Gamified flipped classroom: application of a teaching strategy to develop computational thinking in future teachers

Aula invertida gamificada: aplicación de una estrategia didáctica para trabajar el pensamiento computacional en futuros docentes

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Abstract

This study analyses the impact of gamification and flipped learning on the development of computational thinking in students enrolled in the Bachelor's Degree in Early Childhood Education. The gamified flipped classroom strategy was evaluated for this purpose. The sample included a total of 86 students. The experimental group, consisting of 36 students, received a didactic intervention based on the gamified flipped classroom approach and completed both the pre-test and post-test. The control group, consisting of 50 students, followed a traditional methodology for six weeks and also completed both the pre-test and post-test, allowing for a comparison of the effects of both methodologies. To assess students' development in computational thinking, the Computational Thinking Test (CTT) was used. This instrument was administered both before and after the implementation of the didactic strategy, serving as the pre-test and post-test, respectively. Statistical analyses of the collected data indicated an increase in computational thinking scores in the experimental group. This finding suggests that combining the flipped classroom methodology with gamification elements can be effective in enhancing computational thinking in university students pursuing a degree in Early Childhood Education. Therefore, the study provides evidence that implementing innovative pedagogical strategies, such as the gamified flipped classroom, can have a significant impact on the development of computational thinking in higher education students. However, further research is needed to confirm and expand these findings in different contexts and with larger samples.

Keywords: gamified flipped classroom, computational thinking, higher education.

Resumen

Este estudio analiza el impacto de la gamificación y el aprendizaje invertido en el desarrollo del pensamiento computacional en estudiantes del Grado en Educación Infantil. Para ello, se evaluó la estrategia del aula invertida gamificada. La muestra incluyó un total de 86 estudiantes. El grupo experimental compuesto por 36 estudiantes han recibido una intervención didáctica basada en el aula invertida gamificada y completaron tanto el pretest como el postest. El grupo control, compuesto por 50 estudiantes, siguieron una metodología tradicional durante seis semanas, y completaron también el pretest como el postest, permitiendo una comparación de los efectos de ambas metodologías. Para evaluar la mejora del pensamiento computacional en los estudiantes, se utilizó el Test de Pensamiento Computacional (TPC). Este instrumento se administró tanto antes como después de la implementación de la estrategia didáctica, actuando como pretest y postest, respectivamente. Los análisis estadísticos de los datos recopilados indicaron un incremento en las puntuaciones de pensamiento computacional en el grupo experimental. Este hallazgo sugiere que la combinación de la metodología de aula invertida con elementos de gamificación puede ser eficaz para mejorar el pensamiento computacional en estudiantes universitarios del grado de maestro/a de educación infantil. Por lo tanto, el estudio aporta evidencia de que la implementación de estrategias pedagógicas innovadoras, como el aula invertida gamificada, puede tener un impacto significativo en el desarrollo del pensamiento computacional en estudiantes de educación superior. Sin embargo, es necesaria más investigación para confirmar y expandir estos resultados en diferentes contextos y con muestras más grandes.

Palabras clave: aula invertida gamificada, pensamiento computacional, educación superior.

INTRODUCTION

Higher education is undergoing a significant transformation with the incorporation of innovative methodologies such as gamification and the flipped classroom. These pedagogical strategies are redefining teaching and learning paradigms, offering new perspectives and challenges (Soriano-Sánchez & Jiménez-Vázquez, 2023). The use of flipped learning (FL) and gamification is becoming more prominent in educational settings (Ekici, 2021).

Despite this, there is little research that combines these two approaches (FL and gamification) and analyses the possible improvements in motivation and academic performance at the university stage (Carpena Arias & Esteve Mon, 2022a). The aim of this paper is to present a didactic intervention for university students that uses gamification and FL methodologies to develop computational thinking (CT).

Gamification and the flipped classroom in higher education

Higher education is introducing didactic strategies such as gamification and the flipped classroom, which seek to improve students' motivation and academic performance (Candel et al., 2024). These methodologies have been effectively combined in what is known as the gamified flipped classroom, henceforth AIG, a pedagogical strategy that incorporates game-like elements within a framework of active, student-centred learning (Carpena Arias & Esteve Mon, 2024).

