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ORIGINAL RESEARCH

Teaching the Use of Gamification in Elementary School: A Case in Spanish Formal Education

José-Manuel Sáez-López[1] · **Rolando-Óscar Grimaldo-Santamaría**[2] · **Mª-Pilar Quicios-García**[1] · **Esteban Vázquez-Cano**[1]

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Abstract
Gamification is an educational methodology and tool that offers benefits through mechanics and dynamics. It brings motivating experiences and benefits to the instructional design approach. Several studies highlight that this methodology fosters contributions in commitment, fun, enthusiasm, motivation, satisfaction, and interaction in pedagogical contexts. The sample of 308 teachers was obtained after the mass delivery of the instrument to educational centers in Spain. The sample is nonprobabilistic, and the study participants voluntarily answered the survey. Of the participants, 69.8% were women and 30.2% were men; this proportion is representative of the population of teachers. A descriptive analysis is based on three dimensions: most used programs, devices used, and didactic functionality. These data are triangulated with an analysis through the HJ-Biplot method, which is presented as a multivariate graphical representation of the data from an Xnxp matrix. This analysis details findings on the determining role played by the teacher and the relationship between years of experience, age, devices used, and resources used, detected with descriptive and bivariate analyses. Among the conclusions are that the subjects positively value training in digital teaching competence in terms of gamification, although in real daily practice only 30% of teachers claim to use gamified tools. Gamification provides collaborative and innovative benefits in relation to its didactic functionality.

Keywords Educational technology · Elementary education · Gamification · Instructional design · Teaching

✉ José-Manuel Sáez-López
jmsaezlopez@edu.uned.es

Rolando-Óscar Grimaldo-Santamaría
rgrimaldo@comillas.edu

Mª-Pilar Quicios-García
pquicios@edu.uned.es

Esteban Vázquez-Cano
evazquez@edu.uned.es

[1] Universidad Nacional de Educación a Distancia (UNED), C/ Juan del Rosal 14, Room 2.08, 208040 Madrid, Spain

[2] University of Comillas, Comillas, Spain

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1 Introduction

Gamification is an emerging instructional design approach to creating game experiences (Koivisto & Hamari, 2014), even in non-game contexts (Mylonas et al., 2021; Scriven & Langan, 2020). In educational contexts t is important to enhance the learning experience while maintaining a balance between content, games, and their application in the real world (AUTHOR, AUTHOR, AUTHOR; Sipone et al., 2019). Gamification consists of applying game design elements in real-world contexts, increasing student motivation and performance. Gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" (AUTHOR). It is a method used to create a meaningful and motivating experience through the integration of mechanical play in non-recreational environments and applications.

Several scientific reports have analyzed the evolution and importance of gamification as an emerging trend in educational contexts (UNESCO, 2018; Zainuddin et al., 2020). Gamification has been presented in these reports as a new educational tool. Through mechanics and dynamics, gamification offers highly recommended benefits and advantages to promote motivating experiences among students (Blau & Shamir-Inbal, 2017; Karakoç et al., 2022; Fiş-Erümit & Karakuş Yılmaz, 2022; AUTHOR; AUTHOR). Other reports have highlighted the benefits of this instructional design approach; some of these studies have reported that this methodology produces benefits for students such as commitment, fun, enthusiasm, and motivation (Blunt, 2007; Gooch et al., 2016; Hill, 2015; Manzano-León et al., 2021; Ordiz, 2017); satisfaction (Dicheva et al., 2015; Hursen & Bas, 2019; Nedergård, 2016); and interaction and communication (Yıldırım & Demir, 2016).

The objective advantages found in the application of gamification have been used in different disciplines and contexts. This article enumerates the advantages outlined by primary education teachers in Spain when this instructional design was applied in the classroom. Gamification in education fosters interactive possibilities that allow an adequate, dynamic, and positive organization (Tan Ai Lin et al., 2018; Tóth et al., 2019) of the teaching–learning process. The use of gamification in the teaching–learning process in the primary education stage is important (Ordiz, 2017; Parra-Gonzalez et al., 2020), since different investigations and reports suggest that gamification will be consolidated in the near future in elementary school as a learning methodology (Freeman et al., 2017; Hursen & Bas, 2019).

