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University teaching innovation through digital game-based learning: Pre-service teacher readiness for digital transformation in higher education

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Abstract

The use of game-based digital tools has become a highly relevant and dynamic element in the training of future educators, playing a pivotal role in shaping diverse teaching and learning processes. These tools offer a more engaging, effective, and interactive learning experience, designed to boost student motivation and provide immediate feedback. This study examines the impact of a didactic intervention using gamified digital tools (Genially, Quizizz, & WebQuest) on students' learning and motivation in online university classrooms. The intervention was implemented over five months with future teachers (n = 262) enrolled in Early Childhood and Primary Education programs, as well as Music and Physical Education specializations at a private Spanish university. A design involving measurements before and after the intervention was employed to assess its impact, including an exploratory and a confirmatory factor analysis to validate the instrument's three-dimensional structure. The findings confirm that the use of digital games enhances students' perceptions of their own learning. Moreover, correlation analyses supported the robustness of the results, showing consistent relationships between the dimensions, while differences across age, gender, and degree type remained minimal or disappeared after the intervention. These results have practical implications for higher education, supporting the integration of such tools not only in music and physical education but across a range of curricular subjects.

Keywords: Digital game-based learning, Digital resources, Gamification, Higher education, Motivation, Teacher training.

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Contents

Contribution of this paper to the literature

This study offers novel empirical evidence on how gamified digital tools (Genially, Quizizz, WebQuest) enhance educator readiness in Spanish higher education. It combines a large pre-post sample, psychometric validation, and analysis of demographic variables to advance understanding of Digital Game-Based Learning's role in teacher education.

1. Introduction

The digital transformation of higher education has brought about profound changes in how educational processes are conceived, designed, and implemented, fostering the adoption of innovative methodologies that respond to the demands of the 21st century. This transformation extends beyond the mere integration of technological tools; it involves a deeper epistemological and methodological shift that redefines the role of teaching through the development of key competencies for contemporary society (Cabero & Llorente, 2020).

Beyond possessing the necessary expertise, educators are tasked with preparing professionals who are equipped to navigate and respond to the challenges of a highly digitalized world. It is therefore essential to examine how these institutions facilitate the acquisition and development of digital competencies—skills that are essential for enabling educators to adopt more effective teaching practices (Eyal, Rabin, & Meirovitz, 2023; Girón, Cózar, & González-Calero, 2019). As a result, a wide range of pedagogically diverse initiatives have emerged, including the use of serious games (Lunavictoria, León, Sarango, & Astudillo, 2024; Sandí, 2020), virtual learning environments (Belda-Medina & Calvo-Ferrer, 2022; Zumba-Novay, & Paredes-Chacin, 2022), and interactive proposals aimed at enhancing digital competence (Ferrando-Rodríguez, Gabarda Méndez, Marín-Suelves, & Ramón-Llin Más, 2023; Mikrouli, Tzafilkou, & Protogeros, 2024). In this context, it is no longer sufficient for educators to master disciplinary content alone; they must also demonstrate strong digital competence, enabling them to design, implement, and assess innovative pedagogical proposals that effectively incorporate gamified digital tools into teaching and learning processes (De los Ángeles Domínguez-González, De la Rosa, Hervás-Gómez, & Román-Graván, 2025; Tomczyk et al., 2023). As Hoang et al. (2025) note, this competence encompasses not only technical proficiency with digital tools but also their critical and pedagogical appropriation to energize the classroom, foster student autonomy, and support learner-centered methodologies such as game-based learning, project-based work, and collaborative learning.

Far from being mere technical supports, digital games and gamified tools serve as mediators that facilitate new forms of interaction, knowledge construction, and dissemination, aligned with the demands of increasingly dynamic and interconnected educational environments (Chen & Tu, 2021; Wang, Zhou, Hwang, Wang, & Huang, 2024). Their presence in the classroom enables the design of more personalized, collaborative, and contextualized learning experiences that respond to today's social and professional challenges (Chen, Ming-Chaun, & Kuo, 2023; Lin, Wang, & Hsieh, 2024). Thus, technology not only enhances teaching practices but also acts as a catalyst for methodological innovation. Active methodologies supported by technologies and digital games are gaining increasing momentum in higher education. Tools such as Genially, Quizizz, and WebQuest have proven effective in transforming university classrooms into spaces of experimentation, motivation, and meaningful learning (Nadeem, Oroszlanyova, & Farag, 2023; White, Gault, Shimi, Herd, & Manwaring, 2025). Their value lies not only in capturing students' attention but also in fostering collaborative knowledge construction, critical thinking, and creative problem-solving (Boom-Cárcamo, Buelvas-Gutiérrez, Acosta-Oñate, & Boom-Cárcamo, 2024; Cabrera-Solano, 2022; Torrado Cespón & Díaz Lage, 2022). Notably, their integration into initial teacher education helps cultivate key competencies such as digital literacy, didactic innovation, and professional autonomy, empowering future educators as genuine agents of educational change (Delgado Togra, Martínez Chávez, & Tigrero Vaca, 2022; Magaña, Cuesta, Ariza, & Magaña, 2023). In light of these considerations, the present study aims to design, implement, and validate a questionnaire to assess, through a pre- and post-intervention approach, the impact of a game-based digital didactic experience in university teacher education programs. This initiative promotes a dynamic and integrative pedagogical model that responds to the current challenges of higher education.

