

Construction of learning and analysis of cognitive load through the use of active methodologies as a function of gender

Construcción del aprendizaje y análisis de la carga cognitiva mediante el uso de metodologías activas en función del género

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ABSTRACT. The Breakout educational methodology is an innovative strategy that promotes active learning and student participation. This study analyzes the interaction between cognitive load, gamification and gender in the context of the Breakout methodology, with a sample of 540 future teachers of Primary Education at the University of Seville. Two instruments were used for data collection: the GAMEX scale to evaluate gamification and a cognitive load scale to measure this variable. The results revealed a moderate perception of the difficulty of the tasks, supported by a high valuation of the learning achieved and its improvement. Gamification stood out in dimensions such as fun and absorption, indicating a positive impact on the educational experience, with significant differences according to gender: women perceived knowledge acquisition more positively. Previous experience with Breakout was also associated with a greater tendency to have fun and absorption during the learning process. It is concluded that the Breakout methodology efficiently balances intrinsic and extrinsic cognitive load. Consequently, further research is recommended on gender dynamics in active and gamified educational environments, considering the diversity of the participants.

RESUMEN. La metodología educativa Breakout es una estrategia innovadora que fomenta el aprendizaje activo y la participación de los alumnos. Este estudio analiza la interacción entre carga cognitiva, gamificación y género en el contexto de la metodología Breakout, con una muestra de 540 futuros maestros de Educación Primaria de la Universidad de Sevilla. e utilizaron dos instrumentos para la recogida de datos: la escala GAMEX para evaluar la gamificación y una escala de carga cognitiva, para medir esta variable. Los resultados revelaron una percepción moderada de la dificultad de las tareas, apoyada por una alta valoración del aprendizaje alcanzado y su mejora. La gamificación destacó en dimensiones como la diversión y la absorción, indicando un impacto positivo en la experiencia educativa, con diferencias significativas según el género: las mujeres percibieron más positivamente la adquisición de conocimientos. La experiencia previa con Breakout también se asoció con una mayor tendencia a la diversión y la absorción durante el proceso de aprendizaje. Se concluye que la metodología Breakout equilibra eficientemente la carga cognitiva intrínseca y extrínseca. En consecuencia, se recomienda investigar más en las dinámicas de género en entornos educativos activos y gamificados, considerando la diversidad de los participantes.

KEYWORDS: Cognitive load, Educational technology, Student teachers, Breakout, Gender.

PALABRAS CLAVE: Carga cognitiva, Tecnología educativa, Estudiantes de magisterio, Breakout, Género.

1. Introduction

The emergence of the so-called active methodologies, led by the appearance of Information and Communication Technologies (ICTs) in the teaching and learning processes, has been widely studied in multiple scenarios and educational stages (Burbules et al., 2020; Damirchi et al., 2021). Therefore, the present study analysed the impact of said appearance on the construction of learning in university students, as well as the cognoscitive dynamics they employed in the educational task they carried out, focusing on the gender variable as a specific element of the analysis.

Pattier & Reyero (2022) stated that the effect of technology on human cognitive activity follows two pathways. The first pathway is the impact on the cognitive activity in terms of brain activity, and the second pathway is the impact on the capacities, competences and executive functioning that directly affect the teaching-learning process, such as attention and deep thinking, which are related to an activity marked by the availability of resources, the immediacy of this availability, and the new objectives generated by this availability and its transformative potential.

In this sense, different studies have presented the development of active methodologies as a didactic strategy for the acquisition of practical, problem-solving and responsibility competences, among others (Imran et al., 2019; Garzón et al., 2021). Thus, during the last decades, different researchers have supported the incorporation of active didactic methodologies that involve the acquisition of contents and competences from the perspective of students through an active and leading role (Bager, 2011; Bigg, 2003; De Miguel, 2006; Paños, 2017; Rué, 2007; Ubieto et al., 2008; Gómez-Hurtado, García-Prieto & Delgado-García, 2018; Misseyanni et al., 2018), by implementing collaborative work with the incorporation of ICTs to facilitate the learning of students.