The concept of the "inverted classroom" was first introduced by Lage et al. (2000). However, it was not until 2009 that Bergmann and Sams (2009) definitively popularised the term. They began recording their lessons so that students who could not physically attend class were able to access the content at home. This enabled all students to stay on track with the material and keep up with the pace of the class. This methodology transforms the traditional educational approach by requiring students to first work through the teaching material in advance, using digital resources, readings or videos before attending class (Bergmann & Sams, 2014). This individual preparation allows them to engage in more dynamic and applied activities such as discussions, group work and problem-solving during class time, all supervised and guided by the teacher (Santiago & Bergmann, 2018).

In addition, a study by Bishop and Verleger (2013) showed that the flipped classroom significantly improves the quality of student interactions. By moving direct instruction out of the classroom, students have more opportunities to interact with their teachers during class time, which facilitates deeper understanding and more meaningful learning. According to Touron and Santiago (2014), the FL model fosters greater interaction between students and teachers, promoting more personalised attention and deeper learning.

According to Martín and Tourón (2017), implementing flipped learning supported by digital devices in primary education encourages creativity, critical thinking, communication, collaboration and social skills. Similar benefits have been observed in online training for early childhood education degree students, where the flipped classroom approach has led to improvements in mathematical performance and increased motivation (Sacristán et al., 2017). Moreover, it is essential to consider complementary pedagogical strategies, such as gamification, to further enhance these outcomes.

Gamification in education, understood as the use of game design elements and principles in non-game contexts, aims to motivate and increase student participation, thus improving their learning process (Prieto, 2020). In this sense, gamification is applied in education to make it more engaging and immersive, using game mechanics such as points, badges and leaderboards, which encourage healthy competition and guide students towards specific achievements (Werbach & Hunter, 2015).

In 2014, Marczewski proposed a distinction in gamification approaches, differentiating between shallow and deep gamification, based on the type of motivation that sought to be stimulated. Shallow gamification, often focused on content, uses external elements such as points, badges and leaderboards to encourage extrinsic motivation. In contrast, deep gamification focuses on a holistic integration of game dynamics, mechanics and core game components to cultivate more sustainable and deeper intrinsic motivation (Marczewski, 2014).

The use of gamification and the flipped classroom has emerged as a methodological strategy in higher education, aimed at promoting more interactive and motivational learning. This pedagogical combination has been the subject of much research, which points to its benefits for both student motivation and academic achievement, according to Carpena Arias et al. (2022).

The study by Zainuddin (2018) investigated how gamification in the context of the flipped classroom can improve both learning performance and students' perceived motivation. On the other hand, Zamora-Polo et al. (2019) examined how students from non-scientific disciplines can benefit from an active pedagogy that fuses gamification with the flipped classroom, revealing significant improvements in engagement and understanding of general science concepts. Similarly, Gómez-Carrasco et al. (2019) documented the positive effects of a gamification and flipped classroom programme on trainee teachers, highlighting an increase in motivation and perception of learning.

Additional research, such as that of Sailer and Sailer (2021) highlights how incorporating gamification into flipped classroom activities can enhance interaction and collaboration between students, which in turn improves learning outcomes. Furthermore, the work of Elzeky et al. (2022) on the effectiveness of gamified flipped classroom in nursing students highlights the improvement of clinical competencies and learning motivation, providing evidence of the adaptability of these methodologies to different disciplines. Furthermore, a systematic review conducted by Ekici (2021) on the use of gamification in flipped learning indicates that the combination of these methodologies is gaining ground in various educational contexts, showing promising results in terms of motivation and academic performance.

The implementation of methodologies such as gamification and the flipped classroom in higher education has shown a positive impact on peer interactions, fostering an environment of collaboration and teamwork (Carpena Arias & Esteve Mon, 2022a). Therefore, we can define the AIG methodological strategy as the pedagogical strategy that combines the elements of gamification and FL to enhance student engagement and motivation.

Computational thinking

The term computational thinking (CT) was first introduced by Wing (2006), defining it as the ability to solve problems, design systems and understand human behaviour through the fundamental principles of computer science. Wing argued that computational thinking is as important as learning mathematics and writing for 21st century education, positioning it as an essential skill that everyone should possess. In the following years, this initial definition has been the subject of debate, trying to reach a consensus on what computational thinking is and what elements it incorporates (Serrano, 2022). After several years without reaching an agreement on the definition of computational thinking, a consensus has finally been reached, defining it as: "the (human) ability to solve problems and express ideas using concepts, practices and perspectives of Computer Science" (Román-González, 2022).

