https://doi.org/10.1109/ICALT.2016.126
- Apt, C. C. (1970). Serious games: The art and science of games that simulate life in industry, government and education. Viking.
- Batista, R., & Vaz de Carvalho, C. (2008). Work in progress—Learning through role play games. *2008 38th Annual Frontiers in Education Conference*, T3C-7-T3C-8. https://doi.org/10.1109/FIE.2008.4720599
- Brangier, E., & Marache-Francisco, C. (2020). Measure of the Lived and Functional Effects of Gamification: An Experimental Study in a Professional Context. En *Advances in Ergonomics in Design* (F. Rebelo and M. M. Soares, pp. 242-253). Springer International Publishing.

- Chan, E., Nah, F. F.-H., Liu, Q., & Lu, Z. (2018). Effect of Gamification on Intrinsic Motivation. En F. F.-H. Nah & B. S. Xiao (Eds.), *HCI in Business, Government, and Organizations* (pp. 445-454). Springer International Publishing. https://doi.org/10.1007/978-3-319-91716-0\_35
- Cretu, D. M., & Ho, Y.-S. (2023). The Impact of COVID-19 on Educational Research: A Bibliometric Analysis. *Sustainability*, *15*(6), Article 6. https://doi.org/10.3390/su15065219
- Cruz, S., Urbano, D., Coelho, A., & Pêgo, J. P. (2021). An experience of using Kahoot! While going online. *2021 4th International Conference of the Portuguese Society for Engineering Education (CISPEE)*, 1-4. https://doi.org/10.1109/CISPEE47794.2021.9507221
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining «gamification». *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9-15. https://doi.org/10.1145/2181037.2181040
- Dormann, C., & Biddle, R. (2009). A Review of Humor for Computer Games: Play, Laugh and More. *Simulation & Gaming*, 40(6), 802-824. https://doi.org/10.1177/1046878109341390
- Edwards, E. A., Lumsden, J., Rivas, C., Steed, L., Edwards, L. A., Thiyagarajan, A., Sohanpal, R., Caton, H., Griffiths, C. J., Munafò, M. R., Taylor, S., & Walton, R. T. (2016). Gamification for health promotion: Systematic review of behaviour change techniques in smartphone apps. *BMJ Open*, *6*(10), e012447. https://doi.org/10.1136/bmjopen-2016-012447
- Eisingerich, A. B., Marchand, A., Fritze, M. P., & Dong, L. (2019). Hook vs. hope: How to enhance customer engagement through gamification. *International Journal of Research in Marketing*, *36*(2), 200-215. https://doi.org/10.1016/j.ijresmar.2019.02.003
- Esteves, M., Pereira, A., Veiga, N., Vasco, R., & Veiga, A. (2018). The Use of New Learning Technologies in Higher Education Classroom: A Case Study. En M. E. Auer, D. Guralnick, & I. Simonics (Eds.), *Teaching and Learning in a Digital World* (pp. 499-506). Springer International Publishing. https://doi.org/10.1007/978-3-319-73210-7\_59
- Fiadotau, M., Tramonti, M., Brander, H., & Callaghan, P. (2022). BIG GAME: Balancing Player Preferences and Design Considerations in a Serious Game About Environmental Issues. En K. Kiili, K. Antti, F. de Rosa, M. Dindar, M. Kickmeier-Rust, & F. Bellotti (Eds.), Games and

- *Learning Alliance* (pp. 329-334). Springer International Publishing. https://doi.org/10.1007/978-3-031-22124-8\_34
- Fu, Q.-K., Zou, D., Xie, H., Cheng, G., & Hwang, G.-J. (2022). Effects of a collaborative design approach on pre-service teachers' ability of designing for learning with a digital game. *Education and Information Technologies*, *27*(4), 5641-5664. https://doi.org/10.1007/s10639-021-10818-3
- Gaonkar, Dr. S., Khan, Dr. D., Manisha, M., & Singh, A. (2022). Impact of Gamification on Learning and Development. *Journal of Advances in Education and Philosophy*, *6*(2), 63-70. https://doi.org/10.36348/jaep.2022.v06i02.003
- Gómez-Urquiza, J. L., Hueso-Montoro, C., Correa-Rodríguez, M., Suleiman-Martos, N., Martos-Cabrera, M. B., Gómez-Salgado, J., & Albendín-García, L. (2022). Nursing students' experience using an escape room for training clinical skills and competencies on emergency care: A qualitative observational study. *Medicine*, 101(30), e30004. https://doi.org/10.1097/MD.00000000000030004
- Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does Gamification Work? A Literature Review of Empirical Studies on Gamification. 2014 47th Hawaii International Conference on System Sciences, 3025-3034. https://doi.org/10.1109/HICSS.2014.377
- Hayak, M., & Avidov-Ungar, O. (2023). Knowledge and planning among teachers integrating digital game-based learning into elementary school classrooms. *Technology, Pedagogy and Education*, *32*(2), 239-255. https://doi.org/10.1080/1475939X.2023.2175719
- Hsu, S.-H., Wu, P.-H., Huang, T.-C., Jeng, Y.-L., & Huang, Y.-M. (2008). From Traditional to Digital: Factors to Integrate Traditional Game-Based Learning into Digital Game-Based Learning Environment. *2008 Second IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning*, 83-89. https://doi.org/10.1109/DIGITEL.2008.24
- Hung, C.-M., Huang, I., & Hwang, G.-J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. *Journal of Computers in Education*, *1*(2), 151-166. https://doi.org/10.1007/s40692-014-0008-8
- Hwa, S. P. (2018). Pedagogical Change in Mathematics Learning: Harnessing the Power of Digital Game-Based Learning. *Journal of Educational Technology & Society*, 21(4), 259-276.

- İlhan, A. (2021). The Impact of Game-Based, Modeling, and Collaborative Learning Methods on the Achievements, Motivations, and Visual Mathematical Literacy Perceptions. *SAGE Open, 11*(1), 21582440211003567. https://doi.org/10.1177/21582440211003567
- Kim, E., Rothrock, L., & Freivalds, A. (2020). The impact of gamification on the motivation and performance of engineering students through the lens of self-determination theory. *International Journal of Engineering Education*, 36(3), 1117-1131. Scopus.
- Korn, O., & Schmidt, A. (2015). Gamification of Business Processes: Redesigning Work in Production and Service Industry. *Procedia Manufacturing*, 3, 3424-3431. https://doi.org/10.1016/j.promfg.2015.07.616
- 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
- Lin, C.-H., Huang, S.-H., Shih, J.-L., Covaci, A., & Ghinea, G. (2017). Game-Based Learning Effectiveness and Motivation Study between Competitive and Cooperative Modes. 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), 123-127. https://doi.org/10.1109/ICALT.2017.34
- Martí-Parreño, J., Méndez-Ibáñez, E., & Alonso-Arroyo, A. (2016). The use of gamification in education: A bibliometric and text mining analysis. *Journal of Computer Assisted Learning*, 32(6), 663-676. https://doi.org/10.1111/jcal.12161
- Martínez-Jiménez, R., Pedrosa-Ortega, C., Licerán-Gutiérrez, A., Ruiz-Jiménez, M. C., & García-Martí, E. (2021). Kahoot! As a Tool to Improve Student Academic Performance in Business Management Subjects. *Sustainability*, *13*(5), Article 5. https://doi.org/10.3390/su13052969
- Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2017). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. *Computers in Human Behavior*, 71, 525-534. https://doi.org/10.1016/j.chb.2015.08.048
- Mikic-Fonte, F., Llamas-Nistal, M., Caeiro-Rodríguez, M., & Liz-Domínguez, M. (2020). A Gamification Module for BeA Platform. *2020 IEEE Frontiers in Education Conference (FIE)*, 1-5. https://doi.org/10.1109/FIE44824.2020.9274180
- Morschheuser, B., Hamari, J., & Koivisto, J. (2016). Gamification in Crowdsourcing: A Review. 2016 49th Hawaii International Conference

- on System Sciences (HICSS), 4375-4384. https://doi.org/10.1109/ HICSS.2016.543
- Nadolny, L., Valai, A., Cherrez, N. J., Elrick, D., Lovett, A., & Nowatzke, M. (2020). Examining the characteristics of game-based learning: A content analysis and design framework. *Computers & Education*, *156*, 103936. https://doi.org/10.1016/j.compedu.2020.103936
- Osipovskaya, E., & Miakotnikova, S. (2020). Using Gamification in Teaching Public Relations Students. En *The Challenges of the Digital Transformation in Education* (M. E. Auer and T. Tsiatsos, pp. 685-696). Springer International Publishing.
- Pan, L., Tlili, A., Li, J., Jiang, F., Shi, G., Yu, H., & Yang, J. (2021). How to Implement Game-Based Learning in a Smart Classroom? A Model Based on a Systematic Literature Review and Delphi Method. *Frontiers in Psychology, 12*. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.749837
- Pando Cerra, P., Fernández Álvarez, H., Busto Parra, B., & Iglesias Cordera, P. (2022). Effects of Using Game-Based Learning to Improve the Academic Performance and Motivation in Engineering Studies. *Journal of Educational Computing Research*, 60(7), 1663-1687. https://doi.org/10.1177/07356331221074022
- Pans, M., Madera, J., González, L.-M., & Pellicer-Chenoll, M. (2021). Physical Activity and Exercise: Text Mining Analysis. *International Journal of Environmental Research and Public Health*, *18*(18), Article 18. https://doi.org/10.3390/ijerph18189642
- Pertegal-Felices, M. L., Jimeno-Morenilla, A., Sánchez-Romero, J. L., & Mora-Mora, H. (2020). Comparison of the Effects of the Kahoot Tool on Teacher Training and Computer Engineering Students for Sustainable Education. *Sustainability*, *12*(11), Article 11. https://doi.org/10.3390/su12114778
- Peset, F., Garzón-Farinós, F., González, L. M., García-Massó, X., Ferrer-Sapena, A., Toca-Herrera, J. L., & Sánchez-Pérez, E. A. (2020). Survival analysis of author keywords: An application to the library and information sciences area. *Journal of the Association for Information Science and Technology*, 71(4), 462-473. Scopus. https://doi.org/10.1002/asi.24248
- Rajman, M., & Besançon, R. (1998). Text Mining: Natural Language techniques and Text Mining applications. En S. Spaccapietra & F. Maryanski (Eds.), *Data Mining and Reverse Engineering: Searching for*

- semantics. IFIP TC2 WG2.6 IFIP Seventh Conference on Database Semantics (DS-7) 7–10 October 1997, Leysin, Switzerland (pp. 50-64). Springer US. https://doi.org/10.1007/978-0-387-35300-5\_3
- Read, J. C. (2016). How Fun Can a Serious Game Be? En C. Vaz de Carvalho, P. Escudeiro, & A. Coelho (Eds.), *Serious Games, Interaction, and Simulation* (pp. 9-11). Springer International Publishing. https://doi.org/10.1007/978-3-319-29060-7\_3
- Ritterfeld, U., Cody, M., & Vorderer, P. (Eds.). (2009). *Serious Games: Mechanisms and Effects*. Routledge. https://doi.org/10.4324/9780203891650
- Rocha, J. B., Costa, L. F. C., Prada, R., Silva, A. R., Gonçalves, D., & Correia, P. (2020). Quizzes (As a Tool for Self-Regulated Learning) in Software Engineering Education. *2020 IEEE 32nd Conference on Software Engineering Education and Training (CSEE&T)*, 1-10. https://doi.org/10.1109/CSEET49119.2020.9206235
- Rodrigues, L. F., Oliveira, A., & Costa, C. J. (2016). Playing seriously How gamification and social cues influence bank customers to use gamified e-business applications. *Computers in Human Behavior*, *63*, 392-407. https://doi.org/10.1016/j.chb.2016.05.063
- Rodrigues, L. F., Oliveira, A., & Rodrigues, H. (2019). Main gamification concepts: A systematic mapping study. *Heliyon*, *5*(7), e01993. https://doi.org/10.1016/j.heliyon.2019.e01993
- Sánchez-Martín, J., Corrales-Serrano, M., Luque-Sendra, A., & Zamora-Polo, F. (2020). Exit for success. Gamifying science and technology for university students using escape-room. A preliminary approach. *Heliyon*, *6*(7), e04340. https://doi.org/10.1016/j.heliyon.2020.e04340
- Sardi, L., Idri, A., & Fernández-Alemán, J. L. (2017). A systematic review of gamification in e-Health. *Journal of Biomedical Informatics*, 71, 31-48. https://doi.org/10.1016/j.jbi.2017.05.011
- Slattery, E. J., Butler, D., O'Leary, M., & Marshall, K. (2023). Teachers' experiences of using Minecraft Education in primary school: An Irish perspective. *Irish Educational Studies*, *0*(0), 1-20. https://doi.org/10.1 080/03323315.2023.2185276
- Toda, A. M., Klock, A. C. T., Oliveira, W., Palomino, P. T., Rodrigues, L., Shi, L., Bittencourt, I., Gasparini, I., Isotani, S., & Cristea, A. I. (2019). Analysing gamification elements in educational environments using an existing Gamification taxonomy. *Smart Learning Environments*, *6*(1), 16. https://doi.org/10.1186/s40561-019-0106-1

Tundjungsari, V. (2020). Mobile Learning Design Using Gamification for Teaching and Learning in Algorithms and Programming Language. En *The Challenges of the Digital Transformation in Education* (M. E. Auer and T. Tsiatsos, pp. 650-661). Springer.

**Contact address**: Xavier García-Massó. Universidad de Valencia, Facultad de Magisterio, Departamento de didáctica de la educación física, artística y música. Avenida de los Naranjos 4, Valencia (46022), Spain. E-mail: xavier.garcia@uv.es

# Games and videogames for dyslexia rehabilitation: neurocognitive and psycholinguistic foundations

# Juegos y videojuegos para rehabilitación de la dislexia: fundamentación neurocognitiva y psicolingüística

https://doi.org/10.4438/1988-592X-RE-2024-405-631

## Iluminada Sánchez-Doménech

https://orcid.org/0000-0002-4342-2145 Universidad internacional de La Rioja

## Beatriz Martín del Campo

https://orcid.org/0000-0001-6957-6233 Universidad de Castilla

#### Abstract

Developmental Dyslexia (DD) is a neurodevelopmental disorder that impairs the process of learning to read and write. Its neurological etiology and associated cognitive deficits remain the subject of research. Technology has facilitated the development of platforms, games, and video games (PGVs) for DD rehabilitation. Due to the diversity of hypotheses and therapeutic approaches, it is useful to establish the state of the art, as well as to determine whether PGVs respond to this updated knowledge. With this objective, we review the neurocognitive, cognitive, and psycholinguistic hypotheses that explain DD. We conduct a review and analysis of the PGVs intended for use with DD, and which are supported by published scientific evidence and marketed in Spain. Eight were identified: Galexia, Ubinding, Glifing, Tradislexia, GraphoGame, Jellys, DytectiveU and Minecraft. These are analyzed under four levels of intervention: neurological, cognitive, psycholinguistic and performance. The PGVs are discussed in light of the research evidence in the field. Recommendations are made for further adjustment to this evidence. It is concluded that, although the direct intervention of the professional continues to be essential, the applications constitute a motivating didactic reinforcement. However, it is advisable to have detailed theoreticaltechnical information to personalize the intervention based on the strengths and weaknesses of the child and considering the possible existence of DD subtypes.

*Keywords*: dyslexia, computer-based training, videogames, phonemic awareness, neuropsychology, psycholinguistics.

#### Resumen

La Dislexia del desarrollo (DD) es un trastorno del neurodesarrollo que dificultad el aprendizaje de la lectura y la escritura. Su etiología neurológica y los déficits cognitivos asociados siguen siendo objeto de investigación. La tecnología ha posibilitado el desarrollo de plataformas, juegos y videojuegos (PJV) para la rehabilitación de DD. Ante la diversidad de hipótesis y enfoques terapéuticos, es conveniente conocer el estado de la cuestión, así como comprobar si los PIV responden a este conocimiento actualizado. Con este objetivo, se revisan las hipótesis neurocognitivas, cognitivas y psicolingüísticas explicativas de la DD. Se realiza una revisión y análisis de los PJV disponibles en el mercado español con alguna evidencia científica publicada y comercializados en España y orientados a la DD. Se identifican ocho: Galexia, Ubinding, Glifing, Tradislexia, GraphoGame, Jellys, DytectiveU y Minecraft y se analizan desde cuatro niveles de intervención: neurológico, cognitivo, psicolingüístico y de desempeño. Los PJV se discuten desde el contraste con la evidencia investigadora en el campo. Se realizan recomendaciones para un mayor ajuste a esta evidencia. Se concluye que, a pesar de que la intervención directa del profesional sigue siendo imprescindible, las aplicaciones constituyen un refuerzo didáctico motivador, aunque es conveniente disponer de información teórico-técnica detallada para personalizar la intervención desde las fortalezas y debilidades del sujeto particular y considerando la posible existencia de distintos subtipos de DD.

*Palabras clave*: dislexia, videojuegos, intervención mediada por ordenador, conciencia fonológica, psicolingüística, neuropsicología.

## Introduction

Developmental dyslexia (DD) is a neurobiological disorder that inhibits reading acquisition, despite appropriate school instruction and regardless of general intellectual capacity. Its prevalence in the population is estimated to be between 5% and 10%. The symptoms present as a letter coding deficit, low reading accuracy and/or fluency and dysorthography.

Research into the underlying neurological deficits in DD has generated different explanatory hypotheses. Currently, competing explanations

for reading difficulties in DD include those that posit an underlying deficit in visual processing (Vidyasagar and Pammer, 2010), those that propose an auditory processing deficit (Goswami, 2019), a third suggesting the underlying deficits may be located in both the auditory and visual processing systems (Gori et al., 2016), and a fourth that seeks to integrate the previous postulates and hypothesizes a deficiency in the processing of short, rapid, successive stimuli (Habib, 2021).

The theories based on a single underlying cognitive factor cannot satisfactorily explain the variety of profiles and symptoms (perceptual and motor) in children with dyslexia (Willcut et al., 2019). For example, not all children with DD present only a phonological deficit (Snowling et al., 2018; Norton & Wolf, 2012), despite such a deficit being the most widely accepted hypothesis to explain DD. The double-deficit theory holds that the reading difficulties in DD arise from a deficit in phonological awareness, from a deficit in rapid automatized naming (RAN), or as a result of both (Wolf & Bowers, 2000). In addition to the diversity of cognitive profiles, the predictive utility of phonological awareness varies according to the orthographic transparency of the child's language (Pennington et al., 2012).

Technology has made significant headway in the field of rehabilitation of learning disabilities. There are four levels of technology-assisted/mediated intervention in the rehabilitation of DD: 1) the experimental level derived from hypotheses about the neurological etiology of DD; 2) interventions that aim to train the cognitive deficits underlying reading difficulties; 3) interventions focused on developing metalinguistic and linguistic skills; and 4) the level of intervention seeking to improve reading performance according to symptomatology.

Given the diversity of explanatory theories and therapeutic approaches, we consider it necessary to analyze the state of the art based on the four abovementioned levels. We propose to examine the evidence available on the causes of DD and how the technological applications developed and marketed in Spain and in Spanish address these explanatory hypotheses and scientific evidence in their interventions in DD.

# Methodology

The general aim of this study is to provide an update on the explanatory hypotheses of DD and to examine the PGVs designed for the rehabilitation of DD available on the Spanish market. The specific objectives of this study are as follows: 1) to compare the PGVs with the scientific evidence on DD and its intervention; 2) to provide clinical and educational professionals with neurocognitive and psycholinguistic substantiation for making informed decisions on the use of these PGVs in rehabilitating DD; and 3) to suggest recommendations for designing intervention technology that is compatible with the findings on DD.

The research design is divided into four stages: 1) a search for applications, videogames and platforms for DD rehabilitation that are scientifically evidenced and/or commercially available in Spain; 2) an analysis of the platforms, articles, technical manuals and information supplied by the designers or distributors; 3) a classification of the activities included in the PGVs according to the level of intervention; 4) a search for scientific evidence on the neurological hypotheses, cognitive consequences and symptoms, and on the treatment of DD in each of the levels.

We used the Scopus, WOS, Dialnet and Google Scholar databases to search for PGVs with scientific evidence. No filters were used for the search period. The search was conducted in March 2023. Table I shows the keyword strings used and the results.

Following this first selection, we screened the articles, applying the following inclusion criteria: experimental studies with applications,

TABLE I. Search strings and results

Search string	Results	Selected
Intervención AND dislexia AND tecnología	WOS = 9 Scopus = 5	8
Intervención AND dislexia AND aplicaciones	WOS = 41 Scopus = 2	30
Intervención AND dislexia AND ordenador	WOS=12 Scopus = 8	3
Dificultades lectoras AND ordenador	WOS =55 Scopus=0	122
Intervención asistida por ordenador AND dislexia	Google Académico=6 WOS=3 Scopus=0	0
Dislexia-aplicación-tecnología-videojuego	Dialnet=3	0
		163

Source: Colpiled by the author.

video games and platforms for the rehabilitation of DD in children aged under 18, rehabilitation in Spanish, and referring to the application of a technological game, video game or specific platform used to assess the results. Opinion articles and theoretical or general articles on technology and rehabilitation in DD were excluded. After applying the inclusion criteria, a total of 9 relevant papers presenting empirical data on the efficacy of PGVs in Spanish remained. To find PGVs marketed in Spain, we conducted a Google search using the following words: dyslexia, intervention, reading, application, platform, game, videogame. Two books about commercially available PGVs were found (DytectiveU and Glifing). Table II shows a list of the PGVs in Spanish along with their associated publication, both research articles and books published on the PGVs in the market.

Following the analysis of the PGVs detected, we classified the activities they contain according to four levels of intervention, as described in the results section. A non-systematic bibliographic search was then performed on the theoretical and scientific foundations of each of the levels: neurological, cognitive, psycholinguistic, and performance-related or symptomological.

TABLE II. PGVs commercially available in Spain, with and without supporting scientific evidence

Program	Publication	Impact on experimental group					
Transdislexia	Jiménez & Rojas (2008)	PA and pseudoword reading					
Ubinding	López-Olóriz et al. (2020)	RS and reading accuracy					
	Forne et al. (2022)	RS and reading accuracy					
DytectiveU	Rello (2018)	Phoneme segmentation, spelling, pseudoword reading, transcription and RS					
Jellys	Ostiz-Blanco et al. (2018)	No improvements in rhythm or attention					
Galexia	Serrano et al. (2016)	VL, reading comprehension, reading comprehension mediated by prosodic skills					
Glifing	García i Ortíz et al. (2016)	RS					
Minecraft	Jiménez & Díez (2018)	VF and lexical route of reading					
GraphoGame	Rosas et al. (2017)	RAN and identification of letter sounds					

Note. RAN=rapid automatized naming; PA=phonological awareness; RS=reading speed; VF=verbal fluency. RF=reading fluency. Source: Compiled by the author.

## **Results**

Below, we analyze the four levels of intervention, examining how they are addressed in the PGVs listed in Table II, and in relation to the explanatory hypotheses and the current state of the art in interventions for DD.

## First level of intervention: neurocognitive interventions

First, the phonological deficit hypothesis suggests that dyslexia stems from challenges in processing speech sounds, which affects individuals' ability to associate graphemes with their corresponding phonemes—a fundamental skill for reading in alphabetic systems (Ramus et al., 2003). This deficit may have a neurological correlate with the differences in size and morphology of the Heschl's Gyrus (HG) found in children at risk of developing dyslexia before they begin learning to read (Clark et al., 2014; Kuhl et al., 2020). This structure plays a key role in the analysis and encoding of temporal characteristics of speech. As a result, in children with DD, the neural response to the more informative parts of the speech signal is slightly out of time (Goswami, 2019). As regards this hypothesis, technology is expected to help enhance the auditory processing of speech, for example, by improving the speech envelope, which is dominated by lower frequencies (<10 Hz) that encode prosodic and syllabic features of speech (Klimovich-Gray et al., 2023), by providing training in dichotic listening (Helland et al., 2018) or auditory pacing (Van Hirtum et al., 2019; Van Herck et al., 2022). Regarding auditory rhythm training, Bonacina et al. (2015) found a positive impact on sublexical skills in both reading speed and reading accuracy and significant effects on short pseudoword reading speed (RS), long pseudoword RS, high-frequency long-word reading accuracy and text reading accuracy.

Another hypothesis for the neurological etiology of DD is a deficit in the magnocellular/dorsal system. This is grounded in differences in the morphology and location of the lateral geniculate nucleus (LGN) found in individuals with dyslexia (Giraldo-Chica and Schneider, 2018). The LGN plays a critical role in the transmission of visual stimuli to the cortex through two pathways: the ventral (occipito-temporal) and the dorsal (temporo-parietal). This structure is elemental in visual processing, motion perception (Gori et al., 2016) and the focusing of spatial and temporal attention (Ruffino et al., 2014). These pathways are home to

gyri with key functions for visual processing, such as the fusiform and lingual gyri, in which synaptic disruption or reduced streamlines have been observed (Centanni et al., 2019; Lou et al., 2019), as well as structural differences (Clark et al., 2014) in children at risk for dyslexia and who develop DD later in life. This hypothesis seeks to provide a comprehensive explanation, proposing that phonological decoding deficits in dyslexia may arise from sensory processing deficits in primary areas related to visual and auditory dynamic stimuli (Gori et al., 2016). This hypothesis thus suggests a broader deficit in spatiotemporal sensory processing (Habib, 2021) and may explain why individuals with dyslexia have difficulty remembering the relative position of letters in words, resulting in characteristic mistakes in their writing, such as substitutions, inversions, omissions and additions (Vidyasagar & Pammer, 2010). In support of this hypothesis, it has been evidenced that the inferior parietal cortex is a core region in the explicit internal representation of order, while the dorsal attentional network may intervene in a mental representation in which serial order is represented by spatial positional codes (Zhou et al., 2021). Following this hypothesis, dyslexia interventions involve exercises to improve rapid alternation between visual and auditory attention, along with attentional control through action game adaptations (Bertoni et al., 2021) and the use of specially designed video games for assessment and intervention in educational contexts, according to Tulloch and Pammer (2019).

Table III shows the PGVs that include activities oriented towards this level of intervention.

Among the PGVs analyzed in this study, Jellys (Ostiz-Blanco et al., 2018) focuses on training auditory rhythm and visual attention in children with DD. Tradislexia also incorporates activities intended to identify auditory rhythm and speech perception. In reference to movement perception, it is more than likely that video games such as Minecraft and Galexia intervene in this aspect, despite not being an explicitly stated rehabilitative goal.

# Second level of intervention: cognitive skills

Sufficient evidence has been presented to support the idea that certain cognitive deficits characterize DD, namely, processing speed (PS) and working memory (WM) (Lonergan et al., 2019; Maehler et al., 2019).

TABLE III. Abilities related to the neurological etiology of DD in the PGVs

Program	MP	AU P	AC	AR	VA	DCV	DCA
Tradislexia		×		×			
Ubinding							
DytectiveU						×	×
Galexia							
Glifing							
Jellys				×	×		
Minecraft							
GraphoGame							

Note. MP=Movement perception; AU P=Auditory processing; AC=Attention control; AR=Auditory rhythm; VA=Visual attention; VDC=Visual discrimination and categorization; ADC= Auditory discrimination and categorization. Source: Compiled by the author.

Studies using tests to dismiss comorbidity with ADHD in the composition of samples have found no deficits in sustained attention in DD, but have detected impairments in selective attention (Fernández-Andrés et al., 2019). Additionally, children with DD appear to have longer reaction times in switching attention and present auditory WM deficits (Lonergan et al., 2019). As regards other executive functions (EF), studies are contradictory, arguably due to the high rate of DD/ADHD comorbidity (Lonergan et al., 2019), the different diagnostic criteria used, the cut-off points for including participants in the samples (Doyle et al., 2018) or the types of tests administered (Sánchez-Doménech, 2022).

The PGVs analyzed include tasks that claim to improve cognitive skills. Table IV shows the skills included in each application.

Furthermore, it seems that the population with dyslexia is not entirely homogeneous in terms of WM deficits. For example, Wokuri et al. (2023) found two distinct profiles; one was associated with verbal item WM and phonological impairment, while another presented selective serial WM deficits in both the verbal and visual domains, and thus practitioners should consider the heterogeneous nature of MT impairment in DD when fashioning rehabilitation strategies.

In any event, the insufficient evidence on the efficacy of training in domain-general cognitive skills suggests that the most useful intervention strategy in cognitive deficits associated with DD is that of

TABLE IV. Training in domain-general cognitive skills

Program	PS	WM	EF	STVM	VA
Tradislexia	×	х			
Ubinding		×		х	
DytectiveU		×	×		
Galexia					
Glifing		×	×		
Jellys					х
Minecraft	×	×			
GraphoGame					

Note. PS=Processing speed; WM=Working memory; STVM=Sort-term verbal memory; EF=Executive functions; VA=Visual attention. Source: Compiled by the author.

compensatory initiatives to eliminate barriers in academic settings, with the aim of avoiding school failure in children with dyslexia. An example of compensation for WM deficits in text composition might be to provide a structure with mnemotechnical cues and prior preparation of the orthography of vocabulary involved so that it can be activated in the WM (Hebert et al., 2018).

# Third level of intervention: metalinguistic and linguistic skills

Phonological awareness training appears to have an impact on decoding processes, but the positive impact of this training does not extend to competencies requiring orthographic memory representations, such as orthographically correct spelling and correct reading of foreign words, nor does it affect reading fluency (Wimmer, 2000). *Decoding processes* (DPs), which involve understanding the alphabetic principle, begin by associating the phoneme sound with its graphic representation (phoneme/grapheme conversion) until the mechanics of decoding larger units are mastered. This acquisition is crucial for learning to read in first grade (Ergül et al., 2023), although, used isolatedly, it seems to be less effective than as part of multicomponent teaching programs (Donegan et al., 2021).

In transparent alphabetic languages, where spoken words can be broken down into syllables, beginner readers have been found to learn to read and write more effectively when they are taught grapheme-phoneme units rather than grapho-syllabic sound units (Sargiani et al., 2021). Table V lists the linguistic and metalinguistic skills included in each PGV.

Four of the programs work on decoding, which is addressed by means of tasks related to recognizing graphemes, syllables, words and pseudowords of different complexity and in increasing order of difficulty. Six of the eight programs work on certain aspects of phonological awareness, although none of them deals with this metalinguistic competence in all its facets. In none of the programs does lexical awareness appear as the first in a sequence of tasks of increasing difficulty upon which a PA intervention should be structured, given that auditory processing deficits also affects the segmentation of the spoken string at word level (Schaadt et al., 2019), followed by syllabic awareness, intrasyllabic or rhyme awareness and, finally, phonemic awareness from the age of 6-7 (Defior & Serrano, 2011).

Furthermore, syllabic awareness should be structured in line with the complexity of the syllabic structures (CV, VC, CVC, etc.), and phonemic awareness in relation to the order phonemes are acquired (Susanibar et al. 2013). In this sense, Tradislexia, Glifing and DytectiveU all sequence the activities in accordance with syllabic structure.

TABLE V. Linguistic and metalinguistic skills in the PGVs

Program	PA	SA	ISA	MA	V	SP	D
Tradislexia	×	×	×		×	×	
Ubinding	×	×		×	×	×	
DytectiveU	×	×	×	×	×	×	х
Galexia	×						х
Glifing		×	×	×	×	×	×
Jellys							
Minecraft					×		
GraphoGame	×						×

Note. PA=Phonological awareness; SA=Syllabic awareness; ISA=Intra-syallabic awareness; MA=Morphological awareness; V=Vocabulary; SP=Syntactic processing; D= decodifing. Source: Compiled by the author.

Derivational morphology is closely linked to semantic morphology. It is also considered to bridge phonology and orthography (Bahr et al., 2020). The orthographic transparency of Spanish may encourage finegrained encoding strategies, but delay reliance on significant grains for automatic word reading, and thus the morphological effect emerges late, around sixth grade. (Lázaro et al., 2018). Morphological awareness in Spanish is related to reading comprehension, as it provides access to semantic and syntactic information in new words (D'Alessio, et al., 2019). Oral instruction in derivational and inflectional morphology may involve a preparatory strategy for reading at preschool age in transparent languages (Cohen-Mimran, 2022), being more effective for DD than for typically developing children (Deacon et al., 2019). Three of the programs address some form of morphology: UBinding, DytectiveU, and Glifing.

Empirical attention to *semantics* in DD intervention is limited (Deacon et al., 2019). The lexical quality hypothesis holds that literacy involves the successful integration of phonology, orthography, and semantic information, and that phonological representations alone are insufficient to achieve fluent reading. Furthermore, rapid decoding alone does not enhance comprehension (Perfetti, 2007), while individuals with dyslexia appear to rely more on semantic context than their peers with similar reading abilities, which could be interpreted as a compensatory mechanism (Deacon et al., 2019).

It has been suggested that a more specific and redundant lexicon might facilitate phonological awareness (van Rijthoven et al., 2018). Although the semantic network of children with dyslexia seems to be well evidenced, such children retrieve elements from the network more slowly, resulting in lower semantic fluency (Mengisidou et al., 2020), which aligns with the double deficit hypothesis. According to Viersen et al. (2017), however, children at family risk of dyslexia that were later diagnosed with DD present a delay in the both the receptive and productive development of vocabulary. Interventions should thus incorporate this component. Most of the programs analyzed here include a vocabulary component in their interventions.

With regard to *syntactic processing*, or the knowledge of the functions of words in sentences, two activities have been shown to help students with syntactic problems to improve their sentence writing: 1) rearranging the words in scrambled sentences into the correct; 2) creating sentences from a set of words (nouns, verbs, adjectives and adverbs) and a set of function words (prepositions, conjunctions, pronouns and articles)

(Berninger et al. (2019). This component features in four of the PGVs: Tradislexia, Ubinding, DytectiveU and Glifing.

## Fourth level of intervention: Performance measures

Performance measures are ways of operationalizing reading performance based on the symptoms that characterize DD. The tasks offered by the PGVs are designed to optimize these measures. Table VI shows the performance measures featured in the PGVs.

Reading fluency (RF) refers to a way of reading in which all sublexical units, words and text, as well as the perceptual, linguistic and cognitive processes involved, are processed accurately and automatically, allowing sufficient time and resources to be allocated to comprehension and deeper thought (Norton & Wolf, 2012). Meanwhile, reading speed (RS) is a measure referring to the reading aloud of elements of language (typically words or pseudowords). It is important to distinguish between the two concepts, as the former does not necessarily imply the text is understood. Intervention in RS is crucial in improving RF (Lopez-Escribano, 2016; Rakhlin et al., 2019). This involves automating decoding by means of rapid reading tasks with letters, syllables, and words.

TABLE VI. Performance measures in the PGVs

Program	0	RF	RAN	RC	RS	WS	MAS	ER	EC
Tradislexia	×								
Ubinding	×		×	х	х		х		
DytectiveU	×			х	х	х		х	×
Galexia	×	х							
Glifing	×			х	х				
Jellys									
Minecraft		х							
GraphoGame									

Note. O=Orthography; RF=reading fluency; RAN=Rapid automatized naming or naming speed; RC= Reading comprehension; RS=Reading speed; WS=Writing speed; MAS=Motor articulation speed; ER=Error recognition; EC=Error correction. Source: Compiled by the authors.

However, RF encompasses RS, but further involves other cognitive and linguistic processes that can only be assessed in the reading of a text from which meaning is simultaneously extracted. To date, Galexia is the only program that specifically addresses the improvement of RF, while UBinding, DytectiveU and Glifing work on RS.

Orthography is the most neglected area of study, and there remain many gaps in this field of research (Williams et al., 2017; Dymora & Niemiec, 2019). Writing deficits (dysorthography and dysgraphia) in DD are associated with functional abnormalities in the neural network of multiple brain regions involved in motor execution, visual-orthographic processing, and cognitive control (Yang et al., 2022). According to Berninger et al. (2019), literacy learning should include language by mouth, by eye and by hand, as well as motor planning, motor timing, and control and output skills. When teaching the alphabetic principle, harnessing the visual attributes of letters and explicitly teaching the motor pattern of the corresponding spelling is a strategy that has been found to be effective in automating the graphomotor pattern, thus resulting in a reduced WM load, targeted as the cause of DD-related dysgraphia (Hebert et al., 2018).

Auditory processing disorder involves difficulty in identifying syllable stress and prominent syllables (Jiménez-Fernández et al., 2015), resulting in problems to apply the rules of accentuation and punctuation. According to Toffalini et al. (2017), the high rate of children with spelling disorder in transparent languages could be due to the specific characteristics of such languages, in which reading errors tend to be eliminated at a certain age, but difficulties in the correct writing of words persist, especially when under stress or when specific arbitrary features of spelling must be added. In transparent languages, the difficulty arguably lies in constructing an orthographic lexicon and, therefore, in gaining automatic access to orthographic selection and production, varying significantly depending on the orthographic system of each language (Habib, 2021).

All the programs, except Jellys and GraphoGame, include tasks focused on orthographic recognition through the lexical pathway. DytectiveU uses the strategy of recognizing and self-correcting typical errors in the writing of children with DD, awareness of which improves reading performance and spelling (Rello, 2018).

We found no activities involving the construction of the orthographic lexicon for retrieval in writing tasks, addressing the order of the string of letters that make up words and their specific arbitrary spelling rules. The strategies that have been shown to be most effective in this sense incorporate handwriting for repetition and self-correction (Williams et al., 2017), as well as retention of letter order in visual memory, using games such as "Photographic Leprechaun" and the "Proofreaders' Trick" (Berninger et al., 2013), that could be incorporated into PGVs by digitizing handwriting. Additionally, the explicit instruction in using the computer keyboard, as well as the use of spell checkers, may be considered for interventions in DD, not only from a rehabilitative perspective (the effectiveness of which is yet to be evidenced) or a compensatory perspective, but as part of the technological and academic competence demanded today by society and education (Berninger et al., 2019).

As well as phonological difficulties, the double deficit theory (Wolf & Bowers, 2000), includes the deficit in RAN as an independent core factor of phonological awareness. RAN is a measure of the speed with which we can identify and name objects, colors, numbers, and letters. In transparent orthographies, the negative impacts of the factors underlying early deficit in PA and RAN emerge when reading fluency and orthography become important, despite appropriate instruction and acquisition in first grade (Ergül et al., 2023). Recent studies have found its neurological correlate, associating it with structural white matter anomalies in the left arcuate fasciculus, which is part of the dorsal pathway (Vander Stappen et al., 2020). These abnormalities disrupt connectivity with frontotemporal regions involved in articulation, speech fluency and verbal working memory (Mohammad et al., 2022).

According to Norton & Wolf (2012), the main reason RAN predicts subsequent reading skills is because it measures the ability to automate access to individual linguistic and perceptual components, as well as the connections between them, in serial visual tasks. In regular writing systems, dyslexia is less closely related to decoding accuracy than reading speed is (Padeliadu et al., 2021). Consequently, RAN measures have greater discriminatory power in these languages and at earlier stages of development (Luque et al., 2013). Vander Stappen and Reybroeck (2018) report that RAN-objects training improves reading speed, while PA training enhances orthographic representations. Georgiou et al. (2016) and Papadopoulos et al. (2016) found that RAN is related to fluency when reading aloud, but not to fluency in silent reading, supporting the hypothesis of a relationship between RAN and articulation. Only UBinding includes tasks for RAN and MAS (López-Olóriz, 4-5-2023).

## **Conclusions**

The overall objective of this study was to provide an update on the hypotheses to explain DD and to examine the rehabilitation oriented PGVs available in Spain, supported or not by scientific evidence, from four levels of intervention. Our study reviews the current research on the explanatory hypotheses and examines the efficacy of the most scientifically supported interventions, looking at whether they are addressed in the activities contained in the PGVs analyzed.

With respect to the first specific objective, and in light of our literature review, none of the PGVs brings together all the key components of an intervention in DD, although the most prominent ones are present in them all. It is worth noting that that there are promising elements of DD intervention that are, as yet insufficiently addressed by the PGVs, such as the motor and articulation aspects (Papadopoulos et al., 2016; Liu and Georgiou, 2017; Berninger et al., 2019; Yang et al., 2022) and auditory processing (Bonacina et al., 2015; Habib, 2021). Considering these elements could help develop more comprehensive interventions in DD.

Regarding the second specific objective, we provide clinical and educational professionals with an updated grounding in the neurocognitive and psycholinguistic elements related to DD. This information is hoped to contribute to informed decision making on the use of technological tools in the rehabilitation of DD. It is important for the various types of professionals involved in DD to consider the various explanatory hypotheses and their possible complementarity, considering the potential existence of DD subtypes (Habib, 2021; Lorusso and Toraldo, 2023) and under the adoption of a multiple deficit approach (Pennington et al., 2012). For example, it is worth bearing in mind that, although phonological awareness and decoding processes are crucial to interventions for DD, approximately 25% of cases fail to respond to such interventions (Seiler et al., 2019). In this sense, each individual with DD may present a unique profile of strengths and weaknesses that may require different targets and methods of intervention.

In general terms, methodological weaknesses have been detected in studies examining PGVs, such as limited sample sizes or the lack of a control group (Ostiz-Blanco et al., 2021). In addition, isolating the effects of these programs from those of schooling and the practice effect of PGVs tasks can be complex (Łuniewska et al., 2018). In the case of PGVs

in Spanish, there remains scant empirical evidence. Moreover, it would be desirable for PGVs to include a technical manual in which the neurological and/or cognitive explanatory hypotheses they are based on, the population they have been applied in, and the results of such application are made explicit, as is done with any assessment test or intervention program. While the play-based or gamified environment created by PGVs can create a psychologically stimulating environment for persistence and self-improvement (Dymora & Niemiec, 2019), evidence of the efficacy of the interventions collected by means of rigorous and realistic trials is needed before recommending their implementation in educational settings or specialized centers (Snowling & Hulme, 2011). They should also include a detailed catalog of their activities and, within the framework of rehabilitation, the purpose for which they are designed.