Currently, gamification in educational contexts pose challenges, interactions, and stimuli in educational processes, and they foster the acquisition of knowledge, skills, and attitudes at different stages of the educational system, including primary education (Martín-del-Pozo et al., 2019). Despite its benefits, the implementation of gamification in the teaching–learning process in primary school requires surmounting some difficulties, such as a lack of resources, the long time required to implement them, gaps in teacher training, and difficulties in adjusting the curriculum to innovative approaches. Even so, if an adequate implementation of gamification is achieved in this initial training, it is very possible that positive and significant results will be evidenced, as already highlighted by works that show some effects of gamification in primary education (Blau & Shamir-Inbal, 2017; Uluyol & Sahin, 2016). These and other similar studies have shown the relationship between mathematics and video games (Goehle, 2013; Lameras & Moumoutzis, 2015), science teaching through playful approaches (Fernández-Oliveras, et al., 2021; Puig et al., 2021; Quintas et al., 2020a, 2020b; Sipone et al., 2019), implementation of gamification to achieve higher-level skills, and problem solving that tries to promote active learning with game-based techniques (Liu & Chu, 2021; Quintas et al., 2020a, 2020b; Stephen & Edwards, 2018).

As an instructional design approach, gamification requires tools and resources. Among such resources are accessible apps that use rewards and visually appealing interactive check-ins that allow constant feedback and organization in a virtual space. Many of these tools promote an innovative process of change aimed at improvement, interactivity, fun, and attention using technological means. Sometimes it is complex to combine the demands of educational regulations and the formal curriculum with playful approaches, but if an adequate implementation is achieved, the results provide numerous advantages.

Experiences and methodological implementations that have been described in the scientific literature include the flipped classroom (Parra-Gonzalez et al., 2021) using EdPuzzle-type tools. Tools like Class Dojo or Classcraft help in the communication and feedback process through an organization of badges and rewards in a learning management system. This information allows for the organization of the information in a colorful and entertaining way. The resources listed and others like them are effective and popular in implementing gamification at this stage.

The implementation of gamification in the primary education classroom is done through a global management of classroom interactions, through tasks and prizes with avatars and badges (da Rocha Seixas et al., 2016). Other popular tools are Kahoot, Socrative, or Trivinet. All of them provide interactive and dynamic activities that favor the feedback process with playable synchronous test activities (Bicen & Kocakoyun, 2018; Plump & LaRosa, 2017; Sanchez et al., 2019); this synchronous and fun approach with tests is easy to apply and has a positive impact (Baydas & Cicek, 2019; Göksün & Gürsoy, 2019; Sanchez et al., 2019). The Duolingo app also enables enjoyable interaction for language learning (Rachels & Rockinson-Szapkiw, 2018).

In short, some applications allow didactic progress to be combined with interactive activities in the virtual learning environment (Rodríguez et al., 2019; Sunday et al., 2022), promoting problem solving, interactions, feedback, fun, and enthusiasm. In some studies, significant differences have even been seen in academic performance when using gamification (Horwitz et al., 2022; Manzano-León et al., 2021), although this last variable is not so evident, nor does it present the academic consensus of those previously mentioned in the scientific literature.

2 Aims

The main objective of the study is to analyze the implementation and possibilities of gamification in Primary Education. The specific objectives are:

- To assess the didactic functionality of gamification in elementary school students.
- To analyze most used programs, activities and contents through Learning Centered Design.
- To check teachers' experience, practices and perceived usefulness related to gamification.
- To analyze the devices used in primary school in order to apply a gamification perspective.
- To compare the implementation of gamification based on teaching experience.

As research questions we detail:

- What tools, devices and activities can be used in pedagogical practice, with a gamified approach in Primary Education?
- What influence does teaching experience have on the implementation of gamification in Elementary Education?