2. Literature Review

The analysis of the reviewed studies reveals a growing consensus on the effectiveness of Digital Game-Based Learning (DGBL) as a methodological strategy in higher education. However, this review also highlights significant gaps in the academic literature that require attention, both from theoretical and empirical perspectives.

From a conceptual perspective, the integration of models such as TPACK (Handayani, Hussin, & Norman, 2023) and the ICT-LKT-EPT spiral model of competency development (Alnasib, 2023) has broadened the reference framework for studying teachers' digital competence. These approaches make it possible to articulate disciplinary, pedagogical, and technological knowledge, while also acknowledging the progression in the use of educational technologies from an instrumental (ICT), didactic (LKT), and participatory (EPT) function. However, the specialized literature rarely makes explicit connections between these theoretical frameworks and real-world gamification experiences in initial teacher education contexts. On an empirical level, existing studies have documented promising results regarding the benefits of DGBL, particularly in terms of motivation, active engagement, and enhancement of the learning experience (Alomari, Al-Samarraie, & Yousef, 2019; Climent, 2025; Saleem, Noori, & Ozdamli, 2022). Positive effects have also been reported in the development of digital competencies and critical thinking (De la Peña, Lizcano, & Martínez-Álvarez, 2021; Maspul, 2024). However, a more critical review reveals that most of these studies adopt exploratory or descriptive approaches, focusing primarily on student perceptions without validating instruments or employing research designs that allow for the measurement of the actual impact of instructional interventions. One of the main limitations identified is the scarcity of studies using a quasi-experimental pretest-posttest design that would allow for establishing causal relationships between the use of gamified tools and learning outcomes (Angelova & Nikolova, 2024; Majdoub & Heilporn, 2024). This is further compounded by the lack of psychometrically validated instruments to assess key aspects such as motivation, perceived quality of learning, or the development of digital competencies in university contexts (Di Michele, Gómez, Herrera, & Pulido, 2023). This gap limits the ability to replicate results or transfer experiences to other educational settings, thereby weakening the consolidation of a robust empirical framework. Similarly, a significant portion of the research is confined to specific

disciplines or limited sample sizes, without addressing the cross-cutting applicability of DGBL across different university degrees or modalities (in-person and online). The situation reveals a considerable gap in terms of the generalizability of pedagogical proposals based on digital games. As Maraza-Quispe et al. (2024) point out, there is an urgent need to move toward integrative instructional models in which gamification is not merely a sporadic or supplementary resource, but rather becomes a structural and planned element of the university curriculum, particularly in the initial training of future teachers. Based on all the above, for gamification to truly contribute to the improvement of teacher education, it must be structurally integrated into the curriculum, not as an occasional resource, but as a pedagogical strategy aligned with the progressive development of digital competences, ranging from instrumental use to critical and participatory application in the classroom (Erkinovna, 2024). This integration requires careful planning aligned with learning objectives, the educational context, and student characteristics, fostering sustainable, meaningful, and inclusive learning experiences (Dahalan, Smith, Lee, & Zhang, 2023). Conceiving gamification in this way allows it to be adapted to different teaching modalities (in-person, online, and hybrid) and to respond effectively to the challenges of higher education in digitalized environments. In this regard, its incorporation should be articulated with formative assessment approaches, promoting critical thinking, creativity, and student autonomy, and functioning as a strategy consistent with the principles of quality, equity, and innovation that underpin contemporary university teaching (Cespón & Toyos, 2025).

3. Objectives, Research Questions, and Hypotheses

3.1. General Objective

To evaluate the effectiveness of a gamified digital teaching intervention in enhancing university students' perceptions of motivation, learning quality, and the educational value of digital tools, while also validating the psychometric structure of the measurement instrument.