# **Bibliographic references**

- Bahr, R. H., Silliman, E. R., & Berninger, V. W. (2020) Derivational Morphology Bridges Phonology and Orthography: Insights into the Development of Word-Specific Spellings by Superior, Average, and Poor Spellers. *Language, Speech, and Hearing Services in Schools*. https://doi.org/10.1044/2020\_LSHSS-19-00090
- Berninger, V. W., Lee, Y. L., Abbott, R. D., & Breznitz, Z. (2013). Teaching children with dyslexia to spell in a reading-writers'workshop. *Annals of Dyslexia*, 63, 1–24. https://doi.org/10.1007/s11881-011-0054-0
- Berninger, V. W., Richards, T. L., Nielsen, K. H., Dunn, M. W., Raskind, M. H., & Abbott, R. D. (2019). Behavioral and brain evidence for language by ear, mouth, eye, and hand and motor skills in literacy learning. *International journal of school y educational psychology,* 7 (Suppl 1), 182–200. https://doi.org/10.1080/21683603.2018.1458357
- Bertoni, S., Franceschini, S., Puccio, G., Mancarella, M., Gori, S., & Facoetti, A. (2021). Action Video Games Enhance Attentional Control and Phonological Decoding in Children with Developmental Dyslexia. *Brain sciences*, 11(2), 171. https://doi.org/10.3390/brainsci11020171
- Bonacina, S., Cancer, A., Lanzi, P. L., Lorusso, M. L., & Antonietti, A. (2015). Improving reading skills in students with dyslexia: the efficacy of a sublexical training with rhythmic background. *Frontiers in psychology*, *6*, 1510. https://doi.org/10.3389/fpsyg.2015.01510

- Centanni, T. M., Norton, E. S., Ozernov-Palchik, O., Park, A., Beach, S. D., Halverson, K., Gaab, N., & Gabrieli, J. D. E. (2019). Disrupted left fusiform response to print in beginning kindergartners is associated with subsequent reading. *NeuroImage: Clinical*, 22, 101715. https://doi.org/10.1016/j.nicl.2019.101715
- Clark, K. A., Helland, T., Specht, K., Narr, K. L. Manis, F. R., Toga, A.W., & Hugdahl, K. (2014). Neuroanatomical precursors of dyslexia identified from pre-reading through to age 11. *Brain*, 137(12), 3136–3141, https://doi.org/10.1093/brain/awu229
- Cohen-Mimran, R., Reznik-Nevet, L., Gott, D., & Share, D. L. (2022). Preschool morphological awareness contributes to word reading at the very earliest stages of learning to read in a transparent orthography. *Reading and writing*, 1–21. https://doi.org/10.1007/s11145-022-10340-z
- D'Alessio, M. J., Jaichenco, V., & Wilson, M. A. (2019). The relationship between morphological awareness and reading comprehension in Spanish-speaking children. *Scandinavian journal of psychology*, 60(6), 501–512. https://doi.org/10.1111/sjop.12578
- Deacon, S., Tong, X., & Mimeau, C. (2019). Morphological and Semantic Processing in Developmental Dyslexia. In L. Verhoeven, C. Perfetti, y K. Pugh (Eds.), *Developmental Dyslexia across Languages and Writing Systems* (327-349). Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108553377.015
- Defior, S., & Serrano, F. (2011). Procesos Fonológicos Explícitos e Implícitos, Lectura y Dislexia. *Revista Neuropsicología, Neuropsiquiatría y Neurociencias, 11*(1), 79-94.
- Donegan, R. E., & Wanzek, J. (2021). Effects of reading interventions implemented for upper elementary struggling readers: A look at recent research. *Reading and Writing*, *34*(8), 1943–1977. https://doi.org/10.1007/s11145-021-10123-y
- Doyle, C., Smeaton, A. F., Roche, R. A. P., & Boran, L. (2018). Inhibition and Updating, but Not Switching, Predict Developmental Dyslexia and Individual Variation in Reading Ability. *Frontiers in psychology*, *9*(795). https://doi.org/10.3389/fpsyg.2018.00795
- Dymora, P., & Niemiec, K. (2019). Gamification as a Supportive Tool for School Children with Dyslexia. *Informatics*, *6*(4), 48. https://doi.org/10.3390/informatics6040048
- Ergül, C., Zeynep Bahap Kudret, Z.B., Meral Çilem Ökcün-Akçamuş, M.C., & Akoglu, G. (2023). Double-Deficit Hypothesis and Reading

- Difficulties: A Longitudinal Analysis of Reading and Reading Comprehension Performance of Groups Formed According to This Hypothesis. *Education and Science*, *48*(213), 1–23. https://doi.org/10.15390/EB. 2022.11002
- Fernández-Andrés, M. I., Tejero, P., & Vélez-Calvo, X. (2019). Visual Attention, Orthographic Word Recognition, and Executive Functioning in Children With ADHD, Dyslexia, or ADHD + Dyslexia. *Journal of Attention Disorders*, 25(7), 942–953. https://doi.org/10.1177/1087054719864637
- Forne, S., López-Sala, A., Mateu-Estivill, R., Adan, A., Caldu, X., Rifa-Ros, X., & Serra-Grabulosa, J. M. (2022). Improving Reading Skills Using a Computerized Phonological Training Program in Early Readers with Reading Difficulties. *International Journal of Environmental Research and Public Health*, *19*(18), 11526. https://doi.org/10.3390/ijerph191811526
- García i Ortiz, M., González i Calderon, M., & Garcia-Campomanes, B. (2016). *Glifing: Cómo detectar y vencer las dificultades de la lectura*. Barcelona: Horsori editorial.
- Georgiou, G. K., Aro, M., Liao, C. H., & Parrila, R. (2016). Modeling the relationship between rapid automatized naming and literacy skills across languages varying in orthographic consistency. *Journal of experimental child psychology*, *143*, 48–64. https://doi.org/10.1016/j.jecp.2015.10.017
- Giraldo-Chica, M., & Schneider, K. A. (2018). Hemispheric asymmetries in the orientation and location of the lateral geniculate nucleus in dyslexia. *Dyslexia*, 24(2), 197–203. https://doi.org/10.1002/dys.1580
- Gori, S., Seitz, A. R., Ronconi, L., Franceschini, S., & Facoetti, A. (2016). Multiple Causal Links Between Magnocellular-Dorsal Pathway Deficit and Developmental Dyslexia. *Cerebral cortex*, 26(11), 4356–4369. https://doi.org/10.1093/cercor/bhv206
- Goswami, U. (2019). Speech rhythm and language acquisition: an amplitude modulation phase hierarchy perspective. *Annals of the New York Academy of Sciences*, *1453*(1), 1–12. https://doi.org/10.1111/nyas.14137
- Habib, M. (2021). The Neurological Basis of Developmental Dyslexia and Related Disorders: A Reappraisal of the Temporal Hypothesis, Twenty Years on. *Brain Science*, 1(6), 798. https://doi.org/10.3390/brainsci11060708
- Hebert, M., Kearns, D. M., Hayes, J. B., Bazis, P., & Cooper, S. (2018). Why children with dyslexia struggle with writing and how to help them.

- Language, speech, and hearing services in schools, 49(4), 843–863. https://doi.org/10.1044/2018\_LSHSS-DYSLC-18-0024
- Helland, T., Morken, F., Bless, J. J., Valderhaug, H. V., Eiken, M., Helland, W. A., & Torkildsen, J. V. K. (2018). Auditive training effects from a dichotic listening app in children with dyslexia. *Dyslexia*, 24(4), 336–356. https://doi.org/10.1002/dys.1600
- Jiménez, A. M., & Díez, E. (2018). Impacto de videojuegos en la fluidez lectora en niños con y sin dislexia. El caso de Minecraft. *Revista Latinoamericana de Tecnología Educativa*, 17(1), 77–90. https://doi.org/10.17398/1695-288X.17.1.77
- Jiménez, J. E., & Rojas, E. (2008). Efectos del videojuego Tradislexia en la conciencia fonológica y reconocimiento de palabras en niños disléxicos. *Psicothema*, 20(3), 347–353.
- Jiménez-Fernández, G., Gutiérrez-Palma, N., & Defior, S. (2015). Impaired stress awareness in Spanish children with developmental dyslexia. *Research in Developmental Disabilities*, 37, 152–161. https://doi.org/10.1016/j.ridd.2014.11.002
- Klimovich-Gray, A., Di Liberto, G., Amoruso, L., Barrena, A., Agirre E., & Molinaro, N. (2023). Increased top-down semantic processing in natural speech linked to better reading in dyslexia. *NeuroImage*, en prensa. https://doi.org/10.1016/j.neuroimage.2023.120072
- Kuhl, U., Neef, N. E., Kraft, I., Schaadt, G., Dörr, L., Brauer, J., Czepezauer, I., Müller, B., Wilcke, A., Kirsten, H., Emmrich, F., Boltze, J., Friederici, A. D., & Skeide, M. A. (2020). The emergence of dyslexia in the developing brain. *NeuroImage*, 211, 116633. https://doi.org/10.1016/j.neuroimage.2020.116633
- Lázaro, M., Illera, V., Acha, J., Escalonilla, A., García, S., & Sainz, J. S. (2018). Morphological effects in word identification: tracking the developmental trajectory of derivational suffixes in Spanish. *Reading and Writing*, 31(7), 1669–1684. https://doi.org/10.1007/s11145-018-9858-1
- Liu, C., & Georgiou, G. K. (2017). Cognitive and environmental correlates of rapid automatized naming in Chinese kindergarten children. *Journal of Educational Psychology*, 109(4), 465–476. https://doi.org/10.1037/edu0000151
- Lonergan, A., Doyle, C., Cassidy, C., MacSweeney Mahon, S., Roche, R. A. P., Boran, L., & Bramham, J. (2019). A meta-analysis of executive functioning in dyslexia with consideration of the impact of comorbid ADHD. *Journal of Cognitive Psychology*, *31*(7), 725–749. https://doi.org/10.1080/20445911.2019.1669609

- López-Escribano, C. (2016). Training Reading Fluency and Comprehension of Spanish Children with Dyslexia. In: Khateb, A., Bar-Kochva, I. (eds) Reading Fluency. *Literacy Studies*, 12. https://doi.org/10.1007/978-3-319-30478-6\_9
- López-Olóriz, J. (2023). Comunicación personal Proyecto Ubinding [correo electrónico].
- López-Olóriz, J., Pina, V., Ballesta, S., Bordoy, S., & Pérez-Zapata, L. (2020). Proyecto Petit UBinding: Método de adquisición y mejora de la lectura en primero de primaria. Estudio de eficacia. *Revista de logopedia, foniatría y audiología, 40*(1), 12–22.
- Lorusso, M. L., & Toraldo, A. (2023). Revisiting Multifactor Models of Dyslexia: Do They Fit Empirical Data and What Are Their Implications for Intervention? *Brain Science*, 13, 328. https://doi.org/10.3390/
- Łuniewska, M., Chyl, K., Dębska, A., Kacprzak, A., Plewko, J., Szczerbiński, M., Szewczyk, J., Grabowska, A., & Jednoróg, K. (2018). Neither action nor phonological video games make dyslexic children read better. *Scientific reports*, 8(1), 549. https://doi.org/10.1038/s41598-017-18878-7
- Luque, J. L., López-Zamora, M., Álvarez, C. J., & Bordoy, S. (2013). Beyond decoding deficit: inhibitory effect of positional syllable frequency in dyslexic Spanish children. *Annals of Dyslexia*, 63(3-4), 239–252. doi:10.1007/s11881-013-0082-z
- Maehler, C., Joerns, C., & Schuchardt, K. (2019). Training Working Memory of Children with and without Dyslexia. *Children*, *6*(3), 47. https://doi.org/10.3390/children6030047
- Mengisidou, M., Marshall, C. R., & Stavrakaki, S. (2020). Semantic fluency difficulties in developmental dyslexia and developmental language disorder (DLD): poor semantic structure of the lexicon or slower retrieval processes? *International journal of language y communication disorders*, 55(2), 200–215. https://doi.org/10.1111/1460-6984.12512
- Mohammad, S. A., Nashaat, N. H., Okba, A. A. M. B., Kilany, A., Abdel-Rahman, A. S., Abd-Elhamed, A. M., & Abdelraouf, E. R. (2022). Asymmetry Matters: Diffusion Tensor Tractography of the Uncinate Fasciculus in Children with Verbal Memory Deficits. AJNR. *American journal of neuroradiology*, 43(7), 1042–1047. https://doi.org/10.3174/ajnr.A7535
- Norton, E. S., & Wolf, M. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual Review of Psychology*, 63, 427–452.

- Ostiz-Blanco, M., Bernacer, J., Garcia-Arbizu, I., Diaz-Sanchez, P., Rello, L., Lallier, M., & Arrondo, G. (2021). Improving Reading Through Videogames and Digital Apps: A Systematic Review. *Frontiers in psychology*, *12*, 652948. https://doi.org/10.3389/fpsyg.2021.652948
- Ostiz-Blanco, M., Lallier, M., Grau, S., Rello, L., Bigham, J. P., & Carreiras, M. (2018). Jellys: Towards a Videogame that Trains Rhythm and Visual Attention for Dyslexia. Assets'18: Proceedings of the 20th International Acm Sigaccess Conference on Computers and Accessibility, 447–449. https://doi.org/10.1145/3234695.3241028
- Padeliadu, S., Giazitzidou, S., & Stamovlasis, D. (2021). Developing reading fluency of students with reading difficulties through a repeated reading intervention program in a transparent orthography. *Learning Disabilities: A Contemporary Journal*, 19(1), 49–67.
- Papadopoulos, T. C., Spanoudis, G. C., & Georgiou, G. K. (2016). How is RAN related to reading fluency? A comprehensive examination of the prominent theoretical accounts. *Frontiers in psychology*, 7, 1217. https://doi.org/10.3389/fpsyg.2016.01217
- Pennington, B. F., Santerre-Lemmon, L., Rosenberg, J., MacDonald, B., Boada, R., Friend, A., ... Olson, R. K. (2012). Individual prediction of dyslexia by single versus multiple deficit models. *Journal of Abnormal Psychology*, *121*(1), 212–224. https://doi.org/10.1037/a0025823
- Perfetti, C. (2007). Reading Ability: Lexical Quality to Comprehension. *Scientific Studies of Reading*, 11(4), 357–383. https://doi.org/10.1080/10888430701530730
- Rakhlin, N. V., Mourgues, C., Cardoso-Martins, C., Kornev, A. N., & Grigorenko, E. L. (2019). Orthographic processing is a key predictor of reading fluency in good and poor readers in a transparent orthography. *Contemporary Educational Psychology*, *56*, 250–261. https://doi.org/10.1016/j.cedpsych.2018.12.002
- Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003). Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain: a journal of neurology,* 126(4), 841–865. https://doi.org/10.1093/brain/awg076
- Rello, L. (2018) *Superar la dislexia. Una experiencia personal a través de la investigación*. Barcelona: Paidós educación.
- Rosas, R., Escobar, J. P., Ramírez, M. P., Meneses, A., & Guajardo, A. (2017). Impact of a computer-based intervention in Chilean children at risk of manifesting reading difficulties. *Infancia y Aprendizaje: Journal for*

- *the Study of Education and Development, 40*(1), 158-188. https://doi. org/10.1080/02103702.2016.1263451
- Ruffino, M., Gori, S., Boccardi, D., Molteni, M., & Facoetti, A. (2014). Spatial and temporal attention in developmental dyslexia. *Frontiers in human neuroscience*, *8*, 331. https://doi.org/10.3389/fnhum.2014.00331
- Sánchez-Doménech, I. (2022). Revisión sistemática e implicaciones para el diagnóstico psicopedagógico: comorbilidad Dislexia/TDAH. *REOP Revista Española de Orientación y Psicopedagogía*, *33*(2), 63–84. https://doi.org/10.5944/reop.vol.33.num.2.2022.34360
- Sargiani, R. de A., Ehri, L. C., & Maluf, M. R. (2021). Teaching Beginners to Decode Consonant–Vowel Syllables Using Grapheme–Phoneme Subunits Facilitates Reading and Spelling as Compared with Teaching Whole-Syllable Decoding. *Reading Research Quarterly*, *57*(2). https://doi.org/10.1002/rrq.432
- Schaadt, G., & Männel, C. (2019). Phonemes, words, and phrases: Tracking phonological processing in pre-schoolers developing dyslexia. *Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology, 130*(8), 1329–1341. https://doi.org/10.1016/j.clinph.2019.05.018
- Seiler, A., Leitão, S., & Blosfelds, M. (2019). WordDriver-1: evaluating the efficacy of an app-supported decoding intervention for children with reading impairment. *International journal of language y communication disorders*, *54*(2), 189–202. https://doi.org/10.1111/1460-6984.12388
- Serrano, F., Bravo Sanchez, J. F., & Gomez-Olmedo, M. (2016). Galexia: Evidence-Based Software for Intervention in Reading Fluency and Comprehension. En L. G. Chova, A. L. Martinez, y I. C. Torres (Eds.), Inted2016: 10th International Technology, Education and Development Conference. 2001-2007. Iated-Int Assoc Technology Education and Development.
- Snowling, M. J., Gooch, D., McArthur, G., & Hulme, C. (2018). Language Skills, but Not Frequency Discrimination, Predict Reading Skills in Children at Risk of Dyslexia. *Psychological science*, *29*(8), 1270–1282. https://doi.org/10.1177/0956797618763090
- Snowling, M. J., & Hulme, C. (2011). Evidence-based interventions for reading and language difficulties: creating a virtuous circle. *The British journal of educational psychology, 81*(1), 1–23. https://doi.org/10.1111/j.2044-8279.2010.02014.x

- Susaníbar, F., Huamaní, O., & Dioses, A. (2013). Adquisición fonética-fonológica. *EOS*, 1(1), 19–36.
- Toffalini, E., Giofrè, D., & Cornoldi, C. (2017). Strengths and Weaknesses in the Intellectual Profile of Different Subtypes of Specific Learning Disorder. *Clinical Psychological Science*, *5*(2), 402–409. https://doi.org/10.1177/2167702616672038
- Tulloch, K., & Pammer, K. (2019). Tablet computer games to measure dorsal stream performance in good and poor readers. *Neuropsychologia*, *130*, 92–99. https://doi.org/10.1016/j.neuropsychologia.2018.07.019
- Van Herck, S., Vanden Bempt, F., Economou, M., Vanderauwera, J., Glatz, T., Dieudonné, B., Vandermosten, M., Ghesquière, P., & Wouters, J. (2022). Ahead of maturation: Enhanced speech envelope training boosts rise time discrimination in pre-readers at cognitive risk for dyslexia. *Developmental Science*, 25, e13186. https://doi.org/10.1111/desc.13186
- Van Hirtum, T., Moncada-Torres, A., Ghesquière, P., & Wouters, J. (2019). Speech Envelope Enhancement Instantaneously Effaces Atypical Speech Perception in Dyslexia. *Ear and hearing*, 40(5), 1242–1252. https://doi.org/10.1097/AUD.0000000000000000
- Van Rijthoven, R., Kleemans, T., Segers, E., & Verhoeven, L. (2018). Beyond the phonological deficit: Semantics contributes indirectly to decoding efficiency in children with dyslexia. *Dyslexia*, 24(4), 309–321. https://doi.org/10.1002/dys.1597
- Vander Stappen, C., Dricot, L., & Van Reybroeck, M. (2020). RAN training in dyslexia: Behavioral and brain correlates. *Neuropsychologia*, 146, 107566. https://doi.org/10.1016/j.neuropsychologia.2020.107566
- Vander Stappen, C., & Reybroeck, M. V. (2018). Phonological Awareness and Rapid Automatized Naming Are Independent Phonological Competencies with Specific Impacts on Word Reading and Spelling: An Intervention Study. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.00320
- Vidyasagar, T. R., & Pammer, K. (2010). Dyslexia: a deficit in visuo-spatial attention, not in phonological processing. *Trends in cognitive sciences*, 14(2), 57–63. https://doi.org/10.1016/j.tics.2009.12.003
- Viersen, S., Bree, E., Verdam, M., Krikhaar, E., Maassen, B., Leij, A., & Jong, P. (2017). Delayed Early Vocabulary Development in Children at Family Risk of Dyslexia. *Journal of speech, language, and hearing research*, 60(4). https://doi.org/10.1044/2016\_JSLHR-L-16-0031

- Willcutt, E. G., McGrath, L. M., Pennington, B. F., Keenan, J. M., DeFries, J. C., Olson, R. K., & Wadsworth, S. J. (2019). Understanding Comorbidity Between Specific Learning Disabilities. *New Directions for Child and Adolescent Development*, 165, 91–109. https://doi.org/10.1002/cad.20291
- Williams, K. J., Walker, M. A., Vaughn, S., & Wanzek, J. (2017). A Synthesis of Reading and Spelling Interventions and Their Effects on Spelling Outcomes for Students with Learning Disabilities. *Journal of learning disabilities*, *50*(3), 286–297. https://doi.org/10.1177/0022219415619753
- Wimmer, H., Mayringer, H., & Landerl, K. (2000). The double-deficit hypothesis and difficulties in learning to read a regular orthography. *Journal of Educational Psychology*, 92, 668–680. https://doi.org/10.10371/0022-0663.92.4.668
- Wokuri, S., Gonthier, C., Marec-Breton, N., & Majerus, S. (2023). Heterogeneity of short-term memory deficits in children with dyslexia. *Dyslexia*. https://doi.org/10.1002/dys.1749
- Wolf, M., & Bowers, P. G. (2000). Naming speed and developmental reading disabilities. An introduction to the special issue on the double-deficit hypothesis. *Journal of Learning Disabilities*, 33(4), 322–324.
- Yang, Y., Zuo, Z., Tam, F., Graham, S. J., Li, J., Ji, Y., Meng, Z., Gu, C., Bi, H. Y., Ou, J., & Xu, M. (2022). The brain basis of handwriting deficits in Chinese children with developmental dyslexia. *Developmental science*, *25*(2), e13161. https://doi.org/10.1111/desc.13161
- Zhou, D., Cai, Q., Luo, J. yi, Z., Li, Y., Seger, C. A., & Chen, Q. (2021). The neural mechanism of spatial-positional association in working memory: A fMRI study. *Brain and Cognition*, 152, 105756. https://doi.org/10.1016/j.bandc.2021.105756

**Contact address**: Iluminada Sanchez-Domenech. Universidad Internacional de La Rioja. Avenida de la Paz 137, 26006 Logrono, La Rioja, Espana. E-mail: iluminada.sanchez@unir.net

# Video games, educational implications Videojuegos, implicaciones educativas

https://doi.org/10.4438/1988-592X-RE-2024-405-632

#### Jana María Gallardo Pérez

https://orcid.org/0000-0002-0639-1298 Universidad Internacional de la Rioja

#### Iván Rivilla Arias

https://orcid.org/0000-0002-1533-8069 Universidad Internacional de la Rioja

#### Amaia Ramírez Muñoz

https://orcid.org/0000-0001-9236-1652 Universidad Internacional de la Rioja

### Rosario Castro López

https://orcid.org/0000-0002-2813-1390 Universidad Internacional de la Rioja

# Bárbara San Juan Ferrer

https://orcid.org/0000-0003-1083-8424 Universidad Internacional de la Rioja

## Joel Manuel Prieto Andreu

https://orcid.org/0000-0002-2981-0782 Universidad Internacional de la Rioja

#### **Abstract**

The present article seeks to describe the educational implications of the use of digital technology in young people. To this end, a narrative review was performed through an advanced search of 140 articles with high scientific impact. The search was performed between 2000 and 2023, selecting articles that analysed eSports in young people between the ages of 6 and 21. The term eSports was conceptualised and its relationship with aggressiveness, gender and psychological outcomes was analysed. The potential of the use and application of technology in the educational setting was also considered. With regards to aggression in video games, young people with high levels of aggression were found to be attracted to violence in videogames. The correlation between videogames and aggression may be explained by underlying variables. With regards to gender, fewer females were recruited and males reported longer weekly playing times. This gender gap is present in factors such as experience, performance and gaming skills. With regards to psychological consequences, playing videogames was associated with higher levels of intrapersonal skills, greater stress control and poorer interpersonal skills. Lastly, the educational implications of playing videogames are analysed in young people. Positive aspects emerged such as greater meaningful learning or higher frustration tolerance. Next, negative aspects were examined, since a potential negative implication of exposure to violent content is alcohol consumption or aggression. In consideration of that proposed in the present study, more experimental, longitudinal and correlational studies are needed to clarify the behaviours and consequences of young players regarding the use of videogames. This would allow the educational implications of digital technology to be more precisely defined.

*Keywords:* videogames, e-sports, education, gamification, aggressiveness, gender, psychological characteristics,

#### Resumen

El presente artículo busca describir las implicaciones educativas de la tecnología digital y su consumo en los jóvenes. Para ello, se realizó una revisión narrativa a través de una búsqueda avanzada con 140 artículos de alto prestigio científico entre el periodo del 2000 - 2023, seleccionando aquellos artículos que analizaban los eSports en jóvenes con edades comprendidas entre 6 y 21 años. Se procede a conceptualizar el término eSports y analizar su relación con la agresividad, el género, las consecuencias psicológicas y las posibilidades derivadas de su uso y aplicación en el entorno de la educación. Respecto a la agresividad en los videojuegos, detectamos que los jóvenes con niveles altos de agresión pueden ser atraídos por la violencia de los videojuegos y que la correlación entre el videojuego y la agresividad puede ser causada por variables

subyacentes. En lo referido al género, la presencia femenina es baja y los hombres juegan semanalmente durante más tiempo. Esta brecha de género está presente en factores como la experiencia, el rendimiento y las habilidades de juego. En relación con las consecuencias psicológicas del uso de videojuegos destacamos que el uso de estos está asociado con mayor nivel de habilidades intrapersonales, mayor control del estrés y una baja habilidad interpersonal. En último lugar, se analizan las implicaciones educativas que el uso de videojuegos genera en los jóvenes, desatacando aspectos positivos como el aumento del aprendizaje significativo o la tolerancia a la frustración, y también analizando sus aspectos negativos, ya que a través del contenido violento se puede generar un afecto negativo propiciando la aparición del consumo de alcohol o agresividad. Considerando lo propuesto, es necesario aumentar los estudios experimentales, longitudinales y correlacionales para aclarar los comportamientos y consecuencias de los jóvenes jugadores respecto al uso de videojuegos, lo que permitirá delimitar con mayor precisión las implicaciones educativas de la tecnología digital.

*Palabras clave:* videojuegos, e-sports, educación, gamificación, agresividad, género y características psicológicas.

#### Introduction

New technology use and digital consumption has increased exponentially over the past decade. This reality has contributed new forms of leisure and alternative entertainment to society. Of these, eSports takes on particular relevance.

Esports, also referred to as eSport, e-sport and electronic sports, amongst others, is defined as "sporting activities in which individuals develop and train mental or physical capacities for the use of information and communication technologies" (Wagner 2006). Likewise, at the same time, another type of non-competitive videogames exist such as serious games (López, 2016), which are videogames or applications with a therapeutic basis or educational purpose. It is necessary to differentiate this purpose at the time of extracting educational implications from research findings pertaining to electronic sports and videogames.

In consideration of that discussed above, the present work focuses on the educational implications of new technology and digital consumption at both a curricular and extracurricular level in young people. Issues related with gender, aggression and psychological consequences are addressed, in addition to the potential of technology use and application in the educational setting.

# Methodology

A narrative review was conducted that analysed research indexed in the repositories and databases *Web of Knowledge, Scopus, Pubmed, Google Scholar, ResearchGate* and *Sportdiscus*. Criteria used to guide the document search and analysis required included articles to have been published between 2000 and 2023, on samples of participants aged between six and 21 years, and be available in English or Spanish. In addition, the search employed the descriptors "eSport", "videogame", "exergames", "gender", "aggression" "violence", "serious games" and "psychology". Overall, a total of 140 research studies were selected that met the aims of the present narrative review from the 455 articles gathered for initial analysis. A total of 315 research studies were excluded due to the fact that the methodology employed did not match the aim outlined by the narrative review, eSport use was not related to the review study design and the age of participants was not within the pre-determined range.

# **Education and e-sports**

This section explores the potential offered by videogames in the educational setting. Different educational methodologies used in this setting are compared, including serious games, gamification and game-based learning (GBL), augmented reality, multisensory spaces and exergames, highlighting the most notable characteristics and differences. Social distancing imposed by the COVID-19 pandemic revealed the presence of academic barriers and their negative influence on mental health in students. As argued by Fontana (2020), mental health can strongly influence academic performance, with it being imperative to approach the transition to online learning in an appropriate way.

As stated by Prieto et al. (2022) "gamification is being approached academically from two perspectives: as a methodology targeting student motivation towards their competency-based learning and as a way of strengthening academic performance in different knowledge areas".

# Videogames and digital recreational methodologies in higher education

Inclusion of videogames as an educational tool has given rise to a new field of study that connects with digital generations. Serious games, conceived by Michael and Chen (2006, cited by López, 2016), seek to create learning environments through videogames, exploring real problems. Exergames, for example, promote physical activity through engagement with the game. These games can improve motor skills and understanding of movement principles. Further, gamification, according to Kapp (2014), uses elements of gaming to train abilities and, combined with methodologies such as game-based learning (GBL) and serious games, strives to involve students in more immersive educational experiences. Nonetheless, GBL tends to be more challenging to implement, requiring additional resources such as augmented reality and collaborative working with mobile tools. The convergence of methodologies implemented in higher education strives to achieve specific educational goals more effectively. In this section, the educational implementation of videogames in higher education is examined, reflecting on educational videogame use and their relationship with academic performance, learning and psychological variables.

With regards to academic performance, a study conducted by Smith and Chan (2017) used previous, current and follow-up exam grades in order to quantify student performance through the videogame Space Race. The videogame was well-received with at least 82% of students who played it, recommending it to others. Crucially, those selected to play the game performed better than those who were not selected to play it on the course exam. Along similar lines, Pesek et al. (2020) employed

elements of gamification and the online platform Troubadour, which is an open source personalised and adaptive platform for auditory training, in order to support music theory classes with automated exercises related with the theory behind music. In this study, the experimental group showed improved learning and academic performance.

With regards to learning, a study conducted by Chang et al. (2015) examined the effect of a group videogame called "Multiple-Choice Practice Island" on frustration tolerance and learning through cognitive styles and previous abilities. Findings indicate that low ability students showed more significant improvements, leading them to demonstrate greater tolerance to frustration. Cózar and Sáez-López (2016) examined the impact of game-based learning (GBL) via "MinecraftEdu" and found a significant increase in student motivation. Romero and Kalmpourtzis (2020) investigated a game-based learning module, highlighting improvements in online learning through a games-based design. Learning platforms such as "OneUp" (Dicheva et al., 2018) are essential to gamification and game-based learning (GBL). Educational exergames (Juca, 2018a) combine videogame elements with recognisable cognitive activities, promoting enjoyable physical activity. Kazimoglu (2020) propose using innovative methods, such as serious games, in order to improve motivation and learning in computer programming. Fontana (2020) employed the serious game, "ChemDraw", in order to improve organic chemistry abilities. McEnroe-Petitte and Farris (2020) demonstrated that different types of games promoted deeper learning in nursing students. Tan (2018) and Smith and Chan (2017) employed videogames as a means to improving learning, whilst Verkuyl (2017) emphasised the value of simulations for ensuring safe practice. Chittaro and Sioni (2015) observed that serious games were capable of improving risk perceptions and emotional response. Finally, Simons et al. (2020) discovered that the game "Civilization" provoked improved problem solving and management abilities.

With regards to findings pertaining to psychological variables following the application of videogame experiences, according to Prieto (2022):

"In the topic area of educational gamification, scientific contribution is needed in relation to working with a number of lesser studied

psychological variables such as attitude, commitment, stress, anxiety and performance in gamified teaching proposals" (p.203)

In a study conducted by Tan (2018), students expressed a degree of interest, emotion and trust in their gamification experience, whilst the majority also reported greater competence and mastery after playing a game. In contrast, a study conducted by Javalath and Esichaikul (2020) took a blended eLearning approach as a means of instilling the gaming dynamics, mechanics and components suitable for gamifying a blended electronic learning course. This study suggests that the incorporation of gaming components may provide learning opportunities to motivate and involve students. In another approach, in a study conducted by Soltani et al. (2020), participants practiced different swimming techniques (crawl, back, front and butterfly) in an exergame called "Michael Phelps: Push the Limit" using Microsoft Xbox and Kinect. The main finding of this study was that there was no plausibility to the conclusion that the novelty or competition type (competing against a computer or against peers) affected enjoyment levels. Finally, a study conducted by Roure et al. (2020) used a cycling exergame called "Greedy Rabbit" in order to identify the impact of exergaming on physical activity in 60 pre-graduate students. In this study, the experimental group scored more highly on all physical activity measures and on two situational dimensions of interest (instantaneous enjoyment and demand for attention). The study demonstrated that a cycling exergame may be a good option for improving physical activity outcomes related to players and their situational interest. In conclusion, the aforementioned studies within the higher education setting reveal the benefits of videogames regarding competence, motivation and physical health.

# **Educational implications**

In the following sections, a discussion is provided on the influence of diverse variables in the context of videogames and/or e-sports.

## **Aggression**

Three basic viewpoints exist that explain the potential relationships between exposure to violence in videogames and serious aggressive behaviour. The first is based on learning from the causal influence of subsequent serious aggression. The second suggests that individuals with high levels of aggression are, essentially, attracted to violence in videogames. Finally, the third viewpoint implies that any correlation between videogames and aggression is caused by underlying variables. Next, various studies are presented that are representative of two of these three aforementioned perspectives (Ferguson, 2011).

# Causal influence of exposure to videogames on subsequent serious aggression

Variation in findings regarding aggression may be explained, in part, by differences in videogames, with aggression mainly emerging in relation to games with aggressive content, considering the small amount of variance in aggression that is explained by playing time (Colwell & Payne, 2000). Playing at imaginary aggression represents a primer exercise that increases access to aggressive thoughts, increasing the possibility of engaging in subsequent violent behaviour (Krahé & Möller, 2004). An adolescent player who identifies with a violent and stronger character during game playing may lead to them engaging in more aggressive behaviour in the real world. This study used three realistic violence games (America's Army - U.S. Army, Killzone - Sony Computer Entertainment Europe, and Max Payne - Rock Star Games), three violent fantasy games (Doom 3 - id Software, Quake - id Software and Metroid Prime -Nintendo), three realistic non-violent games (Pro Evolution Soccer -Konami, The Sims 2 - EA Games and Tony Hawk's Underground - Activision) and three non-violent fantasy games (Mario Kart - Nintendo, Mario Sunshine - Nintendo and Final Fantasy - Square Enix) (Konjin et al., 2007). Nonetheless, excitement caused by the game did not significantly differ between aggressive videogames (Violent Video Games, VVG) (Mortal Kombat: Deadly Alliance - PlayStation 2) and any other type of videogame (Hard Hitter Tennis - PlayStation 2). Excitement, thoughts and feelings after playing VVG may give rise to processes that encourage aggression lasting for longer than four to nine minutes, which is enough time to end up in a situation perceived as provocation, hostile feelings

and aggressive thoughts (Barlett et al., 2009). Length of exposure to VVG (for example, Call of Duty and Mortal Kombat) demands greater understanding of the long-term relationship of VVG with aggression, competitiveness (Chen et al., 2022a), speed of action and violent content (Chen et al., 2022b). These aspects may underly the potential association between VVG and increased aggression in the long term (Willoughby et al., 2012; Adachi & Willoughby, 2013). Average mass media consumption has risen to 7.4 hours a day in consideration of the greater and more varied offer currently available through portable devices, pointing to an association between exposure to violence and increased aggressive physical behaviour (Coker et al., 2015; Gentile et al., 2014). Controller type and screen size appear to confirm that technological characteristics of videogames affect aggression level (chosen videogame, The House of the Dead 2) (Kim & Sundar, 2013). The serious behavioural consequences of carrying arms are associated with violent games (Ybarra et al., 2014). In addition, glorification of risk through antisocial characters may bring about alterations in the self-perception of personal singularities, attitudes and values, with consequences including alcohol or tobacco consumption, aggression, delinquency and risky sexual behaviour (participants reported that 32.4% had played Spiderman II, 12.3% Manhunt and 57.9% Grand Theft Auto III) (Hull et al., 2014).

Adopting diverse mentalities through behaviour simulation can affect the behaviour of players in real life (Mass Effect 2) (Ellithorpe, 2015). Playing time had an influence on aggression in a sample after playing competitive videogames (action videogames such as Grand Theft Auto, God of War, combat games such as Mortal Kombat, and competitive games such as FIFA Soccer and Gran Turismo) (Adachi & Willoughby, 2016), whilst the empathy and morality of videogame characters (Mortal Kombat 3) can influence player aggression (Gao et al., 2017)]. All of these elements of debate must be reconsidered, demanding greater precision when using the term "VVG" (the present study found it to be used to refer to both a violent videogame, Tomb Raider 2013, and a non-violent videogame, FIFA) (Ferguson et al., 2016). Nonetheless, exposure to violent media is comparable to the risk of exposure to violence in the real world. Such exposure through the mass media occurs at a large enough scale for violence through such means to be considered a threat to public health, leading to an increase in certain behaviours such as interest in real firearms and shooting firearms (found in a study using three

versions of the videogame Minecraft – Microsoft Corporation, a violent version including guns, another violent version using swords and a non-violent version) (Chang & Bushman, 2019).

# Variables underlying the correlation between videogames and aggression

Research on risk factors influencing aggressive behaviour must consider the interaction between genetic and social risk, with multivariate analysis most commonly using molecular genetics techniques (Ferguson et al., 2009). Prevention of aggressive behaviours may be observed through the lens of peers, family, society, substance abuse and depressive disorders (Ferguson & Meehan, 2010). In order for interventions to be effective, planning must consider the risk factor of sensation searching, following confirmation that VVG use has a long-term effect on aggressive behaviour in the form of physical aggression (Möller & Krahé, 2009). Strategies are needed to inform players (47% of participants report having played violent games such as Dead or Alive, Def Jam, Doom, Driver, Mortal Kombat, Grand Theft Auto, Resident Evil and Prince of Persia) and their families about the negative impact of excessive VVG use (Ybarra et al., 2022) and promote engagement with prosocial videogames, making them more attractive and accessible (Allahverdipour et al., 2010). Issues pertaining to individuals, families and aggressive behaviour must be studied, specifically, whilst, at the same time, implementing interventions targeted towards these aspects (Kim et al., 2017; Ruiz-Fernández et al., 2021). It is also important to consider the influence of social context on the effects of VVG (Verheijen et al., 2018; She et al., 2022). Interventions using electronic games to target mental health may provide effective strategies for reducing associated risk. In the case of "Adventures aboard the S.S. GRIN", knowledge increased regarding social, sentimental and behavioural skills (Sanchez et al., 2017). From the perspective of the family setting, it is important to identify habits and exposure in relation to digital media with regards to violent content, informing families and directing them towards strategies that limit and monitor use (Al-Ali et al., 2018). Despite revealing relationships between playing VVG and engagement in higher levels of aggressive behaviour, there is little evidence that this becomes externalised in the long term. Nonetheless,

existing research urges that potential outcomes pertaining to VVG use (for example, Grand Theft Auto, Assassin's Creed and Halo) (Coyne et al., 2018) are kept in mind.

Normative values for society point to a mediating effect regarding exposure to violence through VVG. The family context regulates the first stage of the mediation process. In a good family context, exposure to VVG exhibits a simple direct effect on aggression, whilst, in an unfavourable family context, alongside these direct effects, indirect effects emerge that are mediated by the effect of normative beliefs on aggression (Shao & Wang, 2019). In the same way, moral disconnect acts as a significant mediator of the positive relationship between exposure to violence in games (for example, Call of Duty: WWII) and subsequent aggression, with effects being greater in adolescents (Teng et al., 2019). It should be added that interventions target rage and hostility as relational factors of VVG and aggressive behaviours (Yao et al., 2019), negative affect (potentially to a greater extent by engaging in virtual reality games (Ferguson et al., 2022)) and shyness (using Player Unknown's Battle Grounds as a violent game and The Sims as a non-violent game) (Tian et al., 2020). When targeting mental health, research supports the potential of selfinstructive games, such as RegnaTales, which was found to be effective at reducing rage issues, in both a clinical and non-clinical population (Ong et al., 2019), and, RAGE-Control, which appeared to bring about improvements in abilities learned in therapeutic settings and in behavioural and physiological changes related with rage (Ducharme et al., 2021).

At the same time, cyberaggression involves accepting and tolerating cyberaggression. Normative beliefs mediate the relationship between players' age and general cyberaggression, and between players' age and cyberaggression. Given that normative beliefs are modifiable and dynamic, cyberaggression can be reduced, with future studies elucidating the specific factors that can transform these beliefs being needed (Hilvert-Bruce & Neill, 2020). Numerous early adolescents play online videogames that target adults, whether characterised by medium risk (for example, Fortnite and Terraria) or high risk (for example, Call of Duty, Grand Theft Auto and Fallout), making these individuals the most at risk of presenting with mental wellbeing issues, due to, for example, decreased sleeping hours leading to a lack of attention, memory, decision making, reaction time and creativity. All of these factors are related to school performance (Charmaraman et al., 2020). Reduced exposure to VVG, rage, moral detachment and cognitive impulsiveness, demands

interventions with programs addressing conscience, self-control and relaxation techniques, helping to manage rage, moral connection and cognitive impulse control in order to decrease aggressive behaviour (Zhao et al., 2021). Toxicity appears to be promoted by individual singularities such as younger ages, male sex, sensation seeking and emotional reactivity, whilst empathy and motivation for socialisation emerge as protective factors (Lemercier-Dugarin et al., 2021). To this, the effect of parental authority must be added (Hou et al., 2022). This has a positive influence in the case of authoritarian parents, who stand out from the permissiveness shown by others and the negative influence this has when it comes to using communication technology (for example, videogames such as Grand Theft Auto III and Manhunt) (Cote et al., 2021). Further, biopsychosocial variables have potent interactive effects in relation to aggressive behaviour (López-Fernández et al., 2021). The impact of unfavourable settings on the effects of VVG must be considered in light of a multicultural context, opening debate around potential factors such as psychiatric background and aggression (Addo et al., 2021).