3 Method

The study is based on the following research hypothesis: "Teachers considers that Didactic functionality of gamification provides innovative advantages, and fosters the development of students' skills using interactive tools". The analytical methodology of the data consisted of the triangulation of three statistical procedures, applied sequentially with the aim of evidencing the individual and group behavior of the variables analyzed. With the application of descriptive statistics, in a first initial phase, it was possible to summarize and show the characteristics of each of the items that make up the three dimensions studied, detecting those variables with the most remarkable behaviors (Table 2, Figs. 1, 2). The above information allowed the application of a second statistical procedure based on the X2 statistic (p value < 0.005), determining the bivariate relationship between the socio-professional variables of the study and the three dimensions studied. The association measures and the corrected typified residuals evidenced the intensity and origin of the relationship detected between the variables. Finally, the third statistical procedure made it possible to represent spatially through a multivariate data graph the simultaneous behavior of the socio-professional variables and the teachers involved. The HJ-Biplot method, a multivariate statistical procedure, allowed through a "Xnxp matrix" the detection of behavior patterns among the variables (Fig. 3). The detailed explanation of the X2 and the HJ-Biplot, as well as the rules of interpretation, are shown and explained in the bivariate and multivariate analysis sections, respectively.

The research process underlying this article began with the application of a survey using a questionnaire. In a first phase, in 2020, the questionnaire validated the use of the Delphi