The growing importance of computational thinking has led to its inclusion in formal education in various ways. For example, in Spain, Real Decreto 95/2022, of 1 February, which establishes the minimum teaching standards for Early Childhood Education (ECE), has for the first time proposed the incorporation of CT as part of the curriculum at this educational stage. This approach is also reflected in INTEF (2021), which concludes that the use of unplugged activities in pre-primary and primary education is a very effective strategy to work on CT while addressing content from different areas of the curriculum.

According to Serrano and Ortuño (2021), teachers do not have adequate training to integrate CT effectively and appropriately. Moreover, the inclusion of CT in established curricula can be complex, especially in areas that have not traditionally been linked to computer science. In relation to teacher training, teachers tend to specialise in programming and robotics, but not in the didactics of the disconnected CT, which is essential for promoting the CT, as Ortuño and Serrano (2024) point out.

In their systematic review, Collado-Sánchez et al. (2023) propose adaptations to teacher training programmes to include CT skills and thus guarantee an education aligned with contemporary technological demands. In their study, Villalustre-Martínez (2024) analyses the level of computational thinking in future teachers, highlighting the influence of gender and previous experience in robotics programming. The study identifies significant differences between men and women, as well as between students with and without previous experience, which underlines the need to adapt teacher training to these profiles.

METHODOLOGY

This research forms part of a larger project that adopts Educational Design research (EDR) methodology, a systematic approach to improving educational practices through iterative development and evaluation of pedagogical interventions, aimed at solving complex problems in real teaching and learning environments (Plomp & Nieveen, 2009). In addition to focusing on the invention of advanced educational solutions, the EDR methodology seeks to generate meaningful theoretical knowledge that is transferable to different educational settings.

In the stages preceding this study, the work was carried out in two phases. First, we conducted a literature review to establish a theoretical basis for combining gamification methodologies and the flipped classroom model in the context of higher education (Carpena Arias & Esteve Mon, 2022a).

Then, during the second stage, we proceeded to create and validate a didactic approach that applied the flipped classroom concept, enriched with gamification elements. This process included consultations with educational technology experts to ensure that our proposal was relevant and coherent (Carpena Arias & Esteve Mon, 2024).

The final stage focused on evaluating how students perceived the effectiveness and applicability of our intervention through personal interviews. This evaluation allowed us to have an approximation of the students' perception of the learning process. In this study we will try to test whether or not the AIG intervention has an impact on the performance of CT skills in students of the Early Childhood Education teaching degree.

The main objective of this study is to determine the effectiveness of a didactic intervention that integrates elements of gamification and flipped classroom, examining its influence on the CT skills of university students. This will be achieved by comparing pre-test and post-test results between an experimental group and a control group. In line with this main objective, the research question is the following: Is the gamified flipped classroom methodology more effective than traditional teaching methods in fostering computational thinking in Early Childhood Education students, based on CTT test results?

Context and participants

Participants were fourth-year students enrolled in the course Information and Communication Technologies in Education, part of the Bachelor's Degree in Early Childhood Education at a public university in Spain. Participants in the study were volunteers, and all information collected through the tests was kept anonymous. Prior to participation, everyone signed an informed consent form, which explained the study procedures, their right to privacy and the possibility of withdrawing at any time without consequences.

This research follows the ethical guidelines established by the British Educational Research Association (BERA, 2018), ensuring respect for the principles of confidentiality, informed consent and participant welfare. The sample included 86 students aged between 20 and 40 years old, distributed across two groups. Experimental group: 36 students (9 males and 27 females) received the gamification and flipped classroom intervention to work on computational thinking and completed both the pre-test and post-test. Control group: 50 students (49 females and 1 male), participated in a conventional teaching approach and also completed the pre-test and post-test. To avoid bias in group assignment, an attempt was made to balance the distribution of participants. In addition, the sample size was determined with a confidence level of 95% and a margin of error of 6%, which resulted in an estimate of 86 participants, exactly matching the students who completed the study.