#### Gender

Differences exist within esports as a function of gender. According to Lucas & Sherry (2004), Jenson & de Castell (2011), Hayday & Collison (2020) and Kim & Lim (2021) female involvement in esports is low. Female participation ranges between 10% (Banyai et al., 2019a) and 20%, approximately (Griffiths et al. 2003; Crawford & Gosling, 2005; Király et al. 2015; Shen et al. 2016; Hayday & Collison, 2020). Gaming frequency also differs as a function of sex. Males tend to play weekly, for longer overall and accumulated time, whilst females, in exchange, play sporadically (Terlecky et al., 2011). The main motivations for gaming in males are social influence, pleasure of gaming (Jang & Byon, 2021), success and capacity for manipulation. In contrast, women play videogames due to factors related with socialisation (Eagly & Karau, 2002; Kidder, 2002; Crawford & Gosling, 2005; Yee, 2006; Williams et al., 2019; Ricoy & Ameneiros, 2016). In addition, males tend to prefer esports related with sports, whilst female preferences tend to vary to a greater extent (Terlecky et al., 2011; Crawford & Gosling, 2005).

Gender stereotypes condition the presence of sexism in esports. Gender differences emerge in factors such as experience, performance and gaming ability, in accordance with (Shen et al., 2016; Choe et al., 2019). Vermeulen et al. (2014) reported that the gaming ability of females was influenced by masculinity and gender bias. These elements act to decrease success (Parshakov et al., 2018) and gaming abilities in females (Terlecky et al., 2011), whilst also increasing the gaming ability of male opponents, leading to, at the same time, the undervaluing of females (Vermeulen et al., 2014; Ruvalcaba et al., 2018; McLean & Griffiths, 2019). Consequently, performance (Griffiths et al., 2003; Yee, 2006; Choe et al., 2019; Hayday & Collison, 2020; Shaw, 2021) and behaviour may be affected in females (Vermeulen et al., 2014; McLean & Griffiths, 2019; Yee, 2006; Kim & Lim, 2021), with this effect being more pronounced within females who value "streaming" (Ruvalcaba et al, 2018). Females do not have role models to look up to in esports (Ruvalcaba et al., 2018; McLean & Griffiths, 2019; Choe et al., 2019; Hayday & Collison, 2020). Given that female characters are often marginalised and sexualised in order to lay the way for male leads, electronic sports has turned into an environment in which male characters are more revered than females, conditioning female participation and propagating sexist attitudes towards females (Kruthika, 2020). Female avatars are often represented through a sexualised body (Kruthika, 2020). Anonymity not only allows, but, also, emboldens toxic behaviour which drives to the propagation of negative behaviours, foregrounding of dominant male cultures and gender inequality (Hayday & Collison, 2020). Further, gender stereotypes are present regardless of the platform used or the type of game played (Wasserman & Rittenour, 2019), with their being little variability in the games promoted towards females (Tang et al., 2021). Males support to combat this problem is nonexistent (Choe et al., 2019; McLean & Griffiths, 2019).

Culturally, esports have been dominated by men, with this having a negative impact on the participation and visibility of females in this ambit. The existing gender gap is not due to the lack of interest or inability of women, but is, instead, the result of hegemonic masculinity in esports, defence of videogaming as a masculine space through defensive hyper-masculinised behaviour, and sexism. Nonetheless, these aforementioned aspects are decreasing with the increase in female participation, especially through esports played on mobile devices (Hayday & Collison, 2020; Peng, 2021; Rogstad, 2022).

## Cognitive psychology

From a cognitive psychology standpoint, Bonny & Castaneda (2017) argued that numerical processing is directly related with the use of MOBA videogames, whilst Kokkinakis et al. (2017) demonstrated that fluid intelligence is correlated with videogame use. Along the same lines, Benoit et al., (2020) revealed that visual-spatial working memory (Spatial Span) in professional gamers was higher than in recreational gamers, with the former also exhibiting better working memory than other professional baseball players (Kang et al., 2020). Likewise, a study conducted by Pardina-Torner et al. (2019) revealed that processing speed was quicker in gamers than in individuals who did not play videogames. This was despite the fact that Matsui et al. (2020) reported that gamers who talked and did live retransmissions did not perform as well, given that they were performing two cognitive activities at the same time. Cognitive performance has also been examined by Gorrindo et al. (2022) and Tartar et al. (2019), who both found inositol containing supplements to be effective at improving accuracy, decision making and reaction time when playing. In a study published by Pishchik et al. (2019), differences were examined between students as a function of whether or not they played videogames, revealing that students who played for more than four hours a day (denominated hardcore gamers) exhibited lower levels of logical and critical thinking than the rest of the sample. This concurs with the finding that playing sedentary electronic games is related with greater interpersonal skills and better management of stress and emotions (Hinkley et al., 2017). Nonetheless, this same study also confirmed that continuous internet use was related with poorer interpersonal skills and better stress management, revealing that psychosocial wellbeing in surveyed children was largely dependent upon the type of electronic media they used.

The aforementioned finding regarding interpersonal skills may be explained in light of findings reported by other similar studies, given that they reveal that professional eSports gamers report engaging in eSports due to the strong sense of belonging they feel in the videogame setting (Martonkik, 2015). In accordance with this, Trepte et al. (2021) also highlight the way in which online games create social ties offline. For this reason, it can be stated that, occasionally, a subculture emerges that

is characterised by the same likes and preferences in relation to other gamers.

Nevertheless, despite belonging to a team, positive outcomes and behaviours are not always found in the community of eSports players. In this sense, aspects such as ego and self-preservation tendency have been analysed, being summarised through use of the phrase "we won" or "they lost" (Downs, & Sundar, 2011). In the same way, Alvino de Mesquita & Becker (2018) stated that specific toxic behaviours, measured as a function of conversation patterns between team members, negatively affected performance, sometimes leading to a toxic scenario overall. In contrast, teams that exhibit non-toxic behaviour tend to produce better performance output, given that they tend to be more positive, focusing on gaming and socialisation tactics. This study topic is at the heart of research into the psychology of eSports is defined as POG (problematic online gaming) and covers psychiatric symptoms (depression, anxiety) and specific gaming motives (escape, achievement). An example of such research is found in a study conducted by Kiraly et al. (2015), which revealed psychological distress to be positively related with gaming as a means of escape and negatively related with competitive gaming. This study also revealed a stronger association between gaming as a means of escape and use of problematic online games. In agreement with that discussed above, Bányai et al. (2019a) found a direct positive effect between psychological distress and gaming disorders, with this association coming through escapism (in other words, excessive gaming to avoid real world problems). For this reason, there is growing interest to know more about gamers' personalities as a function of the characteristics of the game being played (Pérez-Rubio et al., 2017) and to identify motives for gaming in order to strive for alternatives to satisfy them in gamers who are addicted to videogames (Steadman, 2019). There is also growing interest into striving to avoid the potential issues that may arise from inappropriate videogame use. With regards to personality, lower levels of extroversion and friendliness have been found in gamers belonging to higher divisions in LOL than in other gamers belonging to less prestigious divisions (Matuszewski et al., 2020).

Despite that discussed above, some reviewed studies outline that eSports players are not obsessive gamers and that videogame use is not necessarily harmful. Indeed, some studies reveal sufficient satisfaction of basic psychological needs (García Lanzo, 2018; Hulaj et al., 2020) and highlight the variety on offer thanks to the phenomenon of eSports.

#### **Discussion**

Videogames presented in the educational setting within the context of learning place students in an enjoyable context guided by various rules, mechanics and dynamics, which force them to study and learn together with their other classmates. The aim of videogame use in education consists of striving to move forwards towards learning that is not considered as linear but, instead, as contextual, given that students who move in these worlds or fun settings find themselves on a dynamic continuum, reaching agreements, sharing values and engaging in social acts.

After performing the present review, evidence suggests that popular discourse on the harmful effects of videogames should be attenuated in light of the potential positive consequences of videogames with regards to the teaching-learning process. Nonetheless, the variety of videogames available and their potential use for education are diverse and highly complex. In order to include them in the educational setting as an educational tool, it is important to consider the way in which videogames will be employed and what is hoped to be achieved with them. Rodríguez Martín et al. (2022) classified types of videogames with the aim of identifying whether certain types of games significantly differed from others with regards to their relationship with issues pertaining to the educational setting, such as academic performance. This study divided educational videogames into photorealistic immersive action videogames, competitive videogames, anime-based videogames, real-time strategy videogames and general entertainment videogames.

Whether content is presented through a physical boardgame or through a digitalised approach, the teacher's aim is to find the optimal way of improving the teaching and learning process. On the one hand, gamification is often reduced to a simple points-based system with little connection made with the activities being gamified. In this approach, a poorly designed interface makes users feel lost, confused or frustrated, impeding their effective use. On the other hand, serious games and, above all, exergames, should be played actively, which may limit the user population given that some individuals lack experience with videogames or don't have access to the hardware needed to play them. This being said, the majority of studies report benefits that are psychological and

physical in nature, as demonstrated in a review performed by Suelves et al. (2022).

Further, as future lines of research, the effect of VJV on aggressive and violent behaviour continues to be an important topic of interest (Coyne et al., 2018; Ferguson et al., 2022; Shao & Wang, 2019; Yao et al., 2019; Ybarra et al., 2022), alongside impulsivity (Ortiz & Velastegui (2023), understood as the execution of unplanned actions with negative repercussions. In this sense, two standpoints are presented in the literature. The first promotes examination of the different variables and factors that influence the emergence of aggressive behaviours, including the proposed use of videogames to prevent such behaviour. The second standpoint urges the need to reconsider the relationship between VJV and aggression, given the lack of empirical evidence to support the impact of the former on the latter.

Holtz and Appel (2011) argue for the need to conduct further experimental, longitudinal and correlational research in order to clarify relationships and define the risk and protective factors that must be considered. Such research must come from, not only, self-report data but, also, behavioural observation from other involved agents such as family, friends and teachers.

Effects of digital media reveal the power to significantly alter interpersonal behaviour in both a positive and negative way, knowledge of longterm effects may serve as an aid to politicians and the public when it comes to decision making regarding the type of society they want to see and the way in which they can help it come to fruition (Prot et al., 2014). Digital literacy is essential for reducing the types of risk behaviours that predict the propagation of cyberbullying and victimisation (Chang et al., 2015; Richard et al., 2021). In this sense, anti-intimidation programs such as KiVa emerge that are capable of reducing bullying and victimisation at early ages. Thus, schools play a leading role when it comes to making a meaningful contribution to the shared aim of teachers, specifically, to educate healthy students (Kärnä et al., 2011). The learning capacity of students is related with the type of videogame selected, with choices ideally being performed as a function of educational level. In this sense, non-violent videogames that encourage engagement in social interactions are preferred by students with a higher educational status, whilst VVG tend to be chosen more by students with a lower educational status (Bijvank et al., 2012). Alongside this perspective, evolutionary research

must also be considered. This improves outcomes by distancing itself from a simple educational approach to resolving conflict and moving towards a model in which individual differences in given scenarios and student motivational response are considered (Ingram et al., 2012).

In contrast to the perspectives discussed above, Ferguson (Ferguson, 2011; Ferguson et al., 2013), alongside other authors, urges caution and moderation in relation to the conclusions made by research conducted on VVG and current trends towards youth violence so as not to misinform the public. In accordance with this approach, speculation about the potential impact of VVG on personal wellbeing suggests that it is not as harmful as has previously been suggested and that prior warnings are exaggerated, instead, suggesting that fictitious media has a very limited impact on wellbeing (Ferguson & Wang, 2021).

In line with the gender perspective taken by Rogstad (2022), literature reviewed in the present article highlights that the environment inherent to esports is strongly male-oriented, mainly due to in-game masculinised behaviours, forms of communication and male avatars created to play, whilst, at the same time, a higher number of males than females were found to participate. Existing conditions at a sociological and structural level in relation to these factors negatively influence gaming ability and limit player progression and performance. This is due to the fact that females feel conditioned on a motivational level, in their decisions to choose certain videogames over others and with regards to gender stereotypes that represent them through a "masculinised physical appearance" or sexualised avatar. All of this conditions their own self-concept (Merino-Campos et al., 2023) and gives rise to a meritocracy that determines their reduced access and opportunities to engage in esports. The staunch preservation of male dominance in esports means that sexual harassment can be interpreted as a tool of the masculine hegemony to protect its masculine image (Rogstad, 2022), ultimately, being manifested as discrimination against women through psychological factors and social dominance orientations (García-Naveira et al., 2023).

The gender gap is grounded in the challenges faced by females that block their inroads to play, act and access, and, thus, decrease their chances of success in this setting, Education on values needs to form the backbone of the transformation process that must be undergone in esports in order to achieve parity between men and women. To this end, one of the main roads to success could be an increase in the number

of female role models, which would serve to raise the profile of female gamers and support the strive towards male gamers treating female gamers as their peers (Moldes, 2019).

Further studies must be conducted to examine related cognitive processes, given that this may provide additional evidence regarding individual differences (Bonny & Castaneda, 2016), psychosocial impact and behavioural issues (Banyai et al., 2019b). It is very important that research becomes available on changing gaming behaviours over time (Alvino de Mesquita & Becker, 2018; Banyai et al., 2019a) and cultural differences in gaming behaviour (Király et al., 2015; Alvino de Mesquita & Becker, 2018). It would also be of interest to examine the experiences of gamers when playing in collaboration, as opposed to in competition, with members of the oppositive sex (Vermeulen et al., 2014). With regards to the concept of gender, studies should be conducted in which there is equal representation of males and females, or, at least, the female perspective is analysed in relation to esports (Király et al., 2015; Shen et al., 2016; Banyai et al., 2019b; & Choe et al., 2019). A number of studies (Downs & Sundar, 2011; Tortolero et al., 2014; Kokkinakis et al., 2017; Hinkley et al., 2017; Choe et al., 2019; Pardina-Torner et al., 2019; Pishchik et al., 2019), bring attention to the need to examine competitive esports and aspects pertaining to psychological characteristics, affinity and gender (Wasserman & Rittenour, 2019; McLean & Griffiths, 2019; Király, Urbán, Griffiths et al., 2015). Personalisation and the influence of playing through an "avatar" should also be examined in greater depth (Downs & Sundar, 2011; Vermeulen et al., 2014). Finally, future studies should examine the influence of device type and amount of time spent engaged in esports as a function of gender (Hinkley et al., 2017).

With regards to cognitive psychology, a number of studies were identified that reported findings associating a professional playing status and high engagement with videogames with greater working memory, processing speed and visual-spatial working memory (Kang et al., 2020). Amongst the potential explanations behind this finding, the most plausible is that such individuals tend to play and retransmit at the same time. In other words, they engage in two cognitive activities simultaneously, carrying greater concomitant demands (Matsui et al., 2020). Videogame playing was found to be associated with better intrapersonal skills, greater stress control and poorer interpersonal skills. Nonetheless, gamers report a strong sense of belonging to their gaming environment (Martín

& Pedrero, 2019). Negative behaviours have also been detected, including ego and trends towards self-preservation, in addition to toxic behaviours. In the case of the latter, outcomes in team games were poorer than when toxic behaviours were not detected. Further, gamers whose reason for playing was escapism exhibited higher levels of psychological distress and depression (Mentzoni et al., 2011).

With regards to positive practical implications, findings from a number of studies (Smith & Chan, 2017; Troussas et al., 2020) provide strong evidence of the effectiveness of videogames for teaching computing in higher education. In this sense, various studies report better learning (Pesek et al., 2020; Cózar & Sáez-López, 2016; Romero & Kalmpourtzis, 2020; Troussas et al., 2020), academic performance and frustration tolerance (Chang et al., 2015), alongside increased meaningful learning (McEnroe-Petitte & Farris, 2020; Tan, 2018; Jayalath & Esichaikul, 2020), including better emotional response (Chittaro & Sioni, 2015) and physical activity enjoyment(Kim et al., 2020; Mora-González et al., 2020; Soltani et al., 2020; Roure et al., 2020).

Risk prevention targeting improved mental health could be approached through prosocial videogames (Allahverdipour et al., 2010) such as "Adventures aboard the S.S. GRIN" (Sanchez et al., 2017), "RegnaTales" (Ong et al., 2019) and "RAGE-Control" (Ducharme et al., 2021), which have produced improvements in anger management. Intervention programs are needed that target relaxation, self-control, awareness and moral connection in order to reduce aggression (Zhao et al., 2021), in addition to considering the positive influence of parental authority (Hou et al., 2022).

Greater self-efficacy in females was found to be significantly associated with intentions for prolonged engagement in eSports (Hao et al., 2020). Engagement with electronic sports using mobile phones is starting to redress some of the negative aspects related with the gender gap and is helping to increase female participation (Peng, 2021; Rogstad, 2022).

With regards to cognitive aspects, a number of studies revealed improvements in processing speed (Pardina-Torner et al., 2019; Matsui et al., 2020), spatial awareness (Benoit et al., 2020), working memory (Kang et al., 2020) in gamers when compared with non-gamers. Further, cultural diversity within teams has also been shown to be beneficial to the performance of individual members (Parshakov et al., 2018)

Finally, negative practical implications indicate that various elements of VVG, such as their violent content, pace of action (Chen et al., 2022b), identification with antisocial characters (Krahé & Möller, 2004; Barlett et al., 2009), length of exposure (Chen et al., 2022a; Adachi & Willoughby, 2016), screen size, controller type (Kim & Sundar, 2013; Ybarra et al., 2014), moral disconnect (Teng et al., 2019) and negative affect (Ferguson et al., 2022; Tian et al., 2020) can all lead to consequences such as alcohol consumption, smoking, aggression, delinquency and risk-taking during sex (Hull et al., 2014), and obsession with real firearms and shooting (Chang & Bushman, 2019). Playing VVG intended for a mature adult audience during adolescence may lead to issues with mental wellbeing and poorer academic performance (Charmaraman et al., 2020).

Factors pertaining to the violence with some esports (Hartman & Klimmt, 2006) condition behavioural problems in males (Király et al., 2014, 2015) and contribute to reduced participation in females. Masculine behaviours, sexist language and the female body are associated with sexual components (Fox & Tang, 2016; Choe et al., 2019; McLean & Griffiths, 2019). As a result, harassment and verbal aggression are inherent to esports. Sexism is grounded in issues related with non-inclusivity due to gender (Xue et al., 2019). This typically causes females to "hide themselves" behind pseudonyms and "avatars" with male characteristics (Pinto et al., 2017; McLean & Griffiths, 2019). Female engagement in esports is influenced by the prevailing male hegemony (Hayday & Collison 2020).

Players denominated as hardcore gamers exhibit higher levels of critical and logical thinking (Pishchik et al., 2019) and poorer interpersonal skills (Hinkley et al., 2017). It is important to highlight that games who play violent videogames on a daily basis exhibit higher levels of depression (Bányai et al., 2020). The diversity of findings reported leads us to conclude that more studies are needed to continue to shed light on the psychological characteristics of videogames and esports and their implications.

# Bibliographic references

Adachi, P. J., & Willoughby, T. (2013). Demolishing the competition: The longitudinal link between competitive video games, competitive

- gambling, and aggression. *Journal of youth and adolescence, 42*(7), 1090-1104. https://doi.org/10.1007/s10964-013-9952-2
- Adachi, P. J., & Willoughby, T. (2016). The longitudinal association between competitive video game play and aggression among adolescents and young adults. *Child development*, 87(6), 1877-1892. https://doi.org/10.1111/cdev.12556
- Addo, P. C., Fang, J., Kulbo, N. B., Gumah, B., Dagadu, J. C., & Li, L. (2021). Violent video games and aggression among young adults: the moderating effects of adverse environmental factors. *Cyberpsychology, Behavior, and Social Networking*, *24*(1), 17-23. https://doi.org/10.1089/cyber.2020.0018
- Al-Ali, N. M., Yaghy, H. S., Shattnawi, K. K., & Al-Shdayfat, N. M. (2018). Parents' knowledge and beliefs about the impact of exposure to media violence on children's aggression. *Issues in mental health nursing*, 39(7), 592-599. https://doi.org/10.1080/01612840.2017.1422201
- Allahverdipour, H., Bazargan, M., Farhadinasab, A., & Moeini, B. (2010). Correlates of video games playing among adolescents in an Islamic country. *BMC public health*, 10(1), 286. 10.1186/1471-2458-10-286
- Alvino de Mesquita, J., & Becker, K. (2018). Relating conversational topics and toxic behavior effects in a MOBA game. *Entertainment Computing*, *26*, 10-29. https://doi.org/10.1016/j.entcom.2017.12.004.
- Bányai, F., Griffiths, M., Demetrovics, Z., & Király, O. (2019a). The mediating effect of motivations between psychiatric distress and gaming disorder among esport gamers and recreational gamers. *Comprehensive Psychiatry*, 94, 152117.
- Bányai, F., Griffiths, M. D., Király, O., & Demetrovics, Z. (2019b). The Psychology of Esports: A Systematic Literature Review. *Journal of Gambling Studies*, *35*(4), 351–365. https://doi.org/10.1007/s10899-018-9763-1
- Bányai, F., Zsila, Á., Griffiths, M.D., Demetrovics, Z. & Király, O. (2020). Career as a Professional Gamer: Gaming Motives as Predictors of Career Plans to Become a Professional Esport Player. *Psychol*, *11*, 1866.
- Barlett, C., Branch, O., Rodeheffer, C., & Harris, R. (2009). How long do the short-term violent video game effects last? *Aggressive Behavior: Official Journal of the International Society for Research on Aggression*, 35(3), 225-236. https://doi.org/10.1002/ab.20301
- Benoit, J., Roudaia, E., Johnson, T., Love, T., & Faubert, J. (2020). El perfil neuropsicológico de los jugadores profesionales de videojuegos de acción. *PeerJ*, *8*, 10211.

- Bijvank, M. N., Konijn, E. A., & Bushman, B. J. (2012). "We don't need no education": Video game preferences, video game motivations, and aggressiveness among adolescent boys of different educational ability levels. *Journal of adolescence*, *35*(1), 153-162. https://doi.org/10.1016/j.adolescence.2011.04.001
- Bonny, J.W. & Castaneda, L.M. (2016). Impact of the Arrangement of Game Information on Recall Performance of Multiplayer Online Battle Arena Players. *Applied Cognitive Psychology*, *30*, 664-671. https://doi.org/10.1002/acp.3234
- Bonny, J.W. & Castaneda, L.M. (2017). Number processing ability is connected to longitudinal changes in multiplayer online battle arena skill. *Computers in Human Behavior*, 66, 377-387.
- Carrillo-Vera, J. A. (2016). From players to viewers: the construction of the media spectacle in the e-sports https://doi.org/10.7238/a.v0i55.2893
- Chang, F. C., Chiu, C. H., Miao, N. F., Chen, P. H., Lee, C. M., Huang, T. F., & Pan, Y. C. (2015). Online gaming and risks predict cyberbullying perpetration and victimization in adolescents. *International journal of public health*, 60(2), 257-266. https://doi.org/10.1007/s00038-014-0643-x
- Chang, J. H., & Bushman, B. J. (2019). Effect of Exposure to Gun Violence in Video Games on Children's Dangerous Behavior with Real Guns: A Randomized Clinical Trial. *JAMA network open, 2*(5), e194319-e194319. https://doi.org/10.1001/jamanetworkopen.2019.4319
- Charmaraman, L., Richer, A. M., & Moreno, M. A. (2020). Social and behavioral health factors associated with violent and mature gaming in early adolescence. *International journal of environmental research and public health*, *17*(14). https://doi.org/10.3390/ijerph17144996
- Chen, S., Mao, B., & Liu, Y. (2022b). The effect of justified video game violence on aggressive behavior and moderated immersion: An experimental approach. *Aggressive behavior*, 49(1), 68-75. https://doi.org/10.1002/ab.22054
- Chen, S., Yi, Z., Wang, X., Luo, Y., & Liu, Y. (2022a). Competitive game motivation and trait aggression among Chinese adolescent players of Glory of the King: The mediating role of avatar identification and game aggression. *Aggressive behavior*, 48(6), 563-572. https://doi.org/10.1002/ab.22045

- Chittaro, L., & Sioni, R. (2015). Serious games for emergency preparedness: Evaluation of an interactive vs. a non-interactive simulation of a terror attack. *Computers in Human Behavior*, *50*, 508-519.
- Choe, K., Doh, S. J., & Ha, J. (2019). Adolescents' experiences and coping with sexism affect both female and male online gamers in south korea. *Sex Roles*, *83*, *43-53*. https://doi.org/10.1007/s11199-019-01094-0
- Choi, C. (2019). Understanding Media Consumption of Electronic Sports through Spectator Motivation, Using Three Different Segmentation Approaches: The Levels of Addiction, Passion, and Fan Identification. *Sport Mont*, *17*(1), 3-8.
- Coker, T. R., Elliott, M. N., Schwebel, D. C., Windle, M., Toomey, S. L., Tortolero, S. R., & Schuster, M. A. (2015). Media violence exposure and physical aggression in fifth-grade children. *Academic pediatrics*, *15*(1), 82-88. https://doi.org/10.1016/j.acap.2014.09.008
- Colwell, J., & Payne, J. (2000). Negative correlates of computer game play in adolescents. *British Journal of psychology*, *91*(3), 295-310. https://doi.org/10.1348/000712600161844
- Cote, A. C., Coles, S. M., & Dal Cin, S. (2021). The interplay of parenting style and family rules about video games on subsequent fighting behavior. *Aggressive behavior*, 47(2), 135-147. https://doi.org/10.1002/ab.21931
- Coyne, S. M., Warburton, W. A., Essig, L. W., & Stockdale, L. A. (2018). Violent video games, externalizing behavior, and prosocial behavior: A five-year longitudinal study during adolescence. *Developmental psychology*, *54*(10). 1868. https://doi.org/10.1037/dev0000574
- Cózar, R., & Sáez-López, J.M. (2016). Game-based learning and gamification in initial teacher training in the social sciences: an experiment with MinecraftEdu. International *Journal of Educational Technology in Higher Education*. *13*(2), 1-11. https://doi.org/10.1186/s41239-016-0003-4.
- Crawford, G., & Gosling, V. (2005). Toys for Boys? Women's Marginalization and Participation as Digital Gamers. *Sociological Research Online*, 10(1). https://doi.org/10.5153/sro.1024
- Dicheva, D., Irwin, K., & Dichev, C. (2018). OneUp: Supporting Practical and Experimental Gamification of Learning. *International Journal of Serious Games*, 5(3), 5-21. https://doi.org/10.17083/ijsg.v5i3.236
- Downs, E., & Sundar, S. (2011). "We won" vs. "They lost": Exploring ego-enhancement and self-preservation tendencies in the context of

- video game play. *Entertainment Computing*, 2(1), 23-28. https://doi.org/10.1016/j.entcom.2011.03.012
- Ducharme, P., Kahn, J., Vaudreuil, C., Gusman, M., Waber, D., Ross, A., & Gonzalez-Heydrich, J. (2021). A "proof of concept" randomized controlled trial of a video game requiring emotional regulation to augment anger control training. *Frontiers in Psychiatry*. https://doi.org/10.3389/fpsyt.2021.591906
- Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review*, *109*(3), 573–598. https://doi.org/10.1037/0033-295X.109.3.573
- Ellithorpe, M. E., Cruz, C., Velez, J. A., Ewoldsen, D. R., & Bogert, A. K. (2015). Moral license in video games: When being right can mean doing wrong. *Cyberpsychology, Behavior, and Social Networking,* 18(4), 203-207. https://doi.org/10.1089/cyber.2014.0599
- Ferguson, C. J. (2011). Video games and youth violence: A prospective analysis in adolescents. *Journal of youth and adolescence*, 40(4), 377-391. https://doi.org/10.1007/s10964-010-9610-x
- Ferguson, C. J., Garza, A., Jerabeck, J., Ramos, R., & Galindo, M. (2013). Not worth the fuss after all? Cross-sectional and prospective data on violent video game influences on aggression, visuospatial cognition and mathematics ability in a sample of youth. *Journal of youth and adolescence*, 42(1), 109-122. https://doi.org/10.1007/s10964-012-9803-6
- Ferguson, C. J., Gryshyna, A., Kim, J. S., Knowles, E., Nadeem, Z., Cardozo, I., & Willis, E. (2022). Video games, frustration, violence, and virtual reality: Two studies. *British journal of social psychology, 61*(1), 83-99. https://doi.org/10.1111/bjso.12471
- Ferguson, C. J., & Meehan, D. C. (2010). Saturday night's alright for fighting: Antisocial traits, fighting, and weapons carrying in a large sample of youth. *Psychiatric quarterly*, *81*(4), 293-302. https://doi.org/10.1007/s11126-010-9138-y
- Ferguson, C. J., San Miguel, C., & Hartley, R. D. (2009). A multivariate analysis of youth violence and aggression: The influence of family, peers, depression, and media violence. *The Journal of pediatrics*, 155(6), 904-908. 10.1016/j.jpeds.2009.06.021
- Ferguson, C. J., Trigani, B., Pilato, S., Miller, S., Foley, K., & Barr, H. (2016). Violent video games don't increase hostility in teens, but they do stress girls out. *Psychiatric quarterly*, *87*(1), 49-56. https://doi.org/10.1007/s11126-015-9361-7

- Ferguson, C. J., & Wang, C. J. (2021). Aggressive video games are not a risk factor for mental health problems in youth: A longitudinal study. *Cyberpsychology, Behavior, and Social Networking, 24*(1), 70-73. https://doi.org/10.1089/cyber.2020.0027
- Fontana, M. T. (2020). Gamification of ChemDraw during the COVID-19 Pandemic: Investigating How a Serious, Educational-Game Tournament (Molecule Madness) Impacts Student Wellness and Organic Chemistry Skills while Distance Learning. *Journal of Chemical Education*, 97(9), 3358-3368. https://doi.org/10.1021/acs.jchemed. 0c00722
- Fox, J., & Tang., W.Y. (2016). Sexism in online video games: The role of conformity to masculine norms and social dominance orientation. *Computers in human behaviour*, *33*, 314-320. https://doi.org/10.1016/j. chb.2013.07.014
- Gandolfi, E. (2016). To watch or to play, it is in the game: The game culture on Twitch.tv among performers, plays and audiences. *Journal of Gaming & Virtual Worlds*, 8(1), 63-82.
- Gao, X., Weng, L., Zhou, Y., & Yu, H. (2017). The influence of empathy and morality of violent video game characters on gamers' aggression. *Frontiers in psychology*, *8*, 1863. https://doi.org/10.3389/fpsyg.2017.01863
- García-Lanzo, S., & Chamarro, A. (2018). Basic psychological needs, passion and motivations in amateur and semi-professional eSports players. *Aloma: Revista de Psicologia, Ciències de l'Eduació i de l'Esport*, 36(2), 59-68.
- García Naveira, A., León Zarceño, E., & González García, C. (2021). Psicología y jugadores profesionales en esports: análisis temático y agenda de investigación. Revista Interamericana De Psicología/Interamerican Journal of Psychology, *55*(1), e1342. https://doi.org/10.30849/ripijp. v55i1.1342
- García-Naveira, A., Sierra, N. A., & Santos Montiel, O. (2023). Mujeres, videojuegos y esports: una revisión sistemática. *Información Psicológica*, 124, 29–46. https://doi.org/10.14635/ipsic.1948
- García-Naveira, A., & Zarceño, E. L. (2022). Factores psicológicos y crisis de resultados en un equipo profesional de esports. *Revista de Psicología Aplicada al Deporte y al Ejercicio Físico*, 7(1), 1-11.
- Gentile, D. A., Li, D., Khoo, A., Prot, S., & Anderson, C. A. (2014). Mediators and moderators of long-term effects of violent video games on

- aggressive behavior: Practice, thinking, and action. *JAMA pediatrics*, *168*(5), 450-457. https://doi.org/10.1001/jamapediatrics.2014.63
- Gorrindo, I. B., Chamarro, A., & Ventura, C. (2022). Habilidades psicológicas en los esports: Estudio cualitativo en jugadores individuales y de equipo. *Aloma: Revista de Psicologia, Ciències de l'Educació i de l'Esport, 40*(1), 35-41.
- Griffiths, M.D., Davies, M.N., & Chappell, D. (2003). Breaking the Stereotype: The Case of Online Gaming. *Cyberpsychology & behavior: the impact of the Internet, multimedia and virtual reality on behavior and society*, 6(1), 81-91. https://doi.org/10.1089/109493103321167992
- Halbrook, Y. J., O'Donnell, A. T., & Msetfi, R. M. (2019). When and how video games can be good: A review of the positive effects of video games on well-being. *Perspectives on Psychological Science*, *14*(6), 1096-1104. https://doi.org/10.1177/1745691619863807
- Hao L., Lv Q., Zhang X., Jiang Q., Liu S., & Ping L. (2020). Conquering Gender Stereotype Threat in "Digit Sports": Effects of Gender Swapping on Female Players' Continuous Participation Intention in ESports. *Scientific Programming*, *2*, 1–7. https://doi.org/10.1155/2020/8818588
- Hartmann, T., & Klimmt, C. (2006). Gender and computer games: exploring females dislikes. *Journal of Computer-Mediated Communication*, 11(4), 910-931. https://doi.org/10.1111/j.1083-6101.2006.00301.
- Hayday, E.J., & Collison, H. (2020). Exploring the Contested Notion of Social Inclusion and Gender Inclusivity within eSport Spaces. *Journal of Social Inclusion*, 8(3),197–208. https://doi.org/10.17645/ si.v8i3.2755
- Hemphill D. (2005). Cybersport. *Journal of the Philosophy of Sport, 32* (2), 195-207, https://doi.org/10.1080/00948705.2005.9714682
- Hilvert-Bruce, Z., & Neill, J. T. (2020). I'm just trolling: The role of normative beliefs in aggressive behaviour in online gaming. *Computers in Human Behavior*, 102, 303-311. https://doi.org/10.1016/j.chb.2019.09.003
- Hilvert-Bruce, Z., Neill, J., Sjoblom, M. & Hamari, J. (2018). Social motivations of live-streaming viewer engagement on Twitch. *Computers in Human Behavior*, 84, 58-67.
- Hinkley, T., Timperio, A., Salmon, J., & Hesketh, K. (2017). Does preschool physical activity and electronic media use predict later social

- and emotional skills at 6 to 8 years? A cohort study. *Journal of Physical Activity and Health*, 14(4), 308–316. https://doi.org/10.1123/jpah.2015-0700
- Holtz, P., & Appel, M. (2011). Internet use and video gaming predict problem behavior in early adolescence. *Journal of adolescence*, *34*(1), 49-58. https://doi.org/10.1016/j.adolescence.2010.02.004
- Hou, C. Y., Rutherford, R., Chang, H., Chang, F. C., Shumei, L., Chiu, C. H., & Tseng, C. C. (2022). Children's mobile-gaming preferences, online risks, and mental health. *PloS one*, 17(12). https://doi.org/10.1371/ journal.pone.0278290
- Hulaj, R., Nyström, MBT., Sörman, DE., Backlund, C., Röhlcke, S., & Jonsson, B. (2020). A Motivational Model Explaining Performance in Video Games. *Psychol*, *11*, 1510.
- Hull, J. G., Brunelle, T. J., Prescott, A. T., & Sargent, J. D. (2014). A longitudinal study of risk-glorifying video games and behavioral deviance. Journal of personality and social psychology, *107*(2). 300. https://doi.org/10.1037/a0036058
- Ingram, G. P., Hondrou, C., Vasalou, A., Joinson, A., Campos, J., & Martinho, C. (2012). Applying evolutionary psychology to a serious game about children's interpersonal conflict. *Evolutionary psychology*, *10*(5). https://doi.org/147470491201000510.
- Jang, W., & Byon., K. (2021). Investigation of eSports Playing Intention Formation: The Moderating Impact of Gender. *Sport Marketing Quarterly*, *30*(3) 193-206. https://doi.org/10.32731/SMQ.303.0921.03.
- Jayalath, J., & Esichaikul, V. (2020). Gamification to enhance motivation and engagement in blended eLearning for technical and vocational education and training. *Technology, Knowledge and Learning*, 1-28.
- Jenson, J., & Castell, S. (2011). Girls @ play. *Feminsh Studies*, *11*, 167-179, https://doi.org/10.1080/14680777.2010.521625
- Juca, F. (2018a). Los exergames como alternativa para la gamificación de las actividades curriculares de los nativos digitales. *Ciencia, Técnica y Mainstreaming Social*, *0*(2), 149-156. https://doi.org/10.4995/citecma.2018.9160
- Kang, J.O, Kang, K.D, Lee, J.W, Nam, J.J., & Han, D.H. (2020). Comparación de características psicológicas y cognitivas entre jugadores profesionales de juegos de Internet y jugadores profesionales de béisbol. *Revista Internacional de Investigación Ambiental y Salud Pública*, 17(13), 4797.

- Kapp, K. (2014). Gamification: Separating Fact From Fiction. *Chief Learning Officer*, 13(3), 42–46. https://doi.org/10.2304/elea.2005.2.1.5
- Kärnä, A., Voeten, M., Little, T. D., Poskiparta, E., Kaljonen, A., & Salmivalli, C. (2011). A large-scale evaluation of the KiVa antibullying program: Grades 4–6. *Child development, 82*(1), 311-330. https://doi.org/10.1111/j.1467-8624.2010.01557.x
- Kazimoglu, C. (2020). Enhancing Confidence in Using Computational Thinking Skills via Playing a Serious Game: A Case Study to Increase Motivation in Learning Computer Programming. *IEEE Access*, 8, 221831-221851. https://doi.org/10.1109/ACCESS.2020.3043278
- Kidder, D. L. (2002). The influence of gender on the performance of organizational citizenship behaviors. *Journal of Management*, 28(5), 629–648. https://doi.org/10.1177/014920630202800504
- Kim, B., Lee, D., Min, A., Paik, S., Frey, G., Bellini, S., & Shih, P. C. (2020). PuzzleWalk: A theory-driven iterative design inquiry of a mobile game for promoting physical activity in adults with autism spectrum disorder. *Plos one*, 15(9), e0237966. https://doi.org/10.1371/journal.pone.0237966
- Kim, J., & Lim, D. (2021). Exploring on Gender Perception in eSports Gamers. *Cheyuk Gwahag Yeon-Gu*, 32(2), 217–229. https://doi.org/10.24985/kjss.2021.32.2.217
- Kim, J. Y., Lee, J. S., & Oh, S. (2017). A path model of school violence perpetration: introducing online game addiction as a new risk factor. *Journal of interpersonal violence*, *32*(21), 3205-3225. https://doi.org/10.1177/0886260515597435
- Kim, K. J., & Sundar, S. S. (2013). Can interface features affect aggression resulting from violent video game play? An examination of realistic controller and large screen size. *Cyberpsychology, Behavior, and Social Networking*, *16*(5), 329-334. https://doi.org/10.1089/cyber.2012.0500
- Király, O., Griffiths, M. D., Urbán, R., Farkas, J., Kökönyei, G., Elekes, Z., Tamás, D., Demetrovics, Z. (2014). Problematic internet use and problematic online gaming are not the same: findings from a large nationally representative adolescent sample. *Cyberpsychol, Behav Soc Net*, *17*, 749–754. https://doi.org/10.1089/cyber.2014.0475
- Király, O., Urbán, R., Griffith, M., Ágoston, M.A., Nagygyörgy, K., Kökönyei, G., & Demetrovics, Z. (2015). The Mediating Effect of Gaming Motivation Between Psychiatric Symptoms and Problematic Online Gaming: An Online Survey. *Journal of medical internet research*, 17(4): e88. https://doi.org/10.2196/jmir.3515

- Kokkinakis A.V., Cowling, P.I, Drachen, A., & Wade, A.R. (2017). Exploring the relationship between video game expertise and fluid intelligence. *PLoS One*, *12*(11), e0186621. https://doi.org/10.1371/journal.pone.0186621
- Konjin, E.A., Nije Bijvank, M., & Bushman, B.J. (2007). I wish I were a warrior: The role of wishful identification in the effects of violent video games on aggression in adolescent boys. *Developmental psychology*, *43*(4), 1038. https://doi.org/10.1037/0012-1649.43.4.1038
- Krahé, B., & Möller, I. (2004). Playing violent electronic games, hostile attributional style, and aggression-related norms in German adolescents. *Journal of adolescence*, *27*(1), 53-69. https://doi.org/10.1016/j.adolescence.2003.10.006
- Kruthika, N.S. (2020). Esports and Its Reinforcement of Gender Divides. *Marquette Sports Law Review*, 30(2), 347–369.
- Lemercier-Dugarin, M., Romo, L., Tijus, C., & Zerhouni, O. (2021). "Who are the Cyka Blyat?" How empathy, impulsivity, and motivations to play predict aggressive behaviors in multiplayer online games. *Cyber-psychology, Behavior, and Social Networking*, *24*(1), 63-69. https://doi.org/10.1089/cyber.2020.0041
- León-Díaz, Ó., Martínez-Muñoz, L., & Santos-Pastor, M. (2019). Gamificación en Educación Física: un análisis sistemático de fuentes documentales. *Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte, 8*(1), 110-124. http://dx.doi.org/10.24310/riccafd.2019. v8i1.5791
- López, C. (2016). The video game as an educational tool. Possibilities and problems about Serious Game. *Apertura, Revista de Innovación Educativa*, 8(1), 1-15.
- López-Fernández, F.J., Mezquita, L., Etkin, P., Griffiths, M.D., Ortet, G., & Ibáñez, M.I. (2021). The role of violent video game exposure, personality, and deviant peers in aggressive behaviors among adolescents: A two-wave longitudinal study. *Cyberpsychology, Behavior, and Social Networking*, *24*(1), 32-40. https://doi.org/10.1089/cyber.2020.0030
- Lucas, K., & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. *Communication Research*, *31*(5). 499–523. https://doi.org/10.1177/0093650204267930
- Martín Muñoz D., & Pedrero Esteban, L.M. (2019). Los eSports: origen, evolución y tendencias. *Vista*, (4), 75–92. https://doi.org/10.21814/vista.3016
- Martonkik, M. (2015). e-Sports: Playing just for fun or playing to satisfy life goals? *Computers in Human Behavior*, 48, 208–211.