3.2. Specific Objectives

1. To validate the factorial structure and internal consistency of the questionnaire in both the pre- and post-intervention phases.
2. To assess changes in students' perceptions across three dimensions: motivation and engagement, perceived learning quality, and perceived usefulness of digital tools for future teaching.
3. To analyze whether students' sociodemographic variables (age, gender, degree program) and prior attitudes toward digital and traditional teaching (COR1 and COR2) are associated with their responses.

3.3. Research Questions

1. Is the questionnaire psychometrically valid and reliable in both the pre- and post-intervention phases?
2. Does the intervention lead to significant improvements in students' perceptions across the three evaluated dimensions?
3. Are students' perceptions influenced by sociodemographic factors or their initial attitudes toward technology and traditional teaching?

3.4. Hypotheses

1. The questionnaire will demonstrate a stable and valid factorial structure with acceptable reliability in both the pre- and post-test conditions.
2. The intervention will result in significant improvements in students' scores across all three dimensions.
3. No significant differences are expected in intervention outcomes based on age, gender, or degree program, although prior attitudes toward digital and traditional teaching (COR1 and COR2) may be associated with the results.

4. Methodology

4.1. Participants

The study was conducted and concluded during the 2024–2025 academic year with a sample of undergraduate students enrolled in formal teacher education online programs at Atlántico Medio University (Las Palmas de Gran Canaria, Spain), a university with a strong commitment to educational innovation and the integration of emerging technologies.

Participants were drawn from the Early Childhood Education and Primary Education degrees, as well as these degrees' specializations in Music Education and Physical Education. All of these programs are taught in Spanish and include courses focused on active methodologies and the application of digital resources to teaching. The initial pre-intervention (PRE) sample consisted of 295 students who completed the baseline questionnaire and provided informed consent via online forms.

The final post-intervention (POST) sample comprised 262 students who actively participated in the full didactic intervention process and completed the second questionnaire at the conclusion of the instructional experience. As shown in Table 1, demographic data indicate a majority of female participants in both measurements (PRE: 77.6%; POST: 77.9%), with a mean age of 32.89 years (PRE) and 33.15 years (POST). Participant ages ranged from 19 to 56 years. The distribution by degree program was as follows: Early Childhood Education (22.1%), Primary Education (45.8%), Music Education specialization (17.9%), and Physical Education specialization (14.1%).

The study complied with all ethical requirements established by the Atlántico Medio University Research Ethics Committee (Approval Code: CEI/01-012), ensuring the confidentiality and anonymity of all data, in accordance with the principles of the Declaration of Helsinki.

Table 1. Demographic Characteristics of the Sample.

Variable	Pre-intervention, n = 295	Post-intervention, n = 262
Gender		
Man	66 (22.4%)	58 (22.1%)
Woman	229 (77.6%)	204 (77.9%)
Age (Years)		
Average (SD)	32.89 SD=8.42	33.15 SD=8.47
Range	19 -56	19 - 56
Degree program		
Early childhood education	62 (21.0%)	58 (22.1%)
Primary education	125 (42.4%)	120 (45.8%)
Music education	54 (18.3%)	47 (17.9%)
Physical education	54(18.3%)	37 (14.1%)

4.2. Design and Instrument

This study employed a research design with two measurement points: one before the intervention (PRE) and one after the intervention (POST). The intervention was applied to a group of university students enrolled in teacher education programs and aimed to evaluate the impact of gamified digital resources on students' motivation, perceived learning quality, and perceptions of pedagogical usefulness. The intervention lasted five months, from October 2024 to February 2025, and was implemented as a review strategy during the final portion of eight online pedagogical sessions. The digital tools used included Genially, Quizizz, and WebQuest, delivered via Google Sites. These resources were integrated into the sessions to promote active learning through gamification and interactivity.

In October 2024, participants completed the PRE questionnaire and the informed consent form. Between October and January, the intervention was carried out, and in late January 2025, the POST questionnaire, identical to the PRE version, was administered to assess potential changes in students' perceptions. All materials being in Spanish, the questionnaire evaluated different dimensions: motivation and engagement, perceived learning quality, and the usefulness of digital tools for future teaching practice. This design enabled the assessment of statistically significant changes in these areas while also supporting the validation of the instrument's psychometric structure in both the pre- and post-intervention phases.

The questionnaire was adapted from the instrument developed by Calderón, Merono, and MacPhail (2019) previously applied in higher education. The final version comprised 16 items (14 original plus 2 new), rated on a 5-point Likert scale (1 = "Strongly disagree" to 5 = "Strongly agree").