The intervention was carried out over a period of six weeks, during which time students were immersed in a methodological strategy that integrated the flipped classroom model with elements of gamification. This approach encouraged students to take an active role in their learning process, acquiring theoretical knowledge autonomously outside the classroom by consulting digital resources and completing preparatory tasks. They then applied this knowledge in practical activities during face-to-face sessions at the university. Gamification was incorporated as a dynamising element, seeking to boost students' motivation and commitment to the activities and study through the use of playful mechanics and dynamics in an educational context.

Intervention and gamified methodology

MyClassGame is an innovative open-source educational gamification platform that allows teachers across all educational levels to create and design personalised gamified environments. This tool facilitates the integration of active methodologies, making the teaching process a more motivating experience. Teachers can configure elements such as experience points, levels, and missions that assess students through rubrics, all within a game-based framework that seeks to enhance motivation and learning.

In this study, we adopted the principles of gamification proposed by Werbach and Hunter (2015), focusing on dynamics, mechanics and components, commonly referred to by the acronym MDA, together with the phases proposed by Ocón-Galilea (2017) to design our gamified activities. Below, we detail how these elements have been applied in our intervention.

Game Mechanics

The mechanics constitute the fundamental elements of the game, defining its rules and functioning. In our intervention, we have incorporated the following mechanics:

- Collaboration: We encourage teamwork in most of our project activities.
- Challenges: We implemented progressive activities, requiring groups to complete them to advance to the next level.
- Rewards: We used experience points (XP) and powers as incentives for students to overcome challenges.

Game Dynamics

The dynamics represent the more abstract aspects of the gamified environment. In our work, we have used:

- Narrative: The story "The Zombie Apocalypse" served as the backbone of our Gamified Learning Environment (GLE). An introductory video was created that set the context: a pandemic that has led to students becoming "zombie learners" with digital skills deficiencies. The mission was to overcome challenges related to computational thinking to avoid digital illiteracy.
- Progression: We established progression levels (1 enthusiast, 2 beginner, 3 amateur, 4 star, 5 legend) to mark the progress of the students.

Game Components

The components are the concrete and specific elements of the game. In our intervention, we include:

- Avatar: Students created their own avatars.
- Combat: A final battle against the zombies.
- Missions: Specific activities to be completed.
- Collections: Students collected powers on their bounty board.

Figure 1
Gamified classroom management

Figure 2
The components of the game

Behaviour and Penalties

Desirable behaviours and penalties were key to our methodology:

- Rewarded Behaviours: Collaboration, active participation, attendance, punctuality and persistence in work, rewarded with experience points (XP).
- Penalties: 50 life points (Hp) were taken away for being late, disrupting in class or failing to complete assignments.

Narrative Events

The narrative was broken down into key events to maintain interest and motivation:

1. El Reunion: Fight the zombies (1st mission).
2. The Escape: Escape from the zombie prison (2nd mission).
3. The Great Battle: Battle to the Death (3rd mission).
4. The Unravelling: Back to College 5.0 (4th mission).

Each event required overcoming specific challenges related to computational thinking to progress through the narrative. The AIG educational intervention was organised into five distinct phases over six weeks (Carpena Arias & Esteve Mon, 2022b). The first phase consisted of one week of research and implementation, during which students explored computational thinking concepts outside the classroom and prepared presentations based on their research. The second phase lasted two weeks and included classroom discussions on the benefits and challenges of integrating computational thinking and robotics into education. Students then worked on CT-related tasks using platforms such as Code.org and Scratch. Those who participated most actively were awarded badges, which they could exchange for rewards. Students also reflected on their learning by writing personal blog posts. The third phase, also two weeks long, focused on product development. Students worked in teams to produce educational materials linked to computational thinking and to design didactic units adapted for early childhood education. The most participative teams received extra powers within the gamified structure. The fourth phase involved presenting the final product. In classroom sessions, teams demonstrated the materials they had created, and those with more privileges chose their presentation order. The final phase, lasting one week, focused on project evaluation. Students completed self- and peer evaluations of their participation in the project and their peers' performance, using a rubric designed by the teacher. This structure fostered comprehensive, collaborative, and reflective learning about computational thinking and its practical application.