Among the most promising benefits provided in university education, active didactic methodologies efficiently adapt and respond to the different needs and demands, enabling the establishment of responses to the different changes derived from the development of collaborative learning situations for the acquisition of competences in students, as well as the possibility to establish a continuous evaluation, or placing the student at the centre of the teaching-learning process, transforming her/him into the true protagonist (Konopka et al., 2015; Silva & Maturana, 2017; Corelly, 2020).

However, the reality is that the exclusive use of specific methodologies, regardless of how innovative they might be, will not guarantee the success of a formative action; instead, this will depend on how the students and the teacher interact with them.

1.1. Gamification applied to education

Digital breakouts, as a gamified active methodology, provide the educational process with different elements that grant it an added value (Cortizo et al., 2011; Koivisto & Hamari, 2013; Peñalva et al., 2018; Llorente et al., 2022), such as: 1) student follow-up tools based on the frequency of use and visits to places of interest in the gamified application; 2) rewards to the students for their effort and interaction with the gamification tool; 3) impartiality in the distribution of prizes, since these depend exclusively on the attainment of goals; 4) unconventional evaluation possibilities; 5) classroom dynamics based on competence and cooperation; 6) automatic feedback in the interrelations among students and between students and teachers; and 7) creation of a relaxed and playful classroom environment.

In addition to all of the above mentioned, the gamification strategy has been contemplated in university spaces as a tool that helps to solve the possible gender differences, thereby providing and facilitating egalitarian conditions for students. Different studies have been conducted already in this line, presenting gamification as a means for students to achieve equity and access to the different technological resources (Smith & Abrams, 2019). Other researchers have focused on the use and distribution of gamification elements to develop a comprehensive training among peers (Lu et al., 2018). Similarly, there is another research line showing gender



differences in the incorporation of gamification in higher education (Brenik et al., 2019).

Despite all this, the correlations of gamification and/or active methodologies with equality or gender equity have been poorly studied to date. Therefore, the present study proposes a novel and original research line that facilitates the understanding of the importance of gamification for the promotion of gender equity.

1.2. Cognitive load, gender and application in education with ICTs

To determine how students learn with these active methodologies, the Theory of Cognitive Load (TCC) was applied, which states that the learning of a person is based on the amount of cognitive resources she/he uses to carry out a specific activity or task, in an environment where she/he receives and processes information employing three types of sensory memory, i.e., echoic, iconic and haptic, which are partially independent from each other. Sweller (1994) pointed out that this cognitive load is related to the interaction established between the characteristics of the person and the learning task to be performed. Therefore, regarding echoic memory, it is fundamental to consider aspects such as age and the set of capacities and intelligences that the person can develop as a function of the learning task. Consequently, the cognitive load developed is a variable in which the mental resources demanded and the capacity of the person to manage these resources are essential elements.

From an educational perspective, there are different factors or categories that can determine cognitive load, such as the so-called sensory memory. This type of memory receives information from the different sensory channels, such as vision and kinesthesia (tactile and proprioception) and audition (auditory and verbal), which, through the different modalities they can adopt, condition the means or systems of information representation. All this may lead the student to overuse her/his memory resources in the long term, which would influence the general formation of the concepts that are addressed in the classroom. All the combinations that are performed from this perspective, contemplating a correct integration of the different perceptive channels (always based on the characteristics of the didactic model of teaching), incorporate more precise knowledge to design a formative activity that allows integrating ICTs, thereby stressing both on the way in which students process information and on the characteristics of ICTs.

With regard to cognitive load, some studies show that the characteristics of the instructional design may benefit or restrict the learning process (Cárdenas & Cedeño, 2021). Thus, the cognitive effort made by an individual may be negatively affected if the information is not adequately organised, thereby hindering the construction of knowledge (Clark & Mayer, 2008; Mayer, 2005; Sweller et al., 2011; Sweller et al., 1998).

If the aim is to coordinate the content of ICTs to implement the different cognitive processes and the dimensions of knowledge (factual, procedural, symbolic-conceptual and metacognitive), this will lead to what is currently known as multiple intelligences, which are understood as “capacities or skills of a specific human aspect, in a given moment” (Gardner, 1995). In this sense, the types of intelligences observed represent indirect ways of managing the cognitive load of people to produce learning.