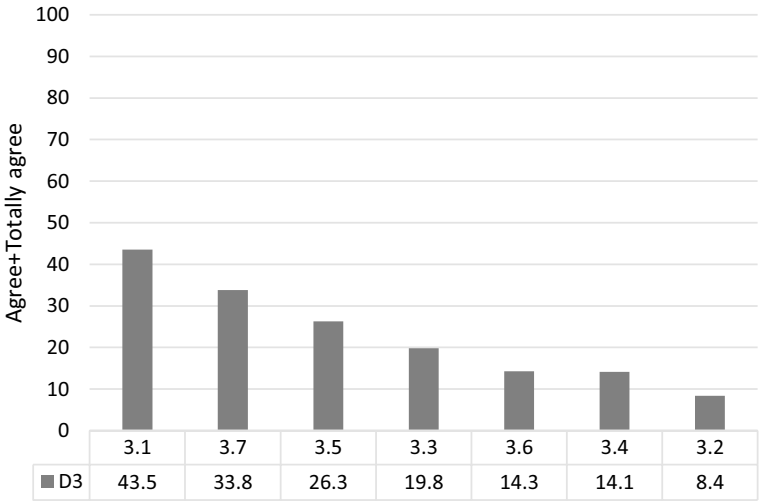

Fig. 1 Dimension 2. Type of devices used. Values 4 = Agree + 5 = Totally agree

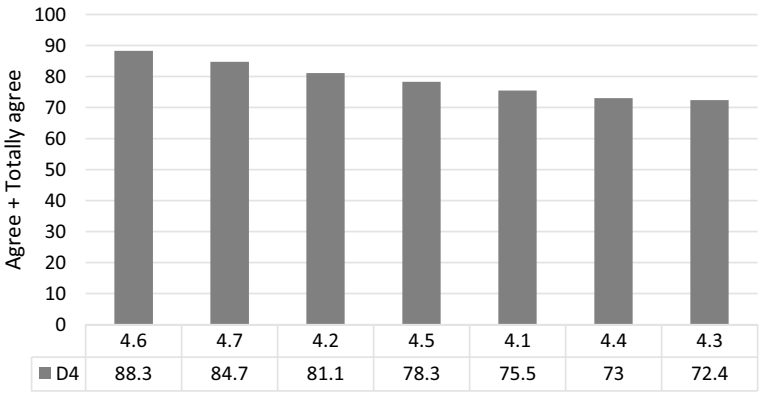

Fig. 2 Dimension 3. Didactic functionality. Values 4 = Agree + 5 = Totally agree

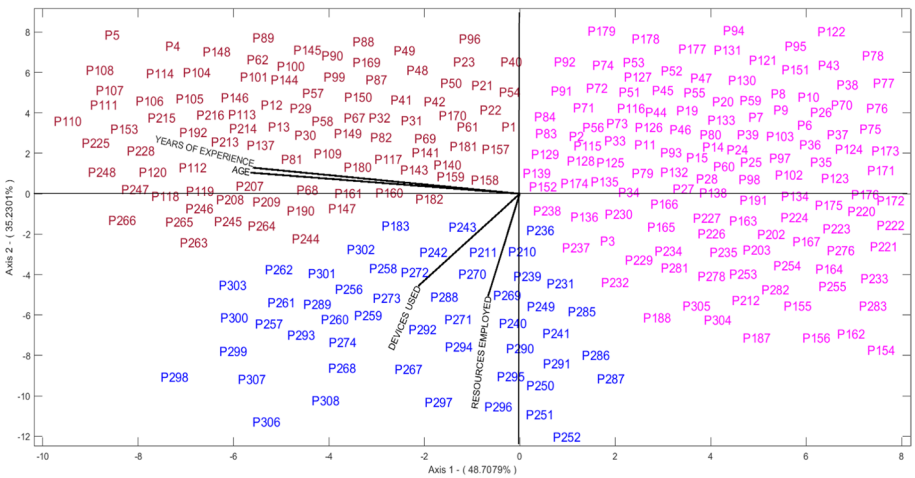

Fig. 3 Factorial representation resulting from the HJ-Biplot, plane 1–2. *Note*[1]: Order of the quandrants: 1st—upper right, 2nd—upper left, 3rd—lower left, 4th—lower right. The figure shows those centers with a representational quality equal to, or greater than, 400 points. *Note*[2]: P (Number of the teacher interviewed). *Note*[3]: Variable: AGE (interviewee's age), ≤ 30 (less than or equal to 30 years), [≥ 31– ≤ 40] (equal to or more than 31 and less than or equal to 40 years), [≥ 41– ≤ 50] (equal to or more than 41 and less than or equal to 50 years) y ≥ 51 (equal to or more than 51 years); YEARS OF EXPERIENCE ≤ 10 (less than or equal to 10 years), [≥ 11– ≤ 20] (equal to or more than 11 and less than or equal to 20 years), [≥ 21– ≤ 30] (equal to or more than 21 and less than or equal to 30 years) y ≥ 31 (equal to or more than 31 years); DEVICES USED (Device that you usually use when using gamification-based applications) (Smartphone, Tablet, PC, Laptop, Game console, others); RESOURCES EMPLOYED (Resources used when programming activities based on gamification) (Software, App, Web Page, Restricted Access Platform, others). *Note*[4]: Cluster 1 (pink color), Cluster 2 (red color), and Cluster 3 (blue color). (Color figure online)

technique and expert judgment, showing reliability with a Cronbach's alpha result of 0.889. This questionnaire was registered under the name "GAUBI-PRO" in the Spanish Patent and Trademark Office, with trademark number M4150516.

The results presented here come exclusively from a three-dimensional study of the GAUBI-PRO questionnaire, deploying the dimensions of most used programs in gamification,

devices used to carry out gamification in primary school, and didactic functionality of gamification. The results were obtained through the contrast and comparison of different analyses and sources. Acting in this way has made it possible to carry out a triangulation of data. This triangulation provides consistency and validity to the study by minimizing the error variance (Cohen et al., 2000). Based on this idea, a descriptive analysis, a contingency analysis, and the application of the HJ-Biplot methodology have been carried out to analyze the data. Likewise, Pearson's chi-square statistic has been applied. The application of this statistic has shown significant results (p value < 0.05), thus fulfilling the assumption that the expected frequencies were not small. Results are open to replication and verification by future studies.

4 Participants

which was non-probabilistic and intentional, was formed of 308 teachers who responded to an online questionnaire delivered to educational centers across Spain. The group was 74.2% women and 25.8 men, which made for a sample that was representative of the gender disparity in this profession. The mean age of the subjects was 41.46 years, with a mean of 15.9 years' teaching experience. The sample was considered to be representative, given its size, age and gender distribution. The sample size was assumed to be normal, as confirmed by the Kolmogorov Smirnov test result. The sample subjects were drawn from state schools (78.6%), state-supported private schools (15.3%) and private schools (6.1%), a proportion that broadly reflects student representation in education in Spain. It was noteworthy that 67.9% of those surveyed were already participating in ICT projects at their schools, which demonstrates the interest of the subjects in their own learning and skills improvement. The other 32.1% stated they were not involved in any ICT project. Another interesting fact was that 52.1% of the subjects were satisfied that the technological resources available to them at their centers, 31.5% believed they could be improved, and 16.2% stated that their digital resources were insufficient.