Instrument and data analysis

The Computational Thinking Test (CTT) developed by Román-González (2015) was used to assess the students' computational thinking skills. The instrument was applied before the intervention (pre-test) and after its completion (post-test) to evaluate the development of computational thinking skills acquired by the students during the study. This CTT evaluates fundamental elements such as sequencing, iterations, conditionals, functions and variable management. The main purpose of the CTT is to estimate the computational thinking skills of the participants, focusing on how students apply computational concepts to solve problems.

This test consists of 28 objective multiple-choice questions each offering four response options and must be completed within 45 minutes. It has a Cronbach's alpha coefficient of 0.74, indicating acceptable reliability in terms of internal consistency. The questions were administered via a Google Forms form at baseline and at the end of the intervention in both groups. Data were collected electronically and analysed using Jamovi statistical software. Following the procedure outlined by Román-González (2015), descriptive analyses were conducted to compare pre-test and post-test results for both groups. This allowed for the calculation of gain score and normalised learning gains.

RESULTS

First, descriptive results are presented for the initial CT level of all students differentiated by gender. As can be seen in Table 1, the mean for all participants is 20.1, with a mean of 20.2 for females and slightly lower for males, at 19.1. The median remains at 20.0 overall, and is identical for females, while for males it is slightly lower, at 19.0. On the other hand, the standard deviation (SD), which indicates the variability of the data, is 4.56 for all participants, 4.45 for females, and is higher for males, at 5.47.

Table 1
Descriptive statistics of the pre-test of the CT test

	Sex	Initial level
N	All	86
	Women	76
	Men	10
Mean	All	20.1
	Women	20.2
	Men	19.1
Median	All	20.0
	Women	20.0
	Men	19.0
SD	All	4.56
	Women	4.45
	Men	5.47
Minimum	All	9
	Women	9
	Men	10
Maximum	All	30
	Women	30
	Men	26

Table 2 below shows the pre-test and post-test results of the CT level after the implementation of the AIG intervention (experimental group) and the traditional methodology (control group).

Table 2
Descriptive statistics for both pre-test and post-test groups

	Experimental Group				Control Group			
	Pre-testM (SD)	Post-testM (SD)	Pass	PwM	Pre-testM (SD)	Post-testM (SD)	Pass.	PwM
CT Total	20.8 (5.08)	23.8 (4.60)	3.06	26,1	20.8 (4.34)	21.1 (4.43)	0.320	10,8
Women	20.6 (4.53)	23.6 (4.81)	3.06	25,8	20.9 (4.33)	21.2 (4.39)	0.347	10,9
Men	20.9 (5.67)	23.9 (4.53)	3.05	25,8	16.0 (5.0)	15.0 (5.0)	-1.00	6,25

In the experimental group, the pre-test showed a mean CT of 20.8 (SD = 5.08) rising to 23.8 (SD = 4.60) at the post-test, which translates into a mean gain of 3.06 points and a normalised learning of 26.1 for the total participants. Broken down by gender, females went from a mean of 20.6 (SD = 4.53) to 23.6 (SD = 4.81), with an identical gain of 3.06 and a normalised learning of 25.8, while males showed an improvement from 20.9 (SD = 5.67) to 23.9 (SD = 4.53), with a gain of 3.05 and a normalised learning of 25.8. In the control group, the pre-test revealed a mean of 20.8 (SD = 4.34), which increased slightly to 21.1 (SD = 4.43) in the post-test, with a minimal average gain of 0.320 and a normalised learning of 10.8 for the total participants. Analysing by gender, females in the control group started from a mean of 20.9 (SD = 4.33) and reached 21.2 (SD = 4.39), having a gain of 0.347 and a normalised learning of 10.9; whereas males had a reduction from a mean of 16.0 (SD = 5.0) to 15.0 (SD = 5.0), with a mean loss of -1.00 and a normalised learning of 6.25.

Finally, to deepen this comparative analysis, Figure 3 and Table 3 show the **estimated** marginal means of the experimental and control groups after pre-test adjustment (Table 3), as well as their graphical representation (Figure 3). These results allow us to visualise the difference between the two groups and the effect of the intervention.