- Maskeliūnas, R., Kulikajevas, A., Blažauskas, T., Damaševičius, R., & Swacha, J. (2020). An Interactive Serious Mobile Game for Supporting the Learning of Programming in JavaScript in the Context of Eco-Friendly City Management. *Computers*, *9*(4), 102.
- Matsui, A., Sapienza, A. & Ferrara, E. (2020). Does Streaming Esports Affect Players' Behavior and Performance? *Games and Culture*, 15(1) 9-31.
- Matuszewski, P., Dobrowolski, P., & Zawadzki, B. (2020). The Association Between Personality Traits and eSports Performance. Parte delantera. *Psychol*, 11, 1490.
- McEnroe-Petitte, D., & Farris, C. (2020). Using Gaming as an Active Teaching Strategy in Nursing Education. *Teaching and Learning in Nursing*. 15. 61-65. https://doi.org/10.1016/j.teln.2019.09.002.
- McLean, L., & Griffiths, M. (2019). Female Gamers' Experience of Online Harassment and Social Support in Online Gaming: A Qualitative Study. *International Journal of Mental Health and Addiction*, *17*, 970-994. https://doi.org/10.1007/s11469-018-9962-0
- Mentzoni, R.A., Brunborg, G.S., Molde, H., Myrseth, H., Skouverøe, K.J.M., Hetland, J., Pallesen, S. (2011). Uso problemático de videojuegos: prevalencia estimada y asociaciones con la salud mental y física. Ciberpsicología Comportamiento. Soc. Neto, 14, 591–596.
- Merino-Campos, C., León-Quismondo, J., Gallardo Pérez, J., & del Castillo Fernandez, H. (2023). Uso de videojuegos en Educación Física y desarrollo del autoconcepto en la adolescencia: diferencias entre sexos (Use of video games in Physical Education and self-concept development in adolescence: sex-based differences). *Retos*, 47, 110–118. https://doi.org/10.47197/retos.v47.93921
- Moldes Farelo, R. (2019). E-Sports y brecha de género: la percepción de las profesionales españolas. *Arxius de sociología*, 40, 139-148.
- Möller, I., & Krahé, B. (2009). Exposure to violent video games and aggression in German adolescents: A longitudinal analysis. Aggressive Behavior. *Official Journal of the International Society for Research on Aggression*, 35(1), 75-89. https://doi.org/10.1002/ab.20290
- Mora-Gonzalez, J., Pérez-López, I.J., & Delgado-Fernández, M. (2020). The "\$ in TIME" gamification project: using a mobile app to improve cardiorespiratory fitness levels of college students. *Games for health journal*, 9(1), 37-44. https://doi.org/10.1089/g4h.2019.0001
- Muñoz, J., Villada, J., & Trujillo, J. (2013). Exergames: a technological tool for the physical activity *Rev. Méd. Risaralda*, 19(2), 126-130.

- Ong, J.G., Lim-Ashworth, N.S., Ooi, Y.P., Boon, J.S., Ang, R.P., Goh, D.H., & Fung, D.S. (2019). An interactive mobile app game to address aggression (RegnaTales): pilot quantitative study. *JMIR serious games*, 7(2). e13242. https://doi.org/10.2196/13242
- Ortiz, D. J., & Velastegui, D. C. (2023). Dependencia a videojuegos y su relación con la impulsividad en estudiantes: *LATAM. Revista Latino-americana de Ciencias Sociales y Humanidades*, 4(1), 1188-1192.
- Pardina-Torner, H., Carbonell, X., & Castejón, M. (2019). A comparative analysis of the processing speed between videogame players and non-players. *Aloma: Revista de Psicologia, Ciències de l'Eduació i de l'Esport, 37*(1),13-20. https://doi.org/10.51698/aloma.2019.37.1.13-20
- Parshakov, P., Coates, D., & Zavertiaeva, M. (2018). Is diversity good or bad? Evidence from eSports teams analysis. *Applied Economics*, 50(47), 5064-5075. https://doi.org/10.1080/00036846.2018.1470315
- Peng, Y. (2021). The role of gender in Chinese esports culture: empirical research of women's participation in esports in China. https://doi.org/10.5525/gla.thesis.82072
- Pérez-Rubio, C., González, J., & Garcés de los Fayos, E.J. (2017). Personalidad y burnout en jugadores profesionales de e-sports. *Cuadernos de Psicología del Deporte*, 17(1), 41-50.
- Pesek, M., Vučko, Ž., Šavli, P., Kavčič, A., & Marolt, M. (2020). Troubadour: A gamified e-learning platform for ear training. *IEEE Access*, 8, 97090-97102. https://doi.org/10.1109/ACCESS.2020.2994389.
- Pinto, D., Cádima, F.R., Coelho, J., & Dias, L. (2017). New uses and challenges for video games: streaming, gender issues and online harassment. *Media & Jornalismo*, *17*(31), 165 -176. https://doi.org/10.14195/2183-5462 31 11
- Pishchik, V.I., Molokhina G.A., Petrenko E.A., & Milova Yu, V. (2019). Features of mental activity of students esport players, *International Journal of Cognitive Research in Science, Engineering and Education*, 7(2), 67-76. https://doi.org/10.5937/IJCRSEE1902067P
- Pizzo, A., Baker, B., Na, S., Lee, M.A., Kim, D., & Funk, D. (2018). eSport vs. Sport: A Comparison of Spectator Motives. *Sport Marketing Quarterly*, 27, 108-123.
- Prieto, J.M. (2022). Sistematic Review about Evaluation of Gamification in Seven Educational Disciplines. *Teoria de la Educacion*, *34*(1), 189-215.
- Prieto, J. M., Gómez-Escalonilla-Torrijos, J.D., & Said-Hung, E. (2022). Gamificación, motivación y rendimiento en educación: Una revisión sistemática. *Revista Electrónica Educare*, *26*(1), 251-273.

- Prot, S., Gentile, D.A., Anderson, C.A., Suzuki, K., Swing, E., Lim, K.M., & Liau, A.K. (2014). Long-term relations among prosocial-media use, empathy, and prosocial behavior. *Psychological science*, *25*(2), 358-368. https://doi.org/10.1177/0956797613503854
- Richard, J., Marchica, L., Ivoska, W., & Derevensky, J. (2021). Bullying victimization and problem video gaming: The mediating role of externalizing and internalizing problems. *International journal of environmental research and public health*, 18(4). https://doi.org/10.3390/ijerph18041930
- Ricoy, C., & Ameneiros, A. (2016). Preferencias, dedicación y problemáticas generadas por los videojuegos: Una perspectiva de género. *Revista Complutense de Educación*, *27*, 1291-1308. https://doi.org/10.5209/revRCED.2016.v27.n3.48445.
- Rodríguez Martín, I.L., Pellejero Silva, M.A., Ramos-Montesdeoca, M., Martín Quintana, J.C., & Lomba Pérez, A. (2022). *Relación entre tipologías de videojuego y variables del contexto educativo*. En IX Jornadas Iberoamericanas de Innovación Educativa en el ámbito de las TIC y las TAC, Las Palmas de Gran Canaria, 17 y 18 de noviembre de 2022, p. 123-132
- Rogstad, E.T. (2022). Gender in eSports research: a literature review. *European Journal for Sport and Society, 19*(3), 195-213. doi.org/10.10 80/16138171.2021.1930941
- Romero, M., & Kalmpourtzis, G. (2020). Constructive Alignment in Game Design for Learning Activities in Higher Education. *Information*, 11(3), 126. https://doi.org/10.3390/info11030126
- Roure, C., Pasco, D., Benoît, N., & Deldicque, L. (2020). Impact of a Design-Based Bike Exergame on Young Adults' Physical Activity Metrics and Situational Interest. *Research quarterly for exercise and sport*, *91*(2), 309–315. https://doi.org/1.1080/02701367.2019.1665621
- Ruiz-Fernández, A., Junco-Guerrero, M., & Cantón-Cortés, D. (2021). Exploring the mediating effect of psychological engagement on the relationship between child-to-parent violence and violent video games. *International journal of environmental research and public bealth*, 18(6), 2845. https://doi.org/10.3390/ijerph18062845
- Ruvalcaba, O., Shulze, J., Kim, A., Berzenski, S., & Otten, M.P. (2018). Women's Experiences in eSports: Gendered Differences in Peer and Spectator Feedback During Competitive Video Game Play. *Journal of Sport and Social Issues*, 42(4), 1–17. https://doi.org/10.1177/0193723518773287

- Sanchez, R., Brown, E., Kocher, K., & DeRosier, M. (2017). Improving children's mental health with a digital social skills development game: a randomized controlled efficacy trial of adventures aboard the SS GRIN. *Games for health journal*, *6*(1), 19-27. https://doi.org/10.1089/g4h.2015.0108
- Scolari, C.A. (2013). *Homo Videoludens 2.0: de Pacman a la gamification*. Universidad Mayor; Universitat de Barcelona. https://tinyurl. com/24hcv7cd
- Shao, R., & Wang, Y. (2019). The Relation of Violent Video Games to Adolescent Aggression: An Examination of Moderated Mediation Effect. *Frontiers in psychology*, 10, 384. https://doi.org/10.3389/fpsyg.2019.00384
- Shaw, K. (2021). You play like a girl": An investigation of the gender-typing of Esports as well as the effect of gender stereotypes on player performances (23), 64. http://gih.diva-portal.org/smash/get/diva2:1601102/FULLTEXT01.pdf
- She, Y., Yang, Z., Xu, L., & Li, L. (2022). The association between violent video game exposure and sub-types of school bullying in Chinese adolescents. *Frontiers in psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.1026625
- Shen, C., Ratan, R., Cai, Y.D., & Leavitt, A. (2016). Do men advance faster than women? Debunking the gender performance gap in two massively multiplayer online games. *Journal of Computer-Mediated Communication*, 21(4), 312–329. https://doi.org/10.1111/jcc4.12159
- Simons, A., Wohlgenannt, I., Weinmann, M., & Fleischer, S. (2020). Good gamers, good managers? A proof-of-concept study with Sid Meier's Civilization. *Review of Managerial Science*, 1-34.
- Sjoblom, M., & Hamari, J. (2016). Why do people watch others play video games? An empirical study on the motivations of Twitch users. *Computers in Human Behavior*, 75, 985-996.
- Smith, S., & Chan, S. (2017). Collaborative and Competitive Video Games for Teaching Computing in Higher Education. *Journal of Science Education and Technology*, *26*(4), 438-457. https://doi.org/10.1007/s10956-017-9690-4.
- Soltani, P., Figueiredo, P., & Vilas-Boas, J.P. (2020). Does exergaming drive future physical activity and sport intentions? *Journal of health psychology*, 25(2). https://doi.org/10.1177/1359105320909866

- Steadman, J. (2019). Gaming Motivations as a Guide to Treating Problematic Gaming Behaviors. *Journal of Technology in Behavioral Science*, 4, 332-339.
- Suelves, D.M., Llin, J.A.R., & Luján, J.F.G. (2022). Exergame en educación: mapeando la investigación. *Retos: nuevas tendencias en educación física, deporte y recreación*, (44), 64-76.
- Tan, Y.L.L. (2018). Meaningful gamification and students' motivation: A strategy for scaffolding reading material. *Online Learning*, 22(2), 141-155. https://doi.org/10.24059/olj.v22i2.1167
- Tang, T., Cooper, R., & Kucek, J. (2021). Gendered Esports: Predicting Why Men and Women Play and Watch Esports Games. *Journal of Broadcasting & Electronic Media*, 65(3), 336-356. https://doi.org/10.1080/08838151.2021.1958815.
- Tartar, J., Kalman, D., & Hewlings, S. (2019). A Prospective Study Evaluating the Effects of a Nutritional Supplement Intervention on Cognition, Mood States, and Mental Performance in Video Gamers. *Nutrients*, 11, 2326. https://doi.org/10.3390/nu11102326
- Teng, Z., Nie, Q., Guo, C., Zhang, Q., Liu, Y., & Bushman, B.J. (2019). A longitudinal study of link between exposure to violent video games and aggression in Chinese adolescents: The mediating role of moral disengagement. *Developmental psychology*, *55*(1), 184. https://doi.org/10.1037/dev0000624
- Terlecky, M., Brown, J., Harner-Steciw, L., Irvin-Hannum, J., Marchetto-Ryan, N., Ruhl, L., & Wiggins, J. (2011). Sex Differences and Similarities in Video Game Experience, Preferences, and Self-Efficacy: Implications for the Gaming Industry. *Current Psychology*, *30*, 22-33. https://doi.org/10.1007/s12144-010-9095-5
- Tian, Y., Gao, M., Wang, P., & Gao, F. (2020). The effects of violent video games and shyness on individuals' aggressive behaviors. *Aggressive behavior*, 46(1), 16-24. https://doi.org/10.1002/ab.21869
- Tortolero, S.R., Peskin, M.F., Baumler, E.R., Cuccaro, P.M., Elliott, M.N., Davies, S.L., Lewis, T.H., Banspach, S.W., Kanouse, D.E., & Schuster, M.A. (2014). Daily violent video game playing and depression in preadolescent youth. *Cyberpsychology, Behaviour, and Social Networking*, *17*(9), 609–615. https://doi.org/10.1089/cyber.2014.0091
- Trepte, S., Reinecke, L., & Juechems, K. (2021). The social side of gaming: How playing online computer games creates online and offline social

- support. *Computers in Human Behaviour*, *28*(3), 832–839. https://doi.org/10.1016/j.chb.2011.12.003
- Troussas, C., Krouska, A., & Sgouropoulou, C. (2020). Collaboration and fuzzy-modeled personalization for mobile game-based learning in higher education. *Computers & Education*, *144*, 103698. https://doi.org/10.1016/j.compedu.2019.103698
- Vaghetti, C.A., Monteiro-Junior, R.S., Finco, M.D., Reategui, E. & Botelho, S.S. (2018). Exergames Experience in Physical Education: A Review. Physical Culture and Sport. *Studies and Research*, 78, 23 32.
- Verheijen, G. P., Burk, W. J., Stoltz, S. E., Van den Berg, Y. H., & Cillessen, A. H. (2018). Friendly fire: Longitudinal effects of exposure to violent video games on aggressive behavior in adolescent friendship dyads. Aggressive behavior, 44(3), 257-267. https://doi.org/10.1002/ab.21748
- Verkuyl, M., Hughes, M., Tsui, J., Betts, L., St-Amant, O., & Lapum, J. L. (2017). Virtual Gaming Simulation in Nursing Education: A Focus Group Study. *The Journal of nursing education*, *56*(5), 274–280. https://doi.org/10.3928/01484834-20170421-04
- Vermeulen, L., Núñez Castellar, E., & Van Looy, J. (2014). Challenging the other: exploring the role of opponent gender in digital game competition for female players. *Cyberpsychology, Behaviour, and Social Networking* 17(5), 303–309. https://doi.org/10.1089/cyber.2013.0331
- Wagner, M. G. (2006, June). On the Scientific Relevance of eSports. In *International conference on internet computing* (pp. 437-442)
- Wang, S. S., & Hsieh, C. T. (2020). Ubiquitous Pokémon Go: Human–Environment Relationships and the Location-Based Augmented Reality Game. *Environment and Behavior*, *52*(7), 695-725. https://doi.org/10.1177/0013916518817878
- Wasserman, J.A., & Rittenour, C.E. (2019). Who Wants to Play? Cueing Perceived Sex-Based Stereotypes of Games. *Computers in Human Behaviour*, *91*, 252-262. https://doi.org/10.1016/j.chb.2018.09.003
- Williams, D., Consalvo, M., Caplan, S., & Yee, N. (2019). Looking for gender: Gender roles and behaviors among online gamers. *Journal of Communication*, *59*, 700–725. https://doi.org/10.1111/j.1460-2466.2009.01453.x
- Willoughby, T., Adachi, P. J., & Good, M. (2012). A longitudinal study of the association between violent video game play and aggression among adolescents. *Developmental psychology*, 48(4), 1044. https://doi.org/10.1037/a0026046

- Xue, H., Newman, J., & Du, J. (2019). Narratives, identity and community in esports. *Leisure Studies*, *38*(6), 845-1002. https://doi.org/10.1080/0 2614367.2019.1640778
- Yao, M., Zhou, Y., Li, J., & Gao, X. (2019). Violent video games exposure and aggression: The role of moral disengagement, anger, hostility, and disinhibition. *Aggressive behavior*, 45(6), 662-670. https://doi.org/10.1002/ab.21860
- Ybarra, M. L., Huesmann, L. R., Korchmaros, J. D., & Reisner, S. L. (2014). Cross–sectional associations between violent video and computer game playing and weapon carrying in a national cohort of children. *Aggressive behavior*, 40(4), 345-358. https://doi.org/10.1002/ab.21526
- Ybarra, M. L., Mitchell, K. J., & Oppenheim, J. K. (2022). Violent media in childhood and seriously violent behavior in adolescence and young adulthood. *Journal of Adolescent Health*, 71(3), 285-292. https://doi.org/10.1016/j.jadohealth.2022.03.003
- Yee, N. (2006). The Demographics, Motivations and Derived Experiences of Users of Massively Multi-User Online Graphical Environments. *Presence*, *15*(3), 309-329. https://doi.org/10.1162/pres.15.3.309
- Zhao, H., Zhou, J., Xu, X., Gong, X., Zheng, J., & Zhou, J. (2021). How to be aggressive from virtual to reality? Revisiting the violent video games exposure-aggression association and the mediating mechanisms. *Cyberpsychology, Behavior, and Social Networking, 24*(1), 56-62. https://doi.org/10.1089/cyber.2019.0762

Contact information: Jana María Gallardo Pérez. Universidad Internacional de la Rioja-UNIR. Facultad de Educación. UNIR. Avda. de la Paz, 137. 26006, Logroño (La Rioja), España. E-mail: janamaria.gallardo@unir.net

# Narrative review of health-related factors of video games and electronic sports

## Revisión narrativa sobre factores relacionados con la salud en los videojuegos y deportes electrónicos

https://doi.org/10.4438/1988-592X-RE-2024-405-633

#### Jorge García Bastida

https://orcid.org/0000-0002-5971-4636 Universidad Internacional de La Rioja

#### Guillermo Mendoza

https://orcid.org/0000-0003-4595-1494 Universidad Privada de Santa Cruz de la Sierra

## Leandro Álvarez-Kurogi

https://orcid.org/0000-0003-0510-1161 Universidad Internacional de La Rioja

## Higinio González-García

https://orcid.org/0000-0002-9921-744X Universidad Internacional de La Rioja

#### **Abstract**

The aim of the present work was to analyse empirical evidence regarding physiological effects, performance and health in relation to video game and electronic sports players. A narrative review of existing scientific literature was performed on the state of the issue regarding to factors associated with physiology, performance and health in the context of video games and electronic sports. Principal findings indicated elevated levels of five hormones, high systolic blood pressure and increased heart rate. In the case of exergaming, favourable outcomes emerged for some ergogenic aids, brain activation, cognitive,

sensorimotor and corticospinal performance, strength, balance, cardiovascular capacity, and social and psychological wellbeing. However, eSports can cause eye fatigue, myofascial syndrome, tendinosis, musculoskeletal pain/syndromes, consumption of unhealthy food, sugary drinks, stimulants and doping substances, sleep disturbance and heart rate variation. Causes, symptoms, characteristics and relationships underlying Internet gaming disorder (IGD) and addiction to video games and electronic sports were also determined. In conclusion, the positive health impact of engaging in electronic sports and video games is noted, however, measures must target electronic sports players in order to avoid the negative effects of excessive video game use.

Keywords: eSport, videogames, exergaming, physical health, physiology, addiction.

#### Resumen

El objetivo de este trabajo fue analizar la evidencia empírica sobre los efectos fisiológicos, rendimiento y salud de jugadores de videojuegos y deportes electrónicos. Se realizó una revisión narrativa de la literatura científica sobre el estado de la cuestión de factores asociados a la fisiología, rendimiento y salud en videojuegos y deportes electrónicos. Los resultados mostraron importantes hallazgos en los niveles de cinco hormonas, alta presión arterial sistólica y mayor frecuencia cardíaca; en los exergaming se mostraron resultados favorables con algunas ayudas ergogénicas, activación cerebral, rendimientos cognitivo, sensoriomotor y corticoespinal, fuerza, equilibrio, capacidades cardiovasculares y bienestar social y psicológico; los eSports pueden suscitar fatiga ocular, síndrome miofascial, tendinosis, dolores/síndromes musculoesqueléticos, consumo de comida insana, bebidas azucaradas, estimulantes o sustancias dopantes, afectar el sueño y variar la frecuencia cardiaca; y se determinaron las causas, síntomas, perfiles y relación del trastorno por juego en Internet (IGD) con la adicción a los videojuegos y deportes electrónicos. Como conclusión, es destacable el impacto positivo de la práctica de deportes electrónicos y videojuegos en distintos aspectos de la salud y se deben adoptar medidas con los jugadores de deportes electrónicos para evitar los efectos negativos de un uso excesivo de videojuegos.

Palabras clave: eSport, videojuegos, exergaming, salud física, fisiología, adicción.

#### Introduction

The relationship between health and videogames has been the subject of public debate and academic research (Ferguson, 2007). Previously

conducted studies have related the use and abuse of videogames with negative effects, such as sedentary behaviour (Santaliestra-Pasías et al., 2013), aggressive behaviour (Anderson & Dill, 2000) and risk of injury or chronic pain (Mcgee & Chiu, 2021; Sekiguchi et al., 2018). In addition, one of the main concerns around the health of video gamers is that they will experience behavioural problems such as addiction (World Health Organization, 2020), despite this actually affecting only a small number of gamers (Kuss & Griffiths, 2012; Weinstein, 2010). This being said, evidence exists of the positive effects of videogames at a physical, cognitive, motivational, emotional and social level (Granic et al., 2014).

The disparity of existing evidence is due to the changing nature of videogames and gamers over recent years and continuous motivational evolution (Dale & Green, 2017). In this sense, when intertwining motivation, together with leisure and entertainment, with competition, denominated "electronic sports" or "eSports", a factor to consider in relation to videogames (Adachi & Willoughby, 2011), the psychological demands entailed are more similar to those found in sport. Whilst competitions date back to 1972, eSports have evolved, over the last decade, to be set apart from video games (Pedraza-Ramírez et al., 2020).

Despite psychological differences (García-Lanzo & Chamarro, 2018), no clear consensus exists on the health of gamers (Yin et al., 2020), although in an attempt to improve their health and extend their careers, eSports professionals tend to engage in physical activity (Giakoni-Ramírez et al., 2022). Whilst exergaming is oriented towards physical exercise, it is not classified as eSports because it lacks a competitive structure (Sween et al., 2014).

Thus, in light of the growing boom in videogames and electronic sports, the present narrative review is novel in its bid to shed light on the relevant physiological effects and health outcomes. In this way, the main aim was to examine empirical evidence of physiological effects, performance and health in individuals who engage in videogames and electronic sports. The narrative review is divided into two sections. The first considers the physiological effects of playing and performance regarding videogames and electronic sports at a recreational and competitive level. The second section considered effects on physical health and the potential development of addiction.

#### Method

Articles gathered from the databases and repositories Web of Knowledge, Scopus, Dialnet, Google Scholar, ORCID and ResearchGate were reviewed. The following keywords were used: "eSport", "addictions", "adicciones", "videogame", "videojuego", "performance", "computer game", "physiology", "salud", "healthy", "exergaming", "gamer". The following search criteria were applied: articles, review articles, books and doctoral thesis completed between 2000 and 2023. Inclusion criteria stipulated that, for inclusion, articles had to present studies that dealt with videogames and/or electronic sports and considered the physiological effects of performance at a recreational and competitive level, health-related effects and addiction development. After running the search, 107 research studies were selected that met the aim of the narrative review.

#### Results

## Physiological effects of playing videogames and electronic sports

## Physiological response

Studies on hormone response have focused on cortisol levels (Mendoza et al., 2021; Schmidt et al., 2020), testosterone (Oxford et al., 2010), DHEA, androstenedione and aldosterone (Gray et al., 2018). Emotions have been shown to be relayed as two pleasant and two unpleasant emotions prior to engaging in a videogame (Behnke et al., 2022). On the other hand, when creating a videogame, emotions have been analysed from a dynamic standpoint harnessing multiple components (Leitão et al., 2020). Lipid profiles have also been considered in children (Manousaki et al., 2020), as has cardiorespiratory fitness and cardiometabolic risk in children and adolescents (Tornquist, et al. 2022).

Regarding to cortisol, pre-competition levels, subjective importance of the match and cognitive anxiety were higher in expert eSports players (Mendoza et al., 2021). On the one hand, prior to and following a game session, cortisol levels increased during the game, as a function of whether videogames players experienced victory or defeat, in such a way that winners reported low-to-moderate levels and greater anxiety (Mendoza et al., 2021). On the other hand, an increase in cortisol has

been seen prior to a tournament, with levels remaining significantly higher immediately afterwards (Oxford et al., 2010).

With regards to testosterone, higher values have been revealed immediately after a game in individuals who most contributed to winning points, whilst average testosterone levels were significantly higher immediately after a match in individuals whose team defeated an external team in a tournament in which they formed part of the ingroup (Oxford et al., 2010). Reductions in aldosterone were also found to be associated with the length of play against others, being positively correlated with increased testosterone, DHEA and androstenedione. In contrast, cortisol has been found to not be negatively related with changes in testosterone, with reductions being more related with the number of matchups played (Gray et al., 2018).

Findings reveal that pleasant and unpleasant emotions do not influence cardiac efficiency when compared to control conditions and that individuals with greater reactivity to cardiac output performed better (Behnke et al., 2022). Further, emotions arise out of the interaction between assessment, expression, motivation and physiology, with the coming together of these resulting in subjective feeling (Leitão et al., 2020). Also of note, obsessive passion has been found to predict negative consequences, although it also predicted better performance in online competitions (Bertran & Chamarro, 2016).

Concerning to assessment of lipid profile in children, no independent association was found between playing videogames/computer games and the lipid profile after adjusting for adiposity and other covariates (Manousaki et al., 2020). Further, high screen time, due to playing videogames, computer use and television viewing, and low cardiorespiratory fitness were related with high systolic blood pressure (Tornquist et al., 2022).

Finally, a higher heart rate was found to be associated with higher ratings when it came to perceiving a game that was about to be played as a challenge (Kätsyri et al., 2013a), in addition to winning more points and the belief that they are better than other more experienced players (Maciej et al., 2020). Also, a first-person shooting game produced a greater change in maximum heart rate (Sousa et al., 2020).

#### Cognitive performance

When it comes to assessment of aspects related to the brain, males were mostly examined (De Las Heras et al., 2020; Ding et al., 2018; Giboin et al., 2021; Gong et al., 2019; Hyun et al. 2013), with the exception of

a study conducted by Tartar et al. (2019). The first cited study revealed that *eSports* are related with plasticity of central executive functions and default mode areas. In the second study, multi-player videogames set in battlefields were found to be associated with cognitive capacities including tracking multiple objects, concentration and visuospatial awareness, and personality traits such as conscientious, with this potentially being due to training effects. On the other hand, in individuals without pathologies, regular and prolonged play was found to be related with volume changes in the prefrontal and parietal cortex, which was, in turn, associated with cognitive flexibility (Hyun et al. 2013). In addition, consumption of inositol-stabilized arginine silicate, nooLVL®, may improve executive functioning in *gamers* during play via improved accuracy, decision making and reaction time (Tartar et al., 2019).

With regards to cerebral and physiological aspects, ergogenic aids were examined in three research studies. In one such study, nooLVL® intake increased vigour-energy and decreased rage (Tartar et al., 2019). In a second study, the energy drink ReloadTM was found to have no effect on either mental performance, specifically, attention, reaction time and working memory, or physical performance, specifically, handgrip strength and finger tapping speed (Thomas et al., 2019). Finally, in the third study, 3 mg/kg of caffeine was found to improve accuracy and simple reaction time for hitting (Sainz et al., 2020). On the other hand, the use of hypoxia was found to increase the number of errors committed in the discrimination of angles/distances, increasing levels of anxiety and stress and impinging intellectual working, thinking and performance in general, despite it potentially producing benefits for routine operations based on responses to simple signals (Tambovtseva & Sechin, 2019). Further, following an eSports session involving two types of games, first-person shooting and MOBA, it was concluded that both types of games reduced inhibitory control and accuracy of executive functioning, suggesting that increased activation of the sympathetic nervous system may be at play (Sousa et al., 2020).

Concerning to sensorimotor performance and corticospinal characteristics related with action videogames, greater corticospinal excitability has been observed, with varying relationships emerging with reaction time and intracortical inhibition, which could potentially mask excitatory and topographic differences (Giboin et al., 2021).

Finally, a brief intense cardiovascular exercise, prior to gaming, improved accuracy, the capacity to eliminate targets and positive affective state (De Las Heras et al., 2020).

#### The brain during electronic sports competitions

Brain activation is associated with the win-lose binomial (Kätsyri et al., 2013b) and, given recent interest in transcranial random noise stimulation (tRNS), effectiveness of this approach in relation to learning and performance of a complex task was examined (Chenot et al., 2022). Another study examined neuronal desensitisation in relation to a violent videogame (Goodson et al., 2021).

The first study mentioned reported that brain activation was greater when winning and upon achieving victory. Further, prefrontal ventromedial cortex and dorsal striatum responses were found to be stronger for winning when subjects were winning against another human being (Kätsyri et al., 2013b). Next, a group subjected to high definition tRNS showed more improvements over the long-term than a comparison group receiving simple definition tRNS, as they tended to learn more quickly and performed better against simulated groups (Chenot et al., 2022). Finally, in contrast to the aforementioned potential harmful effect of playing violent videogames, no hormonal desensitisation was uncovered (Goodson et al., 2021).

## Physical health and addiction to videogames and electronic sports

## Physically active videogames

Active video gaming or exergaming is the combination of gaming and physical exercise (Gao et al., 2016), with the aim of perforating screen time with exercise that is performed in a fun way (Best, 2013; Höchsmann et al., 2016; Simons et al., 2015). The perception of enjoyment may be a crucial factor for promoting exergaming as an alternative to generic physical activity, as this may provoke greater adherence (Feltz et al., 2014; Lee et al., 2017; Schättin et al., 2022) and increase daily physical activity in individuals with sedentary lifestyles (Best, 2013; Gao et al., 2016; Simons et al., 2015). Further, it can be used to improve physical abilities in older individuals and patients with cardiac diseases, obesity, Parkinson's and osteoporosis (Agmon et al., 2011; Höchsmann et al., 2016; Hurkmans et al., 2011; Maranesi et al., 2022; Rezaei et al., 2022). In this sense, greater strength and improved balance helps to prevent falls and improve cardiovascular fitness (Agmon et al., 2011; Martin-Niedecken et al., 2021; Schättin et al., 2022; Vernadakis et al., 2012)

and executive function (Huang, 2020; Moret et al., 2022). It may also lead to greater connection between family members, especially between grandparents and grandchildren, which seems to drive to better social and psychological wellbeing (Wollersheim et al., 2010).

#### Effects on physical health

Sedentary behaviour was found to be associated with a greater risk of premature death and health complications (Silva et al., 2016), however, regular exergaming may help to attenuate this (Best, 2013; Gao et al., 2016; Höchsmann et al., 2016; Martin-Niedecken et al., 2021). In this sense, competing and spending a large amount of time each day engaged in eSports (three to ten hours/day) may be harmful (Bonis, 2007; DiFrancisco-Donoghue et al., 2022), with eye strain, neck and back pain, myofascial syndrome and tendinosis all being more common amongst gamers (Kaczmarek et al., 2022; Silva et al., 2016; Zapata et al., 2006). Notably, adolescents exhibit a high prevalence of musculoskeletal pain/syndromes (Queiroz et al., 2018), with 42.6% of eSports gamers reporting that they suffer from some type of musculoskeletal pain (Lindberg et al., 2020) with, specifically, 36% reporting wrist pain, 32% hand pain and 31% back pain. This being said, only 2% reported requiring medical assistance to deal with this pain (DiFrancisco-Donoghue et al., 2019).

In young overweight individuals, excessive screen time increases sedentary behaviour and the consumption of unhealthy foods and sugary drinks (Smith et al., 2021). Additionally, playing videogames may affect sleep and heartrate variability (Ivarsson et al., 2013), especially in the case of e-games players, due to long playing hours. This also goes hand in hand with greater consumption of stimulants, such as caffeine, and doping substances, such as dextroamphetamine (Holden et al., 2018). Likewise, engaging in videogames for longer than three hours a day, combined with the sporting aspect, may increase the risk of suffering injuries to the elbow and shoulder joints (Sekiguchi et al., 2018).

## Addiction to videogames and electronic sports

Videogames may produce negative effects in 8-14% of gamers (Choo et al., 2010) and, whilst little evidence is available about addictions to

electronic sports (Chen & Bu, 2022), interest has grown over the last twenty years with regards to disordered online game use (Choi et al., 2018; Mao, 2021; Paulus et al., 2018). Interest is mainly born out of the fact that excessive engagement in electronic sports can turn into internet gaming disorder (IGD). According to Maldonado-Murciano et al. (2022), the main causes of IGD are depression, anxiety, childhood trauma, authoritarian parenting, negligent parenting, permissive parenting, the male sex and the parent's job, amongst others (Buiza-Aguado et al., 2018; Choi et al., 2018; Gonzálvez et al., 2017). Symptoms of IGD include reduced sleep time, obesity, raised blood pressure, low high-density cholesterol, high triglycerides, high insulin resistance (Turel et al., 2016), worrying about the game, withdrawal syndrome, greater tolerance (need for greater commitment to the game), inability to cut down on game time, dropout from other activities, continuing to play despite the associated problems, lying to relatives, using games to alleviate negative mood states and loss of work or sentimental relationships (American Psychiatric Association, 2013). It is also important to note that IGD increases when more than one device is used, such as a mobile telephone and a computer, leading, as a result, to greater depression, anxiety and substance abuse disorders (Paik et al., 2017).

In consideration of the aforementioned causes and symptoms, the combination of variables inherent to IGD were examined in a sample of gamers who were subsequently classified according to different profiles (Colder & Kardefelt-Winther, 2018; Martín-Fernández et al., 2017). In the case of the former citation, this corresponded to 2.2% of gamers being assigned to the IGD class, 63.5% to the normative class, 7.3% to the engaged class and 23.6% to the concerned class (Colder & Kardefelt-Winther, 2018). In contrast, Martín-Fernández et al. (2017) identified two profiles with one being characterised by few IGD symptoms and the other, comprising a small number of individuals, describing severe IGD symptoms. Given that gamers with IGD may have the same neurocognitive and social deficiencies as methamphetamine users, IGD is considered to be an addiction (Jiang et al., 2020).

Addiction risk is significantly greater in children, in individuals with poor academic performance and in those who prefer online multiplayer games (Wang et al., 2014), with worse addiction being associated with average amount of weekly time spent playing, frequency with which money is spent on games and length of time spent on games, lack of family harmony and absence of close friendships (King et al., 2020;

Meduna et al., 2020). Likewise, diminished happiness and altered time perceptions whilst playing have been found to be the variables with the most predictive power in terms of addiction (Hull et al., 2013).

Nonetheless, a degree of controversy exists, given that DSM-V diagnostic criteria (American Psychiatric Association, 2013) do not separate multiplayer online role-playing games (MMORPG) from gambling, games of chance, pornography and other types of addictions associated with the Internet (Carbonell, 2014; Griffiths et al., 2016; Šincek et al., 2017). For this reason, inclusion of IGD in the International Classification of Diseases is being considered (Aarseth et al., 2017) as a means to improving assessment and understanding of the symptoms discussed above (Faust & Prochaska, 2018; Király et al., 2015; Maldonado-Murciano et al., 2022).

#### **Discussion**

The aim of the present study was to examine existing empirical evidence of the physiological, performance and health effect of videogame and electronic sports players. Hormone response, brain activation, cardiovascular reactivity, pleasant-unpleasant emotions, performance parameters, anxiety, heart rate and lipid profile have all been examined, increasing knowledge regarding the impact of some videogames and electronic sports on the human body and the interactions that take place within it. Nonetheless, the relatively small sample size represents a limitation of the present review (Chenot et al., 2022; Giboin et al., 2021; Kätsyri et al., 2013a; Kätsyri et al., 2013b; Leitão et al., 2020; Maciej et al., 2020; Oxford et al., 2010), as does inconsistency in the videogames chosen for examination (e.g. FIFA 19, Space Fortress, BZFlag, Counter-Strike: Global Offensive and Unreal Tournament 2004) (Behnke et al., 2022; Chenot et al., 2022; Kätsyri et al., 2013a; Maciej et al., 2020; Oxford et al., 2010), predominance of the male sex (Behnke et al., 2022; Chenot et al., 2022; De Las Heras et al., 2020; Ding et al., 2018; Giboin et al., 2021; Gong et al., 2019; Gray et al., 2018; Hyun et al., 2013; Kätsyri et al., 2013a; Kätsyri et al., 2013b; Maciej et al., 2020; Oxford et al., 2010) and failure to specify sex distribution in a sample of 630 individuals (Manousaki et al., 2020). Likewise, included studies present numerous differences in terms of sample split, actual playing time, inclusion of computers as an

assist, procedure and the baseline characteristic data available on gamers. This makes it impossible to, not only, generalise findings to a larger number of individuals, bigger range of videogames and females but, also, prevents comparisons and conclusions from being made with the aim of establishing more meaningful and robust parameters, which would favour the development of intervention guidelines and/or pertinent measures. In any case, the reviewed published research provides a reference base upon which increasingly comprehensive advances can be made in this field of knowledge. This will be essential given the growing number of gamers (Jonasson & Thiborg, 2010).

Performance assessment in gamers has focused on aspects pertaining to human development and equilibrium, however, as is the case in the leisure setting, research into eSports is still in the preliminary stages (Reitman et al., 2020) and the demands of gamers must be investigated in order to optimise their health and performance outcomes (Thomas et al., 2019). Indeed, certain psychological, neurophysiological and perceptual motor parameters are starting to be prioritised over physical parameters, given that professional and high performance gamers are physically active, engaging in around 1.08 hours of physical exercise in 5.28 overall hours of training (Kari et al., 2019). In this sense, anxiety appears to have a greater impact on performance than physiological excitation (cortisol and heart rate variability) (Schmidt et al., 2020), whilst some nutritional supplements, i.e. new inositol-stabilized arginine silicate, nooLVL®, and caffeine, may improve executive function and perceptual motor skills (Sainz et al., 2020; Tartar et al., 2019). This being said, it must be born in mind that another supplement, ReloadTM, did not lead to any type of mental or physical improvement (Tambovtseva & Sechin, 2019). Consequently, it is possible to identify the association between some videogames, three nutritional supplements and certain psychological, neurophysiological and perceptual motor parameters. In conclusion, future research is urged, not only, to continue to consider variables with an already growing research base but, also, to examination the combination of variables, recruit larger samples, include more females, standardise variables and videogames, and examine potential psychomotor implications for neuromotor development, physical and affective-social health, and management of leisure and free time.

The adaptive effect of *eSports* on human development may be as demanding at a cognitive and physical level as traditional sports (Gong

et al., 2019), making it, potentially, a suitable tool for cognitive, cerebral, educational (Boot, 2015; Latham et al., 2013) and physical research. However, in contrast to the improvement seen in executive function (Cain et al., 2012; Colzato et al., 2010; Glass et al., 2013; Hyun et al., 2013), its impact at a physical level appears to be more convoluted, given its predominant use of the upper body at the expense of other parts of the body, together with long periods of sitting during matches. For this reason, gamers may be more active than the population average, bearing in mind that no less than 95% of gamers engage in physical exercise through participation in traditional sports (Hebbel-Seeger, 2012) and are, therefore, physically active (Kari et al., 2019). Further, given that continuous engagement in exergaming improves health (Best, 2013; Gao et al., 2016; Höchsmann et al., 2016; Martin-Niedecken et al., 2021), game design should be personalised in order to modulate intensity, duration and the skills targeted for improvement (Moret et al., 2022; Williams & Ayres, 2020). In addition, in both eSports and videogames, potential associated risks should be considered, such as the consumption of unhealthy foods (Simons et al., 2015), strain injuries due to excessive screen time (Pourmand et al., 2017; Stavrinos et al., 2009; Stavrinos et al., 2011), and overuse injuries due to excessive repetition of a determined movement (Cowley & Minnaar, 2008; Sparks et al., 2009; Tripette et al., 2014).

With regards to addictions, whilst obsessive use of videogames and eSports may emerge in 8-14% of gamers (Choo et al., 2010), for those who do not experience negative symptoms, gaming may bring some benefits. Potential benefits include reduced stress, improved problem solving techniques, greater coordination, greater capacity for critical thinking, social skills, greater attention span and greater team working capacity, amongst others (Abedini et al., 2012; Saquib et al., 2017; Shi et al., 2020). Further, in the case of gamers who do not experience IGD, there is growing evidence to suggest that emotional intelligence and social support may be preventive factors (Dang et al., 2019; Tham et al., 2020). Nevertheless, gamers with IGD may confuse pleasure and happiness when associating their affective states to videogames (Gros et al., 2020). As a result, they may be less likely to engage in cognitive reappraisal and more likely to repress their emotions (Yen et al., 2017). In this regard, high levels of cognitive reappraisal and inability to suppress emotions was shown to be related with depression, anxiety and hostility amongst gamers with IGD. Thus, the development of interventions targeting emotional intelligence in gamers with IGD may help to nullify

negative symptoms. Likewise, given the scarcity of research examining videogame addiction from a multi-factorial standpoint, it would be of great interest to conduct studies that examine the combination of gamer profiles and conceive personalised interventions.

#### **Conclusions**

In conclusion, a notable increase in publications on factors related with human physiology, performance and health is highlighted, which provides increasingly comprehensive knowledge in relation to videogames, eSports and human beings. Specifically, with regards to physiological effects and performance, levels of the hormones cortisol, testosterone, aldosterone, DHEA and androstenedione were found to be altered, depending on the point in the match at which measurements were made. On the other hand, high systolic blood pressure was found to be related with low cardiorespiratory fitness and excessive screen time. Further, higher heart rate was positively associated with performance and favourable outcomes were uncovered in relation to some ergogenic aids, brain activation and cognitive, sensorimotor and corticospinal parameters. In relation to physical health, the physical activity engaged in during exergaming improves strength, balance and cardiovascular capacity, whilst also benefiting social and psychological wellbeing when engaged in with family members. On the other hand, eSports can lead to eye strain, myofascial syndrome, tendinosis, musculoskeletal pain/syndromes, and consumption of unhealthy food, sugary drinks and stimulants or doping substances, in addition to affecting sleep and heart rate. Finally, an in-depth look was taken of the causes, symptoms and profiles inherent to IGD and its relationship with addiction to videogames and electronic sports. This addiction, despite debate around DSM-V diagnostic criteria and the potential inclusion of IGD in the International Classification of Diseases, was characterised in accordance with two personality types regarding susceptibility and other relevant variables.