5 Instrument and Variables

The data were gathered between September 1st and October 21st (2021). A questionnaire was designed to be completed online by the teachers, having given prior informed consent, under the Spanish Research Project (Blind). For this study, three dimensions of GAUBI-PRO questionnaire were used, deploying the dimensions of most used programs in gamification, devices used to carry out gamification in primary school, and didactic functionality of gamification. In a first phase, in 2020, the questionnaire validated the use of the Delphi technique and expert judgment, showing reliability with a Cronbach's alpha result of 0.889 and KMO = 0.891 (Table 1). In appendix, we present the Delphi results and the dimensions of the questionnaire. This questionnaire was registered under the name "GAUBI-PRO" in the Spanish Patent and

Table 1 KMO and Bartlett's test

Kaiser–Meyer–Olkin measure of sampling adequacy		0.891
Bartlett's Test of Sphericity	Approx. Chi-Square	2876.912
	df	35
	Sig	0.000

Trademark Office, with trademark number M4150516. The questionnaire was sent to the official email account of the different schools. The questionnaire contained four latent variables with 24 items. The teachers had to respond to each item by scoring it on a 1–7 scale, 1 meaning "totally disagree" and 7 "totally agree". Informed consent was obtained from all participants for being included in the study.

The Bartlett test's significance score ($p < 0.05$) indicated that our matrix differed from the matrix unit with a confidence level of 95%, thus, there were significant correlations between the variables to indicate the possible existence of latent variables (Table 1). The KMO test presented a value close to 1 (0.891), thus, the partial correlations of our variables were minor. The Cronbach alpha score was 0.889.

6 Results

6.1 Descriptive Analysis

Dimension 1: Most used programs (Table 1).

In this dimension, as observed by the data presented, the importance that the sample gives to training in gamification in teacher training stands out.

Item 1.5, stating that continuous training in digital teaching competence in gamification is considered necessary, was affirmed by 87.4% of participants. Additionally, 62% stated that they had received training in digital competence as part of their continuing education (item 1.6); only 6.8% stated that they had received training in their initial university education (item 1.4). Items 1.1 and 1.2 refer to how essential game-based learning is in education and immersive environments in initial university education, with responses above 70%. These results are related to objective 2 and to the first research question.

Dimension 2: Devices used (Table 2, Fig. 1).

The participants, in general, reported nonuse of the applications included in the analysis instrument. The most used application (43.5% of subjects) was the interactive test of the Kahoot/Socrative type. Usage of the resources Classdojo, Edmodo Flashcards, and Quizlet (items 2.5 and 2.7) approached 30% of participants. The least used resources (lower than 20% of participants) were Minecraft, Scratch, VR, Classcraft (items 2.2, 2.4, and 2.6), and StoryTelling (item 2.3). These results are related to objective 4 and to the first research question.

Dimension 3: Didactic functionality.

The most supported item was 3.6 (90% of respondents), which indicates that the educational applicability of gamification depends on the positive attitude of teachers. This item is followed in support by item 3.5 (80%), which defined gamification as an educational innovation. The same value is reached in item 3.2, represented in Fig. 2. It is essential the importance of the degree of teaching digital competence (item 3.4), the availability of resources, and the need for time and preparation (3.7).

One piece of data that stands out in this dimension is that these approaches foster collaborative learning (item 3.1) and that around 75% of the subjects consider that gamification improves learning outcomes (item 3.3). These results are related to objective 1 and 3, and to the second research question.