The factors that allow determining the construction of learning and the cognitive load used to this end are influenced by the three types that can be defined, which, according to Paas et al. (2003) and Sweller (2007), are:

- a) Intrinsic cognitive load. This is derived from the nature of incoming stimuli and it is inherent to the complexity of the task and personal experience. Therefore, it is not modified by instructional interventions, since the interactivity of the element is intrinsic and conditioned by sensory memory, as well as by the different perception channels.
- b) Extrinsic cognitive load. This is fostered by instructional interventions, which makes it dangerous, as it can saturate the students, contaminating and affecting their working memory.
- c) Relevant cognitive load. This directly contributes to learning. It is used when the working memory is

employed for learning and for the automation of schemes; therefore, it is controlled by the teacher in the learning process.

On their part, studies on the incorporation of ICTs as a function of gender have gained great interest (Melner et al., 2006; Solsona, 2013; Mills et al., 2014), as well as those about the development of teachers' digital competence (Cabero et al., 2021; Manrique & García, 2022; Dirckinck et al., 2023; Martín et al., 2023). Thus, in the current study, the gender variable is assumed as an interpersonal capacity or intelligence of students to adequately manage their cognitive load as a group and collaboratively, in order to enhance their learning.

Focusing on the educational scope, where the sociocognitive context is a priority, the role of women represents an interpersonal variable that can be predictive, based on a diversity that aims to promote collaborative learning in environments mediated by ICTs. The goal is to analyse the relevant information provided by the effect of gender to examine the latter as a possible characteristic of the student who carries out her/his formative action with the characteristics of ICTs. Considering the scarcity of studies on the relationship between gender, cognitive load and the incorporation of active methodologies, this study has the potential to unravel the effects of gender on cognitive load in the propositions of didactic innovation mediated by ICTs, as well as to better understand the learnings attained by the students.

2. Methodology

The experience carried out presents the design of a formative proposition through the development of a digital Breakout (<https://view.genial.ly/60141861dafa320d8b90fd37/game-breakout-tic>) for student teachers in the Degree of Pedagogy, Early Childhood Education and Primary Education. Specifically, this formative action was performed in the subject of "Information and Communication Technologies applied to education". The data were gathered in different groups (9 groups in total), whose members were all from the same year and had similar sociological characteristics. To conduct the gamified practice, we selected those contents that presented greater difficulty for the students, in order to verify whether the degree of effort perceived was alleviated with the use of active methodologies.

2.1. Research objectives

The central objectives of this study were:

1. To know the level of cognitive load (mental effort) carried out to learn with Breakout (O1).
2. To know the degree of gamification developed in an educational experience mediated by Breakout (O2).
3. To explore whether the gender variable influenced the perception of the complexity level of the tasks performed through Breakout (O3).
4. To explore whether the gender variable influenced the perception of the developed gamification (O4).
5. To verify whether the previous experience of the participants with Breakout influenced the perceived degree of gamification (O5).

2.2. Population and sample

The study population was constituted by student teachers of primary education registered in the subject of Information and Communication Technologies applied to education. The potential participants were in the first year of the degree of primary education at the University of Seville (Spain), in the academic year 2020/2021. This population consisted of 540 students distributed in 9 groups.

The sample was extracted from these 9 groups, using incidental or convenience criteria, that is, students who frequently attended the lectures (Hernández-Sampieri et al., 2014). The final sample consisted of 518 students, who carried out the experience and completed the evaluation instruments. This high participation rate ensured a confidence level above 99%.



The sample was mainly composed of women (84%), and the participants were aged between 18 and 22 years, with a mode of 18 years. For 77% of the participants, this was their first experience with a breakout.

2.3. Data-gathering instrument and procedure

To gather the data of the study, the following two instruments were used:

1. To verify the effects of the gamified methodology, the GAMEX scale was used, which was developed and validated in English by Eppmann et al. (2018) and translated to Spanish and validated by Parra-González and Segura (2019). The response options are in a scale of 1 (totally disagree) to 5 (totally agree), and it consists of 6 dimensions: fun, absorption, creative thinking, activation, negative thinking, and mastery.
2. Cognitive load was measured with the psychometric instrument validated by Leppink et al. (2013) and expanded by Leppink et al. (2014). It consists of a total of 13 items measured in a scale of 0 (no agreement) to 10 (maximum agreement).