The instrument consisted of two main sections:

- Section 1: Contextual and demographic information (e.g., age, gender, degree program), along with two additional correlational items:
- COR1: "Do you regularly use technologies to study?".
- COR2: "Does teaching still rely mostly on lectures and rote learning?".
- Section 2: Core construct of 14 items, which were subjected to psychometric validation through Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The analysis supported a three-factor structure comprising:
- DIM1: Perceived Motivation and Engagement.
- DIM2: Perceived Usefulness and Learning Quality.
- DIM3: Support for Active and Autonomous Learning.

4.3. Procedure: Description of the Educational Experience

The didactic proposal was implemented over the course of one semester. The primary objective was to enhance student learning by integrating gamified digital tools that fostered motivating, participatory, and student-centered environments. To this end, various applications of Genially were employed, along with Quizizz and WebQuest, which enriched the sessions through visually engaging, interactive, and playful activities aimed at reviewing content, introducing new topics, and activating prior knowledge. In all these experiences, the digital games were designed to be used synchronously, with each student working individually on their own computer or electronic device. Subsequently, all the game responses were discussed collectively in class through cooperative and collaborative group work, under the supervision of the course instructors throughout the learning process.

Below is a pie chart illustrating the percentage distribution of students' preferences for the gamified digital tools used during the implementation of the didactic experience. This visualization highlights which tools were most valued by the future teachers:

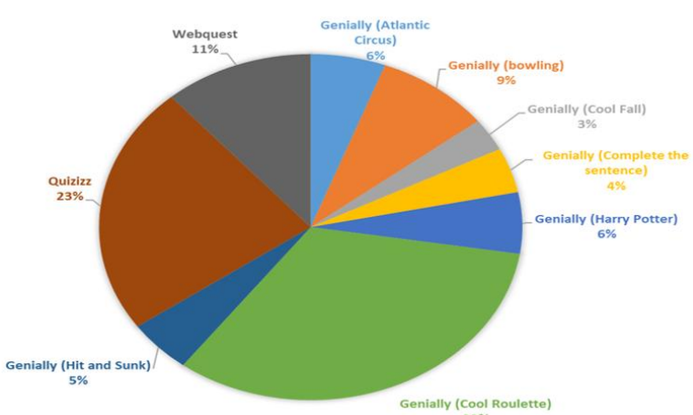

Figure 1. Most preferred gamified digital tools by students.

As shown in Figure 1, Genially, specifically its "Ruleta Genial" template, was the most frequently selected option among students, accounting for 32.8% of all responses. Quizizz ranked second with 23.3%, followed by WebQuest with 11.5%. Other Genially templates also received notable levels of preference: Bowling (8.8%), Harry Potter (5.7%), Atlantic Circus (5.7%), Battleship (5.0%), Complete the Sentence (4.2%), and Amazing Drop (3.1%).

As previously noted, Genially was the most preferred gamified digital tool during the implementation of the didactic experience, with a clear preference reflected in 65.3% of total responses. Its popularity was particularly associated with templates like "*Ruleta Genial*"[1] valued for their visual appeal, interactivity, and capacity to energize the classroom environment. One of Genially's main advantages in educational contexts is its potential to promote active and collaborative learning. In this regard, Castillo-Cuesta, Cabrera-Solano, and Ochoa-Cueva (2024) highlight that the use of visual and multimedia elements enhances both comprehension and content retention. "*Ruleta Genial*" game features a virtual wheel containing options related to music theory, such as notes, rhythms, intervals, and musical figures. When the wheel is spun, students must respond to the selected item, allowing them to apply their knowledge in a practical, dynamic format.

The second most highly rated resource among students was *Atlanticland*.[2] Set in a virtual amusement park, the game guided students through a series of challenges, each requiring correct answers to questions based on the course's theoretical content. As students progressed through the activity, the virtual rewards they earned not only boosted their motivation but also reinforced their understanding of key topics. In this context, Calderón et al. (2019) emphasize that student-centered digital environments, especially those incorporating motivational elements, enhance the learning climate and contribute positively to academic performance in Physical Education teacher training.

The third most highly rated game among students was *Play Bowling* [3]by Genially, an interactive tool designed to support the learning of essential music history content in an engaging and playful manner. In this digital game, students are tasked with knocking down virtual "pins," each representing a music-related topic, such as renowned composers, their most iconic works, musical forms, or historical periods. By correctly answering questions, students knock down the pins, progressing through the game while reviewing and reinforcing their knowledge of music theory.

Furthermore, as illustrated in Figure 1, Quizizz[4] was another gamified digital tool that received a high level of student endorsement, garnering 23.3% of responses. This interactive platform allows instructors to create customized quizzes that support dynamic and game-based learning through formats such as multiple-choice, true/false, and other interactive question types (López & Martínez, 2023; Pitoyo & Asib, 2020). Students participate via mobile devices, receiving immediate feedback and engaging with gamified elements. This strategy not only reinforces theoretical content but also enhances student engagement, fostering a more active, motivating, and participatory learning environment (Singh & Chaudhary, 2022).