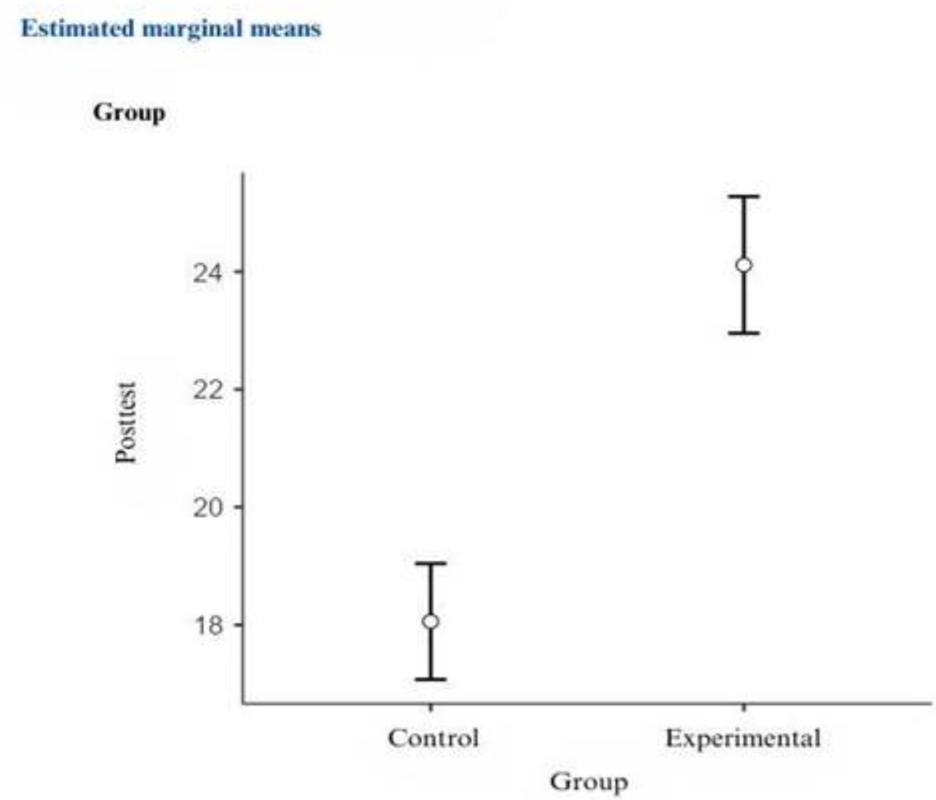

Figure 3

Estimated marginal means for the post-test variable in the analysis of covariance (ANCOVA).

Table 3

Estimated marginal means for the Post-Test after adjustment for Pre-test

Estimated Marginal Measures - Group				
			95% Confidence Interval	
Group	**Mean**	**SE**	**Lower Bound**	**Upper Bound**
Control	18.1	0.495	17.1	19.0
Experimental	24.1	0.584	23.0	25.3

Analysis of covariance (ANCOVA) showed a significant difference between the experimental and control groups after adjusting for the pre-test. In the comparison of estimated marginal means (Table 3), the experimental group obtained an adjusted mean of 24.1 (95% CI: 23.0 - 25.3), while the control group had an adjusted mean of 18.1 (95% CI: 17.1 - 19.0). The difference between the groups was 6.0 points, indicating a better performance of the experimental group. The group effect in the ANCOVA model was significant (p<.001p < .001p<.001), suggesting that the applied intervention had an impact on the dependent variable. Furthermore, as shown in Figure 3, the confidence intervals of the two means do not overlap, which reinforces the existence of a real difference between the groups and the robustness of the effect found.

DISCUSSION AND CONCLUSIONS

The present study focused on evaluating the effectiveness of gamification combined with flipped learning to enhance computational thinking in university students of Early Childhood Education. The sample consisted of 86 students aged between 20 and 40, divided into two groups. The experimental group, made up of 36 students, received an intervention based on gamification and the flipped classroom, completing both the pre-test and the post-test. The control group, consisting of 50 students, followed traditional teaching and also completed both tests. The sample size was calculated with a confidence level of 95% and a margin of error of 6%, resulting in 86 participants, which exactly matches the number of students who completed the study. This ensures that the sample is representative and supports the reliability of the findings.