Both instruments were administered face to face, but in digital format. Although the instruments had been previously validated in other studies (Parra-González & Segura, 2019; Leppink et al., 2014), Cronbach's alpha was applied to both of them. As can be observed in Table 1, there was high significance at the global level, since correlations in the range of 0.8 to 1 can be considered "very strong" and, consequently, they would indicate high levels of reliability (Bisquerra, 1987).

Reliability statistics	
Cognitive load	Cronbach's alpha .839
GAMEX	Cronbach's alpha .903

Table 1. Reliability. Source: Self-made.

2.4. Data analysis

Firstly, a descriptive analysis was conducted to determine the level of cognitive load (mental effort) performed with the learning mediated by Breakout (O1) and the degree of gamification developed through the educational experience conducted (O2). Contrast statistics were also applied to explore whether the gender variable influenced the perception of the complexity level of the tasks performed through Breakout (O3) and perceived gamification (O4). Lastly, we analysed whether the previous experience of the participants with Breakout methodologies influenced the degree of perceived gamification (O5).

Specifically, descriptive and central tendency statistics were applied, as well as the non-parametric statistics Mann-Whitney U and Wilcoxon's W, since the Kolmogorov-Smirnov fit test showed that the data did not present a normal distribution. All the obtained data were analysed with SPSS statistical package (v.26).

3. Results

This section presents the results obtained in the study based on the objectives set.

3.1. Mental effort made during the formative experience with Breakout

Table 2 shows the results of the cognitive load used during the learning experience with EscapeRoom (O1).

	Min	Max	M	SD	Min
1. The contents of EscapeRoom were very complex.	.0	10.0	5.193	2.1216	.0
2. The tasks of EscapeRoom were very complex.	.0	10.0	4.654	2.2400	.0
3. In EscapeRoom, very complex terms were mentioned.	.0	10.0	4.559	2.1018	.0
4. I invested great mental effort in the complexity of this activity.	.0	10.0	5.387	2.2954	.0

	Min	Max	M	SD	Min
5. The explanations and instructions of EscapeRoom were somewhat unclear.	.0	10.0	2.681	2.6692	.0
6. The explanations and instructions of EscapeRoom were full of unclear terms.	.0	10.0	2.414	2.4053	.0
7. The explanations and instructions of EscapeRoom were very inefficient in terms of learning.	.0	10.0	2.389	2.5054	.0
8. I invested great mental effort in understanding the unclear and inefficient explanations and instructions of EscapeRoom.	.0	10.0	3.124	2.6502	.0
9. This activity really improved my understanding of the content that was addressed in EscapeRoom.	.0	10.0	7.371	1.8784	.0
10. This activity really improved my understanding of the problems that were addressed in EscapeRoom.	.0	10.0	7.323	1.8558	.0
11. This activity really improved my knowledge of the terms that were mentioned in EscapeRoom.	.0	10.0	7.549	1.7543	.0
12. This activity really improved my knowledge and understanding of how to tackle the contents of EscapeRoom.	.0	10.0	7.507	1.7260	.0
13. I invested great mental effort during this activity to improve my knowledge and understanding of the contents of EscapeRoom.	.0	10.0	6.476	2.1281	.0

Table 2. Cognitive load used. Source: Self-made.

As can be observed in Table 2, on the one hand, items 1 to 4 stand out, which show that the perceived difficulty of the task was moderate, since the results range from 4 to 5.4. On the other hand, the explanations and indications of the task were positively valued (items 5 to 7). Finally, items 8 to 13 indicate that the perception of learning and improvement was high, with scores ranging between 6.5 and 7.5. The responses to the items show that the perceived difficulty of the task was low, and the perception of learning was high. This is very important, since the contents addressed under this methodology were selected for having been previously perceived as the most complex for the majority of students.

3.2. Degree of gamification developed in an educational experience mediated by Breakout

Table 3 shows the obtained results of the degree of gamification perceived by the students who participated in the experience (O2).