Through this platform, students explore key ideas related to music theory, composition, and musical genres in an engaging and interactive way, boosting both their motivation and active participation. Activities of this kind support meaningful learning, enabling the development of essential creative skills in music education (Méndez, Rodríguez, & Soto, 2023).

Another of the most valued digital resources was the WebQuest (*Acrosport*)[5], created with Google Sites. This inquiry-based tool supports critical thinking, creativity, and synthesis (Aslanyan Rad, 2024). In subjects like Physical Education and Music, it effectively blends theory and practice, encouraging active and interdisciplinary learning (Zhao, Muntean, Chis, Rozinaj, & Muntean, 2022). It also promotes autonomy and collaboration (De Souza, De Franco Rosa, & Bonacin, 2020). In this study, the WebQuest supported an interdisciplinary approach as an alternative sport, linking body expression and musical analysis. Students examined rhythmic and formal elements of a musical piece to prepare a group choreography combining content from both music and physical education subjects.

Moreover, the selection of Genially, Quizizz, and WebQuest was not based solely on their visual appeal or playful nature, but rather on their pedagogical alignment with the learning objectives and the development of key teaching competences outlined in the intervention. Each of these digital tools supports core principles of active learning, the development of digital competence, self-regulated learning, and collaborative engagement, which are essential elements in current teacher education models.

Genially was used to design interactive and visually appealing instructional materials that enabled students to explore content autonomously while developing digital communication skills and visual literacy. Its flexibility facilitated the creation of self-assessment resources such as virtual wheels, interactive boards, and formative challenges, which are directly aligned with key dimensions such as motivation, perceived learning quality, and autonomous learning. Quizizz, in turn, was employed as a formative assessment tool with immediate feedback, reinforcing self-regulation and encouraging active participation in alignment with the principles of assessment for learning.

Finally, WebQuest made it possible to structure tasks based on guided inquiry, in which students are required to search for, analyze, and apply information to real educational contexts, thereby developing critical thinking, collaboration, and knowledge transfer. As noted by Sampson and Fytros (2008) and Wesselink and Giaffredo (2015) the integration of digital technologies into the classroom must be guided by explicit pedagogical objectives and aligned with competence-based learning models.

4.4. Statistical Analysis

A comprehensive statistical analysis was conducted to validate the questionnaire, assess its internal consistency, examine the effects of the intervention, and explore associations with demographic and contextual variables. Analyses were performed using IBM SPSS (v.26) and Mplus (v.8.3).

An initial Exploratory Factor Analysis (EFA) was conducted to identify the latent structure of the scale, followed by a Confirmatory Factor Analysis (CFA) to validate a three-factor model comprising: (1) Perceived Motivation and

[1] *Awesome Roulette.* Music Education. URL: https://view.genially.com/67ade59dee2324136830c3f1.
[2] *Atlanticland.* Physical Education and its teaching. URL: https://view.genially.com/67c16f519d51e7031ac84307.
[3] *Play Bowling.* History of Music. URL: https://view.genially.com/67add63a4228c5614e3ed6ae.
[4] *Quizizz.* Music and Musical Creativity. URL https://quizizz.com/admin/assessment/67adf3761209deff99a95eaf?source=lesson_share.
[5] *Acrosport.* Physical education and music. URL: https://sites.google.com/view/acrosportmusical/start.

Engagement, (2) Autonomous Learning and Learning Quality, and (3) Support for Active and Autonomous Learning. As presented in Table 2, the model fit indices obtained confirmed a good fit (Bentler, 1990; Tucker & Lewis, 1973), supporting the structural validity of the questionnaire. Factor loadings ranged from acceptable to excellent, confirming strong and consistent item–factor relationships. Internal consistency was assessed using Cronbach's alpha (Tavakol & Dennick, 2011) and Composite Reliability (CR) (Hair, Black, Babin, & Anderson, 2010) with all values exceeding .80 for each dimension and the overall scale, indicating high reliability. As the Kolmogorov-Smirnov and Shapiro-Wilk tests revealed violations of normality in most items, non-parametric tests were used. Specifically, Mann–Whitney U tests were conducted to compare scores between the pre-test and post-test phases. Statistically significant improvements were detected in several items and dimensions following the intervention. Effect sizes (r) were calculated and interpreted using standard benchmarks (Cohen, 1988) to evaluate the magnitude of observed differences. To assess potential response bias, we compared students who completed both the pre- and post-intervention questionnaires (n = 262) with those who only participated in the pre-test (n = 295). Chi-square and Mann–Whitney U tests showed no significant differences in gender, age, or academic program, supporting the representativeness of the post-intervention sample. Lastly, associations between questionnaire responses and demographic/contextual variables were explored using Spearman's rho correlations (Schober, Boer, & Schwarte, 2018).