A bivariate analysis was performed through Pearson's chi square (X2). We detail nonparametric statistical test of the null hypothesis of statistical independence through significance tests in contingency tables. With data incompatible with the hypothesis of

Table 2 Questionnaire and dimensions, frequency analysis

Dimensions	Items	1	2	3	4	5
1. Most used programs	1. A game-based learning approach is essential to train future teachers	6.2	7.5	14.3	**37**	**35.1**
	2. It is important to work in immersive environments in initial university education	5.2	5.5	10.7	**36.4**	**42.2**
	3. Interactive 3D game environments are beneficial in initial teacher training	4.2	14.3	27.6	**38.3**	**15.3**
	4. Has worked with gamification-based applications at university	**67.5**	**14.9**	10.7	3.9	2.9
	5. Considers continuous training in teaching digital competence in the field of gamification to be necessary	1.9	1	9.7	**29.9**	**57.5**
	6. Has received training in digital competence	4.2	9.7	24	**41.2**	**20.8**
2. Devices used	1. Use programs like Kahoot, Socrative, Plickers, or similar to evaluate	32.8	10.1	13.6	25.3	18.2
	2. Use programs like "Minecraft" or "Scratch" in your classes	**69.5**	**15.6**	6.5	6.5	1.9
	3. Use programs or applications to create digital narratives "storytelling"	**49**	**14.9**	16.2	15.3	4.5
	4. Use augmented or virtual reality programs or applications	**49.7**	**15.3**	20.8	12.1	2
	5. Use "flashcards" or "study units" applications with programs like "Quizlet" or similar	**39.6**	**16.2**	17.9	12	14.3
	6. Use an educational platform or video game such as "Classcraft" or similar	**51.3**	**18.5**	15.6	8.4	5.9
	7. Use programs like "Classdojo," "Edmodo" or similar to interact with families and students	**41.6**	**13**	11.7	16.9	16.9
3. Didactic functionality	1. Games linked to learning activities encourage collaborative learning	0.6	5.5	16.2	**33.1**	**43.2**
	2. The educational applicability of gamification depends on the degree of teaching digital competence	3.2	3.9	11.7	**36**	**45.1**
	3. Considers that the use of gamification improves learning outcomes	3.6	5.5	17.9	**45.8**	**26.6**
	4.The educational applicability of gamification depends on the availability of resources	2.9	5.2	18.8	**35.7**	**37.3**
	5. Consider gamification as an educational innovation	3.9	5.2	11.7	**37.7**	**40.6**
	6.The educational applicability of gamification depends on the positive attitude of teachers	1.9	0.6	9.1	**29.2**	**59.1**
	7. The proper use of gamification in the classroom requires a large investment of preparation time	1	2.9	11.4	**32.9**	**51.8**

Values 1 = Totally disagree, 2 = Disagree, 3 = Medium, 4 = Agree, 5 = Totally agree

In bold the trend and the highest values are highlighted

independence, the probability of association (X2) will have values less than 0.05 and the variables will be determined to be associated.

6.2 Bivariate Analysis

Considering the variables in this study, Kendall's Tau-c coefficient was used to express the intensity of the detected association. The sign of the coefficient indicates the direction of the relationship. The absolute value indicates the force. The values range between − 1 and 1. The strongest relationships are indicated by the extreme values.

The corrected standardized residuals correspond to the difference between the observed and expected frequency in terms of standardized Z score. These values allow the precise detection of the combinations that make the association between the variables possible. The main utility of these residuals lies in their distribution with zero mean and one standard deviation that is easily interpretable. Using the confidence level of 0.95, corrected standardized residuals greater than 1.96 reveal the cells with more cases than should exist in the event that the variables analyzed were independent. The reverse happens with residuals less than − 1.96. The corrected standardized residuals, after the chi square statistic and the quantification indices, are the most accurate option to explain the association between the variables studied (Mateos-Aparicio Morales & Hernández Estrada, 2021).

Table 3 shows the information of the X2, the association index, and the standardized residuals corrected for the variables related statistically significant with the age of the sample. The Kendall's Tau-c coefficient in all associations has a relatively small absolute value, but with a negative sign. In other words, interviewee age is associated with a slight decrease in the application of the tools used inside and outside the classroom. The Flashcards variable is the one that most accentuates this finding. The corrected standardized residuals, in the case of the Kahoot variable, show that teachers under 30 years of age are those who use this tool to a greater extent, and those over 51 the least. Exactly the same thing happens with the Flashcards variable and, to a lesser extent, with the rest of the variables. These results show that age is a determining factor in the use of tools.