Gamification	Min	Max	M	SD
Fun				
1. Playing was fun	1.0	5.0	4.510	.7720
2. I liked playing	1.0	5.0	4.524	.7696
3. I really enjoyed playing	1.0	5.0	4.275	.9245
4. My experience with the game was pleasant	1.0	5.0	4.198	.9930
5. I think that playing is very entertaining	1.0	5.0	4.592	.7090
6. I would play this game on my own, not only when I'm asked to	1.0	5.0	3.730	1.0809
Absorption				
7. Playing made me forget where I was	1.0	5.0	3.497	1.2435
8. I forgot about my immediate surroundings while I played	1.0	5.0	3.566	1.2297
9. After playing, I felt like coming back to the "real world" after a trip	1.0	5.0	3.206	1.2678
10. Playing "took me away from everything"	1.0	5.0	3.202	1.2825
11. While I played, I was completely disconnected from my surroundings	1.0	5.0	3.464	1.2382
12. While I played, I lost track of time	1.0	5.0	3.752	1.2528
Creative thinking				
13. Playing awoke my imagination	1.0	5.0	3.924	1.0502
14. While I played, I felt creative	1.0	5.0	3.913	1.0640
15. While I played, I felt that I could explore things	1.0	5.0	3.823	1.0466
16. While I played, I felt adventurous	1.0	5.0	3.841	1.0820



Activation				
17. While I played, I felt active	1.0	5.0	4.372	.8227
18. While I played, I felt nervous	1.0	5.0	4.054	1.0934
19. While I played, I felt frenetic	1.0	5.0	3.678	1.1513
20. While I played, I felt excited	1.0	5.0	4.047	.9931
Negative thinking				
21. While I played, I felt irritated	1.0	5.0	1.789	1.0990
22. While I played, I felt hostile	1.0	5.0	1.764	1.0623
23. While I played, I felt frustrated	1.0	5.0	2.213	1.2592
Mastery				
24. While I played, I felt dominant / I had the feeling of being in charge	1.0	5.0	2.802	1.1422
25. While I played, I felt influential	1.0	5.0	3.304	1.1193
26. While I played, I felt autonomous	1.0	5.0	3.346	1.1198
27. While I played, I felt confident	1.0	5.0	3.762	.9631
Global	.89	4.25	3.1874	.51708

Table 3. Perceived gamification. Source: Self-made.

Taking into account the items that compose each of the dimensions, it can be observed that “fun” obtained the highest scores, followed by “activation” and “creative thinking”, then “absorption”, and, lastly, “negative thinking”, which obtained very low scores. Therefore, the experience reached good levels of gamification and satisfaction.

Figure 1 shows the mean valuation obtained in each dimension.

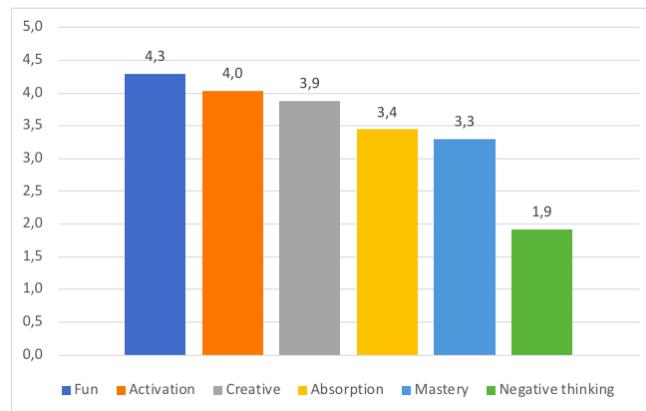


Figure 1. Valuation by dimension. Source: Self-made.

3.3. Perception of the level of complexity of the tasks performed through Breakout as a function of gender

With the aim of verifying whether gender could be a variable that influences the perception of cognitive load used in the task (O3), the Mann-Whitney U-test was conducted. Table 4 presents the two items in which there were significant differences between genders: “the tasks of EscapeRoom were very complex” and “this activity really improved my knowledge and understanding of the contents addressed in EscapeRoom”.