## Limitations and future perspectives

Limitations of the present work include the predominance of males in included samples, use of different videogames by individual research studies, failure to specify the sex distribution in a sample of 630

individuals, non-standardised sample split and research setting, different research settings, non-controlled actual playing times, variable inclusion of computers as assists and different availability of baseline characteristic data for gamers. These limitations prevent generalisation of findings. Further, the growing nature of the sector, which is growing out of step with the rate at which research is being conducted, makes it difficult to examine many of the findings obtained in a number of studies and slows knowledge transfer. Likewise, challenges exist to evaluating the effects of videogame use in different countries, given variations in the degree of digitalisation between locations. Thus, the limitations highlighted here should be addressed through future lines of research.

To this end, future studies are urged, not only, to consider the factors discussed above, but, also, to consider additional aspects more broadly, for instance, by examining the impact of attention span, concentration and other psychological variables, in addition to variables pertaining to executive brain functions, potential psychomotor outcomes, motor skills and physical capacities, physical and affective-social health, management of leisure and free time, and educational outcomes, amongst others.

## Bibliographic references

- Aarseth, E., Bean, A. M., Boonen, H., Colder, M., Coulson, M., Das, D., Deleuze, J., Dunkels, E., Edman, J., Ferguson, C. J., Haagsma, M. C., Helmersson Bergmark, K., Hussain, Z., Jansz, J., Kardefelt-Winther, D., Kutner, L., Markey, P., Nielsen, R. K., Prause, N., ... Van Rooij, A. J. (2017). Scholars' open debate paper on the World Health Organization ICD-11 Gaming Disorder proposal. *Journal of Behavioral Addictions*, 6(3), 267-270. https://doi.org/10.1556/2006.5.2016.088
- Abedini, Y., Zamai, B. E., Kheradmand, A., & Rajabizadeh, G. (2012). Impacts of mothers' occupation status and parenting styles on levels of self-control, addiction to computer games, and educational progress of adolescents. *Addict Health*, *4*(3-4), 102-110. https://doi.org/10.22122/ahj.v4i3-4.106
- Adachi, P. J., & Willoughby, T. (2011). The effect of violent video games on aggression: Is it more than just the violence? *Aggression and Violent behavior*, 16(1), 55-62. https://doi.org/10.1016/j.avb.2010.12.002

- Agmon, M., Perry, C. K., Phelan, E., Demiris, G., & Nguyen, H. Q. (2011). A Pilot Study of Wii Fit Exergames to Improve Balance in Older Adults. *Journal of Geriatric Physical Therapy*, *34*(4), 161-167. https://doi.org/10.1519/jpt.0b013e3182191d98
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM-5)*. Arlington, VA: American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890425596
- Anderson, C. S., & Dill, K. E. (2000). Video games and aggressive thoughts, feelings, and behavior in the laboratory and in life. *Journal of Personality and Social Psychology*, 78(4), 772-790. https://doi.org/10.1037/0022-3514.78.4.772
- Behnke, M., Gross, J. J., & Kaczmarek, L. D. (2022). The role of emotions in esports performance. *Emotion*, 22(5), 1059-1070. https://doi.org/10.1037/emo0000903
- Bertran, E., & Chamarro, A. (2016). Video gamers of League of Legends: The role of passion in abusive use and in performance. *Adicciones*, 28(1), 28. https://doi.org/10.20882/adicciones.787
- Best, J. R. (2013). Exergaming in Youth. *Zeitschrift für Psychologie*, *221*(2), 72-78. https://doi.org/10.1027/2151-2604/a000137
- Bonis, J. (2007). Acute Wiiitis. *New England Journal of Medicine*, *356*(23), 2431-2432. https://doi.org/10.1056/nejmc070670
- Boot, W. (2015). Video games as tools to achieve insight into cognitive processes. *Frontiers in Psychology*, *6*, 1-3. https://doi.org/10.3389/fpsyg.2015.00003
- Buiza-Aguado, C., Alonso-Canovas, A., Conde-Mateos, C., Buiza-Navarrete, J., & Gentile, D. A. (2018). Problematic Video Gaming in a Young Spanish Population: Association with Psychosocial Health. *Cyberpsychology, Behavior, and Social Networking, 21*(6), 388-394. https://doi.org/10.1089/cyber.2017.0599
- Cain, M. S., Landau, A. N., & Shimamura, A. P. (2012). Action video game experience reduces the cost of switching tasks. *Attention, perception & psychophysics*, 74(4), 641-647. https://doi.org/10.3758/s13414-012-0284-1
- Carbonell, X. (2014). La adicción a los videojuegos en el DSM-5. *Adicciones*, 26(2), 91. https://doi.org/10.20882/adicciones.10
- Chen, Z., & Bu, X. (2022). A Grounded Theory Construction of the eSports Endogenous Drive Model. *International Journal of environmental and public health*, 7731127. https://doi.org/10.1155/2022/7731127

- Chenot, Q., Hamery, C., Lepron, E., Besson, P., De Boissezon, X., Perrey, S., & Scannella, S. (2022). Performance after training in a complex cognitive task is enhanced by high-definition transcranial random noise stimulation. *Scientific Reports*, *12*, 4618. https://doi.org/10.1038/s41598-022-08545-x
- Choi, C., Hums, M. A., & Bum, C. H. (2018). Impact of the family environment on juvenile mental health: esports online game addiction and delinquency. *International Journal of Environmental Research and Public Health*, *15*, 2850. https://doi.org/10.3390/ijerph15122850
- Choo, H., Gentile, D. A., Sim, T., Li, D., Khoo, A., & Liau, A. K. (2010). Pathological Video-Gaming among Singaporean Youth. *Annals Academy of Medicine Singapore*, *39*(11), 822-829. https://doi.org/10.47102/annals-acadmedsg.v39n11p822
- Colder, M., & Kardefelt-Winther, D. (2018). When addiction symptoms and life problems diverge: A latent class analysis of problematic gaming in a representative multinational sample of European adolescents. *European Children Adolescent Psychiatry*, *27*(4), 513–525. https://doi.org/10.1007/s00787-018-1108-1
- Colzato, L., van Leeuwen, P., van den Wildenberg, W., & Hommel, B. (2010). DOOM'd to switch: superior cognitive flexibility in players of first person shooter games. *Frontiers in Psychology, 1*, 1-6. https://doi.org/10.3389/fpsyg.2010.00008
- Cowley, A. D., & Minnaar, G. (2008). Watch out for Wii shoulder. *BMJ*, 336(7636), 110.5-110. https://doi.org/10.1136/bmj.39461.631181.be
- Dale, G., & Green, C. S. (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
- Dang, D. L., Zhang, M. X., Leong, K. K., & Wu, A. M. S. (2019). The Predictive Value of Emotional Intelligence for Internet Gaming Disorder: A 1-Year Longitudinal Study. *International Journal of Environmental Research and Public Health*, 16, 2762. https://doi.org/10.3390/ijerph16152762
- De Las Heras, B., Li, O., Rodrigues, L., Nepveu, J., & Roig, M. (2020). Exercise Improves Video Game Performance: A Win–Win Situation. *Medicine and Science in Sports and Exercise*, *52*(7), 1595-1602. https://doi.org/10.1249/mss.0000000000002277
- DiFrancisco-Donoghue, J., Balentine, J., Schmidt, G., & Zwibel, H. (2019). Managing the health of the eSport athlete: an integrated

- health management model. *BMJ Open Sport & Exercise Medicine*, *5*(1), e000467. https://doi.org/10.1136/bmjsem-2018-000467
- DiFrancisco-Donoghue, J., Werner, W. G., Douris, P. C., & Zwibel, H. (2022). Esports players, got muscle? Competitive video game players' physical activity, body fat, bone mineral content, and muscle mass in comparison to matched controls. *Journal of Sport and Health Science*, 11(6), 725-730. https://doi.org/10.1016/j.jshs.2020.07.006
- Ding, Y., Hu, X., Li, J., Ye, J., Wang, F., & Zhang, D. (2018). What Makes a Champion: The Behavioral and Neural Correlates of Expertise in Multiplayer Online Battle Arena Games. *International Journal of Human–Computer Interaction*, *34*, 682-694. https://doi.org/10.1080/10447318.2018.1461761
- Faust, K. A., & Prochaska, J. J. (2018). Internet gaming disorder: a sign of the times, or time for our attention? *Addictive Behaviors*, 77, 272-274. https://doi.org/10.1016/j.addbeh.2017.07.009
- Feltz, D. L., Forlenza, S. T., Winn, B., & Kerr, N. L. (2014). Cyber Buddy Is Better than No Buddy: A Test of the Köhler Motivation Effect in Exergames. *Games for health journal*, *3*(2), 98-105. https://doi.org/10.1089/g4h.2013.0088
- Ferguson, C. J. (2007). The Good, The Bad and the Ugly: A Meta-analytic Review of Positive and Negative Effects of Violent Video Games. *Psychiatric Quarterly*, 78(4), 309-316. https://doi.org/10.1007/s11126-007-9056-9
- Gao, Z., Lee, J. E., Pope, Z., & Zhang, D. (2016). Effect of Active Videogames on Underserved Children's Classroom Behaviors, Effort, and Fitness. *Games for Health Journal*, *5*(5), 318-324. https://doi.org/10.1089/g4h.2016.0049
- García-Lanzo, S., & Chamarro, A. (2018). Basic psychological needs, passion and motivations in amateur and semi-professional eSports players. *Aloma*, 36(2), 59-68. https://doi.org/10.51698/aloma.2018.36.2.59-68
- Giakoni-Ramírez, F., Merellano-Navarro, E., & Duclos-Bastías, D. (2022). Professional Esports Players: Motivation and Physical Activity Levels. *International Journal of Environmental Research and Public Health*, 19(4), 2256. https://doi.org/10.3390/ijerph19042256
- Giboin, L. S., Reunis, T., & Gruber, M. (2021). Corticospinal properties are associated with sensorimotor performance in action video game players. *NeuroImage*, *226*, 117576. https://doi.org/10.1016/j.neuroimage.2020.117576

- Glass, B., Maddox, W., & Love, N. (2013). Real-Time Strategy Game Training: Emergence of a Cognitive Flexibility Trait. *Plos One*, 8(8), e70350. https://doi.org/10.1371/journal.pone.0070350
- Gong, D., Ma, W., Liu, T., Yan, Y., & Yao, D. (2019). Electronic-Sports Experience Related to Functional Enhancement in Central Executive and Default Mode Areas. *Neural Plasticity*, 1-7. https://doi. org/10.1155/2019/1940123
- Gonzálvez, M. T., Espada, J. P., & Tejeiro, R. (2017). Problem video game playing is related to emotional distress in adolescents. *Adicciones*, 29(3), 180-185. https://doi.org/10.20882/adicciones.745
- Goodson, S., Turner, K. J., Pearson, S. L., & Carter, P. (2021). Violent Video Games and the P300: No Evidence to Support the Neural Desensitization Hypothesis. *Cyberpsychology, Behavior, and Social Networking*, 24(1), 48-55. https://doi.org/10.1089/cyber.2020.0029
- Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American Psychologist*, 69(1), 66-78. https://doi.org/10.1037/a0034857
- Gray, P., Vuong, J., Zava, D., & McHale, T. (2018). Testing men's hormone responses to playing League of Legends: No changes in testosterone, cortisol, DHEA or androstenedione but decreases in aldosterone. *Computers in Human Behavior*, 83, 230-234. https://doi.org/10.1016/j. chb.2018.02.004
- Griffiths, M. D., van Rooij, A. J., Kardefelt-Winther, D., Starcevic, V., Király, O., Pallesen, S., Müller, K., Dreier, M., Carras, M., Prause, N., King, D. L., Aboujaoude, E., Kuss, D. J., Pontes, H. M., Lopez Fernandez, O., Nagygyorgy, K., Achab, S., Billieux, J., Quandt, T., ... Demetrovics, Z. (2016). Working towards an international consensus on criteria for assessing internet gaming disorder: a critical commentary on Petry et al. (2014). *Addiction (Abingdon, England)*, 111(1), 167–175. https://doi.org/10.1111/add.13057
- Gros, L., Debue, N., Lete, J., & Van de Leemput, C. (2020). Video Game Addiction and Emotional States: Possible Confusion Between Pleasure and Happiness? *Frontiers in Psychology*, *10*, 2894. https://doi.org/10.3389/fpsyg.2019.02894
- Hebbel-Seeger, A. (2012). The relationship between real sports and digital adaptation in e-sport gaming. *International Journal of Sports Marketing and Sponsorship*, *13*, 43-54. https://doi.org/10.1108/IJSMS-13-02-2012-B005

- Höchsmann, C., Schüpbach, M., & Schmidt-Trucksäss, A. (2016). Effects of Exergaming on Physical Activity in Overweight Individuals. *Sports Medicine*, 46(6), 845-860. https://doi.org/10.1007/s40279-015-0455-z
- Holden, J. T., Kaburakis, A., & Rodenberg, R. M. (2018). Esports: Children, stimulants and video-gaming-induced inactivity. *Journal of Paediatrics and Child Health*, *54*(8), 830-831. https://doi.org/10.1111/jpc.13897
- Huang, K. (2020). Exergaming Executive Functions: An Immersive Virtual Reality-Based Cognitive Training for Adults Aged 50 and Older. *Cyberpsychology, Behavior, and Social Networking, 23*(3), 143-149. https://doi.org/10.1089/cyber.2019.0269
- Hull, D., Williams, G., & Griffiths, M. (2013). Video game characteristics, happiness and flow as predictors of addiction among video game players: A pilot study. *Journal of Behavioral Addictions*, *2*(3),145-152. https://doi.org/10.1556/JBA.2.2013.005
- Hurkmans, H. L., Ribbers, G. M., Streur-Kranenburg, M. F., Stam, H. J., & van den Berg-Emons, R. J. (2011). Energy expenditure in chronic stroke patients playing Wii Sports: a pilot study. *Journal of NeuroEngineering and Rehabilitation*, 8(1), 38. https://doi.org/10.1186/1743-0003-8-38
- Hyun, G. J., Shin, Y. W., Kim, B. N., Cheong, J. H., Jin, S. N., & Han, D. H. (2013). Increased Cortical Thickness in Professional On-Line Gamers. *Psychiatry Investigation*, 10, 388-392. https://doi.org/10.4306/pi.2013.10.4.388
- Ivarsson, M., Anderson, M., Åkerstedt, T., & Lindblad, F. (2013). The Effect of Violent and Nonviolent Video Games on Heart Rate Variability, Sleep, and Emotions in Adolescents With Different Violent Gaming Habits. *Psychosomatic Medicine*, 75(4), 390-396. https://doi.org/10.1097/psy.0b013e3182906a4c
- Jiang, C., Li, C., Zhou, H., & Zhou, Z. (2020). Individuals with internet gaming disorder have similar neurocognitive impairments and social cognitive dysfunctions as methamphetamine-dependent patients. *Adicciones*, 20(10), 1-11. https://doi.org/10.20882/adicciones.1342
- Jonasson, K., & Thiborg, J. (2010). Electronic sport and its impact on future sport. *Sport in Society*, *13*, 287-299. https://doi.org/10.1080/17430430903522996
- Kaczmarek, L. D., Behnke, M., & Dżon, M. (2022). Eye problems and musculoskeletal pain in Pokémon Go players. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-22428-1
- Kari, T., Siutila, M., Karhulahti, V. M., & Dubbels, B. R. (2019). An Extended Study on Training and Physical Exercise in Esports. *Exploring the*

- Cognitive, Social, Cultural, and Psychological Aspects of Gaming and Simulations, 1-23. https://doi.org/10.4018/978-1-5225-7461-3.ch010
- Kätsyri, J., Hari, R., Ravaja, N., & Nummenmaa, L. (2013a). The Opponent Matters: Elevated fMRI Reward Responses to Winning Against a Human Versus a Computer Opponent During Interactive Video Game Playing. *Cerebral Cortex*, *23*, 2829–2839. https://doi.org/10.1093/cercor/bhs259
- Kätsyri, J., Hari. R., Ravaja, N., & Nummenmaa, L. (2013b). Just watching the game ain't enough: striatal fMRI reward responses to successes and failures in a video game during active and vicarious playing. *Frontiers in Human Neuroscience*, 7, 1-13. https://doi.org/10.3389/fnhum.2013.00278
- King, D. L., Russell, A., Delfabbro, P. H., & Polisena, D. (2020). Fortnite microtransaction spending was associated with peers' purchasing behaviors but not gaming disorder symptoms. *Addictive behaviors*, 104, 106311. https://doi.org/10.1016/j.addbeh.2020.106311
- Király, O., Griffiths, M.D. & Demetrovics, Z. (2015). Internet Gaming Disorder and the DSM-5: Conceptualization, Debates, and Controversies. *Current Addiction Reports*, *2*, 254-262. https://doi.org/10.1007/s40429-015-0066-7
- Kuss, D. J., & Griffiths, M. D. (2012). Internet Gaming Addiction: A Systematic Review of Empirical Research. *International Journal of Mental Health and Addiction*, 10(2), 278-296. https://doi.org/10.1007/s11469-011-9318-5
- Latham, A., Patston, L., & Tippett L. (2013). The virtual brain: 30 years of video-game play and cognitive abilities. *Frontiers in Psychology, 4*, 1-10. https://doi.org/10.3389/fpsyg,2013.00629
- Lee, S., Kim, W., Park, T., & Peng, W. (2017). The Psychological Effects of Playing Exergames: A Systematic Review. *Cyberpsychology, Behavior,* and Social Networking, 20(9), 513–532. https://doi.org/10.1089/ cyber.2017.0183
- Leitão, J., Meuleman, B., Van De Ville, D., & Vuilleumier, P. (2020). Computational imaging during video game playing shows dynamic synchronization of cortical and subcortical networks of emotions. *PLoS Biol*, 18(11), e3000900. https://doi.org/10.1371/journal.pbio.3000900
- Lindberg, L., Nielsen, S. D., Damgaard, M., Sloth, O. R., Rathleff, M. S., & Straszek, C. L. (2020). Musculoskeletal pain is common in competitive gaming: a cross-sectional study among Danish esports athletes. *BMJ open sport and exercise medicine*, *6*(1), 000799. https://doi.org/10.1136/bmjsem-2020-000799

- Maciej, B., Kosakowski, M., & Kaczmarek, L. (2020). Social challenge and threat predict performance and cardiovascular responses during competitive video gaming. *Psychology of Sport and Exercise*, 46, 101584. https://doi.org/10.1016/j.psychsport.2019.101584
- Maldonado-Murciano, L., Guilera, G., Montag, C., & Pontes, H. M. (2022). Disordered gaming in esports: Comparing professional and non-professional gamers. *Addictive behaviors*, *132*, 107342. https://doi.org/10.1016/j.addbeh.2022.107342
- Manousaki, D., Barnett, T., Mathieu, M. E., Maximova, K., Simoneau, G., Harnois-Leblanc, S., Benedetti, A., Mcgrath, J. J., & Henderson, M. (2020). Tune out and turn in: the influence of television viewing and sleep on lipid profiles in children. *International Journal of Obesity*, 44(5), 1173-1184. https://doi.org/10.1038/s41366-020-0527-5
- Mao E. (2021). The structural characteristics of esports gaming and their behavioral implications for high engagement: A competition perspective and a cross-cultural examination. *Addictive behaviors*, 123, 107056. https://doi.org/10.1016/j.addbeh.2021.107056
- Maranesi, E., Casoni, E., Baldoni, R., Barboni, I., Rinaldi, N., Tramontana, B., Amabili, G., Benadduci, M., Barbarossa, F., Luzi, R., Di Donna, V., Scendoni, P., Pelliccioni, G., Lattanzio, F., Riccardi, G. R., & Bevilacqua, R. (2022). The Effect of Non-Immersive Virtual Reality Exergames versus Traditional Physiotherapy in Parkinson's Disease Older Patients: Preliminary Results from a Randomized-Controlled Trial. *International Journal of Environmental Research and Public Health*, 19(22), 14818. https://doi.org/10.3390/ijerph192214818
- Martín-Fernández, M., Matalí, J. L., García-Sánchez, S., Pardo, M., Lleras, M., & Castellano-Tejedor, C. (2017). Adolescents with Internet Gaming Disorder (IGD): profiles and treatment response. *Adicciones*, *29*(2), 125-133. https://doi.org/10.20882/adicciones.890
- Martin-Niedecken, A. L., Schwarz, T., & Schättin, A. (2021). Comparing the Impact of Heart Rate-Based In-Game Adaptations in an Exergame-Based Functional High-Intensity Interval Training on Training Intensity and Experience in Healthy Young Adults. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.572877
- McGee, C., & Chiu, D. K. (2021). Tendinopathies in Video Gaming and Esports. *Frontiers in sports and active living, 3.* https://doi.org/10.3389/fspor.2021.689371
- Meduna, M., Steinmetz, F., Ante, L., Reynolds, J., & Fiedler, I. (2020). Loot boxes are gambling-like elements in video games with harmful

- potential: Results from a large-scale population survey. *Technology in Society*, 63, 101395. https://doi.org/10.1016/j.techsoc.2020.101395
- Mendoza, G., Clemente-Suárez, V. J., Alvero-Cruz, J. R., Rivilla, I., García-Romero, J., Fernández-Navas, M., & Jiménez, M. (2021). The Role of Experience, Perceived Match Importance, and Anxiety on Cortisol Response in an Official Esports Competition. *International Journal of Environmental Research and Public Health*, *18*(6), 2893. https://doi.org/10.3390/ijerph18062893
- Moret, B., Nucci, M., & Campana, G. (2022). Effects of exergames on mood and cognition in healthy older adults: A randomized pilot study. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.1018601
- Organización Mundial de la Salud. (22 de Octubre, 2020). Addictive behaviours: Gaming disorder. https://www.who.int/news-room/questions-and-answers/item/addictive-behaviours-gaming-disorder
- Oxford, J., Ponzi, D., & Geary, D. (2010). Hormonal responses differ when playing violent video games against an ingroup and outgroup. *Evolution and Human Behavior*, *31*, 201–209. https://doi.org/10.1016/j.evolhumbehav.2009.07.002
- Paik, S. H., Cho, H., Chun, J. W., Jeong, J. E., & Kim, D. J. (2017). Gaming Device Usage Patterns Predict Internet Gaming Disorder: Comparison across Different Gaming Device Usage Patterns. *International Journal of Environmental Research Public Health*, 14, 1512. https://doi.org/10.3390/ijerph14121512
- Paulus, F. W., Ohmann, S., Von Gontard, A., & Popow, C. (2018). Internet gaming disorder in children and adolescents: a systematic review. *Developmental Medicine and Child Neurology*, 60(7), 645-659. https://doi.org/10.1111/dmcn.13754
- Pedraza-Ramirez, I., Musculus, L., Raab, M., & Laborde, S. (2020). Setting the scientific stage for esports psychology: A systematic review. *International Review of Sport and Exercise Psychology, 13*(1), 319-352. https://doi.org/10.1080/1750984x.2020.1723122
- Pourmand, A., Lombardi, K., Kuhl, E., & O'Connell, F. (2017). Videogame-Related Illness and Injury: A Review of the Literature and Predictions for Pokémon GO! *Games for Health Journal*, *6*(1), 9-18. https://doi.org/10.1089/g4h.2016.0090
- Queiroz, L. B., Lourenço, B., Silva, L. E. V., Lourenço, D. M. R., & Almeida Silva, C. A. (2018). Musculoskeletal pain and musculoskeletal

- syndromes in adolescents are related to electronic devices. *Jornal de Pediatria*, 94(6), 673-679. https://doi.org/10.1016/j.jped.2017.09.006
- Reitman, J., Anderson-Coto, M., Wu, M., Seok Lee, J., & Steinkuehler, C. (2020). Esports Research: A Literature Review. *Games and Culture*, *15*(1), 32–50. https://doi.org/10.1177/1555412019840892
- Rezaei, M. K., Torkaman, G., Bahrami, F., & Bayat, N. (2022). The effect of six week virtual reality training on the improvement of functional balance in women with type-I osteoporosis: A preliminary study. *Sport Sciences for Health*, *19*(1), 185-194. https://doi.org/10.1007/s11332-022-01018-8
- Sainz, I., Collado-Mateo, D., & del Coso, J. (2020). Effect of acute caffeine intake on hit accuracy and reaction time in professional e-sports players. *Physiology & Behavior*, 224, 113031 https://doi.org/10.1016/j. physbeh.2020.113031
- Santaliestra-Pasías, A. M., Rey-López, J. P., & Moreno-Aznar, L. A. (2013). Obesity and sedentarism in children and adolescents: what should be bone? *Nutricion hospitalaria*, *28*(5), 99-104.
- Saquib, N., Saquib, J., Wahid, A., Ahmed, A. A., Dhuhayr, H. E., Zaghloul, M. S., Ewid, M., & Al-Mazrou A. (2017). Video game addiction and psychological distress among expatriate adolescents in Saudi Arabia. *Addictive Behaviors Reports*, 6, 112–117. https://doi.org/10.1016/j. abrep.2017.09.003
- Schättin, A., Pickles, J., Flagmeier, D., Schärer, B., Riederer, Y., Niedecken, S., Villiger, S., Jurt, R., Kind, N., Scott, S. N., Stettler, C., & Martin-Niedecken, A. L. (2022). Development of a Novel Home-Based Exergame With On-Body Feedback: Usability Study. *JMIR Serious Games*, 10(4), e38703. https://doi.org/10.2196/38703
- Schmidt, S., Gnam, J.P., Kopf, M., Rathgeber, T., & Woll, A. (2020). The Influence of Cortisol, Flow, and Anxiety on Performance in E-Sports: A Field Study. *BioMed Research International*, 1-6. https://doi. org/10.1155/2020/9651245
- Šincek, D., Humer, J. T., & Duvnjak, I. (2017). Correlates of problematic gaming Is there support for proneness to risky behaviour? *Psychiatria Danubina*, 29(3), 302-312. https://doi.org/10.24869/psyd.2017.302
- Sekiguchi, T., Hagiwara, Y., Yabe, Y., Tsuchiya, M., Itaya, N., Yoshida, S., & Itoi, E. (2018). Playing video games for more than 3 hours a day is associated with shoulder and elbow pain in elite young male baseball players. *Journal of shoulder and elbow surgery*, *27*(9), 1629-1635. https://doi.org/10.1016/j.jse.2018.06.005

- Shi, L., Wang, Y., Yu, H., Wilson, A., Cook, S., Duan, Z., Peng, K., Hu, Z., Ou, J., Duan, S., Yang, Y., Ge, J., Wang, H., Chen, L., Zhao, K., & Chen, R. (2020). The relationship between childhood trauma and Internet gaming disorder among college students: A structural equation model. *Journal of Behavioral Addictions*. https://doi.org/10.1556/2006.2020.00002
- Silva, G. R., Pitangui, A. C., Xavier, M. K., Correia-Júnior, M. A., & De Araújo, R. C. (2016). Prevalence of musculoskeletal pain in adolescents and association with computer and videogame use. *Jornal de Pediatria*, *92*(2), 188-196. https://doi.org/10.1016/j.jped.2015.06.006
- Simons, M., Chinapaw, M. J., Brug, J., Seidell, J., & de Vet, E. (2015). Associations between active video gaming and other energy-balance related behaviours in adolescents: a 24-hour recall diary study. *International Journal of Behavioral Nutrition and Physical Activity*, 12(1). https://doi.org/10.1186/s12966-015-0192-6
- Smith, J. R., Carbine, K. A., Larson, M. J., Tucker, L. A., Christensen, W. F., LeCheminant, J. D., & Bailey, B. W. (2021). To play or not to play? The relationship between active video game play and electrophysiological indices of food-related inhibitory control in adolescents. *European Journal of Neuroscience*, *53*(3), 876-894. https://doi.org/10.1111/ejn.15071
- Sousa, A., Ahmad, S., Hassan, T., Yuen, K., Douris, P. C., Zwibel, H., & DiFrancisco-Donoghue, J. (2020). Physiological and Cognitive Functions Following a Discrete Session of Competitive Esports Gaming. *Frontiers in Psychology*, 11, 1-6. https://doi.org/10.3389/ fpsyg.2020.01030
- Sparks, D., Chase, D., & Coughlin, L. (2009). Wii have a problem: a review of self-reported Wii related injuries. *Journal of Innovation in Health Informatics*, 17(1), 55-57. https://doi.org/10.14236/jhi.v17i1.715
- Stavrinos, D., Byington, K. W., & Schwebel, D. C. (2009). Effect of Cell Phone Distraction on Pediatric Pedestrian Injury Risk. *Pediatrics*, 123(2), e179-e185. https://doi.org/10.1542/peds.2008-1382
- Stavrinos, D., Byington, K. W., & Schwebel, D. C. (2011). Distracted walking: Cell phones increase injury risk for college pedestrians. *Journal of Safety Research*, 42(2), 101-107. https://doi.org/10.1016/j. jsr.2011.01.004
- Sween, J., Wallington, S. F., Sheppard, V., Taylor, T., Llanos, A. A., & Adams-Campbell, L. L. (2014). The role of exergaming in improving physical

- activity: a review. *Journal of Physical Activity and Health*, 11(4), 864-870. https://doi.org/10.1123/jpah.2011-0425
- Tambovtseva, R, & Sechin, D. (2019). Effects of Normobaric Hypoxia on Sensory-Motor Responses in Elite Esports. *International Journal of Applied Exercise Physiology*, *8*, 231-236. https://doi.org/10.26655/IJAEP.2019.10.1
- Tartar, J., Kalman, D., & Hewlings, S. (2019). A Prospective Study Evaluating the Effects of a Nutritional Supplement Intervention on Cognition, Mood States, and Mental Performance in Video Gamers. *Nutrients*, *11*, 1-14. https://doi.org/10.3390/nu11102326
- Tham, S., Ellithorpe, M., & Meshi, D. (2020). Real-world social support but not in-game social support is related to reduced depression and anxiety associated with problematic gaming. *Addictive Behaviors*, 106, 106377. https://doi.org/10.1016/j.addbeh.2020.106377
- Thomas, C., Rothschild, J., Earnest, C., & Blaisdell, A. (2019). The Effects of Energy Drink Consumption on Cognitive and Physical Performance in Elite League of Legends Players. *Sports*, 7(9), 196. https://doi.org/10.3390/sports7090196
- Tornquist, D., Tornquist, L., Sehn, A. P., de Borba Schneiders, L., Pollo Renner, J. D., Rech Franke, S. I., Reuter, C. P., & Kelishadi, R. (2022). Cardiorespiratory fitness, screen time and cardiometabolic risk in South Brazilian school children. *Annals of Human Biology*, 49(1), 10-17. https://doi.org/10.1080/03014460.2022.2030405
- Tripette, J., Murakami, H., Gando, Y., Kawakami, R., Sasaki, A., Hanawa, S., Hirosako, A., & Miyachi, M. (2014). Home-Based Active Video Games to Promote Weight Loss during the Postpartum Period. *Medicine & Science in Sports & Exercise*, 46(3), 472-478. https://doi.org/10.1249/mss.0000000000000136
- Turel, O., Romashkin, A., & Morrison, K. (2016). Health Outcomes of Information System Use Lifestyles among Adolescents: Videogame Addiction, Sleep Curtailment and Cardio-Metabolic Deficiencies. *Plos One*, 11(5). https://doi.org/10.1371/journal.pone.0154764
- Vernadakis, N., Gioftsidou, A., Antoniou, P., Ioannidis, D., & Giannousi, M. (2012). The impact of Nintendo Wii to physical education students' balance compared to the traditional approaches. *Computers & Education*, *59*(2), 196-205. https://doi.org/10.1016/j.compedu.2012.01.003

- Wang, C. W., Chan, C. L., Mak, K. K., Ho, S. Y., Wong, P. W., & Ho, R. T. (2014). Prevalence and correlates of video and internet gaming addiction among Hong Kong adolescents: a pilot study. *The Scientific World Journal*, 874648. https://doi.org/10.1155/2014/874648
- Weinstein, A. M. (2010). Computer and video game addiction—a comparison between game users and non-game users. *The American journal of drug and alcohol abuse*, *36*(5), 268-276. https://doi.org/10.3109/00952990.2010.491879
- Williams, W. M., & Ayres, C. G. (2020). Can Active Video Games Improve Physical Activity in Adolescents? A Review of RCT. *International Journal of Environmental Research and Public Health*, *17*(2), 669. https://doi.org/10.3390/ijerph17020669
- Wollersheim, D., Merkes, M., Shields, N., Liamputtong, P., Wallis, L., Reynolds, F., & Koh, L. (2010). Physical and Psychosocial Effects of Wii Video Game Use among Older Women. *International Journal of Emerging Technologies and Society*, 8(2), 85-98.
- Yen, J., Yeh, Y., Wang, P., Liu, T., Chen, Y., & Ko, C. (2017). Emotional Regulation in Young Adults with Internet Gaming Disorder. *International Journal of Environmental Research and Public Health*, *15*(1), 30. https://doi.org/10.3390/ijerph15010030
- Yin, K., Zi, Y., Zhuang, W., Gao, Y., Tong, Y., Song, L., & Liu, Y. (2020). Linking Esports to health risks and benefits: Current knowledge and future research needs. *Journal of sport and health science*, *9*(6), 485-488. https://doi.org/10.1016/j.jshs.2020.04.006
- Zapata, A. L., Moraes, A. J., Leone, C., Doria-Filho, U., & Almeida Silva, C. A. (2006). Pain and musculoskeletal pain syndromes related to computer and video game use in adolescents. *European Journal of Pediatrics*, *165*(6), 408-414. https://doi.org/10.1007/s00431-005-0018-7

**Contact address:** Leandro Álvarez-Kurogi. Universidad Internacional de La Rioja, Facultad de Educación y Departamento de Didáctica de la Educación Física y salud. Avenida de la Paz, 137, 26006, Logroño, La Rioja. E-mail: leandro. alvarez@unir.net

# Gamification in education: challenges, potentialities and perspectives for implementation

## La gamificación en el ámbito educativo: desafíos, potencialidades y perspectivas para su implementación

https://doi.org/10.4438/1988-592X-RE-2024-405-634

#### Laura Pérez Granados

https://orcid.org/0000-0001-6284-9614 Universidad de Málaga

#### Laura de la Concepción Muñoz González

https://orcid.org/0000-0003-1073-9098 Universidad de Málaga

#### **Abstract**

Gamification, or the concept of employing game design elements such as levels, badges, and others in non-game contexts, has rapidly gained ground in the field of education. In recent years, an intense debate has emerged regarding this concept, coinciding with the growth of research in its application. The majority of studies indicate that it can enhance student motivation, interest, and academic performance, as well as facilitate the acquisition of cognitive skills and learning strategies. However, there is limited examination of the influence and impact of decisions made by educators when selecting gamification elements to design educational activities. In this regard, this article focuses on analyzing gamification as a central element within the educational sphere, identifying contradictory findings between the pedagogical actions promoted by this practice and the theoretical foundations that support them. Furthermore, it aims to provide educators with a framework and perspective that enables them to consider the relevant aspects of gamification for its implementation in their educational practice. Within this context, teacher training is considered essential to fully harness the advantages offered by this methodological strategy in the current educational landscape. Additionally, this work advocates for the need to promote a significant transformation in how educators perceive, think, and act in the educational domain. This entails a shift not only in the conception of education and learning but also in the adoption of new digital skills and competencies for the design of gamified educational activities. Ultimately, it is anticipated that this perspective can benefit both educators and students, offering opportunities for learning and motivation in an evolving educational environment.

*Keywords*: gamification, teacher education, learning strategy, educational planning, educational innovation.

#### Resumen

La gamificación o, lo que es lo mismo, la idea de usar elementos de diseños de juegos (como niveles, insignias y otros) en contextos que no son de juegos, ha ganado terreno rápidamente en el campo educativo. En los últimos años, se ha generado un intenso debate en torno a este concepto, al mismo tiempo que han crecido las investigaciones sobre su práctica. La mayoría de los estudios, señalan que puede mejorar la motivación, el interés y el rendimiento académico de los estudiantes, así como favorecer la adquisición de habilidades cognitivas y estrategias de aprendizaje. Sin embargo, poco se cuestiona la influencia y el impacto que pueden tener las decisiones tomadas por el profesorado a la hora de seleccionar los elementos de la gamificación para diseñar actividades educativas. A este respecto, el presente artículo se enfoca en analizar la gamificación como elemento central en el ámbito educativo, identificando los hallazgos contradictorios entre las acciones pedagógicas promovidas por esta práctica y las bases teóricas que las respaldan. Por otro lado, pretende proporcionar a los docentes, un marco y una perspectiva que les permita tener en cuenta los aspectos relevantes de la gamificación para implementarla en su práctica educativa. En este contexto, la formación del profesorado se plantea fundamental para aprovechar al máximo las ventajas que ofrece esta estrategia metodológica en el contexto educativo actual. Asimismo, este trabajo también aboga por la necesidad de promover una transformación significativa en la forma de ver, pensar y actuar del profesorado. Esto implica un cambio no solo en la forma de concebir la educación y el aprendizaje, sino también en la adopción de nuevas habilidades y competencias digitales para el diseño de actividades educativas gamificadas. Finalmente, se espera que esta perspectiva pueda favorecer tanto a docentes como a estudiantes, brindando oportunidades de aprendizaje y motivación en un entorno educativo cambiante.

Palabras clave: gamificación, formación de profesores, estrategia de aprendizaje, planificación educativa, innovación pedagógica.

#### Introduction

A powerful current of educational design and strategy has emerged in recent years, largely influenced by entertainment technology: gamification. Although still considered in some literature to be an innovative tool that is worth exploring, new perspectives and approaches arising from preliminary studies suggest that gamification is also gaining recognition as an educational technique with significant potential, warranting further analysis beyond its initial novelty (González-Fernández et al., 2022; Parra-González and Segura-Robles, 2020).

Analysis, reflection and debate on its pedagogical use place it at the heart of the transformation in the way teaching and learning processes are conceived. Indeed, recent research (Boller and Kapp, 2017; Pozo-Sánchez et al., 2022; Mattera et al. (2021) highlights its capacity to enhance the educational process, make tasks more attractive for students, promote greater participation, and improve academic outcomes. This research shows that participants experienced changes in their behaviour, attitude and psychological state, resulting in improved academic performance. Studies such as that of De-Marcos et al. (2014) support these findings, concluding that the incorporation of game elements in the educational setting enhances the acquisition of knowledge and facilitates deeper learning. Hernández-Horta et al. (2018) highlight the importance of considering gamification principles in the design of educational activities, given their ability to increase interest in the subject matter. Ortiz-Colón et al. (2018) also state that it reduces dropout rates and improves engagement in the teaching process, favouring competency development.

Contrary to the popular belief that gamification has revolutionised educational methods, certain studies suggest that it has not brought about significant improvements and, in some cases, has merely resulted in a superficial duplication of existing activities (Sailer et al., 2017; Zhang et al., 2020). Furthermore, its impact on academic performance outcomes continues to be debated due to its varying effects among students, raising questions about its benefits and indicating the need for further research.

One of the main criticisms of gamification is the excessive use of external rewards in long-term learning, which can distort and restrict students' genuine interest. Koivisto and Hamari (2014) note that the appeal of a gamified system may stem from its novelty, with positive

effects such as engagement and interest decreasing over time. In the current context, characterised by speed, information overload and the constant presence of technologies, it is becoming increasingly important for teachers to motivate students to cultivate cognitive skills and learning strategies of greater educational depth. Placing learners at the heart of the teaching/learning process and improving their competencies also entails using new educational approaches to help them adapt to potential losses of motivation and interest over time within a gamified setting.

Given the holistic transformation that education has undergone in recent decades (encompassing social, cultural and technological aspects), there is an increasing urgency to promote a change in teaching and harness the benefits these tools provide as a way to improve quality of education (Adell, 2020).

According to Pérez Gómez (2019), the perspectives, cultures and practices currently found in teacher training are in need of a substantial overhaul. The approach to what constitutes quality learning has evolved dramatically, as have educational requirements. More personalised, contextualised learning experiences are now advocated in order to develop relevant competencies in students' daily and professional lives (Bolivar, 2008). Gamification provides a valuable opportunity to help reflect on this contentious shift in teachers' pedagogical culture.

It is therefore worth considering which aspects of gamification could be suitable for promoting meaningful learning (Pérez Gómez, 2012), allowing students to autonomously construct their own understanding while facilitating the reflective reconstruction of their knowledge, emotions and behaviours, all without perpetuating a purely technical approach to teaching. This article examines gamification as a core aspect of the educational context, identifying its pedagogical potential in the didactic design and any potential discrepancies between the pedagogical strategies it promotes and the underlying logics that justify them.

## Gamification and learning in educational environments

Rapid technological advances have significantly influenced the field of educational technology, resulting in the integration of technological applications into teaching processes, methods and approaches, thereby impacting the educational process as a whole. In particular, the growth of games (both serious and general-purpose) as an industry and field of research is evidence that games and technologies are increasingly transcending the traditional boundaries of their domains (De Gloria et al., 2014). As mentioned above, the most recent phenomenon in this growth field is gamification, a strategy that allows the incorporation of game elements into teaching in order to improve student motivation, engagement and learning (Mohamed-Rosly and Khalid, 2017), which, in education, can be referred to as gamified learning (Sailer and Homer, 2020).

However, it is important to distinguish gamification from other game-related terms. One of the terms that causes most confusion is serious games, defined as "games with an explicit, carefully planned educational purpose that are not intended to be played only as a distraction or mere entertainment" (Abt, 1987, p. 9). Although these terms may appear similar, there are technical distinctions when referring to education (Seaborn et al., 2015). Landers (2014) stresses that the main difference lies in the attributes of the learning process itself. In serious games, learning takes place directly through the game's content, while in gamification learning occurs indirectly, since the main goal is to enhance engagement and motivation in students during their day-to-day activities.

Another important aspect in a gamified situation is that the learning goals are always visible to students and the context represents real-world situations or problems, whereas serious games keep their goals hidden and focus on developing skills through simulations (Hu, 2020).

It is also necessary to differentiate gamification from game-based learning (GBL), which is a strategy that uses existing games in the classroom as a way to facilitate learning (Oña, 2022). These games can be in both physical and digital formats (board games, video games, apps, etc).