Table 2. Model Fit Statistics.

Index	PRE	POST	Interpretation[6]
χ^2	240.271	240.179	$p < 0.01$ in both cases
df	101	101	
χ^2/df	2.38	2.38	Acceptable
RMSEA	0.081	0.081	Acceptable
CFI	0.972	0.974	Excellent (> 0.95)
TLI	0.964	0.966	Excellent (> 0.95)
SRMR	0.057	0.053	Excellent (< 0.08)

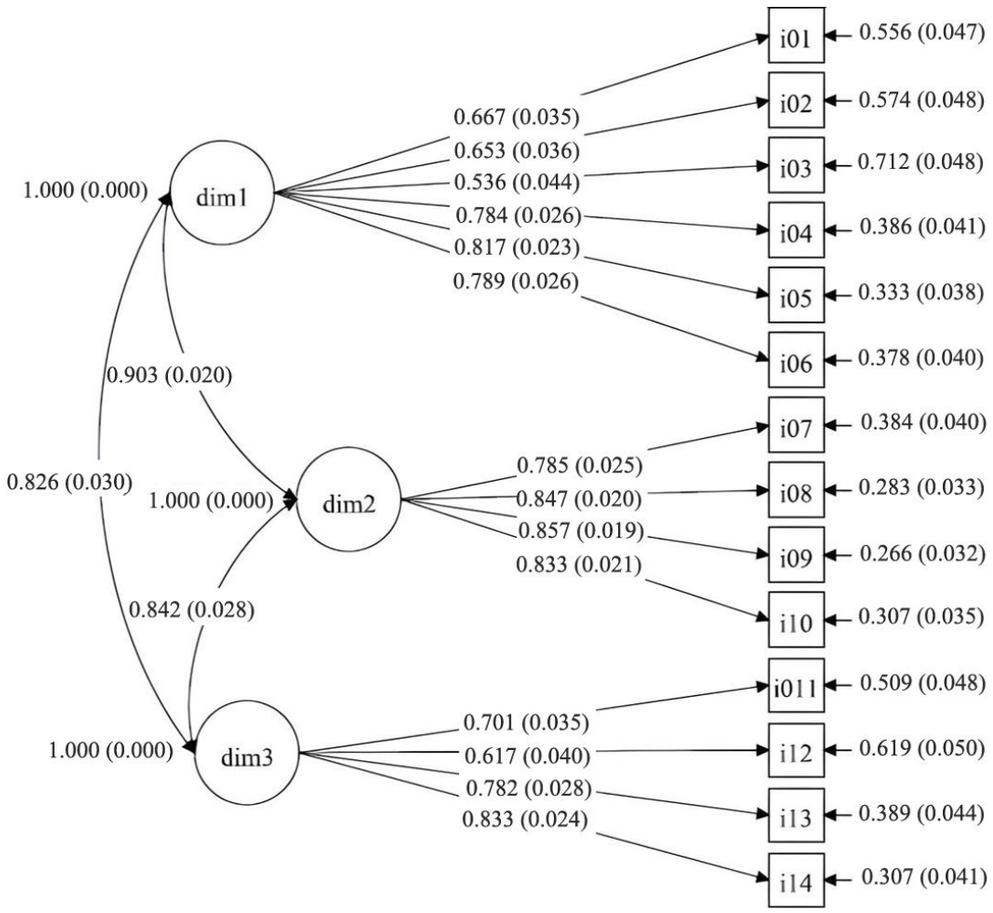

Figure 2. Factor loadings: PRE- test.

[6] Fit Indices. *Chi-square (χ^2) and χ^2/df Ratio.* Satorra-Bentler scaled chi-square (Satorra & Bentler, 2001) is applied to adjust for the non-normality of data. For (χ^2/df), values below or equal to 2 indicate a good fit, and values between 2 and 3 are considered acceptable (Schermelleh-Engel, Moosbrugger, & Müller, 2003). *Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI).* CFI (Bentler, 1990) and TLI (Tucker & Lewis, 1973) as comparative fit indices. Values above .90 are indicative of an acceptable fit, while values above .95 are considered excellent, providing evidence that the model adequately captures the variance in the data structure. *Standardized Root Mean Square Residual (SRMR).* SRMR values, ideally below .08, are interpreted in conjunction with other fit indices to obtain a comprehensive understanding of model fit (Chen, Curran, Bollen, Kirby, & Paxton, 2008). *Root Mean Square Error of Approximation (RMSEA).* RMSEA is particularly informative for evaluating model parsimony, with values below .08 indicating an acceptable fit, and values below .05 indicating a good fit (Steiger & Lind, 1980).