The AIG educational intervention was carried out in five phases over six weeks. In the first week, students investigated concepts related to computational thinking outside the classroom. The next two weeks were spent discussing the use of PCs and robotics, with hands-on practice on platforms such as code.org and Scratch. The third phase involved creating educational materials in teams. In the fourth phase, teams presented their final products, and in the final week they conducted self- and co-assessments, encouraging collaborative and reflective learning about computational thinking. This approach encouraged students to take an active role in their learning, gaining computational thinking skills autonomously. The composition of the sample reflects the reality of the Bachelor's Degree in Early Childhood Education, where the majority of the enrolment was female. Although this distribution does not affect the validity of the results, it is a factor to consider in their interpretation and in the possibility of extrapolating them to contexts with a more balanced gender representation.

In relation to the research question, the results indicate that, in general, in both groups (experimental and control) demonstrated improvement after the intervention, regardless of whether traditional or AIG methodology was used. However, the results of the research show that the group that participated in the AIG methodology obtained better results than the control group. That is, there is an improvement in computational thinking skills after the educational intervention in the experimental group, suggesting that the use of AIG may be more effective than the traditional methodology for working on CT skills. This is consistent with findings from studies such as Zainuddin (2018), where higher performance and engagement was observed in students who participated in a gamified flipped classroom. The incorporation of components of the AIG methodological strategy has had a positive effect on the results of the experimental group, these results coincide with those obtained by Recabarren et al. (2021). The results of this study are also in line with other research, such as those of Huang and Hew (2019), which have demonstrated the benefits of gamification and flipped learning in terms of improved academic outcomes. The observed improvement in computational thinking among participants in the experimental group supports the idea that these innovative pedagogical methodologies can be particularly effective in higher education settings, especially for future teachers.

The results obtained indicate that the intervention applied to the experimental group had a positive effect compared to the control group. The difference of 6.0 points in the adjusted mean, together with the statistical significance (p<.001p < .001p<.001), suggests that the implemented treatment contributed to a substantial improvement in the participants' performance. These findings are consistent with previous studies that have reported similar improvements following the application of specific methodologies in similar contexts. The absence of overlap in the confidence intervals reinforces the robustness of the observed effect and reduces the likelihood that the difference is attributable to chance. However, it is important to consider that while the difference between the groups is clear from a statistical point of view, its practical impact needs to be assessed according to the context and the size of the effect. Future studies could analyse the long-term impact of the intervention and explore the influence of other variables that might be mediating the results obtained. These results may imply that, in the context of teacher education, the integration of gamified and inverted didactic strategies promotes not only the acquisition of knowledge but also the ability to apply it in practical situations. This is in line with similar research highlighting the benefits of using a gamified flipped classroom model in university education (Carpena Arias & Esteve Mon, 2022a). The combination of computational thinking and gamification in teacher education is presented as a promising strategy, but careful design and possibly longer intervention is needed to maximise its benefits (Bueno-Baquero et al., 2024).

Despite the results, it is important to recognise the limitations of the study. The quantitative design would benefit from being complemented by qualitative data, such as interviews or focus groups, to gain richer insight into how students engage with and perceive the AIG methodology. Furthermore, for future research, it will be essential to base our didactic intervention in the development of computational thinking on an existing model, such as the 5CT model. This model proposes a five-phase didactic sequence that allows for the integration of CT in teacher training. These are: Real problems, Unplugged activities, Programming of digital devices, Programming of physical objects and Exposure of resources (Ortuño & Serrano, 2024). This approach will ensure that the pedagogical strategies employed are grounded in proven educational theories and practices, allowing for more effective implementation and measurable results in the learning of computational thinking. The adoption of validated theoretical and practical models will provide a more robust structure for evaluating and continuously improving CT teaching strategies.

In conclusion, this study demonstrates how the combination of the didactic methodologies of flipped classroom and gamification can be an effective strategy to enhance computational thinking in higher education students, especially in initial teacher training. AIG not only facilitates the acquisition of CT skills but also promotes students' autonomy and intrinsic motivation. However, more research is needed to confirm and expand these results in different educational contexts of initial teacher education and with larger samples, to fully understand the underlying mechanisms and to optimise the adaptation of these approaches to various teaching and learning situations. On the other hand, it will be necessary to incorporate a specific methodological approach to CT in initial teacher education in order to combine it with AIG and thus test whether computational thinking skills are further enhanced.

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