Indeed, gamification has become increasingly popular in the classroom due to its capacity to assist students in developing decision-making skills and applying their knowledge to real-life scenarios. Mitchell and Savill-Smith (2004) state that, by challenging players and helping them overcome problems, games can be an effective way to promote learning and skill acquisition. Griffiths (2002) also stresses that they are "particularly useful when they are designed to address a specific problem or to teach a specific skill" (p. 42).

In this regard, teachers are increasingly embracing gamification approaches based on problem-based learning (PBL) thanks to the educational benefits they offer. Its principles are based on the premise that learning goes beyond academics; learning is not about reducing educational goals down to just content (Gimeno, 2010), but rather involves developing skills and building knowledge relevant to daily life (Pérez Gómez, 2012). Students can feel more motivated and committed to the learning process when they see that what they are learning has use value (Santos Guerra, 2005). The study by Kapp (2012) on understanding and influencing people's behaviour through gaming strategies demonstrates that the brain works in harmony with gamification, triggering the release of dopamine and enhancing participants' motivation and enjoyment.

#### Attributes of Gamification

In this symbiotic relationship between pedagogy and gamification, it is important to understand the most relevant attributes in terms of facilitating learning. Some of these attributes would be as follows:

- It stimulates an emotional connection in learning. Emotions have the ability to facilitate the efficient encoding and retrieval of information, resulting in a more profound and enduring learning experience. Learning involves feeling, getting excited and establishing relationships between content and experiences, making emotions an inseparable part of the educational process (Bisquerra, 2015). Gamification can help build an emotional connection between the content and participants, significantly impacting their engagement with the suggested activities.
- It promotes long-term learning. Authors such as Richter (2010) state that people's attention span has decreased from 12 to 8 seconds, with such changes being attributed to the digital revolution, excessive use of technology, and constant exposure to online information. Gamification provides an interactive learning method that can enhance the ability to learn and process information. This relates to the manner in which our brain processes and retains new information, which is closely connected to Ausubel's (2002) theory of meaningful learning. The way content is presented, the way information is structured in fragments, and the short time intervals involved are aspects of gamification that can help to counteract the lack of attention and improve students' ability to remember what they have learned during class.

- It awakens motivation through storytelling. Games often incorporate narrative elements, such as characters and plots, which enrich the learning experience. This approach is what most sparks students' interest and motivation, since stories are more attractive to the brain than facts, as suggested by Postigo-Fuentes (2021). In well-designed gamification, the narrative gives the activity context by establishing goals, limiting actions, and evoking emotional reactions, while students grapple with intricate, real-world challenges (Squire et al., 2003). Creating a framework and an immersive narrative that offer learners a comprehensive learning context and engaging experiences is therefore key to successfully integrating gamification into education.
- It improves endorphin release and keeps the brain healthy. Thanks to their ability to stimulate the release of endorphins, gamification strategies have a powerful impact on well-being, calmness and concentration. Gamification allows us to create experiences that give students a sense of accomplishment. We should capitalise on this view of learning that goes beyond the acquisition of knowledge or specific skills, and focus on harnessing participants' enthusiasm in order to generate interest and stimulate neural pathways, helping increase neuroplasticity. Gamification therefore not only generates interest in learning, but also has a positive impact on cognitive development (Gee, 2003).
- It facilitates social interaction. It is worth mentioning that, thanks to the link between learning and social context, gamification illustrates Vygotsky's sociocultural theory of cognitive development. Gamification creates opportunities for the social dissemination of ideas and behaviours, making actions and decisions that are inherently private visible to peers and colleagues (Aguiar-Castillo et al., 2019). Rohman and Fauziati (2022) explain that students interact with each other during the gamified experience, thereby creating interactive contexts in the process of building their knowledge and also fostering collaboration, teamwork and learning based on the zone of proximal development (ZPD). Taking ZPD (Vygotsky, 2012) into account in gamification allows us to offer challenges and tasks that make full use of participants' individual skills and abilities, assigning appropriate roles and responsibilities.

■ Feedback as an ally. Feedback, according to Castañeda-Cantillo (2013), is essential to the learning process, providing students with an understanding of their progress. A key aspect of most games is the presence of a systemic interaction that offers immediate feedback, which Prensky (2001) believes enhances student motivation and engagement, enables them to recognise their strengths and weaknesses, and fosters a stronger dedication to learning.

In terms of the attributes of gamification, it is clear that emerging pedagogical practices are heavily influenced by deeply routed pedagogical theories, such as social constructivism and project-based learning. Only by understanding how it works can we develop an engaging, motivating didactic design that effectively incorporates game elements into the school and classroom environment. Adell and Castañeda (2012) acknowledge that these strategies present both opportunities and constraints, and it is the duty of teachers to be aware of them. Although it is promoted as an innovative tool, does it actually favour educational innovation? Del Río-Fernández (2023) stresses that educational innovation is a constant process and should not be conceived as an isolated act. According to Sola (2016), there is often an empty discourse that promotes technology and creativity as a source of innovation that in many cases leads to "activism for activism's sake", with these new activities lacking a psychopedagogical foundation or clear significance for students. As we shall see below, the key lies in the teacher and his or her role around helping people to learn, which obviously requires having the knowledge and competencies necessary to understand the benefits of this tool and incorporate them appropriately in professional practice.

## Intrinsic motivation in planning gamified environments

The concept of "motivation" can vary depending on the context, but, in general, it encompasses internal and external processes that provide an explanation for our actions, both past and future. According to Ainley and Ainley (2011), motivation is the reason behind behaviour, which defines *what* and *why* we do something. A lack of motivation is one of the most frustrating obstacles to learning that teachers can encounter. Despite its

apparent simplicity, the complexity of this subject has been extensively researched in an attempt to define and understand it. Motivation has proven to be a crucial factor in learning and achieving goals, which has led to ongoing interest in analysing its attributes from various fields of knowledge, including education. In Table I, Becta (2001) presents some characteristics that influence motivation in relation to the attributes or procedural principles of gamified activities:

As can be seen, some of the features that promote motivation are connected to the pedagogical principles mentioned earlier, which stress active, meaningful, relevant learning where students build their own knowledge through experience and interaction with the environment. Gamified learning pursues two primary goals: to identify students' motivations for engaging in the task, and to manage this information to improve activities and predict how they will work in the specific context. In the educational field, focusing on the first of these goals is key to adapting gamification elements to students' interests and needs, engaging them in their learning processes. However, planning a gamified environment is a complex task because individuals are motivated by a

TABLE I. Characteristics that influence motivation

What does motivation indicate?	Autonomous work Self-directed problem-solving Persistence Pleasure in learning
What generates motivation?	Active participation Intrinsic, quick feedback Challenging but achievable goals A mixture of uncertainty and openness
What can help motivation in a useful way?	Collaborative interaction Peer-mediated scaffold learning Creative competition or cooperation Equal opportunities
What does sustained motivation depend on?	Link to reality Relevance for the user Recognisable, desirable roles for players
What are the problems with motivation?	Motivation can lead to obsession Motivation can cause transference from fantasy to reality Motivation can induce selfishness

Source: Becta, 2001, p.2.

range of different factors, such as the desire for rewards or simply the enjoyment of taking part.

Two differentiating features that play an important role in player motivation are identified in current approaches: intrinsic and extrinsic motivation (Deci et al., 2001). In intrinsic motivation, a behaviour or action is associated with an internal value, a personal enjoyment, while in extrinsic motivation, external rewards or punishments are given in exchange for continued commitment or behaviour. In learning, intrinsic motivation has proven to be particularly significant due to its numerous educational advantages. Aguilar (2016) identifies it as the interest and satisfaction derived from engaging in an activity for oneself, demonstrating a sense of power, effectiveness and autonomy that is inherent to the value of the task. This results in an increased inclination towards learning, improved information retention, and enhanced ability to apply acquired knowledge in relevant contexts (Pérez Gómez, 2012). However, an unbalanced, inconsistent gamified design that relies excessively on prizes and rewards may primarily encourage extrinsic motivation and short-term engagement. Zichermann (2011) argues that this approach omits the positive potential of gamification beyond awarding prizes. Extrinsic incentives, when used correctly, can send the message that skill rather than effort alone is rewarded. As Kalat (2011) notes, the reward in a gamified environment would be the mere fact of using one's own skills. However, extrinsic motivation should be used to enhance intrinsic motivation by rewarding students for seeking new challenges, demonstrating curiosity in learning, or completing tasks for the pleasure of learning (Lepper et al., 2005). Teachers can cultivate this motivation in order to enhance the learning process by balancing the internal and external elements that constitute the desire to learn for the pleasure of doing so.

As for the effectiveness of gamification, research has often used Ryan and Deci's (2017) self-determination theory (SDT) as a framework for analysing students' motivation and learning engagement. This theory encompasses intrinsic and extrinsic motivations and considers three essential psychosocial needs in these human motivations: *Personal attribution*, which is satisfied with free choice and alternatives to solve the task, thereby increasing perceived autonomy and, in turn, intrinsic motivation (Ryan and Deci, 2000); *Competence*, which is encouraged by providing feedback on attractive tasks and challenges, promoting motivation to complete the activity; and *Relationship*, which is satisfied

when feeling connected to others and being part of a community with common interests and goals. Studies into SDT and education have shown that supporting these intrinsic needs facilitates deeper, internalised learning (Rigby and Przybylski, 2009).

Sherry et al. (2006), in addition to *Competence* and *Relationship*, point to four motivational factors that make young people want to play video games, namely excitement, challenge, fun, and fantasy. *Excitement* comes from fast action and high-quality graphics; *Challenge* involves pushing oneself to a higher level of skill or personal accomplishment; *Fun* is often used to avoid stress or responsibilities, pass the time, and relax; and *Fantasy* allows participants to do things that are unattainable in real life.

Knowing these aspects will be crucial in order to understand the *what* (content) and *why* (process) of pursuing goals and to provide explanations for motivational behaviour. Understanding the reasons that lead young people to play video games enables us to anticipate which gamification elements should be considered when designing the activity (Keller, 2009). Intrinsic motivation is considered the most beneficial, given its ability to satisfy the three psychological needs of SDT and facilitate long-lasting, high-quality learning (Ryan and Deci, 2017; Deci and Ryan, 2000). Gamification combines these two motivations by using extrinsic rewards such as levels, points and badges to enhance engagement, while also bolstering autonomy and a sense of belonging (Muntean, 2011).

## Educational possibilities of gamification: key components for implementation

As noted above, gamification takes game elements and uses them to enhance teaching and learning, fostering student engagement and focus. Its goal is to establish an engaging interactive educational experience that promotes a willingness to learn and encourages positive behavioural changes, both at individual and collective levels (Ibarra, 2022). According to López-Marí et al. (2022), the concept of "civic gamification" is used to describe this strategy's ability to foster cooperation and engagement among participants. It is also associated with creating a "flow experience" (Oliveira et al., 2020), where students are fully immersed in the task and harmonise goals and emotions, "sustaining effort and performance through a sense of enjoyment derived from the balance between challenge and enjoyment" (Oña, 2022, p. 25).



Source: drafted internally.

Figure I presents a basic approach to gamification design. Although implementing gamification in the classroom might seem a simple task, it is actually quite complex. Unlike linear educational sessions, this methodology may require storyboards, flowcharts, prototypes, computer code and a cycle of continued experimentation, assessment, feedback and modification. Planning and outlining the different elements of the game is a somewhat complex task.

To ensure a better understanding of gamification and apply best educational practices, this text presents the key components that should be included when implementing a gamified experience in the classroom. Although some of these elements have been mentioned in previous sections, here they are connected and focused on the design of didactic activities and their adaptation to the context:

■ Fictional framework: this involves developing a broad, consistent story (Raftopoulos, 2014) with a well-developed narrative that actively engages learners and immerses them in an engaging adventure: "Pirate Plunder", "Time Globetrotters: the adventure of time travel", are just a few suggestive titles that can frame the plot and enhance a gamification project. This will help generate a stimulating immersive environment for learning, promoting a sense

of belonging and emotional connection, as well as participation and engagement.

- Roles and avatars: the gamified experience is enriched when participants embody personalised roles represented through avatars. This gives students an identity and ensures they are the central figures in their own learning adventure. This role should be in line with the type of player identified with. In this sense, Bartle's (1996) categorisation of the four types of player profile could be taken into account:
  - Achievers: achievers are focused on achieving the goals of the game with efficiency and integrity. While they do not necessarily seek to beat other players, they strive to outdo themselves and complete tasks properly. Their attitude can make them good leaders who motivate the team in the pursuit of their goals.
  - Explorers: explorers are passionate about discovering new things and exploring all the possibilities offered in the game. Their main motivation lies in facing uncertainty and surprise, and in solving the challenges they face. They are willing to take risks and are not so concerned with controlling or dominating the game. They enthusiastically share their findings and knowledge, looking for everyone to benefit from their explorations. This type of player can bring a creative, innovative approach to the team, finding novel solutions.
  - Socialisers: socialisers enjoy the social interactions that the game provides, seeking to establish relationships with other players through participation. For them, the game is an opportunity to share experiences, emotions, ideas and, in short, to make new friends. They are especially attracted to team play, where they can collaborate with others and develop social skills. Their work can be very useful in creating a good working environment and fostering cooperation. They can also help with conflict mediation and with building positive relationships within the team.
  - Killers: killers like to demonstrate their control, superiority and dominance. Their main goal is to win, and they will have

no qualms about doing so at the expense of other players. Competition and recognition are the most important things to them, and they enjoy bragging about their victories. This type of player can bring a competitive and challenging perspective, stimulating the team to improve and surpass themselves. However, it is important to ensure that their approach is not too aggressive or detrimental to the team as a whole (Monzón-Honrubia, 2021).

Each type of player can bring valuable skills and perspectives to a team in a gamified classroom experience, so it is worth identifying them and considering their distribution in order to form balanced groups.

- Challenges, feats or missions: the tasks to be carried out by the students in order to develop the competencies and meet their goals. This involves navigating and resolving challenges or obstacles in accordance with the rules of the activity, varying levels of difficulty, and, in certain cases, chance elements that can either benefit or hinder players throughout their adventure. Developing challenges, feats or missions requires meticulous preparation that strikes a balance between participants' abilities and the level of challenge posed by the game. Ensuring that tasks are neither too difficult nor too easy will reduce participants' frustration and allow learners to gain self-confidence (Hammond, 2001). This balance is essential to maintain motivation and to capture attention in the long term. In this sense, we have already mentioned the link to ZPD and the importance of knowing the student's level of cognitive development.
- Progress measurement standard: rubrics, cumulative experience scoring through achievements, activity logs (Lee and Hammer, 2011), or any other gamified system that can establish and identify the team's or the participant's path and current situation (similar to a continuous assessment system) can be used to motivate learners through successful experiences and a sense of achievement. The plot of the fictional framework may also progress based on the success achieved in various activities. In any case, the ethical and pedagogical component will always be fundamental. Monzón-Honrubia (2021) emphasises the importance of the gamified experience resulting from teamwork and from acknowledging joint progress, with students working together to meet goals, fostering attitudes such as altruism and positive communication.

Continuous feedback through badges and symbolic rewards: according to Ortiz-Colón et al. (2018) and Foncubierta and Rodríguez (2016), constant feedback is one of the biggest advantages of gamification and helps foster tolerance to failure, freedom to make mistakes, awareness of the learning process, and a sense of progress. Systems including experience points, badges, achievements and narratives can be used to provide this feedback. However, their educational value will depend largely on the type of activity in question, such as problem-solving, knowledge tests, open-ended questions, writing or speaking, and their relevance to the pedagogical goals. This is the most controversial element, since its application can intrinsically or extrinsically influence motivation, with the former, as discussed above, being the one that has a real pedagogical significance.

## Key considerations for teachers

Implementing gamification in the classroom places significant responsibility on the teaching team. The success of this strategy will depend to a large extent on how the project is designed and planned. However, the most relevant factor will not be what to teach (despite this also being important), but rather how to teach it, i.e. which processes, models and techniques will be used, since "the educational quality of these activities, will determine, to a large extent, the possibilities of student learning" (Alcaraz et al., 2019, p. 125).

Below are five key points that every teacher should take into consideration when carrying out a gamified experience:

- Know the risks of gamification: although successful experiences are well known, it should be noted that inadequate implementation and design are also quite common in gamification (Navarro et al., 2021). For example, the excessive use of extrinsic rewards can detract from and limit real interest in learning. Moreover, focusing excessively on competition within a group may lead students to prioritise outperforming their peers rather than focusing on personal growth, resulting in a decrease in both self-esteem and motivation.
- **Minimum training in gamification:** designing a gamified educational experience implies knowing its specific characteristics

in order to maximise the benefits and reduce the drawbacks. As noted above, we must differentiate gamification from other strategies that it tends to be confused with, such as serious games or GBL. Oña (2022) also distinguishes between superficial gamification and deep gamification. Throughout the article, we have discussed the concept of deep gamification, which entails creating an immersive experience in the classroom through a complex narrative. Superficial gamification, meanwhile, uses online tools for simple activities with game elements (Quizizz, Genialy, Kahoot!, Socrative, Poll, Everywhere, Plickers, Quizlet, Super Teacher, etc.). There is often confusion between these approaches, as stated by Navarro et al. (2021) in their research involving 118 gamified experiences, with 62 being excluded due to non-compliance with the true methodology.

- Count on the latest advances in neuroeducation: neuroscience, and especially neuroeducation, has discovered that meaningful learning is linked to emotions. As already mentioned, positive rather than negative emotions favour the neuronal synapses in charge of learning. Without emotion, there is no motivation; and without motivation, it is difficult to learn anything (Monzón-Honrubia, 2021). Gamification cannot be fully understood without addressing emotions and motivation, as these factors are where its greatest potential lies.
- **Know our students:** a key element in the design of any gamified project is to know the context of the school and the classroom: the school year in which the experience will take place, participants' abilities, their interests, and their profile as players. We previously talked about the four types of players; identifying which one our students identify with can make it easier to form teams, thereby enhancing engagement and, consequently, the effectiveness of the gamification.
- Establish consistent goals and procedural principles: a gamified experience must be based around activities arising from the curriculum and be aligned with the competencies and pedagogical processes that facilitate learning, since, as García-Tuleda (2019) points out, "gamification provides motivation and interactivity, but not the actual process of learning". (p. 3)

In this sense, it will be necessary to establish clear goals and procedural principles that will serve as guidelines to think through, modify or develop activities: Do we want students to be the main players in the process? Do we want the proposal to be inclusive? Do we want it to encourage reflection, cognitive links and metacognition? Do we want the assessment to be formative and continuous?

Each teacher has his or her own conception of what is valuable and possible in the field of education, which is shaped by his or her personal experiences, training, environment and interactions with other professionals in the sector. Consequently, the way in which teachers approach their educational work is influenced by their own visions of the meaning and function of the school and their roles in it.

When designing and developing a gamified experience, it is essential to establish clear procedural principles to ensure that the actions around practice are purposeful and intentional, aligning with the pedagogical values we wish to promote.

## **Conclusions**

Gamification has become an increasingly influential educational trend over recent years, thanks to its potential in terms of integrating playful elements that enhance student motivation, engagement and the learning process. While some studies argue that this approach has not had a significant impact on education, emphasising the negative effects of extrinsic rewards over a prolonged period, other research acknowledges its potential to bring about transformative changes in the teaching-learning process, as well as its capacity to foster student engagement and interest.

In this sense, motivation is the central factor underlying student behaviour, which can be manifested intrinsically or extrinsically. The two dimensions of motivation are therefore closely linked to the characteristic elements of gamification. However, if we prioritise the educational value of the activities, our main focus should be on promoting processes that enhance intrinsic motivation (e.g. autonomy in decision-making, emotional connection through social interactions) and on applying knowledge to practical situations, all of which, as we have seen, are crucial for the cognitive process.

However, when assessing the integration of gamification in the classroom, the first step should be to acknowledge that it is one of many instructional approaches, distinguished by a specific design which should always be guided by a pedagogical purpose that goes beyond just its motivational aspect. Moreover, adaptation to the context and type of students should consider their personal and cognitive characteristics, as well as their age and developmental stage.

Adequate training in the components and particularities of gamification (fictional framework; roles and avatars; challenges, feats or missions; progress measurement method; feedback through badges and symbolic rewards) will help prevent it being confused with other related educational strategies, such as serious games or GBL.

It must not be forgotten that the success or failure of gamified learning cannot be solely attributed to the resources used, but rather depend primarily on the design, planning and meaningfulness of the experience. Indeed, highly motivated students may become tired of poorly structured dynamics, meaningless activities or poorly calibrated challenges (Foncubierta and Rodríguez, 2016). Training around gamification is therefore key in order for teachers to design meaningful experiences that favour student motivation and learning, guaranteeing its success in the classroom.

## Information

Research project: "Estudio sobre las interacciones en Redes Sociales de Gamers y Creadores de Contenido Digitales y Fanáticos. Influencia en el rendimiento deportivo y profesional (INTERS-GAMERS)". Cátedra estratégica eSports. Ref: Redes Gamers 2023/00000201.

## Bibliographic references

Abt, C. (1987). Serious Games. University Press of America.

Adell, J. (2020). *Cambiar la educación para cambiar el mundo*. Ediciones Octaedro.

Adell, J., & Castañeda, L. (2012). Tecnologías emergentes, ¿pedagogías emergentes? En J. Hernández, M. Pennesi, D. Sobrino y A. Vázquez

- (coord.). *Tendencias emergentes en educación con TIC* (pp. 13-32). Asociación Espiral, Educación y Tecnología. https://digitum.um.es/digitum/bitstream/10201/29916/1/Adell\_Castaneda\_emergentes2012. pdf
- Aguiar-Castillo, L., Clavijo-Rodriguez, A., Saa-Perez, D., & Perez-Jimenez, R. (2019). Gamification as an approach to promote tourist recycling behavior. *Sustainability*, 11(8), 2201. https://doi.org/10.3390/su11082201
- Aguilar, J. E. (2016). Un modelo estructural de motivación intrínseca. *Acta de Investigación Psicológica*, 6, 2552-2557. https://doi.org/10.1016/j.aipprr.2016.11.007.
- Ainley, M., & Ainley, J. (2011). Student engagement with science in early adolescence: The contribution of enjoyment to students' continuing interest in learning about science. *Contemporary Educational Psychology*, *36*(1), 4-12. https://doi.org/10.1016/j. cedpsych.2010.08.001
- Alcaraz Salarirche, N., Fernández Navas, M., & Pérez Granados, L. (2019). Principios de procedimiento y escenarios reales en la formación inicial de maestros/as. *Aula De Encuentro*, *21*(1), 123–142. https://doi.org/10.17561/ae.v21i1.7
- Ausubel, D. (2002). Adquisición y retención de conocimiento. Una perspectiva cognitiva. Ediciones Paidós.
- Bartle, R. (1996, 28 de agosto). *Hearts, clubs, diamonds, spades: Players who suit muds.* https://bit.ly/3r0xOQN
- Becta (2001). *Computer Games in Education project* [Archivo PDF]. https://cibermemo.files.wordpress.com/2015/12/edujoc2004.pdf
- Bisquerra, R., Pérez-González, J.C., & García Navarro, E. (2015). *Inteligencia emocional en educación*. Editorial Síntesis.
- Bolívar, A. (2008). Competencias básicas y ciudadanía. *Caleidoscopio*, revista de contenidos educativos del CEP de Jaén, 1, 1-32.
- Boller, S., & Kapp, K. M. (2017). *Play to learn: Everything you need to know about designing effective learning games.* Association for Talent Development.
- Castañeda-Cantillo, A.E. (2013). *La evaluación del aprendizaje, una mirada sistémica*. Ediciones Usta.
- De Gloria A., Bellotti F., & Berta R. (2014). Serious games for education and training. *International Journal of Serious Games*, 1(1), 1-15. https://doi.org/10.17083/ijsg.v1i1.11

- Deci, E. L., Koestner, R., & Ryan, R. M. (2001). Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research*, 71(1), 1-27. https://doi.org/10.3102/00346543071001001
- Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/10.1207/S15327965PLI1104\_01.
- De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and Social networking on e-learning. *Computers & Education*, 75, 82-91. https://doi.ogr/10.1016/j.compedu.2012.12.020.
- Del Río-Fernández, J.L. (2023). A vueltas con la llamada innovación educativa. Algunas reflexiones para suscitar el debate. *Márgenes, Revista de Educación de la Universidad de Málaga, 4*(1), 7-19. https://doi.org/10.24310/mgnmar.v4i1.15923
- García-Tuleda, P. A. (2019). Gamificación e inclusión: rutas de aprendizaje en Educación Primaria. En C. Martínez y F.J. Murillo. *XIX Congreso Internacional de Investigación Educativa AIDIPE 2019* (pp.78-85). Asociación Interuniversitaria de Investigación Pedagógica.
- Gee, J.P. (2003). What Video Games have to Teach Us about Learning and Literacy. Palgrave/Macmillan.
- Gimeno Sacristán, J. (2010). ¿Qué significa el currículum? En J. Gimeno Sacristán (Comp.). Saberes e incertidumbres sobre el currículum (pp.19-43). Morata.
- González-Fernández, A., Revuelta-Domínguez, F.-I., & Fernández-Sánchez, M.R. (2022). Models of Instructional Design in Gamification: A Systematic Review of the literature. *Educ. Sci*, *12*(1), 44. https://doi.org/10.3390/educsci12010044
- Griffiths, M.D. (2002). Playing video games seems to have few serious acute adverse effects on health. *British Medical Journal*, *324*. https://doi.org/10.1136/bmj.324.7346.1159
- Foncubierta, J., & Rogríguez, Ch. (2016). Didáctica de la gamificación en la clase de español. *Editorial Edinumen*. https://bit.ly/3IZjdve
- Hammond, J. (2001). *Scaffolding Teaching and Learning in Language and Literacy Education*. Primary English Teaching Association.
- Hernández-Horta, I. A., Monroy-Reza, A., & Jiménez-García, M. (2018). Aprendizaje mediante Juegos basados en Principios de Gamificación en Instituciones de Educación Superior. *Formación universitaria*, 11(5), 31-40.

- Hu, J. (2020). Gamification in Learning and Education: Enjoy Learning Like Gaming. *British Journal of Educational Studies*, 68(2), 265–267. https://doi.org/10.1080/00071005.2019.1682276
- Ibarra Maturin, J. G. (2022). La Gamificación: Una Técnica para Potencializar el Aprendizaje en Primaria. *Formación Estratégica*, 4(01), 141–155. https://www.formacionestrategica.com/index.php/foes/article/view/61
- Kalat, J. W. (2011). *Introduction to Psychology*. Wadsworth Cengage Learning.
- Kapp, K. M. (2012). The gamification of learning and instruction: game-based methods and strategies for training and education. John Wiley & Sons.
- Keller, J. M. (2009). *Motivational design for learning and performance: The ARCS model approach*. Springer.
- Koivisto, J., & Hamari. J. (2014). Demographic differences in perceived benefit from gamification. *Computers in Human Behavior*, 35,179-188. https://doi.org/10.1016/j.chb.2014.03.007
- Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming*, 45(6), 752–768. https://doi.org/10.1177/1046878114563660
- Lee, J., & Hammer, J. (2011). Gamification in Education: What, How, Why Brother? *Academic Exchange Quarterly*, 115(2), 146.
- Lepper, M.R., Iyengar, S.S., & Corpus, J.H. (2005). Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology*, 97(2), 184–196. https://doi.org/10.1037/0022-0663.97.2.184
- López-Marí, Peirats-Chacón y Martín-Alonso (2022): Visiones sobre la gamificación como estrategia metodológica inclusiva en educación primaria. *Revista: Aloma 40*(2), 59-69. https://doi.org/10.51698/aloma.2022.40.2.59-69
- Mattera, M., Gava, L., Urena, R., & Ropero, E. (17-19 de marzo de 2021). Backing the Right Horse: Gamification and Mixed Realities in Higher Education. 4th International Conference on Information Science and Systems, Edinburgh, United Kingdom.
- Mitchell, A., & Savall-Smith, C. (2004). *The use of computer and video games for learning. A review of the literature*. The learning and skills development agency.
- Mohamed-Rosly, H., & Khalid, F. (2017). The Effectiveness of Gamification in the Learning Process: An Empirical Study. *Journal of Education and e-Learning Research*, 4(2), 30-38.

- Monzón-Honrubia, A. (2021). *La gamificación como metodología educativa en un aula de educación primaria* [Trabajo Fin de Grado. Universidad Católica de Valencia]. https://n9.cl/ombrc
- Muntean, C. I. (28-29 de octubre de 2011). *Raising engagement in e-learning through gamification*. Proceedings 6th International Conference on Virtual Learning ICVL (pp. 323—329), vol. 1 Cluj-Napoca, Romania, Europe.
- Navarro, C., Pérez, I., & Femia, P. (2021). La gamificación en el ámbito educativo español: revisión sistemática. *Retos, 42.* 507-516. https://doi.org/10.47197/retos.v42i0.87384
- Oliveira, W., Toda, A., Toledo, P., Shi, L., Vassileva, J., Bittencourt, I.I., & Isotani, S. (2020). *Does tailoring gamified educational systems matter? The impact on students' flow experience*. Hawaii International Conference on System Sciences. 10.24251/HICSS.2020.152
- Oña, D. (2022). Gamificación en la Educación Primaria, ventajas y contrapartidas: una revisión sobre el origen, las perspectivas teóricas y el estado de la cuestión [Trabajo Fin de Grado, Universitat de les Illes Balears]. http://hdl.handle.net/11201/159482
- Ortiz-Colón, A.-M., Jordán, J., & Agredal, M. (2018). Gamificación en educación: una panorámica sobre el estado de la cuestión. *Educação e Pesquisa*, 44(1), 1-17. https://doi.org/10.1590/S1678-4634201844173773
- Pérez Gómez, A. I. (2019). Ser docente en tiempos de incertidumbre y perplejidad. *Márgenes, Revista de Educación de la Universidad de Málaga*, *0*(0), 3-17. https://doi.org/10.24310/mgnmar.v0i0.6497
- Pérez Gómez, A. I. (2012). Educarse en la Era digital. Morata.
- Parra-González, M. E., & Segura Robles, A. (2020). Producción científica sobre gamificación en educación: un análisis cienciométrico. *Revista de Educación*, 390, 169-189. https://doi.org/10.4438/1988-592X-RE-2020-390-4265
- Postigo-Fuentes, A.Y. (2021). Aprendizaje de una lengua extranjera en una liga de eSports amateur. Un estudio de caso [Tesis doctoral]. Universidad de Málaga.
- Pozo-Sánchez, S., Lampropoulos, G., & López-Belmonte, J. (2022). Comparing Gamification Models in Higher Education Using Faceto-Face and Virtual Escape Rooms. *Journal of New Approaches in Educational Research*, 11(2), 1–16. https://doi.org/10.7821/naer.2022.7.1025

- Prensky, M. (2001). Digital Game-Based Learning. McGraw-Hill.
- Raftopoulos, M. (2014). "Towards Gamification Transparency: A Conceptual Framework for the Development of Responsible Gamified Enterprise Systems". *Journal of Gaming & Virtual Worlds* 6(2), 159–178.
- Richtel, M. (6 de junio de 2010). Attached to technology and paying a price. *The New York Times*. https://www.nytimes.com/2010/06/07/technology/07brain.html
- Rigby, C. S., & Przybylski, A. K. (2009). Virtual worlds and the learner hero: How today's video games can inform tomorrow's digital learning environments. *Theory and Research in Education*, 7(2), 214—223. https://doi.org/10.1177/1477878509104326
- Rohman, D., & Fauziati E. (2022). Gamification of Learning in the Perspective of Constructivism Philosophy Lev Vygotsky. *Budapest International Research and Critics Institute-Journal*, *5*(1), 4467-4474. https://doi.org/10.33258/birci.v5i1.4156
- Ryan, R. M., & Deci, E. L. (2017). Self-determination theory: Basic psychological needs in motivation, development, and wellness. The Guilford Press.
- Ryan, R., & Deci, E. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist*, *55*(1), 68.
- Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, 69, 371-380. https://doi.org/10.1016/j.chb.2016.12.033
- Sailer, M., & Homner, L. (2020). The Gamification of Learning: a Metaanalysis. *Educational Psychology Review*, 32(1), 77–112. https://doi. org/10.1007/s10648019-09498-w
- Santos Guerra, M.A. (18 de junio de 2005). *Valor de cambio*. [Blog El Adarve]. https://mas.laopiniondemalaga.es/blog/eladarve/2005/06/18/valor-de-cambio/
- Seaborn, K., & Deborah I. F. (2015). Gamification in Theory and Action: A Survey. *International Journal of Human-Computer Studies*, 14–31. https://doi.org/10.1016/j.ijhcs.2014.09.006
- Sherry, J.L., Greenberg, B. S., Lucas, K., & Lachlan, K. (2006). Video game uses and gratifications as predictors of use and game preference. En J.

- Bryant. *Playing computer games: Motives, responses and consequences* (pp.213-224). LEA.
- Squire K., Jenkins, H., Holland, W., Miller, H., O'Driscoll, A., Tan, K.P., & Todd, K. (2003). Design principles of next-generation digital gaming for education. *Educational Technology*, *43*(5), 17–23.
- Sola, M. (2016). ¿Por qué es necesario innovar? En M. Fernández y N. Alcaraz (coords.). *Innovación Educativa. Más allá de la ficción* (27-40). Pirámide.
- Vygotsky, L. (2012). El desarrollo de los procesos psicológicos superiores. Austral.
- Zhang, B., Zheng, Y., Liu, C., & Chen, X. (2020). A critical review of gamification research in educational contexts from 2008 to 2019. *Journal of Educational Computing Research*, 58(5), 1064-1098. https://doi.org/10.1177/0735633120902887
- Zichermann, G. (23 de Agosto de 2011). *Gamification is here to stay (and it's not bullshit)* [Blog Kotaku]. http://kotaku.com/5833631/gamification-is-here-to-stay-and-its-not-bullshit

**Contact address:** Laura Pérez Granados. Universidad de Málaga Universidad de Málaga, Facultad de Ciencias de la Educación, Departamento de Didáctica y Organización Escolar. Boulevard Louis Pasteur, 25, 29010. Campus Teatinos. Málaga. E-mail: lpgranados@uma.es

# Analysis of the teaching role in a gamification proposal in the teacher's master's degree

# Análisis del rol docente en una propuesta de gamificación en el máster de profesorado

https://doi.org/10.4438/1988-592X-RE-2024-405-635

#### Carmen Navarro-Mateos

https://orcid.org/0000-0002-0757-7975 Universidad de Granada

## Isaac José Pérez-López

https://orcid.org/000-0002-4156-7762 Universidad de Granada

## **Carmen Trigueros Cervantes**

https://orcid.org/000-0001-7870-1411 Universidad de Granada

#### **Abstract**

Introduction: learning environments have suffered enormous changes in the last few years, as a consequence of social transformations and the students' new demands. Furthermore, motivation in higher levels of education is related with a better academic performance, with the teaching staff's role as a key aspect to have an impact on it. In this context, gamification is especially relevant, since it takes advantage of the attractiveness and significance of games and videogames to boost the implication and the learning experience. On the other hand, TV programs are a format that generates a great interest in university students. Therefore, the objective of this article is to analyse the teaching staffs' role in a gamification proposal inspired by the TV program *Masterchef*, based on the narratives of its participants, with the intention of knowing its incidence and the aspects highlighted by them. Methodology: the participants were 29 students (4 female, 25 male) from the MA in Teaching from the University of Granada. A qualitative methodology was employed, and a phenomenological study was conducted. Through an open question approach, and using *Google Drive*,

the students shared, anonymously and voluntarily, their emotions, the things they learned and both the negative and positive aspects they lived throughout the experience. The analysis was done using the software *Nvivo*. Results: the three characteristics that the students highlighted about the professor, and that according to their narratives, had the most impact on the degree in which they took advantage of the proposal, were: the levels of exigence (which made them give the better of themselves), the feedback (which favoured the learning process and the feeling of making progress) and the care for details (which contributed in the immersion of the participants and the credibility of the proposal). Conclusions: seeing the obtained results, the teacher/professor is a key differentiator element in these types of approaches, resulting in a higher degree of implication from the students and a higher degree of satisfaction with the proposal.

Keywords: teaching role, gamification, learning, university, students.

#### Resumen

Introducción: los entornos de aprendizaje han sufrido enormes cambios en los últimos años, como consecuencia de las transformaciones sociales y las nuevas demandas del alumnado. Además, la motivación en educación superior se relaciona con un mejor rendimiento académico, siendo el rol del docente un aspecto clave para incidir en la misma. En este contexto, adquiere especial relevancia la gamificación, pues aprovecha el atractivo y significatividad de los juegos y videojuegos para favorecer la implicación y el aprendizaje. Por otro lado, los programas de televisión son un formato que genera un gran interés en los estudiantes universitarios. Por tanto, el objetivo del presente artículo es analizar el rol del docente en una propuesta de gamificación basada en el concurso Masterchef, a partir de las narrativas de sus participantes, con la intención de conocer su incidencia y los aspectos más destacados por ellos. Metodología: los participantes fueron 29 estudiantes (4 chicas y 25 chicos) del máster de profesorado de la Universidad de Granada. Se ha utilizado la metodología cualitativa, llevando a cabo un estudio fenomenológico. A través de una pregunta abierta, mediante Google Drive, los estudiantes compartieron, de manera anónima y voluntaria, sus emociones, aprendizajes y aspectos más y menos positivos a lo largo de la experiencia. El análisis se realizó con el software Nvivo. Resultados: las tres características que el alumnado más destacó del docente y que, según sus narrativas, más incidieron en el grado de aprovechamiento de la propuesta, fueron: la exigencia (que les hizo sacar su mejor versión), el feedback (que favoreció su aprendizaje y sensación de progreso) y el cuidado de los detalles (que incidió en la inmersión de los participantes y la credibilidad de la propuesta). Conclusiones: a tenor de los resultados obtenidos, el docente es un elemento diferenciador en este tipo de planteamientos, propiciando un mayor grado de implicación del alumnado y de satisfacción con la propuesta.

Palabras clave: rol docente, gamificación, aprendizaje, universidad, alumnado.

## Introduction

The pedagogical methods that involve students and make them work actively in learning tasks and through reflective processes, represent in recent years a new model of teaching at different stages, including the university level (Pires, 2021). In this context, different digital resources are combined with in-person teaching, achieving students' proactive behaviors in training processes (Andrade and Brookhart, 2020; Van Laer and Elen, 2017). With the rapid development of educational information technologies, traditional teaching environments have undergone enormous changes, also requiring a transformation of the teaching role. The knowledge transfer function of the teacher has been replaced by a role more related to the development, guidance and facilitation of learning (Liu, 2018). However, assuming the role of information facilitator requires adaptation and flexibility on the part of the teacher, understanding learning as a process (Hernández et al., 2018; Reeve, 2006).

On the other hand, the concept of leadership typical of the area of marketing and business, can be transferred to the field of education, where the teacher must be aware of the importance of creating an environment conducive to learning and motivation (Peña and Wandosell, 2015). In fact, motivation in higher education is directly linked to academic performance and, ultimately, to educational success (Okada, 2023; Robbins et al., 2004). Similarly, the relationship between the teacher and the student is another key predictor of academic performance (Frenzel et al., 2009; Yoon, 2002). Knowing what students expect from teachers is essential when playing the teaching role, and improving teacher-student relations (Poulou, 2014; Wubbels, 2005).

If we analyze the profile of the ideal teacher based on the perceptions of students (Marín et al., 2011), students related to the field of social sciences highlight three aspects: teachers' skills to teach (fluency in explaining, good communicative skills, etc.), the relationship with students (understanding and receptive person, etc.) and their social skills (close person, not authoritarian, etc.). Focusing on the teachers themselves, they highlight the importance of personal skills to develop their profession, such as pedagogical love, motivation, enthusiasm, creativity or self-criticism (Alonso-Sainz, 2021). These were followed by didactic-pedagogical skills, such as reflection on teaching practice, innovation or the use of teaching strategies that include active methodologies.

Therefore, the technical vision of education should be put aside in higher education and bet on an approach in which the personal growth of both student and teacher takes precedence, achieving significant learnings related to the objectives set by the teacher (Orón and Blasco, 2018). Different authors highlight the key role that motivation, through the role of the teacher, plays in the teaching and learning processes, since the relationships that are established with the students and the methodology selected will influence the interest and development of the students' skills (González-Castro et al., 2021; Rodríguez-Pérez, 2012; Valenzuela et al., 2015).

## Audiovisual influence

In the current audiovisual panorama, television series are the ones that achieve the greatest impact on the population, with a growing trend in the supply of titles and possibilities in recent years in the different streaming platforms (Albornoz and García, 2022). Young people today prefer to watch series and films on these platforms (Cortés-Quesada et al., 2022; Navarro-Robles and Vázquez-Barrio, 2020), although for the viewing of contests or reality shows they continue betting on traditional television (Navarro-Robles and Vázquez-Barrio, 2020). In addition, this generation has a tendency to connect audiovisual content and social networks, as they share their opinions through the Internet, which further expands the possibilities (Guerrero-Pérez, 2018).

Therefore, as Arufe-Giráldez (2019) says, the current media boom is a great opportunity for teachers, since college students are frequent consumers of television programs. This significance can be used to adapt successful formats to the educational context, generating a greater attraction in the way a subject is presented and carried out.

Some examples are the works of González and Pujolà (2021) and Pérez-López and Navarro-Mateos (2023a) developed in Spain. The former took advantage of the *Peking Express* television contest, including missions as a characteristic element of the programme for foreign language teaching and game-based learning as a methodology. Thanks to this, they managed to influence the motivation and learning of students, highlighting the potential of play in the educational context. The work of Pérez-López and Navarro-Mateos (2023a), called "*Este profe me suena*", was carried out in the Master's degree in teaching and was inspired by the Spanish well-known program "*Tu cara me suena*". It included the main roles that

appear in the contest (host, jury and contestants), and elements as the push button, combined with learning based on challenges. Students showed enormous satisfaction for the learning acquired through an approach of these characteristics, given its attractiveness and significance. In addition, in the international scientific literature, we find more proposals that, although they do not recreate the sensations and emotions of television programs as such, they use instead their potential to work with content from different subjects and reflect on current social issues (Black, 2001; Huilin and Hyangkeun, 2020; Klein, 2011; Wang, 2012).