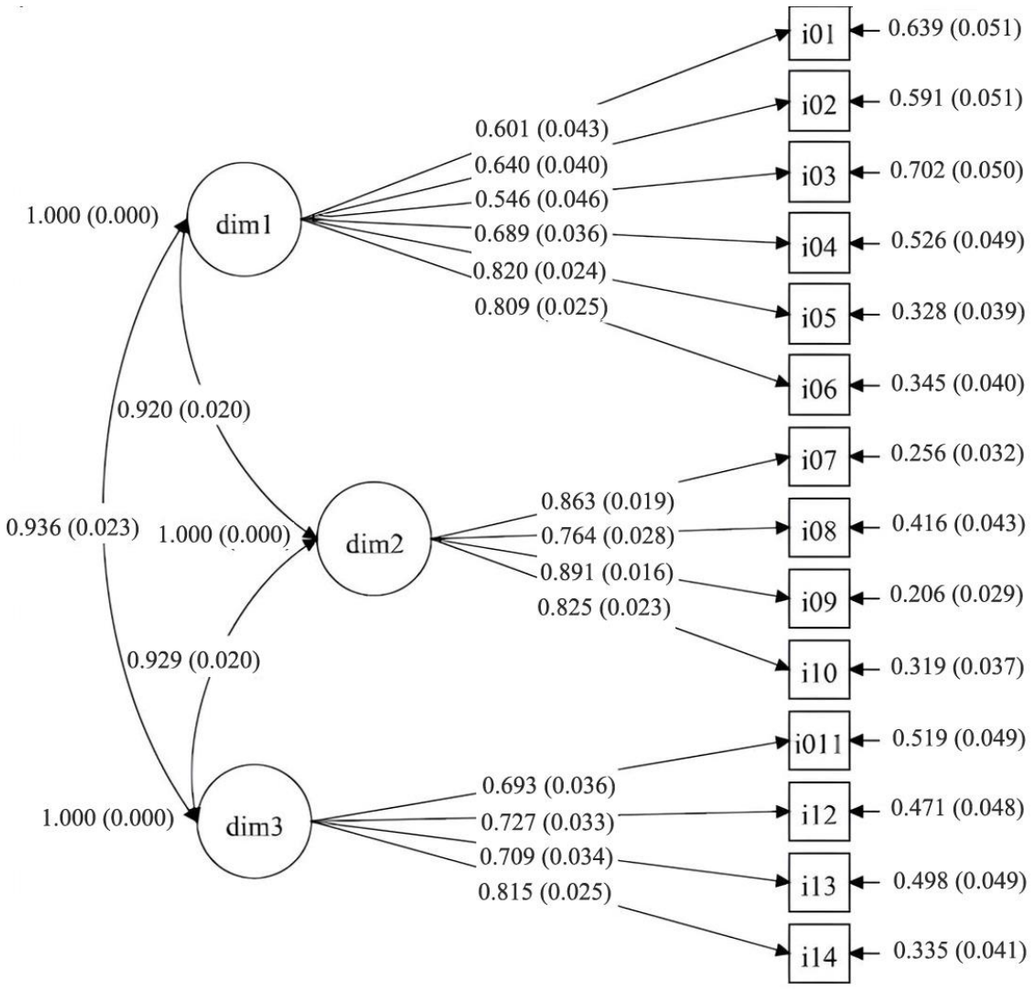

Figure 3. Factor loadings: POST- test.

All factor loadings were statistically significant and conceptually coherent. In both the PRE and POST samples, most items demonstrated excellent standardized loadings (> .70), while the remaining items fell within the acceptable range (.40 – .69)[7] (Figures 2 and 3). These results confirm a robust internal structure, supporting the instrument's suitability.

4.5. Pre-Post Intervention Analysis

To check for selection bias due to attrition, age, gender, and academic degree were compared between participants who completed both phases and those who only did the PRE. Mann–Whitney U and chi-square tests showed no significant differences (all $p > .05$), indicating the POST sample remained representative and supporting internal validity. To examine changes in participants' responses following the intervention, Mann–Whitney U tests were applied ($n = 295$ PRE; $n = 262$ POST), as the assumption of normality was violated. As shown in Table 3, significant increases in mean ranks were observed across all three dimensions in the POST scores, indicating a positive impact of the intervention on students' perceptions.