	2. The tasks of EscapeRoom were very complex.	12. This activity really improved my knowledge and understanding of the contents addressed in EscapeRoom.
Mann-Whitney U	16062.000	15681.500
Wilcoxon's W	107868.000	19597.500
Z	-2.196	-2.521
Asymptotic sig. (bilateral)	.028	.012

Table 4. Contrast of cognitive load and gender. Source: Self-made.

As can be observed, the value in both items was below 0.05, which indicates that, with 99% significance level, there were significant differences as a function of gender.

To make a more detailed interpretation, Table 5 presents the average ranges.

	Gender	Average range	Sum of loads
2. The tasks of EscapeRoom were very complex.	Woman	252.03	107868.00
	Man	289.98	25518.00
	Total		
12. This activity really improved my knowledge and understanding of the contents addressed in EscapeRoom.	Woman	265.86	113788.50
	Man	222.70	19597.50
	Total		

Table 5. Average ranges of cognitive load and gender. Source: Self-made.

Table 5 indicates that men perceived greater complexity in the tasks, whereas women had a more positive perception toward the acquisition of knowledge and understanding of the contents addressed through EscapeRoom. This suggests that gender may influence the perception of complexity and, thus, the cognitive load required and the perception of the learning attained.

3.4. Perception of gamification as a function of gender

To verify whether gender influenced the gamified experience (O4), the Mann-Whitney U-test was applied. Table 6 presents the results of this analysis.

	While I played, I felt nervous	While I played, I felt irritated	I liked playing	I think that playing is very entertaining
Mann-Whitney U	14345.000	15241.500	15702.500	15550.000
Wilcoxon's W	17666.000	109636.500	19105.500	18871.000
Z	-2.775	-2.118	-1.948	-2.014
Asymptotic sig. (bilateral)	.006	.034	.051	.044
a. Grouping variable: Gender				

Table 6. Contrast of gamification and gender. Source: Self-made.

As can be observed in Table 6, four variables presented a value equal to or below 0.05, thus we can confirm that, with 99% and 95% confidence level, there were significant differences between genders.

Table 7 presents the average ranges, which indicate that women stated to a greater extent that they liked playing, and that they found the game entertaining, whereas men showed a greater tendency toward feeling nervous and irritated, thus gamification had a greater negative effect on the latter.

	Gender	Average range	Sum of ranges
While I played, I felt nervous	Woman	218.10	17666.00
	Man	264.87	
	Total		
While I played, I felt irritated	Woman	252.62	109636.50
	Man	286.83	23233.50
	Total		
I liked playing	Woman	262.15	113249.50
	Man	232.99	19105.50
	Total		
I think that playing is very entertaining	Woman	262.09	113484.00
	Man	232.98	18871.00
	Total		

Table 7. Average ranges of gamification and gender. Source: Self-made.



3.5. Previous experience with Breakout methodologies and degree of perceived gamification

To verify whether the previous experience of the participants with Breakout methodologies influenced the gamified experience (O5), Wilcoxon's W was applied. Table 8 presents the results of this analysis.

Test statistics ^a		
	I really enjoyed playing	Playing made me forget where I was
Mann-Whitney U	20882.000	19474.500
Wilcoxon's W	27903.000	26495.500
Z	-2.009	-2.828
Asymptotic sig. (bilateral)	.045	.005

a. Grouping variable: first experience

Table 8. Contrast of previous experience and perceived gamification. Source: Self-made.

As can be observed in Table 8, two items presented a value below 0.05, which indicates that, with 99% confidence level, there were statistically significant differences in the items "I really enjoyed playing" and "Playing made me forget where I was", which belong to the Fun and Absorption dimensions, respectively.

Table 9 displays the average ranges, showing that the students who had had experiences with Breakout had a greater tendency toward fun and absorption during the learning process.

	First experience	Average range	Sum of ranges
I really enjoyed playing	No	236.47	27903.00
	Yes	265.03	105483.00
	Total		
Playing made me forget where I was	No	224.54	26495.50
	Yes	267.32	105859.50
	Total		

Table 9. Average ranges of gamification and first experience. Source: Self-made.