## Gamification

In close relation to the previous section, and in regards with the importance of increasing motivation of students to favor their learning, in the last decade there has been a boom of gamification in the educational context (Dicheva et al., 2015; Subhash and Cudney, 2018). One of its main objectives, precisely, is to influence students' motivation in the teaching and learning process through different mechanics and elements of games and video games and, thus, achieve greater involvement in the learning process (Kapp, 2012). In fact, the different theories that support their inclusion in the educational context are based on a positive relationship between gamification and learning outcomes (Landers, 2014; Sailer and Homner, 2020).

In many cases, the concept of gamification has been mistakenly associated with the use of three very characteristic elements of video games: points, badges and leaderboards (PBL). In the educational field, gamification cannot be limited to the extrinsic component, since it is intended to achieve transcendent objectives that go beyond the exclusive use of rewards (Kapp, 2012; Pérez-López and Navarro-Mateos, 2022a; Zichermann and Cunningham, 2011). That is why other aspects should be included such as, for example, a narrative, challenges and missions, or the actions and emotions characteristic of the thematic universe selected to make the most of the full potential of gamification in the classroom (Marczewski, 2018; Pérez-López and Navarro-Mateos, 2023b).

Gamification can be carried out under a formative approach or a experiential one, but this does not mean that in any of the approaches is dispensed with what characterizes the other (Pérez-López and Navarro-Mateos, 2022b). In postgraduate education, the emphasis should undoubtedly be placed more on the formative approach, giving students

the opportunity to consolidate and build on the learning acquired previously in their undergraduate studies. Further, we talk about a profile of students with a higher level of competence, and it is highly recommended that they become aware that they are the main responsible for achieving quality training. As the authors point out, the approach of a television format (or talent show), with a more sequenced approach and closed structure and design beforehand, can be a good option for postgraduate students (Pérez-López and Navarro-Mateos, 2022b). In fact, this circumstance is not incompatible with uncertainty, curiosity and surprise, key aspects in the training processes to achieve significant learning (Domínguez-Márquez, 2019; Mora, 2017; Oudeyer et al., 2016). In addition, the performance of the participants will determine "their continuity in the (television) program", testing the commitment to their training and the development of core competencies for their future work performance.

#### Contextualization

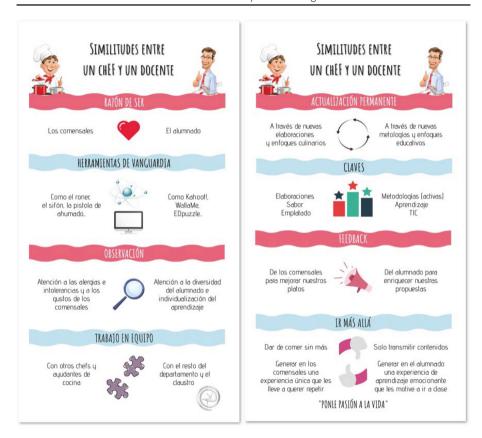
The present proposal was developed in a course of the specific module *Learning and Teaching of Physical Education*, of the University Master in Teaching in Compulsory Secondary Education and Baccalaureate, Vocational Training and Language Teaching (in the specialty of PE-Physical Education-) of the University of Granada (Spain). It involved 29 students (4 girls and 25 boys), and had a teaching load of 12 credits. The main objectives or learning outcomes of this course are:

- Knowing and analyzing the curricular elements, establishing correspondences between them and evaluating the suitability of these.
- To know and use the basic concepts of the didactic of PE to make a global analysis of the teaching and learning processes.
- Plan a school educational program in PE from a critical perspective, assessing its suitability and making modifications consistent with the aims of education.
- To acquire teaching skills for the future development of their professional work.

## **Proposal description**

A proposal was made with gamification and active methodologies as a reference, so that the students had the leading role. The popular television contest called *Masterchef* was used, given the great impact of this show, and adapted to the educational field. In fact, after a first analysis of its main elements and structure, it was possible to see the enormous potential it had in this regard, as shown in Figure I.

FIGURE I. Similarities between the world of culinary and teaching



Source: Compiled by author.

During the whole experience, students were made to feel like the contestants of the program, recreating the emotions and feelings of the participants in each challenge they had to face (emotions management, time pressure, teamwork or creative approach), and transferring all of it to the future reality of a PE teacher.

The teacher (chEF -EF is from Educacion Fisica in Spanish, Physical Education in English-) was in charge of presenting the different contest tests, as in the original program, and presenting weekly the "ingredients" (formative contents) with which the contestants had to elaborate the "dishes" (challenges) that must meet different standards characteristic of the culinary field: "flavor" (degree of compliance with the objectives set), "logic of the dish" (coherence between the contents presented) and "plate up" (format in which it was presented).

The three classes a week (Monday, Wednesday and Thursday) were used to recreate the structure of the original program, maintaining the three tests that characterize *Masterchef*:

- Individual test (on Mondays): the contestants had different "ingredients" to use in their "dish", either in some concrete way or in a free way. In this test the most outstanding candidates were chosen, becoming the captains of the team event.
- Team test (on Wednesdays): the captains chose the members of their teams and the "menu" (a combination of different challenges) they preferred to perform. The challenge was to work as a team in an organized way to get all the "dishes" out in time. Teams that got the worst feedback faced the elimination test (happening on Thursdays).
- Proof of "elimination" (on Thursdays): the contestants who stood out the day before had to perform individually the challenge that the jury had prepared for that day. Those responsible for the "dishes" that did not meet the established criteria were no longer eligible to win the title of *MasterchEF Granada* (unless they managed to stand out in the retake of the penultimate week of the contest). However, all of them continued to participate in the tests and challenges of each week, acquiring the same learning as the rest of the peers.

One of the key aspects to making the experience more immersive and credible was the care of small details and language. In this sense, the characteristic objects of the program (figure II) were used, such as the logo, the mysterious box, the clock that marks the cooking time or the immunity pin, as well as the white aprons of the contestants (and black for the elimination test).

FIGURE II. Example of elements included to increase immersion and credibility



Source: Compiled by author.

Each week the challenges were built around one or several "ingredients", as detailed below:

- Week 1. Presentation and class climate.
- Week 2. Educational legislation and planning in PE.
- Week 3. Value of PE and profile of a good teacher.

- Week 4. Active methodologies and importance of communication skills.
- Weeks 5 and 6. Teaching intervention through practical sessions in PE.
- Week 7. Game-based learning and play point.
- Week 8. Evaluation, escape room and gamification.
- Week 9. Creative cooking (developing creativity in education), serious games and retake test.
- Week 10. Semifinal and final.

#### Method

The work has been framed within the interpretive paradigm (Denzin, 2010; Denzin and Lincoln, 2012; Silverman, 2001). A qualitative methodology has been used, and a phenomenological study was performed to understand the experience lived in all its complexity (Fuster, 2019; Van Manen, 2017). We aimed to have a vision of the feelings, perceptions and experiences of the participants involved in the project. The analysis aims to know and understand the perceptions that students have of the teaching role in a proposal of gamification. Therefore, the objectives of this work are:

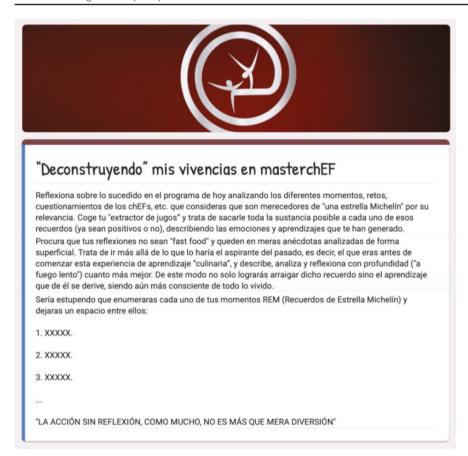
- To describe the structure and main elements of a gamification project developed in the Master of teaching, and inspired by the *Masterchef* cooking television program.
- To analyze and interpret the testimonies that students made throughout the proposal with respect to the performance of the teacher, identifying the aspects that had the most impact on them.

The production of information has been done through the testimonies that the students made throughout the experience (Biglia and Bonet-Martí, 2009). The aim was to understand the depth and transcendence of the teaching-learning process (Bolívar et al., 2001). The information production technique involved the testimonies collected through a questionnaire with an open question on *Google Drive*. Through this questionnaire they shared, voluntarily and anonymously, their main

experiences and perceptions, learning, emotions and other aspects (figure III). A total of 265 testimonies were collected at the end of the project. By having the date of realization, this allowed us to classify the contributions of the students in three moments, relating them with the culinary field:

Starters": first contact with the narrative and structure of the sessions (week 1).

#### FIGURE III. Google Drive open question header



Source: Compiled by author.

- "Main course": work of the different contents and competences of the course, and phase of practical PE sessions (from week 2 to week 8).
- "Dessert": presentation of different products (a board game on contents of the subject of PE and a teaching unit with innovative approach) that happened the same weeks of the semifinal and final of the contest (week 9 and week 10).

The analysis were performed using the *NVivo* software, by a thematic and categorical analysis (Bernard and Ryan, 2010; Mieles-Barrera et al., 2012; Vaismoradi et al., 2013), which used the initial word frequency to find the key categories (and their corresponding subcategories) derived from the participants' speech.

Ethics in research was guaranteed by an informed consent approved by the ethics committee of the University of Granada, which guaranteed the confidentiality and anonymity of the participants. At the time of writing the results, the names of the students have been replaced by those of Spanish reference chefs to not reveal the identity of the students.

## **Results**

First of all, we should highlight the enormous volume of testimonies that talk about the teaching role, being the most referred category, ahead of some with enormous formative value as "Learning" or "Emotions". This aspect is of great relevance, because it makes us see the impact that the teacher has in a proposal of gamification. Therefore, we will analyze what characteristics and competencies the students highlight about the teacher role, and the impact that it could have on the degree of use of the proposal, as well as the value that they give to its future professional work.

The starting point will be a hierarchical map, to compare the subcategories related to the teaching role according to the number of references of each of them (figure IV).

As we can see in figure IV, the "Demanding" is the subcategory to which students most allude, with a total of 95 coding references. In them, the participants highlighted the high intensity and demand of the format, and the fact that the teacher does not agree with the minimum necessary from students but makes them go further to get their best version.

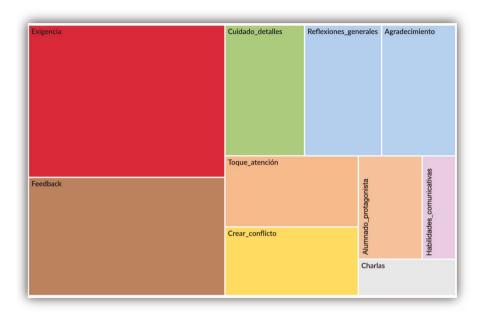


FIGURE IV. Hierarchical map of the subcategories that make up "Teaching role"

Source: Compiled by author.

This idea can be seen in the testimony shared by Eneko Atxa, as it reflects on the teaching role and its impact on the degree of achievement of student achievements: "The chEF is very tight and even if you think you have it, he is always able to find something to improve. Without this requirement, it is true that we would have never improved as we did in this subject" (testimony 132). We also find another fragment in which Pedro Subijana reflects on the way a good educator should act, linking it directly with the teacher's demanding profile:

I believe that squeezing your students within the particular conditions, which the teacher must know, is part of the work of a good educator. Take them to the frontier of their possibilities and once there, they will be able to cross it (testimony 115).

In this line, Valenzuela-Carreño (2007) points out that reducing the level of demand from the teacher would cause a misperception of the

value of the effort in academic achievement. In addition, in this context, it will be essential to develop strategies that allow for a coherent response to the needs of the environment. Thus, being able to activate suitable skills to meet the requirements posed at the training level for their subsequent professional transfer (López-Aguilar et al., 2022).

On the other hand, it is interesting to see how this demanding spirit posed by the teacher ends up becoming a requirement towards the students, prioritizing the formative component to the narrative/experiential. All this can be seen in the fragment of Martin Berasategui, in which her degree of critical awareness regarding his own performance is revealed:

I was not among the candidates for elimination, but I was still not happy with myself. When the candidates wearing the black apron (those for elimination) started working, I decided to join them and voluntarily perform the work alongside them. I wanted to take advantage of that day and relieve myself from the thoughts that I might not have deserved to be among the participants saved that week (testimony 20).

This approach that many of the participants had is very meritorious, because it is opposite to the dynamic to which they are accustomed (and whose formula worked for them for years), as perfectly expressed by Elena Arzak, «I'm not saying it can't be done, because then you can find time for everything, but it is just that we're not used to being demanded that much. We are used to being given everything done or do things by the path of least resistance» (testimony 188). To be under that demand leads them to discover what they are capable of, and to leave the comfort to which they are accustomed, as is the case of Joan Roca: «these challenges are very hard psychologically and make you see that you can work much more than we believe» (testimony 74).

The second subcategory that stands out is that of "Feedback", with a total of 74 references. The students emphasize how necessary it is for their formative process to make them see certain things that they were not aware of at first, although it was not always easy to assimilate because, as Eva Arguiñano says, «finally, I wanted to add that all this reflection has been enriched thanks to the feedback that our chEF always gives us, which however hard it is, I do not change it for anything» (testimony 145).

They also mention how important it is to point out individual and group progress, as this recognition motivates them to continue working

even more. In fact, the sense of progress is considered one of the fundamental motivators in the educational field (Hailikari et al., 2016) and also in gamification (Kapp 2012; Marczewski, 2018), connecting with the concept of competence from the theory of self-determination (Ryan and Deci, 2000). When a person feels that the proposed challenge is achievable (and not too easy) he improves his skill levels with its execution, allowing him to face even greater challenges. This concept is also related to the flow concept (flow channel) because when you have a clear and immediate feedback, and the level of difficulty of a challenge is properly balance with the competence of the person, you can get into that optimal work area (Csikszentmihalyi, 2000), and connect with intrinsic motivation (Mehta and Vyas, 2022). The testimony of Paco Roncero collected the essence of these ideas as he received the pin recognition of immunity for his good work during the holidays, since he voluntarily worked on the "dishes" that he had not "prepared" properly during the contest: "The chefs have taken into consideration the work I have done during Christmas and the evolution I have had since day one. I felt proud, fulfilled, happy with what I have managed to cook from my harvest...» (testimony 98).

Thirdly, the category "Care of details" should be highlighted, with 33 references. In the testimonies from this category, the participants focus on all the work behind each program: use of language and characteristic objects, adaptation of the main events of the contest, presentation of the ingredients, etc. These details make the difference, as expressed by Carme Ruscalleda «... our chefs did not hesitate to dress up with our soundtrack, and as they said, any excuse is good to show their involvement in this experience, every little detail counts and that is transmitted<sup>»</sup> (testimony 6). In this sense, when a proposal inspired by an audiovisual reference is made, making the greatest number of similarities and nods to the original reference increases immersion and credibility (Navarro-Mateos and Pérez-López, 2022; Pérez-López and Navarro-Mateos, 2019), and participants like José Andrés value them enormously: «The chef presents the dishes, David Muñoz and I looked to each other, and we love it, this is Masterchef 100%. Further, it is the winner of the previous test the one who distributes the dishes, this is incredible!» (testimony 35).

Students also value the effort required to plan and execute such a project, wanting to reciprocate. This concern is present in many testimonies, highlighting that of Vicky Sevilla: «I do not like to think that

after all the effort, the desire and the time that our chefs dedicate to us, they feel disappointed with us, unmotivated or sad» (testimony 196).

Table I presents the matrix with the subcategories and the corresponding temporal moments ("starters", "main course" or "dessert"), to analyze their evolution throughout the gamification project.

It can be seen how in the "starters" the degree of demand from the teacher stands out, because in that first week they were given enormous emphasis on how important it would be for them to take advantage of this specific training that preceded their teaching work. Thus, we were clear with the approach of the proposal and we also clarify that, for us, this was the best way for them to grow at the formative and personal level. A summary of the above is found in the testimony of Dani García:

From the beginning we could observe the degree of demand from the teacher, and more after not sending the first homework. Undoubtedly, this first class helped me to assimilate what a real job is and what it entails, involvement and effort, but I also know that the satisfaction of doing things well will come, even more after feeling not ok with myself that, which encourages me to excel every day (testimony 30).

TABLE I. Results of the guery matrix in relation to temporal moments

	Entrante	Plato_principal	Postre
Agradecimiento	2	19	10
Alumnado_protagonista	7	8	6
Charlas	2	8	1
Crear_conflicto	4	24	1
Cuidado_detalles	8	20	5
Exigencia	25	59	11
Feedback	8	58	8
General_reflexiones	2	11	19
Hab_comunicativas	0	10	1
Toque_atención	10	19	1
Total	68	236	63

Source: Compiled by author.

All this was connected in a coherent way with the degree of demand that characterizes the *Masterchef* competition. To recreate the sensations and emotions of the program, a fundamental aspect in gamification (Pérez-López and Navarro-Mateos, 2019), characteristic elements such as the clock that marks the time of cooking were included. In regards to this, Ángel León says that it made them have to manage multiple emotions, a fundamental competence as a future teacher: «Again this day the degree of uncertainty was similar to that of demand. My feeling towards the task posed was initially of enough tension and stress, since we had to work against the clock» (testimony 31).

In regards with the "starters" it is also necessary to mention the subcategory "Wake-up call" because during the first week, the chEF devoted special attention to awareness. The various reflections were directed towards the necessary competences as future teachers and to the deficiencies that each student detected in regards with them, which generated the need to improve their training. In addition, the presentation of the first "ingredients" (such as those related to legislative aspects), which were the common basis of all "dishes", made participants like Pepe Rodríguez reflect the following:

I have realized that I have no idea of almost anything related to legislation and it is very important for the teaching work, so it is an area in which I have to go much deeper and I must get up to date (testimony 29).

A noteworthy aspect is the ability of the teacher to tell students off when necessary and instead of reducing their involvement, it motivates them to action. In fact, the students are very aware of it and, by living it in the first person, it helps them to be aware of its value and to extrapolate it to their future work, since «... even if you scold us, you motivate us to do things better and demand the maximum. It is something that I would like to be able to do myself, that is to say to tell my future students off at the same time that I motivate them. Here is an objective» (Susi Díaz, testimony 37). Something like this would be complex to achieve if a good classroom climate had not been previously built. An example of this is what Jordi Roca shares: «This reflects how important the climate of a classroom is to favor an emotional and sensitive environment, also trust and comfort, which also encourages participation as has been clearly demonstrated» (testimony 2). There is no doubt that if the teacher is in

a bad mood, it creates a tense work environment, in which the students are afraid to participate and if, on the contrary, the teacher is close and motivates them to learn with effort and dedication, the predisposition that will generate in the students will be completely different (Peña and Wandosell, 2015).

With respect to the "main course", the "Demand" stands out in a remarkable way, together with the "Feedback". During these weeks, topics and skills directly related to their professional work were addressed, such as planning in PE, active methodologies, the teaching intervention guidelines to be taken into account in the practical sessions or different evaluation instruments. At all times we tried to squeeze the full potential of the contestants, being very aware of it Andoni Luis Aduriz «... all teams were working in a good way today so I wanted to see our nomination as a favor for ourselves. Perhaps the chEF wanted to force our group to get something different from us next time. Honestly, he got this» (testimony 102).

In fact, in a large number of references related to "Demand" and "Feedback", the contestants are the ones who directly assume the responsibility and consequences of their decisions, denoting a high level of maturity. A good example of this is the story shared by Karlos Arguiñano: «I arrived nervous because I was not able to send my homeworks to the chEF in time, so again I thank you chEF for doing what you thought was right» (testimony 119). In fact, another gesture that denotes enormous maturity is shown by Alberto Chicote, because he is able to understand that giving the best version of oneself is a gesture of generosity, since «that the fact that level is high makes us all improve more, because we cannot relax but give our best instead» (testimony 149).

Finally, in the "main course" the subcategory "Create conflict" is analyzed, understood as that cognitive flexibility that is required to adapt to new circumstances (Diamond, 2013). This is a basic competence for teachers in training, because tomorrow they will have to be able to adapt to the requirements of complex and changing situations (Mamani-Ruiz, 2017; Savchuk et al., 2020). For this purpose they were tested in the different "cooking", breaking the schemes so that they trained their resilience and were able to react to unexpected situations. An example of a test in which it was carried out is narrated by Quique Dacosta: «Four captains were appointed (I was one of them) to prepare the dishes of the next day, forming groups in which a surprise arose, rotating of group» (testimony 111). Fina Puigdevall delves into the emotions and sensations that this change of groups generated in the captains:

I love that unexpected things like this happen, that force us to change and adapt from one moment to another. Above all, the place of the captains had to be even weirder, since I'm sure they were thinking who to choose and why, and suddenly... they ran into a new team, composed of members whom they had not chosen (testimony 121).

We arrived at the final part: the "dessert". In this part the "Demand" subcategory remains present, a constant throughout the proposal. The subcategory with the most references in this case is that of "General reflections". In it the participants took stock of the experience, shared their feelings and summarized their perception with respect to the experience and the teacher. Some people pointed out that it was an unforgettable experience, not only because of what was lived, but because of the applicability of the resources learned, as Toño Pérez says: «It is not a common subject you have in college. It has been a process that will never be forgotten and I hope that in my days as a teacher, if I ever arrive, I will use all the resources learned» (testimony 253). In addition, in this last phase the gratitude to the teacher was constant, as can be seen in figure V.

FIGURE V. Word cloud that make up the dessert of the category "Teaching role"



Source: Compiled by author.

To conclude and, in order to connect with the ideas discussed in the introduction, a fragment is shared in which Ferran Adrià extracts the *MasterchEF* juice and the essence of the teaching-learning process:

I would like to highlight that of which is talked up so much, the one-toone correspondence, which is to establish a symbiotic relationship in the teaching-learning process of a student, so that a synergy is formulated between teacher and student. This teaching and therefore learning must be reciprocal and bidirectional (testimony 115).

### **Conclusions**

In this article we have described the main aspects to take into account when adapting a talent show, specifically, the Masterchef television program, to the training of future teachers in the Master's degree in teaching. To recreate the essence of the contest and, therefore, generate sensations and emotions similar to those experienced by the participants of the original program, it will be essential to include the structure, language and characteristic objects. At the same time, the perceptions and assessments of the participating students on the role of the teacher in the proposal have been shown. The three fundamental aspects that stood out from him were: the demand, the feedback and the care of details. These "ingredients" together with others such as, for example, the transfer of learning to their future teaching work or the students leading role, characteristic of active methodologies, had an impact on the development of their skills and the degree of acquisition of the contents of the course. Therefore, the role of teachers is a differentiating element in this type of approach, fostering a greater degree of involvement of students and satisfaction with the proposal.

With regard to future lines of research, it would be interesting to analyze the impact of the teacher in a proposal built on a PBL system, to see if its incidence would be greater, or not, than in an approach such as the one described here. Another possibility would be to make the comparison using, instead of a television program, a film reference (television series or films), given the great significance they also have for today's young people.

### **Acknowledgements**

This research has been carried out thanks to a pre-doctoral contract from the Junta de Andalucía.

### **Bibliographical references**

- Albornoz, L., & García, M. T. (2022). Netflix Originals in Spain: Challenging diversity. *European Journal of Communication*, *37*(1), 63-81. https://doi.org/10.1177/02673231211012174
- Alonso-Sainz, T. (2021). ¿Qué caracteriza a un" buen docente"? Percepciones de sus protagonistas. *Profesorado, revista de currículum y formación del profesorado*, *25*(2), 165-191. https://doi.org/10.30827/profesorado.v25i2.18445
- Andrade H. L., & Brookhart S. M. (2020). Classroom assessment as the co-regulation of learning. *Assessment in Education: Principles, Policy & Practice*, *27*(4), 350–372. https://doi.org/10.1080/096959 4X.2019.1571992
- Arufe-Giráldez, V. (2019): Experiencia didáctica de una adaptación de tres famosos programas de TV: First Dates, MásterChef y Pekín Express al aula universitaria. In E. De la Torre Fernández (Ed.), *Contextos universitarios transformadores: construíndo espazos de aprendizaxe* (pág. 99-116). Universidad de A Coruña.
- Bernard, H. R., & Ryan, G. W. (2010). El análisis de datos cualitativos: enfoques sistemáticos. In *Analyzing qualitative data: Systematic approaches* (pp. 3–16). SAGE Publications.
- Biglia, B., & Bonet-Martí, J. (2009). La construcción de narrativas como método de investigación psico- social. Prácticas de escritura compartida. *Forum: Qualitative Social Research*, *10*(1). https://www.qualitative-research.net/index.php/fqs/article/download/1225/2665?inline=1
- Black, C. (2001). Un gars, une fille: plaidoyer pour la culture avec un 'petit c'dans un cours de français langue étrangère. *Canadian modern language review*, *57*(4), 628-639. https://doi.org/10.3138/cmlr.57.4.628
- Bolívar, A., Domingo, J., & Fernández, M. (2001). *La investigación biográfico-narrativa. Enfoque y metodología*. La Muralla.

- Cortés-Quesada, J. A., Barceló-Ugarte, T., & Fuentes-Cortina, G. (2022). Estudio sobre el consumo audiovisual de la Generación Z en España. *Fonseca, Journal of Communication*, *24*(18), 19-32. http://hdl.handle.net/10366/150230
- Csikszentmihalyi, M. (2000). *Beyond boredom and anxiety*. Jossey-Bass. Denzin,N.K.(2010).Moments,mixedmethods,andparadigmdialogs. *Qualitative Inquiry*, *16*(6), 419–427. https://doi.org/10.1177/1077800410364608
- Denzin, N. K., & Lincoln, Y. S. (2012). Introducción general. La investigación cualitativa como disciplina y como práctica. In N. K. Denzin & Y. S. Lincoln (Eds.), *El campo de la investigación cualitativa* (Vol. I, pp. 43–116). Gedisa.
- Diamond, A. (2013). Executive functions. *Annual review of psychology*, 64, 135-168. https://doi.org/10.1146/annurev-psych-113011-143750
- Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Journal of educational technology & society*, *18*(3), 75-88. https://www.jstor.org/stable/jeductechsoci.18.3.75
- Domínguez-Márquez, M. (2019). Neuroeducación: elemento para potenciar el aprendizaje en las aulas del siglo XXI. *Educación y ciencia*, 8(52), 66-76.
- Frenzel, A. C., Goetz, T., Lüdtke, O., Pekrun, R., & Sutton, R. E. (2009). Emotional Transmission in the Classroom: Exploring the Relationship Between Teacher and Student Enjoyment. *Journal of Educational Psychology*, 101(3), 705-716. https://doi.org/10.1037/a0014695
- Fuster, D. E. (2019). Investigación cualitativa: Método fenomenológico hermenéutico. *Propósitos y Representaciones*, 7(1), 201–229. https://doi.org/10.20511/pyr2019.v7n1.267
- González, V., & Pujolà, J. T. (2021). Del juego a la gamificación: una exploración de las experiencias lúdicas de profesores de lenguas extranjeras. In F. J. Hinojo, S. V. Arias, M. N. Campos & S. Pozo (Eds.), *Innovación e investigación educativa para la formación docente*. (pp. 398-412). Dykinson S.L.
- González-Castro, I., Vázquez-García, M. A., & Zavala-Guirado, M. A. (2021). La desmotivación y su relación con factores académicos y psicosociales de estudiantes universitarios. *Revista Digital de Investigación en Docencia Universitaria*, 15(2). https://doi.org/10.19083/ridu.2021.1392

- Guerrero-Pérez, E. (2018). La fuga de los millennials de la televisión lineal. *Revista Latina de Comunicación Social*, 73, 1231-1246. https://doi.org/10.4185/RLCS-2018-1304
- Hailikari, T., Kordts-Freudinger, R., & Postareff, L. (2016). Feel the Progress: Second-Year Students' Reflections on Their First-Year Experience. *International Journal of Higher Education*, *5*(3), 79-90. https://doi.org/10.5430/ijhe.v5n3p79
- Hernández, R. M., Orrego, R., & Quiñones, S. (2018). Nuevas formas de aprender: La formación docente frente al uso de las TIC. *Propósitos y representaciones*, *6*(2), 671-685. https://doi.org/10.20511/pyr2018. v6n2.248
- Huilin, Z., & Hyangkeun, S. (2020). A Study on the Self-directed Learning Using TV Shows-Focusing on Education for Korean Culture in Universities of China. *Journal of the International Network for Korean Language and Culture*, 12(1), 283-308. https://www.earticle.net/Article/A373650
- Kapp, K. M. (2012). The gamification of learning and instruction: game-based methods and strategies for training and education. John Wiley & Sons.
- Klein, B. (2011). Entertaining ideas: Social issues in entertainment television. *Media, Culture & Society*, *33*(6), 905-921. https://doi.org/10.1177/0163443711411008
- Landers, R. N. (2014). Developing a theory of gamified learning: linking serious games and gamification of learning. *Simulation & Gaming*, 45(6), 752–768. https://doi.org/10.1177/1046878114563660
- Liu, H. (march of 2018). Reflections on Teaching Role Transformation of University Teachers in the New Period. In *2nd International Conference on Culture, Education and Economic Development of Modern Society (ICCESE 2018)* (pp. 53-55). Atlantis Press.
- López-Aguilar, D., Álvarez-Pérez, P. R., & Ravelo-González, Y. (2022). Capacidad de adaptabilidad e intención de abandono académico en estudiantes universitarios. *Revista de Investigación Educativa*, 40(1), 237-255. https://doi.org/10.6018/rie.463811
- Mamani-Ruiz, T. H. (2017). Efecto de la adaptabilidad en el rendimiento académico. *Educación Superior*, *2*(1), 38-44. http://www.scielo.org. bo/scielo.php?script=sci\_arttext&pid=S2518-82832017000100004&lng=es&tlng=es.
- Marczewski, A. (2018). Even Ninja Monkeys like to play. Unicorn Edition. Gamified UK.

- Marín, M., Martínez-Pecino, R., Troyano, Y., & Teruel, P. (2011). Student perspectives on the university professor role. *Social Behavior and Personality: an international journal*, *39*(4), 491-496. https://doi.org/10.2224/sbp.2011.39.4.491
- Mehta, P., & Vyas, M. (2022). A Systematic Literature Review on the Experience of Flow and its Relation to Intrinsic Motivation in Students. *Indian Journal of Positive Psychology*, *13*(3), 299-304. https://www.proquest.com/scholarly-journals/systematic-literature-review-on-experience-flow/docview/2723857415/se-2
- Mieles-Barrera, M. D., Tonon, G., & Alvarado, S. V. (2012). Investigación cualitativa: elanálisis temático para el tratamiento de la información desde el enfoque de la fenomenología social. *Universitas Humanística*, 74, 195–226. http://www.scielo.org.co/scielo.php?script=sci\_arttext&pid= S0120-48072012000200010&lng=en&tlng=es.
- Mora, F. (2017). Neuroeducación: Solo se puede aprender aquello que se ama. Editorial Alianza.
- Navarro-Mateos, C., & Pérez-López, I. J. (2022). A phone app as an enhancer of students' motivation in a gamification experience in a university context. *Alteridad. Revista de Educación*, 17(1), 64-74.
- Navarro-Robles, M., & Vázquez-Barrio, T. (2020). El consumo audiovisual de la Generación Z. El predominio del vídeo online sobre la televisión tradicional. *Ámbitos: Revista internacional de comunicación*, *50*, 10-30. https://doi.org/10.12795/Ambitos.2020.i50.02
- Okada, R. (2023). Effects of Perceived Autonomy Support on Academic Achievement and Motivation Among Higher Education Students: A Meta-Analysis. *Japanese Psychological Research*, 65(3), 230-242. https://doi.org/10.1111/jpr.12380
- Orón, J. V., & Blasco, M. (2018). Revealing the hidden curriculum in higher education. *Studies in Philosophy and Education*, 37, 481-498. https://doi.org/10.1007/s11217-018-9608-5
- Oudeyer, P. Y., Gottlieb, J., & Lopes, M. (2016). Intrinsic motivation, curiosity, and learning: theory and applications in educational technologies. *Progress in brain research*, 229, 257-284. https://doi.org/10.1016/bs.pbr.2016.05.005
- Peña, B., & Wandosell, G. (2015). The Emotional Leadership of Managers Applied to University Teaching Role. In *2015 International Conference on Education Reform and Modern Management* (pp. 128-130). Atlantis Press.

- Pérez-López, I. J., & Navarro-Mateos, C. (2019). *Gamificción*: qué, cómo y por qué. Un relato basado en hechos reales. In 15° Congreso Internacional de Ciencias del Deporte y la Salud (pp. 108-119). Sportis.
- Pérez-López, I. J., & Navarro-Mateos, C. (2022a). *Gamificación*: lo que es no es siempre lo que ves. *Sinéctica*, 59. https://doi.org/10.31391/S2007-7033(2022)0059-002
- Pérez López, I. J., & Navarro Mateos, C. (2022b). *Gamificar* en tiempos revueltos. *Tándem: didáctica de la educación física*, 76, 60-68. https://hdl.handle.net/11162/235951
- Pérez-López, I. J., & Navarro-Mateos, C. (2023a). "Ese profe me suena": una experiencia de innovación docente en el Máster de Profesorado. In *Educar para transformar: Innovación pedagógica, calidad y TIC en contextos formativos* (pp. 2015-2021). Dykinson.
- Pérez-López, I. J., & Navarro-Mateos, C. (2023b). Guía para gamificar. Construye tu propia aventura. Copideporte S.L.
- Pires, F. (2021). The Wheel of Competencies to Enhance Student-Teacher Role Awareness in Teaching-Learning Processes: The Use of a Classical Coaching Tool in Education. In Z-Hunaiti (Ed.), *Coaching Applications and Effectiveness in Higher Education* (pp. 48-77). IGI Global.
- Poulou, M. (2014). The effects on students' emotional and behavioural difficulties of teacher–student interactions, students' social skills and classroom context. *British Educational Research Journal*, 40(6), 986-1004. https://doi.org/10.1002/berj.3131
- Reeve, J. (2006). Teachers as Facilitators: What Autonomy-Supportive Teachers Do and Why Their Students Benefit. *The elementary school journal*, 106(3), 225-236. https://doi.org/10.1086/501484
- Robbins, S. B., Lauver, K., Le, H., Davis, D., Langley, R., & Carlstrom, A. (2004). Do Psychosocial and Study Skill Factors Predict College Outcomes? A Meta-Analysis. *Psychological Bulletin*, *130*(2), 261–288. https://doi.org/10.1037/0033-2909.130.2.261
- Rodríguez-Pérez, N. (2012). Causas que intervienen en la motivación del alumno en la enseñanza aprendizaje de idiomas: el pensamiento del profesor. *Didáctica, Lengua y Literatura*, 24, 381-409. https://doi.org/10.5209/rev\_DIDA.2012.v24.39932
- Ryan, R., & Deci, E. L. (2000). La Teoría de la Autodeterminación y la Facilitación de la Motivación Intrínseca, el Desarrollo Social, y el Bienestar. *American psychologist*, *55*(1), 68-78.

- Sailer, M., & Homner, L. (2020). The gamification of learning: A metaanalysis. *Educational Psychology Review*, *32*(1), 77-112. https://doi. org/10.1007/s10648-019-09498-w
- Savchuk, B., Kondur, O., Rozlutska, G., Kohanovska, O., Matishak, M., & Bilavych, H. (2020). Formation of cognitive flexibility as a basic competence of the future teachers' multicultural personality. *Space and Culture, India*, 8(3), 48-57. https://doi.org/10.20896/saci.vi0.1016
- Silverman, D. (2001). *Interpreting Qualitative Data*. SAGE Publications. Subhash, S., & Cudney, E. A. (2018). Gamified learning in higher education:
- A systematic review of the literature. *Computers in human behavior*, 87, 192-206. https://doi.org/10.1016/j.chb.2018.05.028
- Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, *15*(3), 398–405. https://doi.org/10.1111/nhs.12048
- Valenzuela, J., Muñoz-Valenzuela, C., Silva-Peña, I., Gómez-Nocetti, V., & Precht-Gandarillas, A. (2015). Motivación escolar: Claves para la formación motivacional de futuros docentes. *Estudios pedagógicos (Valdivia)*, 41(1), 351-361. https://doi.org/10.4067/S0718-07052015000100021
- Valenzuela-Carreño, J. (2007). Exigencia académica y atribución causal: ¿qué pasa con la atribución al esfuerzo cuando hay una baja significativa en la exigencia académica? *Educere*, *11*(37), 283-287. http://ve.scielo.org/scielo.php?script=sci\_arttext&pid=S1316-49102007000200014&ln g=es&tlng=es.
- Van Laer S., & Elen J. (2017). In search of attributes that support self-regulation in blended learning environments. *Education and Information Technologies*, 22(4), 1395–1454. https://doi.org/10.1007/s10639-016-9505-x
- Van Manen, M. (2017). But Is It Phenomenology? *Qualitative Health Research*, 27(6), 775–779. https://doi.org/10.1177/1049732317699570
- Wang, D. (2012). Self-directed English Language Learning Through Watching English Television Drama in China. *Studies in Culture and Education*, 19(3), 339-348. https://doi.org/10.1080/135868 4X.2012.704584
- Wubbels, T. (2005). Student perceptions of teacher-student relationships in class. *International Journal of Educational Research*, 43(1-2), 1-5. https://doi.org/10.1016/j.ijer.2006.03.002

- Yoon, J. S. (2002). Teacher characteristics as predictors of teacher-student relationships: Stress, negative affect, and self-efficacy. *Social Behavior and Personality: An international journal*, *30*(5), 485-494. https://doi.org/10.2224/sbp.2002.30.5.485
- Zichermann, G., & Cunningham, C. (2011). *Gamification by design*. O'Reilly.

**Contact address:** Carmen Navarro Mateos. Universidad de Granada. Facultad de Ciencias del Deporte. Departamento de Educación Física y Deportiva. Camino de Alfacar, 21, 18071 Granada. E-mail: carmenavarro@correo.ugr.es

# The Engineer: enhancing bachelor students' English technical engineering vocabulary proficiency with a serious video game

# The Engineer: mejora del dominio de vocabulario de ingeniería técnica en inglés entre estudiantes de grado mediante el uso de un videojuego serio

https://doi.org/10.4438/1988-592X-RE-2024-405-636

### Ricardo Casañ Pitarch

https://orcid.org/0000-0002-1689-7954 Universitat Politècnica de València

#### **Abstract**

Since the decade of 2010, the game-based approach has given rise to new research in education. The quick advance of technology has also helped to introduce more powerful and sophisticated devices and digital applications in the classroom. As a result, gamifying a subject with serious video games is a new rising trend in the educational sector. Therefore, this research is based on the use of a serious video game that has been developed with institutional support and it aims to reinforce a university bachelor's degree subject. The Engineer is a serious game designed to teach English for engineering and gives support to a textbook for the subject English B2 for Industrial Engineers at the Universitat Politècnica de València. This research aimed to measure the learners' acquisition of new engineering vocabulary in English after using the game and the associated textbook. In our experiment, 64 Industrial Engineering degree students were divided into an experimental group that used the game and textbook and a control group that only used the textbook. Both groups took a pre-test and a post-test to measure their knowledge of general and specific engineering vocabulary. Results showed that the use of the serious game increased the exposure time to the foreign language, leading to better results among the experimental group. Students in the experimental group also showed more satisfaction with the course. The study concludes that serious games can be an effective tool for language learning and teaching as it extends the time of exposure to the new content and it also motivates the students due to its playful component.

*Keywords:* The Engineer, serious video games, gamification, game-based learning, teaching english as a foreign language, language for specific purposes, industrial engineering.

#### Resumen

Desde la década de los 2010, el enfoque basado en el juego ha dado lugar a nuevas investigaciones en el campo de la educación. El rápido avance de la tecnología también ha ayudado a introducir dispositivos y aplicaciones digitales más potentes y sofisticadas en el aula. Como resultado, gamificar una asignatura con videojuegos serios es una nueva tendencia al alza en el sector educativo. Por lo tanto, esta investigación se basa en el uso de un videojuego serio que se ha desarrollado con apoyo institucional con el objetivo de reforzar una asignatura de grado universitario. The Engineer es un juego serio diseñado para enseñar inglés para ingeniería y ofrece apoyo a un libro de texto para la asignatura Inglés B2 para Ingenieros Industriales en la Universitat Politècnica de València. El objetivo de la investigación es medir la retención de los estudiantes del nuevo vocabulario sobre ingeniería en inglés después de usar el videojuego y el libro de texto asociado. En nuestro experimento, se dividieron 64 estudiantes de grado en Ingeniería Industrial en un grupo experimental que usó el juego y el libro de texto, y un grupo de control que solo usó el libro de texto. Ambos grupos realizaron una prueba previa y una posterior para medir su conocimiento del vocabulario de ingeniería general y específico. Los resultados mostraron que el uso del juego serio aumentó el tiempo de exposición al idioma extranjero, lo que llevó a mejores resultados entre el grupo experimental. Los estudiantes en el grupo experimental también mostraron más satisfacción con la asignatura. El estudio concluye que los juegos serios pueden ser una herramienta efectiva para el aprendizaje y la enseñanza de idiomas ya que extiende el tiempo de exposición al nuevo contenido y también motiva a los estudiantes debido a su componente lúdico.

Palabras clave: The Engineer, videojuegos serios, gamificación, aprendizaje basado en juegos, enseñanza del inglés como lengua extranjera, lengua para fines específicos, ingeniería industrial.

### Introduction

The use of video games for educational purposes in tertiary education is real. Some studies have proved that using video games to support the teaching of specific subjects is an effective pedagogical strategy. In the

field of foreign language teaching, some studies have previously focused on the development of language skills or the acquisition of new language forms and its effectiveness. Some examples are *Duolingo* (Loewen et al., 2019), *Guadalingo* (Casañ-Pitarch & Wang, 2022; Díaz-Bravo, 2019), *Her Story* (Lee, 2019), *ImmerseMe* (Casañ-Pitarch & Gong, 2021; He & Smith, 2019), *LyricsTraining* (Casañ-Pitarch, 2020; Yin, 2021), *Subtitle Legends* (Calvo-Ferrer & Belda-Medina, 2021), *The Conference Interpreter* (Calvo-Ferrer & Belda-Medina, 2015), *Twine* (Ford, 2016).