Table 3. Summary of Differences Between PRE and POST Scores.

Dimension	Z value	p-value	Interpretation
DIM1 – Pedagogical value	-2.443	0.015	Significant improvement
DIM2 – Engagement & motivation	-3.370	0.001	Highly significant improvement
DIM3 – Digital Autonomy	-3.804	0.000	Highly significant improvement

These results confirm that the use of gamified digital resources significantly enhanced students' perceptions across all evaluated dimensions.

4.6. Correlation Analysis

Spearman correlations and Kruskal–Wallis/Mann–Whitney tests were conducted to examine relationships between the three dimensions and various participant characteristics:

- Age showed a weak but statistically significant negative correlation with most dimensions in both the PRE and POST phases, indicating slightly less favorable perceptions among older students. However, no correlation was found with the change scores (POST – PRE), suggesting that age did not influence the magnitude of improvement.
- Gender was not significantly associated with differences in dimension scores or individual item responses, except for a single POST item (I09_Q15), where a minor difference was observed.
- Degree type (across four groups) exhibited some differences in PRE scores for DIM1 and DIM2, but these

[7] Factor Loadings and Interpretation. Factor loadings for items are crucial in determining model quality. Following Hair et al. (2010) and Kline (2015) loadings above .70 are considered strong, indicating that the factor explains at least 50% of the item's variance. Loadings between at least .30 (preferably .40) and .69 are acceptable but suggest weaker association, and these items may be reviewed for potential revision or removal to improve model clarity

differences were no longer present in the POST data, indicating a convergence in perceptions following the intervention.

- COR1 (use of technology in study routines) correlated significantly and positively with all three dimensions in both PRE and POST phases, underscoring its predictive value.
- COR2 (perceived predominance of traditional lecture-based teaching) showed weak and inconsistent correlations, with minimal predictive relevance.

Overall, these findings reinforce both the robustness and the contextual sensitivity of the instrument across diverse demographic subgroups.

5. Discussion and Conclusions

This study confirms that the implementation of digital games as a teaching–learning strategy in university teacher education programs generates positive impacts across three key dimensions. First, regarding pedagogical value and professional relevance (DIM1), students reported increased perceptions of the applicability and usefulness of digital tools for their future teaching practice, thereby enhancing their sense of professional readiness (Gouseti et al., 2024; Mexhuani, 2025). Second, improvements were evident in motivation and engagement (DIM2), with significant gains in intrinsic motivation and active participation, both essential components of meaningful and sustained learning (David & Weinstein, 2024; Roy, Smith, Lee, & Zhang, 2025). Third, the dimension of digital competence and learning autonomy (DIM3) was strengthened through the development of skills related to self-regulated learning and the competent use of digital technologies, crucial elements for navigating contemporary educational challenges (García, Díaz, Reche, & Maldonado, 2025; Magaña et al., 2023).

Consistent results across age, gender, and academic programs highlight the broad relevance of game-based learning in higher education. Its strong link with COR1 (technology use for study) emphasizes the need to build digital literacy early. Curricula should integrate digital games regularly, aligned with learning goals. Teacher training must also focus on reflective, context-aware use of technology (Basilotta-Gómez-Pablos, Estévez-Méndez, Brígido-Mero, & Nistal-Anta, 2025). These strategies foster active, hybrid learning that enhances autonomy, motivation, and real-world skill transfer, preparing educators for innovation (Adeoye, Prastikawati, & Abimbowo, 2024; Hinojo-Lucena, Romero-Rodríguez, Martínez-Menéndez, & Piñero-Lardín, 2025). In summary, the findings of this study underscore the need to transform university-based teacher education models by strategically integrating digital games and active pedagogies that foster more engaging, autonomous, and transferable learning experiences (Khaldi, Bouzidi, & Nader, 2023; Mellado & Cubillos, 2024). The empirical evidence presented demonstrates that technology-mediated pedagogical innovation not only enhances immediate learning outcomes but also contributes to the development of key 21st-century competencies, aligning with international frameworks for inclusive, high-quality education (Alonso-Sánchez, Alonso, & Santana-Monagas, 2025; Avdiu, Bekteshi, & Gollopeni, 2025).

This study has limitations. The lack of a control group limits causal claims, and self-reported data may involve bias; future research should include qualitative methods and longitudinal designs. Also, results from a single institution limit generalizability, so replication in diverse contexts is needed.

Despite this, the study provides a strong basis for future research on digital game-based learning in teacher education. It also underscores the importance of exploring how digital literacy, self-efficacy, and self-regulation interact, and calls for adaptive, innovative teacher training for the digital age.

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