4. Discussion

Firstly, the general perception of the difficulty of the tasks as moderate, together with the high valuation of learning and improvement, suggest that the instructional intervention attained an effective balance between intrinsic and extrinsic cognitive load. This result is in line with the principles of TCC, which points to efficiently managing mental resources during tasks to facilitate an effective learning (Cabero-Almenara et al., 2023). The capacity of the participants to address the tasks with moderate difficulty while experiencing a high level of learning indicates a successful implementation of the Breakout methodology, thus supporting the idea that the intrinsic cognitive load of tasks is manageable (Sweller et al., 1998). The evidence of a high score in the "fun" and "activation" dimensions strengthens the importance of gamification in the educational context. This result is supported by the literature, which highlights the positive impact of the instructional design on cognitive effort (Cárdenas & Cedeño, 2021). Similarly, the absence of "negative thinking" indicates that gamification not only facilitated learning, but it also contributed to creating a positive and motivating educational environment.

The differences of perception between genders underline the significant influence of this variable on the educational experience. While the women tended to perceive the acquisition of knowledge in a more positive manner, the men perceived greater complexity in the tasks. These results, in line with those of Melner et al. (2006), Solsona (2013) and Romero-Tena et al. (2022), point out the importance of considering gender

differences when designing and applying active methodologies.

Lastly, the positive influence of previous experience with Breakout on the perception of fun and absorption during the learning process highlights the relevance of previous knowledge on the management of cognitive load. The students who were familiarised with this methodology showed greater predisposition to enjoy and immerse themselves in the educational activity, demonstrating the importance of the instructional design to maintain the interest and participation of the students (Sweller et al., 1998; Mayer, 2005).

5. Conclusions

The results of this study provide a comprehensive perspective about the interaction between cognitive load, gamification, gender and previous experience with the Breakout methodology. The balance attained between cognitive load and learning supports the effectiveness of instructional interventions, indicating that this methodology is manageable and facilitates an effective learning, in line with the principles of TCC (Sweller, 1994).

This work demonstrates the effectiveness of using gamified methodologies and that these can increase motivation and active participation in the learning process. The perception of the students in terms of mental effort made was low, while their perception of learning was high. Moreover, according to the obtained results, previous experience with this type of activity has a positive influence on the realisation of the latter. The positive influence of gamification, which is reflected by the high scores of “fun” and “absorption”, aligns these findings with the literature, which highlights the beneficial impact of the instructional design on cognitive effort (Cárdenas & Cedeño, 2021).

Furthermore, gender emerges as a determining variable, since women presented higher results in gamification (greater absence of negative thinking). In addition, women have a lower perception of complexity compared to men, and greater acquisition of knowledge and learning. Consequently, gender could have an influence on the perception of complexity, the cognitive load required, and the perception of the attained learning. This points out the need to consider variations in the design of active methodologies, which corroborates previous findings about the influence of gender on cognitive load and perceived learning (Melner et al., 2006; Solsona, 2013; Romero-Tena et al., 2022).

Likewise, the importance of previous experience with Breakout underlines the relevance of previous knowledge in the management of cognitive load, demonstrating that familiarised students have greater predisposition to enjoy and engage in the educational activity, which highlights that importance of the instructional design to maintain the interest and participation of the students (Villalustre, 2024).

However, the current study has a set of limitations, due to the fact that the participants were recruited by convenience sampling, and it was a cross-sectional study restricted to the moment of application. Moreover, the homogeneity of the characteristics of the participants could limit the generalisation of the findings to more diverse contexts.

Lastly, the research line marked in this work is highly transcendent, as it helps to avoid a sexist bias in the methodological models and educational strategies that are implemented in formative experiences, thereby enhancing gender equity. Future research should carry out longitudinal studies that delve into the long-term impact of these methodologies on the learning and motivation of students. In addition, studies that explore the interaction between cognitive load and other variables, such as learning style, could enrich the understanding of how to design active methodologies adapted to the individual characteristics of the students. Similarly, the inclusion of qualitative measures could provide broader perspectives about the experience of students in active and gamified environments.



Data availability

The database is available on the project page: <https://cutt.ly/NwXuFe8j>

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