In this paper, *The Engineer*, a serious video game created to help students acquire new technical language forms, was implemented among Industrial Engineering bachelor's students; and whose results have been considered to measure its effectiveness. The objective of this research is to measure the effectiveness of the video game, which mainly aims at teaching professional industrial engineering English. To achieve our purpose, an experiment with industrial engineering students was carried out, in which the game was tested, and the students completed pre- and post-language tests to measure their progress within the development of the subject English B2 during the second term of the school year 2022-2023. The participants in the experiment were divided into two groups, an experimental group, and a control group.

The Engineer is played individually, and it is addressed to industrial engineering bachelor's students from Universitat Politècnica de València who are enrolled in the subject 'English B2'. The purpose of this subject is to help students with at least an English B1 level (CEFRL) to gain English B2 proficiency and learn specific language related to the professional field of industrial engineering. This video game is adhered to a teaching book called 'The Engineer: English Language for Industrial Engineering'. This book contains six lessons, which are the content of the subject 'English B2'. These lessons combine both general B2 English content and technical language for industrial engineers. In this sense, the video game mainly focuses on the technical language, which gives support to the book with additional activities in an immersive gamified environment.

Regarding the synopsis of the game, *The Engineer* introduces a recently graduated industrial engineer who aims at getting their first engineering job. The main character can be either male or female, and the gender choice is made at the beginning of the story. With the support of a labor consultancy from the university, the main character finds a job offer for an internship as an Industrial Engineer at the company *Albuferum*, located in the industrial city of *Fallas*. The language used in this company is

English, and the main character must do a series of tasks and complete six missions related to the industrial engineering profession.

The new employee is expected to learn by doing and get motivated with the inclusion of rewards and the personal satisfaction of learning. The exercises are related to the industrial engineering industry and based on puzzles, tests, fictional dialogues, search and use of objects, and other skill games. *The Engineer* offers an environment of linguistic immersion through functional language, reading comprehension, and the interaction of the protagonist with other computerized characters. The new knowledge is introduced in the teaching book and practiced along with the corresponding missions of the video game. The following image shows some extracts from the video game.

IMAGE I. Image extracted from The Engineer



Source: The Engineer.

### Literature Review

The dimension of this paper involves three fundamental terms that need to be defined: game-based learning, serious video games, and gamification. The ideas presented in this paper are based on the principles of game-based learning, which is an educational approach that uses video games and simulations as the primary tool for teaching and learning (Pivec, 2007; Tokac et al., 2019). The aim of game-based learning is to create an engaging learning experience that immerses students through gameplay mechanics, narratives, and other elements commonly found in video games (Kapp, 2017; Sailer, et al., 2017). As a result, the game-based approach pretends to make learning more interactive, enjoyable, and effective by leveraging the engagement and motivation that video games provide (Papastergiou, 2016; Sailer et al., 2017). This idea is related to the flow theory, which suggests that individuals are highly engaged and motivated when they are in a 'state of flow', where they are challenged but still able to accomplish their objectives.

According to Gee (2003), game-based learning offers a 'situated cognition' approach to learning, where learners are placed in a context that requires them to use specific knowledge and skills to solve problems and achieve goals. He argues that game-based learning is particularly effective for teaching complex systems, such as scientific or social issues, because it allows learners to explore and experiment with these systems in a safe and interactive environment. In addition to situated cognition and the flow theory, another theoretical principle related to game-based learning is constructivism, which suggests that game-based focuses on constructivism, a theoretical framework that highlights the importance of learners creating their own knowledge by actively exploring, experimenting, and reflecting about the world (De-Marcos et al., 2014; Squire, 2011).

After defining and explaining the main principles of game-based learning, this paper focuses on serious games and distinguishes them from conventional ones. In this sense, serious video games are designed with the goal of instructing a learner in particular knowledge or skills (Michael & Chen, 2005; Zyda, 2005; Ritterfeld et al., 2009). On the other hand, conventional games focus on entertainment, and learning is not primary (Casañ-Pitarch, 2022; Escribano, 2012). These games have gained significant popularity in foreign language learning as they provide an engaging and interactive method of language acquisition (Garris, Ahlers & Driskell, 2002). In contrast to traditional language learning techniques, such as textbooks or audio recordings, serious video games offer learners the opportunity to practice and apply their language skills in an immersive environment that is also enjoyable and engaging (Liu &

Zhang, 2017). Although the design and structure of serious video games for foreign language learning can vary, they frequently incorporate language learning content into gameplay mechanics, such as quests, puzzles, or challenges, and provide learners with feedback and rewards for their progress (Casañ-Pitarch, 2017a, 2022; Don & Wang, 2019). These games typically introduce immersive storylines and characters, which can help learners to connect emotionally with the language they are learning and stay motivated to continue playing (Liu & Zhang, 2017). One advantage of serious video games for language learning is their capacity to customize the learning experience for each learner (Arnab et al., 2013). These games can adjust the difficulty of the language content according to the learner's proficiency level, enabling them to progress at their own pace and feel a sense of achievement as they improve their language skills (Plass et al., 2013).

Among other benefits, serious video games provide learners with opportunities to practice real-world language skills (Prensky, 2003; Gee, 2003). These games can simulate real-life situations, such as ordering food in a restaurant or having a conversation with a native speaker, which can help learners to feel more confident and prepared when they encounter similar situations in real life. Serious video games can also provide learners with immediate feedback on their language skills, which is a valuable tool for improving language proficiency (Don & Wang, 2019; Pivec, 2007). This feedback can come in the form of corrective feedback on grammar or vocabulary, or positive reinforcement for correct answers or successful completion of a task. As a result, serious video games can be a valuable tool for foreign language learning, particularly for learners who are looking for a fun and engaging way to practice their language skills. By incorporating language learning content into game mechanics, providing immediate feedback and rewards, and simulating real-life language situations, serious video games can offer a unique and effective way for learners to improve their language proficiency.

For the interest of this paper, the third and last element that needs to be defined is gamification. We understand gamification as the process of transforming non-game content into educational games (Deterding et al., 2011; Werbach & Hunter, 2015). These games can be connected among them through a story or competition along which the learning flows (Casañ-Pitarch, 2017b; Edmond, 2011). The purpose of gamification is to increase learners' engagement and motivation by making non-game activities more game-like. Gamification often involves adding points, badges,

leaderboards, and other elements of game mechanics to non-game activities. In this sense, Deterding et al. (2011) argue that gamification is effective because it appeals to the intrinsic human desire to compete, achieve goals, and receive rewards. They suggest that gamification can be used to motivate learners to engage with material that might not be motivating for the students and also can reinforce learning by providing immediate feedback and rewards. In this sense, Kapp (2017) argues that gamification can help to create a more engaging and interactive learning experience. He suggests that gamification can be used to motivate learners to complete tasks, to foster collaboration and competition among learners, and to provide feedback and recognition for progress and achievement.

These ideas imply that the purpose of gamification is to motivate students. The process of gamification was explained by Robson et al. (2016) and then adapted by Casañ-Pitarch (2022). In these models, these authors explain how to transform non-game teaching material into gamified resources. This mechanism has been used in this research to transform the subject English B2 for industrial engineers into the serious video game *The Engineer*.

### Method

### **Participants**

This experiment included 64 participants. They were bachelor students of the Industrial Engineering degree at Universitat Politècnica de València and were taking the subject English B2. These students belong to two different groups, but they were taking the same subject. The experimental group was formed by 31 students, and the control group had 34 students.

### **Tools**

Regarding the tools utilized in this research, we used the video game *The Engineer* and the associated book *The Engineer: English Language for Industrial Engineering*. For the tests, there were 8 pre-tests and 8 post-tests, which were developed using Google Forms. The students started with a pre-test on General B2 English and another one on specific

language, and they ended the experiment with their two equivalent posttests. These tests contained 30 multiple-choice questions each.

The questions for the General B2 English test were extracted from the 'English Unlimited Placement Test' (Cambridge University Press, 2010). This test contains 120 multiple-choice questions and covers the language levels from A2 to C1. To simplify our test, we focused on the B2 and C1 level questions (60) and created two tests with 30 questions each. The first test introduced the odd numbers (i.e., 1, 3, 5), and the post-test used the even numbers (i.e., 2, 4, 6). The test for the specific language was self-created and included the elements studied in class. To equalize the level of the pre and post-tests, we selected pairs of language forms that were similar to each other, and each one was used in one of the tests.

The remaining tests corresponded to the six lessons covered with our material. There was a pre-test and an equivalent post-test with 15 questions for each of the six lessons. These questions focused on the language forms studied in each mission, including both general and specific English language.

### **Procedure**

The experiment consisted of teaching the same content to both the control group and the experimental group. The difference lay in the fact that the control group did not use the video game to reinforce their learning. The time for the lessons was the same for each group (30 hours), and while the experimental group played with the video game after completing the book lessons in class, the control group extended their practice with additional exercises similar to the ones done in class. The students were exposed to this material for six weeks, with two weekly sessions of two and a half hours each.

The students from both groups completed two pre-tests before the first lesson and two post-tests after the last lesson. One of the tests focused on General B2 English, and the other focused on the specific language forms studied in class. Both the book and the video game contained six missions/lessons. The students also completed a pre-test before each lesson and a post-test after completing the lesson and having practiced with the video game or having done the homework exercises. After completing the twelve lessons, the data was compiled and analyzed. The analysis

consisted of measuring and comparing the progress before and after the teaching hours, including the progress within each lesson.

### **Results**

The results of the experiment revealed that the experimental group made greater progress than the control group. Table I displays the performance of the experiment, including the pre- and post-test scores, the difference between their initial and final results, and the percentage variation to demonstrate their progress. Both groups exhibited progress in their posttests. From a general perspective, the participants in the experimental group made progress of 36.36% in the general B2 English test, 52.29% in the specific language test, and the average progress among the six units was 39.59%. Remarkably, the experimental group's most substantial progress was observed in the specific language test, at 52.29%, while the lowest progress occurred in the unit 4 test, at 31.11%. Conversely, the control group demonstrated progress of 26.52% in the general B2 English test, 33.24% in the specific language test, and the average progress among the six units was 24.87%. Unit 3 had the most significant progress in the control group, with 33.74%, whereas the lowest progress was recorded in unit 4, at 19.83%.

TABLE I. Experimental and control groups' general results

T4	Experimental Group			Control Group				
Test	Pre-T	Post-T	Dif.	<b>V</b> %	Pre-T.	Post-T.	Dif.	<b>V</b> %
General B2	16.39	22.35	5.96	36.36	16.48	20.85	4.37	26.52
Specific L.	17.19	26.23	9.04	52.59	17.15	22.85	5.7	33.24
Unit 1	16.13	22.45	6.32	39.18	15.76	19.88	4.12	26.14
Unit 2	16.19	23.68	7.49	46.26	16.36	20.85	4.49	27.44
Unit 3	16.9	25.29	8.39	49.64	16.36	21.88	5.52	33.74
Unit 4	18.45	24.19	5.74	31.11	18.36	22.00	3.64	19.83
Unit 5	18.19	24.32	6.13	33.70	17.88	21.64	3.76	21.03
Unit 6	18.13	25.23	7.1	39.16	18.18	22.24	4.06	22.33
Mean U.1-6	17.33	24.19	6.86	39.59	17.15	21.42	4.27	24.87

Source: Compiled by the author.

Table II presents a comparison between the experimental and control groups at various stages of the study, analyzing their pre-test and post-test results. The findings reveal that during the pre-test, the experimental group's score in the General B2 English level test was 0.55% lower than the control group's score. However, in the post-test, the experimental group exhibited a remarkable improvement, surpassing the control group by 7.19%. Moreover, in the specific language test, the experimental group had a slight superiority over the control group, 0.23%, which significantly increased to 14.79% in the post-test. The results from units 1 to 6 replicated the previous cases, with the difference between the experimental and control groups ranging from -1.04% (unit 2) to 3.30% (unit 3) in the pre-tests, and from 9.95% (unit 4) to 15.59% (unit 3) in the post-tests. The average score across all six units showed that the experimental group scored 1.06% better than the control group in the pre-tests, and the difference increased to 13.44% in the post-test.

Table III presents a comparative analysis of the progress made by the experimental and control groups, revealing that the former outperformed the latter. Specifically, the experimental group demonstrated higher average progress compared to the control group. In the general English B2 level test, the experimental group progressed by 36.36%, while the control group's progress was limited to 26.52%. The percentage variation of

TABLE II. Difference between experimental and control groups in pre- and post-tests

Dif. % Test Exp Cont.	Pre-T%	Post-T%
General B2	-0.55	7.19
Specific L.	0.23	14.79
Unit 1	2.35	12.93
Unit 2	-1.04	13.57
Unit 3	3.30	15.59
Unit 4	0.49	9.95
Unit 5	1.73	12.38
Unit 6	-0.28	13.44
Mean U.1-6	1.06	12.97

Source: Compiled by the author.

TABLE III. Comparison of Progress between Experimental and Control Groups

Dif. V% Progress Exp-Cont	Exp.	Cont.	<b>V</b> %
General B2	36.36	26.52	37.13%
Specific L.	52.59	33.24	58.23%
Unit 1	39.18	26.14	49.88%
Unit 2	46.26	27.44	68.57%
Unit 3	49.64	33.74	47.14%
Unit 4	31.11	19.83	56.92%
Unit 5	33.70	21.03	60.25%
Unit 6	39.16	22.33	75.36%
Mean U.1-6	39.59	24.87	59.20%

Source: Compiled by the authors.

these progresses was 37.13% favorable to the experimental group. Similarly, in the specific language test, the experimental group demonstrated significant progress of 52.59%, while the control group progressed by only 33.24%. This highlights a substantial difference of 58.23% in favor of the experimental group, which had played the video game. In addition, the control of the six teaching units revealed that the experimental group made considerable progress of 39.59%, while the control group exhibited inferior progress, 24.87%. Consequently, there is a substantial difference of 59.20% in favor of the experimental group. More specifically, an examination of the individual units reveals that the experimental group progressed from 31.11% (unit 4) to 49.64% (unit 3), whereas the control group progressed from 19.83% (unit 4) to 33.74% (unit 3). Moreover, the percentage variation of their progress ranged from 47.14% (unit 3) to 75.36% (unit 6), highlighting the significant impact of the video game on improving language acquisition among the experimental group.

### Conclusion

The present research aims to assess the effectiveness of using a serious video game, *The Engineer*, as a language learning instrument for

industrial engineering students enrolled at the Universitat Politècnica de València. The primary objective of this study is to examine whether playing video games can enhance the language learning process and lead to more significant progress in contrast to other conventional methods of language learning. More specifically, this study aims to measure the participants' learning and acquisition of language for specific purposes related to the engineering industry, as well as their overall knowledge of English at the B2 level.

The results of the study suggest that using *The Engineer* as a language learning tool can enhance the students' language learning process, resulting in greater progress than other traditional methods of language learning. As observed, the experimental group showed considerably higher progress in comparison to the control group, indicating that the use of video games as a language learning instrument can be an effective and engaging approach to language learning.

As previously specified, the primary aim of the video game is to teach professional industrial engineering English. The findings of the study reveal that the students made greater progress regarding language for specific purposes than in general B2 English. Although the students participated in lessons that addressed both general B2 English and language for specific purposes associated with the engineering industry, it should be noted that the principal objective of the video game is to teach professional industrial engineering English, although it also introduces general B2 English content. Consequently, it was expected that the participants would show progress in both areas, with greater advancement in the specific language assessment.

This study findings align with the principles introduced in the literature review. In this sense, the best performance of the experimental group seems to be related to a motivational factor. The exercises that were completed as homework were similar for both groups; the main difference was that whereas one group completed the exercises using a paper book, the other completed the same exercises by playing a video game. This refers to the engaging, immersive, interactive, enjoyable, and also effective environment created by playing a serious video game, as suggested by some authors (Kapp, 2017; Papastergiou, 2016; Sailer, et al., 2017).

In addition, *The Engineer* offers an environment that promotes specific language and technical knowledge and skills to solve problems and achieve goals, as proposed by Gee (2003). These ideas connect with the

principles of situated cognition, flow theory, and constructivism exposed in this paper (De-Marcos et al., 2014; Gee, 2003; Squire, 2011). The application of these principles implies opportunities to practice and apply their language skills in an immersive enjoyable and engaging environment (Liu & Zhang, 2017). To this respect, *the Engineer* seems to own the characteristics to be considered a serious video game, introducing language learning content into gameplay mechanics, such as quests, puzzles, dialogues, or other challenges, and providing learners with feedback and rewards for their progress (Casañ-Pitarch, 2017a; 2022; 2022; Don & Wang, 2019). Furthermore, this video game is based on a story with fictional characters, which helps learners to connect emotionally with the language they are learning and stay motivated to continue playing (Liu & Zhang, 2017).

In this case, the students would also have felt motivated because they could identify themselves with the main characters and the story narrated along the video game, which simulated the life of a graduated engineer who gets a first job. This is beneficial because they also practiced real-world language and knowledge related to a specific profession (Prensky, 2003; Gee, 2003). Another characteristic of serious video games is that the learning experience is customized for each learner, in which students can play at their own pace and learn with their own rhythm (Arnab et al., 2013; Plass et al., 2013). As a result, learners avoid the comparison or pressure of learning slower or faster than other students, avoiding the feeling of stress and making the learning experience more pleasant and enjoyable.

In conclusion, using *The Engineer* among industrial engineering degree students offers a gamified version of the subject English B2, which connects the content through a story. The purpose of using this gamified material is to help learners increase their engagement and motivation by making an ordinary subject more game-like. The positive results obtained among the experimental group in this research seem to validate that the use of *The Engineer*, or other serious video games, in the foreign language classroom can be a suitable option to enhance learners' motivation and, consequently, their performances.

At last, it shall be acknowledged that this study has been limited to be the first time it has been used in the classroom, and some bugs were discovered by the participants. This fact made some students have to restart their missions occasionally, and we think that this could lead to a certain degree of frustration or demotivation. In further research, the same process could be repeated, and the motivational factor be introduced to measure its influence on the learning process. Some tests that could be used are the learning motivation questionnaire: LMQ (Alario-Hoyos et al., 2017), the learning satisfaction questionnaire: LSQ (Kim et al., 2012), Motivated Strategies for Learning Questionnaire: MSLQ (Pintrich et al., 1993).

### Acknowledgment

This work is one of the results of the educational innovation and improvement project, A+D 2023 – PIME C, reference number: 1920, entitled "Enseñanza de inglés para el negocio de la ingeniera industrial a través de simulación, juego y gamificación", funded by the Vice-Rector's Office for Studies, Quality and Accreditation of the Universitat Politècnica de València: 2023 Learning + Teaching Call. Previously, the creation of the video game was founded by the Autonomous Government of the Valencian Community (Spain), Subvencions a grups d'investigació emergent, and whose reference number is GV/2021/035, which we should also acknowledge.

### **Bibliographic references**

- Alario-Hoyos, C., Estévez-Ayres, I., Pérez-Sanagustín, M., Delgado Kloos, C., y Fernández-Panadero, C. (2017). Understanding Learners' Motivation and Learning Strategies in MOOCs. *The International Review of Research in Open and Distributed Learning*, *18*(3), 119-137. https://doi.org/10.19173/irrodl.v18i3.2996.
- Arnab, S., Brown, K., Clarke, S., Dunwell, I., Lim, T., Suttie, N., Louchart, S., Hendrix, M., & De Freitas, S. (2013). The development approach of a pedagogically-driven serious game to support Relationship and Sex Education (RSE) within a classroom setting. *Computers & Education*, 69, 15-30. https://doi.org/10.1016/j.compedu.2013.06.013.
- Cambridge University Press (2010). English Unlimited Placement Test. https://shorturl.at/luzDU.
- Casañ-Pitarch, R. (2017a). Language for Specific Purposes and Graphic-Adventure Videogames: Supporting Content and Language Learning. *Obra digital*, *13*, 169-183. https://shorturl.at/tLN07.

- Casañ-Pitarch, R. (2017b). Storyline-Based Videogames in the FL Classroom. *Digital Education Review*, *31*, 80-92. https://doi.org/10.1344/der.2017.31.80-92.
- Casañ-Pitarch, R. (2020). Enhancing Listening Skills and Learning Specific Language with Transcription Activities Using LyricsTraining. En Olmo-Cazevielle, F., Carrió-Pastor, M.L. Periñan-Pascual, C. and Romero-Forteza, F. (Eds.), *Estudios de lingüística aplicada IV*, 69-81. Universitat Politècnica de València.
- Casañ-Pitarch, R. (2022). On Serious Games, Gamification, & Digital Game-Based Learning: Foreign Language Learning in the Digital Age. Tirant lo Blanch.
- Casañ-Pitarch, R., & Gong, J. (2021). Testing ImmerseMe with Chinese students: acquisition of foreign language forms and vocabulary in Spanish. *Language Learning in Higher Education*, *11*(1), 219-233. https://doi.org/10.1515/cercles-2021-2016.
- Casañ Pitarch, R., & Wang, L. (2022). Spanish B1 vocabulary acquisition among Chinese students with Guadalingo. *The International Journal of Information and Learning Technology*, 39(2), 197-208. https://doi.org/10.1108/IJILT-07-2021-0101
- Calvo-Ferrer, J. R., & Belda-Medina, J. (2015). Análisis de la satisfacción del alumnado de L2 con respecto a la adquisición de terminología especializada por medio de videojuegos: estudio del caso. *Porta Linguarum: revista internacional de didáctica de las lenguas extranjeras*, 24, 179-190. https://doi.org/10.30827/Digibug.53869
- Calvo-Ferrer, J. R., & Belda-Medina, J. (2021). El videojuego subtitle legends para la enseñanza de lengua inglesa en el ámbito de la traducción y la interpretación: planificación docente y percepción del alumnado. *Lenguas Modernas*, 58, 71-86. https://shorturl.at/opV45.
- De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. *Computers & education*, 75, 82-91. https://doi.org/10.1016/j.compedu.2014.01.012
- Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining gamification. *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments* (pp. 9-15). Association for Computing Machinery. https://doi.org/10.1145/2181037.2181040

- Díaz-Bravo, R. (2019). Guadalingo: aprendizaje experiencial de español LE/L2 en un entorno virtual gamificado. *Journal of Spanish Language Teaching*, 6(1), 64-70. https://doi.org/10.1080/23247797.2019.1613078.
- Don, Y., & Wang, Y. (2019). Gamification in foreign language learning: A systematic review. *Computer Assisted Language Learning*, 32(8), 727-761.
- Edmonds, S. (2011). Gamification of learning. *Training and Development in Australia*, *38*(6), 20-22. https://doi.org/10.3316/24743546. 2011.7542648.
- Escribano, F. (2012). 10 Gamification as the Post-Modern Phalanstère: The video game industry: Formation, present state, and future. In P. Zackariasson and T. L. Wilson (eds.), *The video game industry: formation, present state, and future* (pp. 198-219). Routledge.
- Ford, M. (2016). Writing interactive fiction with Twine. Que Publishing.
- Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming*, *33*(4), 441-467. https://doi.org/10.1177/1046878102238607
- Gee, J. P. (2003). What video games have to teach us about learning and literacy. New York: Palgrave Macmillan.
- He, L., & Smith, J. (2019). ImmerseMe. *Pronunciation in Second Language Learning and Teaching Proceedings*, 10(1), 461-466. https://www.iastatedigitalpress.com/psllt/article/id/15402/.
- Kapp, K. M. (2017). The gamification of learning and instruction: game-based methods and strategies for training and education. John Wiley & Sons.
- Kim, M. K., Kim, S. M., Lee, C., & Chun, J. (2012). Evaluation of online learning modules: Application of the contextualized evaluation framework to an e-learning course on health information management. *Educational Technology Research and Development*, 60(2), 325-341. https://doi.org/10.1186/s12909-021-02609-8.
- Lee, S. M. (2019). Her Story or their own stories? Digital game-based learning, student creativity, and creative writing. *ReCALL*, *31*(3), 238-254. https://doi.org/10.1017/S0958344019000028
- Liu, D., & Zhang, Z. (2017). A comparative study of the effectiveness of mobile game-based and traditional vocabulary learning in Chinese EFL learners. *ReCALL*, *29*(1), 82-99. https://doi.org/10.1177/2158244 0211003092.

- Loewen, S., Crowther, D., Isbell, D. R., Kim, K. M., Maloney, J., Miller, Z. F., & Rawal, H. (2019). Mobile-assisted language learning: A Duolingo case study. *ReCALL*, 31(3), 293-311. https://doi.org/10.1017/S0958344019000065.
- Michael, D. R., & Chen, S. L. (2005). *Serious games: Games that educate, train, and inform.* Cengage Learning PTR.
- Papastergiou, M. (2016). Digital game-based learning (DGBL): Effects on students of social studies in secondary education. *Computers & Education*, 94, 1-12. https://doi.org/10.1016/j.compedu.2008.06.004
- Pintrich, P. R., Smith, D. A. F., Garcia, T., & Mckeachie, W. J. (1993). Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (Mslq). *Educational and Psychological Measurement*, 53(3), 801–813. https://doi.org/10.1177/0013164493053003024
- Pivec, M. (2007). Play and learn: potentials of game-based learning. *British journal of educational technology*, *38*(3), 387-393. https://doi.org/10.1111/j.1467-8535.2007.00722.x
- Plass, J. L., O'Keefe, P. A., Homer, B. D., Case, J., Hayward, E. O., Stein, M., & Perlin, K. (2013). The impact of individual, competitive, and collaborative mathematics game play on learning, performance, and motivation. *Journal of educational psychology*, 105(4), 1050. https://doi.org/10.1037/a0032688
- Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment*, 1(1), 21-21. https://doi.org/10.1145/950566.950596
- Robson, K., Plangger, K., Kietzmann, J. H., McCarthy, I., & Pitt, L. (2016). Game on: Engaging customers and employees through gamification. *Business horizons*, *59*(1), 29-36. https://doi.org/10.1016/j.bushor.2015.08.002.
- Ritterfeld, U., Cody, M., & Vorderer, P. (2009). Serious games: Mechanisms and effects. Routledge.
- Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, 69, 371-380. https://doi.org/10.1016/j.chb.2016.12.033.
- Squire, K. (2011). *Video games and learning: Teaching and participatory culture in the digital age.* Teachers College Press.
- Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning*, *35*(3), 407-420. https://doi.org/10.1111/jcal.12347

- Werbach, K., & Hunter, D. (2015). The gamification toolkit: dynamics, mechanics, and components for the win. University of Pennsylvania Press.
- Yin, Q. (2021). LyricsTraining: una propuesta docente para la enseñanza de lengua extranjera. Universitat Politècnica de València.
- Zyda, M. (2005). From visual simulation to virtual reality to games. Computer, 38(9), 25-32. https://doi.org/10.1109/MC.2005.297

Contact address: Ricardo Casañ-Pitarch. Universitat Politècnica de València C/ Vera S/N. E-mail: ricapi@upv.es



Reviews

## Kaan, E. and Grüter, T. (Eds.) (2021). *Prediction in Second Language Processing and Learning*. Amsterdam: John Benjamins. 234 pp. ISBN: 978-90-27209-70-2

It has been documented that language users' listening and reading comprehension relies heavily on the process of prediction. However, the specific features and purposes of individual prediction, as well as the relationship between prediction and language processing and learning, remain unclear. Prediction in Second Language Processing and Learning provides a comprehensive overview of the current status of research on prediction in second language (L2) processing and learning, and offers insights into future directions in this field. The book is organized into ten chapters, which explore individual differences in predictive processing within and across L2 learners.

Chapter 1, titled *Prediction in second language processing and learning: Advances and directions*, serves as an introduction to the book. The chapter begins by presenting various perspectives on the role of prediction in language processing and learning. It then provides an overview of research trends related to predictive processing in both first language (LI) and L2 contexts. Kaan and Grüter emphasize that the effectiveness and efficiency of prediction in language processing can be influenced by multiple factors, and therefore argue that the utility of prediction should be considered. The chapter concludes by briefly introducing the subsequent chapters in the book, and proposing directions for future research.

Chapter 2, titled *Automaticity and prediction in non-native language comprehension*, presents a theoretical framework for investigating prediction in L2 processing within production-based models of prediction. The authors first introduce a graded view of automaticity, which suggests that predictive processing is largely non-automatic, and they apply this framework to a language prediction model. The chapter then provides an overview of relevant research on prediction and comprehension in both L1 and L2 contexts.

Both Chapter 3 and Chapter 4 present studies that investigate the factors that influence prediction using visual-world eye-tracking experiments. Chapter 3, titled *Second language prediction ability across different linguistic domains: Evidence from German*, focuses on how L2 learners use lexical semantics and morphosyntax information to generate predictions during sentence processing. Schlenter and Felser conducted

two eye-tracking experiments using the visual-world paradigm with Russian learners of German to examine the extent to which morphosyntactic prediction is limited in L2 compared to L1, and whether there is a greater difference between semantic and morphosyntactic predictions in L2. The results revealed subtle differences in predictive processing between LI and L2 speakers via lexical-semantic and morphosyntactic cues, and that lower proficiency speakers had difficulty integrating competing cues during sentence processing.

Chapter 4, titled *Influence of syntactic complexity on second language prediction*, investigates how syntactic complexity affects prediction in L2 processing. Chun, Chen, Liu, and Chan compared L2 listeners' predictions when comprehending syntactically simple and complex sentences by conducting a visual-world eye-tracking experiment. The results showed that compared to prediction generation during syntactically simple sentence processing, L2 speakers took longer to generate predictions during syntactically complex sentence processing, indicating that syntactic complexity increased the cognitive load of L2 learners during sentence processing.

Both Chapters 5 and Chapters 6 explore the role of cross-linguistic influence (CLI) in prediction, with Chapter 5 taking a macroscopic perspective and Chapter 6 focusing on a specific population of bilingual children. Chapter 5, titled *Language prediction in second language: Does language similarity matter*, emphasizes the importance of CLI in L2 predictive processing. After providing a general overview of CLI's impact on language processing, Foucart offers a detailed examination of CLI's potential role in L2 prediction and proposes how CLI could be incorporated into existing predictive models, such as the error-based implicit learning model and prediction-by-production model.

Chapter 6, titled *Prediction in bilingual children: The missing piece of the puzzle*, compares the prediction abilities of bilingual children to those of monolingual children and adults who speak a L2. Karaca, Brouwer, Unsworth, and Huettig argue that exploring the complex relationships between prediction, language proficiency, and language experience requires in-depth investigation of bilingual children. These children receive different amounts and types of input in each language, which can impact their language proficiency and ability to generate predictions during language processing. The authors suggest that studying bilingual children can shed light on the developmental trajectory of predictive processing abilities in language learners.

Chapter 7, titled *Code-switching: A processing burden, or valuable resource for prediction*, explores the effect of code-switching on bilingual prediction. Tomié and Valdés Kroff conducted two eye-tracking experiments involving Spanish-English bilinguals who were exposed to monolingual or code-switched sentences containing target words with varying frequencies and emotional valence. The findings suggest that while code-switching may involve some integration costs, it can also serve as a cue for prediction, thus enhancing subsequent language processing.

The last three chapters focus on the relationship between predictive processing and L2 learning. Chapter 8, titled *Prediction and grammatical learning in second language sentence processing*, explores the influence of prediction on L2 grammatical learning. After discussing models that link prediction to learning in L1 and L2 processing, Hopp examines differences in prediction generation between LI speakers and adult L2 learners. Hopp argues that effective utilization of prediction errors for learning in L2 learners is contingent on their ability to appropriately revise their predictions following error occurrences.

Chapter 9, titled *The role of prediction in second language vocabulary learning*, examines the relationship between learners' prediction abilities and their vocabulary acquisition. Gambi illustrates how prediction, especially prediction errors, can serve as a catalyst for vocabulary learning and aid in the retention of lexical knowledge in the learners' long-term memory. The chapter concludes with a discussion on how prediction-based mechanisms can stimulate and maintain learners' motivation to continue learning a second language.

Chapter 10, titled Forcing prediction increases priming and adaptation in second language production, delves into the inquiry of whether mandating L2 learners to predict forthcoming information heightens the facilitation and adjustment of L2 production. Grüter, Zhu, and Jackson conducted a written production priming experiment with Korean L2 learners of English. The findings demonstrated that compared to the control group performing a standard repetition priming task, participants who were forced to make predictions showed a slight increase in priming and a significant growth in adaptation. The study suggests that L2 leaners are most likely to benefit from priming when they actively generate predictions about upcoming information.

This volume provides a comprehensive and in-depth overview of existing research on the relationship between prediction and L2 processing and learning, and offers directions for further investigations.

On the one hand, the chapters in this book present various studies regarding prediction in L2 processing and learning, such as prediction in grammatical and lexical processing, with participants including both adult L2 learners and bilingual children. On the other hand, the authors suggest directions for future work to explore the relationship between prediction and L2 learning and processing, such as conducting longitudinal studies to examine the development of prediction abilities and their relationship with learning. Additionally, the use of more naturalistic experimental stimuli is recommended to probe the applicability, suitability, and comprehensiveness of current research findings. However, the body of empirical research examined in this book centers predominantly around experiments utilizing eye-tracking methodology. Other methods, such as event-related potential (ERP) and functional magnetic resonance imaging (fMRI), may also provide invaluable insights into prediction and its relationship with language processing and learning. Including studies employing these techniques could enhance the book's informativeness.

Taken together, this book would be highly beneficial for researchers interested in prediction, and language processing and learning. It provides valuable insights into individual differences in predictive processing and offers a useful reference for readers seeking to understand these differences both within and across individuals.

Lin Fan y Zilong Zhong

### Torralba, J. M. (2022). A Liberal Education. In praise of the Great Books. Madrid: Encuentro. 172 pp. ISBN: 978-84-1339-095-6

The present work raises a fundamental question concerning higher education: how can the contemporary university prepare the truly competent citizens that today's democratic society requires for its authentic development? What methods should be used to achieve specialized professionals, with a sense of personal and social responsibility, genuine critical thinking, and moral autonomy? This alludes to the challenge facing the contemporary university: How to educate professionals with a humanistic mindset?

In today's socio-cultural environment marked by the exaltation of freedom, it could be thought that the author intends, with this title, a new provocation in line with current trends of social thought. However, it is not the case in that sense, but it does aim to capture the reader's attention to guide them to the understanding of the thesis being upheld and developed: it belongs to the identity of the university to combine humanistic education with professional training. So, what is the "liberal education" that the author proposes as a response to the initial question? It is one whose value does not lie in utility, but in the inherent dignity of the individual to whom it is directed.

Throughout the seven chapters that make up the text, the reader is invited to reflect on the humanist ideal and the genuinely educative mission that gave rise to the university institution in Bologna and how it has been called into question with the emergence of the new technocratic and scientific paradigm. Likewise, it argues how "liberal education" responds to the demands of today's democratic society regarding the mission of the modern university, in the context of authentic integral education.

Based on the author's own experience at the University of Chicago, where he experienced this educational style, he dedicated a few pages to exposing and assessing a specific methodology to carry out such a liberal education: the reflective reading of the fundamental texts of culture, the so-called "great books". The results obtained from its implementation in a Spanish university support the comprehensive explanation provided about the implementation of this initiative, aiming to generate interest in adapting it to any other university.

What is the educational value of such a methodological strategy? It can be summarized in the five educational virtues of the great books outlined in the work: 1) the participants are existentially involved; 2)

you learn directly from the best authors of the tradition; 3) facilitates the development of critical capacity; 4) provides the experience of a high-level intellectual conversation; 5) It helps to educate the gaze to formulate relevant questions. Each of these virtues is argued and illustrated with examples and anecdotes from the author's own experience.

Liberal education, then, offers the coordinates for students to harmoniously develop their virtues, enabling them to outline a project of fully personal life sustained by a coherent existential meaning. However, it would be pretentious to think that this type of education makes, by itself, the whole person. On the contrary, patient cultivation and care are required to achieve the formation of one's own character.

An ethical education is needed because the crux of the matter is not in the head, but in the heart, in the will. Conversation with the greatest minds in history have the ability to move people's inner springs toward noble ideals. This justifies the invitation for universities to value and strengthen the humanistic education of students, summarized in ten principles at the end of the text. This illustrates the idea that the university is the breeding ground for citizens who will lead society and not just an institution that dispenses degrees to ensure a skilled qualified workforce. It is not only possible, but necessary and consistent with the essence of the university, to offer a humanistic education in the university institution, in order to prepare an authentic democratic citizenship and overcome the reductionism of strict professionalization.

In conclusion, there is no insurmountable opposition, as is often claimed, between the ideals of liberal education and the contemporary university oriented towards research and professional preparation.

Ana Risco Lázaro

## Blanchard Giménez, M. and Muzás Rubio, M. D. (2020). Working on Developmental Learning Projects in Early Childhood Education. Narcea. 134 pp. ISBN: 978-84-27727-779

Early Childhood Education is recognised as a crucial stage in the integral development of individuals. Moreover, its importance has undergone a remarkable evolution over time, especially in recent decades. This is why it is now widely recognised as a fundamental period in which the foundations for learning are laid and essential aspects of early childhood cognitive, emotional, social and motor development are shaped.

In a society marked by technological evolution and changing social demands, teaching and learning have undergone a remarkable metamorphosis, requiring innovative and effective pedagogical approaches. Recognising the importance of Early Childhood Education and early childhood, this book proposes a transformative approach centred on Learning Projects. This methodology not only promotes the acquisition of knowledge and skills, but also fosters the curiosity, creativity and autonomy of students, making them active protagonists of their own process.

Learning Projects (LP) are based on students' intrinsic desire to discover the world around them. In this paradigm, children become the main actors in their learning process, while educators take on the roles of mediators, facilitators and guides. The essence of the LP lies in their ability to foster curricular globalisation, integrating diverse areas of knowledge around a shared axis of interest.

The structure of the book is composed of two main parts. First, it explores the theoretical and practical foundations of LP, from their conceptualisation to their implementation in the classroom. Key aspects such as the importance of listening to and understanding students' motivations, strategies for self-regulation of learning and the need for innovation in early childhood education are addressed. In this way, this section of the book explains in detail how to integrate curricular content and key competences into the project itself, which is a challenge for most teachers today. Therefore, the methodology used for the development of a project is addressed, considering its structural axis and the corresponding diagram of contents.

The book not only presents Learning Projects as an educational alternative, but also addresses a series of urgent questions that often arise in this environment: Can Learning Projects be developed in Early Childhood Education? How can an educational process be established based on the interests and motivations of the students? Why is it important to innovate in Early Childhood Education?

This is followed by concrete examples of projects developed by teaching teams, accompanied by a reflective analysis of the experience, implementation and evaluation of these projects. As explained in the text itself, in order to carry out a truly reflective practice, it is essential to adopt a constant analytical character throughout the project (Perrenoud, 2017). Moreover, it is even more enriching when this reflection is carried out as a team, incorporating diverse educational perspectives in a collaborative action-research process.

The book stands out for its rigorous approach and its ability to articulate theory and practice, offering educators a detailed guide to design, implement and evaluate LP focused on Early Childhood Education. In addition, it underlines the need for a continuous process of training and pedagogical innovation and, therefore, proposes tools for training in this active methodology.

In this sense, the project-based learning approach is presented as a powerful tool to nurture critical thinking, problem solving and collaboration, preparing students at this stage to be active and competent citizens in a society in constant transformation.

In summary, Working on Learning Projects in Early Childhood Education is an essential resource for education professionals seeking to enhance the holistic development of their students, promoting meaningful, collaborative and contextualised learning in the world around them. Its in-depth content and practical approach make it a valuable tool for transforming educational practice and responding to the challenges of the 21st century.

Paula Martínez Enríquez

### Gamification, Video Games and eSports

### SUMMARY OF THE MONOGRAPHIC SECTION

### MANUEL JIMÉNEZ LÓPEZ, MANUEL FERNÁNDEZ NAVAS. ANA YARA POSTIGO FUENTES

Presentation: Gamification, Video games and eSports.

### AI FXANDRA SANTAMARÍA URBIETA

Hint Strategies in Educational Escape Rooms: A Process Mining Approach.

### LINDA CASTAÑEDA, SYLVESTER ARNAB, GEMMA TUR, FRIDE KLYKKEN, BARBARA WASSON, INMACULADA HABA-ORTUÑO, RUTH MALOSZEK, BARBARA DE BENITO-CROSETTI

Co-creating pedagogically informed games for data literacy.

### ANDREA BUENO-BAQUERO, JAVIER DEL OLMO-MUÑOZ, JOSÉ ANTONIO GONZÁLEZ-CA-LERO. RAMÓN CÓZAR-GUTIÉRREZ

Gamified approaches to computational thinking in teacher training.

### MARÍA CARIDAD SIERRA-DAZA, MARTA MARTÍN-DEL-POZO, MARÍA ROSA FERNÁN-DEZ-SÁNCHEZ

Video Games and learning in the university stage: a systematic review.

### XAVIER GARCÍA, SERGIO MONTALT-GARCÍA, LUIS-MILLÁN GONZÁLEZ

Game-based learning in scientific literature: text mining analysis.

### ILUMINADA SÁNCHEZ-DOMÉNECH, BEATRIZ MARTÍN DEL CAMPO

Games and videogames for dyslexia rehabilitation: neurocognitive and psycholinguistic foundation.

JANA MARÍA GALLARDO PÉREZ, IVÁN RIVILLA ARIAS, AMAIA RAMÍREZ MUÑOZ, ROSARIO CASTRO LÓPEZ, BÁRBARA SAN JUAN FERRER, JOEL MANUEL PRIETO ANDREU

Video games, educational implications.

### JORGE GARCÍA BASTIDA, GUILLERMO MENDOZA, LEANDRO ÁLVAREZ-KUROGI, HIGINIO GONZÁ-LEZ-GARCÍA

Narrative review on factors related to health in video games and electronic sports.

### LAURA PÉREZ GRANADOS LAURA DE LA CONCEPCIÓN MUÑOZ GONZÁLEZ

Gamification in the educational context: challenges, potential and perspectives for implementation.

### CARMEN NAVARRO-MATEOS, ISAAC JOSÉ PÉREZ-LÓPEZ, CARMEN TRIGUEROS CERVANTES

Analysis of the teaching role in a gamification proposal in the teacher's master's degree.

### RICARDO CASAÑ-PITARCH

The Engineer: Enhancing Bachelor Students' English Technical Engineering Vocabulary Proficiency with a Serious Video Game.