Table 4 shows the relationship between years of experience of the teachers interviewed and the most used and significant tools. The behavior of the association between the variables is quite similar to that detected with the age variable, although with a slightly lower Kendall's Tau-c coefficient. The conclusion drawn is that the more years of experience the less use of the tools. The corrected standardized residuals corroborate this same conclusion for almost all the tools.

Table 5 provides conclusions similar to those shown by years of experience and age of the teacher. In addition to showing that some tools are not statistically significant, the absolute value of Kendall's Tau-c is somewhat smaller than that obtained in the previous analyses, but still with negative signs. This indicates that there is a slight variation in the use of the tool depending on the work center. Tools such as Minecraft, Classcraft, Augmented Reality, and Flashcards tend to be more used in public centers and the last two at an intermediate level in private centers. The private centers show limitations in the use of these tools.

Table 6 shows the relationship between the age of the teacher and the didactic functionality of gamification in the statistically significant variables. Kendall's Tau-c, with quite low absolute values, but with negative signs in all cases, shows that the younger the teacher, the greater the increase in the assessment of the didactic functionality of gamification, and vice versa. The corrected typified residuals account for this relationship, as

Table 3 Relationship between age and the most used tools inside and outside the classroom

Variable		Kahoot	Storytelling	Augmented reality	Flashcards	Classcraft	Classdojo
Age	S.S	$X^2 = 29.860$	$X^2 = 31.915$	$X^2 = 21.206$	$X^{2=}46.774$	$X^2 = 42.842$	$X^2 = 39.624$
		D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12
		P.V = 0.003*	P.V = 0.001*	P.V = 0.047*	P.V = 0.000*	P.V = 0.000*	P.V = 0.000*
	M.A	KTc = −0.227	KTc = −0.148	KTc = −0.128	KTc = −0.257	KTc = −0.111	KTc = −0.159
	A.P	≤30 & 1 (csr = −3.1)	[≥31–≤40] & 1 (csr = −3.3)	[≥31–≤40] & 1 (csr = 1.9)	≤30 & 1 (csr = −3.1)	≤30 & 1 (csr = −2.4)	≤30 & 1 (csr = −2.4)
		≥51 & 1 (csr = 3.6)	[≥31–≤40] & 4 (csr = 3.0)	[≥31–≤40] & 4 (csr = 2.5)	≤30 & 4 (csr = 4.4)	≤30 & 4 (csr = 4.0)	[≥31–≤40] & 1 (csr = −1.9)
		≤30 & 5 (csr = 3.2)	≥51 & 1 (csr = 4.4)	≥51 & 1 (csr = 2.5)	[≥31–≤40] & 1 (csr = −2.0)	[≥31–≤40] & 2 (csr = 3.5)	[≥31–≤40] & 2 (csr = 3.6)
		≥51 & 4 (csr = −2.0)	≥51 & 2 (csr = −2.0)		[≥31–≤40] & 4 (csr = −2.9)	[≥31–≤40] & 3 (csr = −2.7)	[≥41–≤50] & 2 (csr = −4.4)
			≥51 & 4 (csr = −2.4)		≥51 & 1 (csr = 4.0)	[≥41–≤50] & 2 (csr = −3.2)	[≥41–≤50] & 4 (csr = 2.0)
			≥51 & 5 (csr = −1.9)		≥51 & 5 (csr = −3.1)	[≥41 y ≤50] & 3 (csr = 2.2)	≥51 & 1 (csr = 2.5)

[1] S.S. (Statistical Significance), M.A. (Measure of Association), A.P. (Association Patterns), X^2 (Chi-square), D.F. (Degrees of Freedom), KTc (Kendall's Tau-c), csr (Corrected Standardized Residuals)

[2] Age, ≤30 (less than or equal to 30 years), [≥31–≤40] (equal to or more than 31 and less than or equal to 40 years), [≥41–≤50] (equal to or more than 41 and less than or equal to 50 years) y ≥51 (equal to or more than 51 years)

[3] response scale between 1 and 5, where 1 is not at all and 5 is a lot

[4] *P.V. (*p* Value) < 0,05; csr (≥1.96 and ≤ −1.96)

Table 4 Relationship between years of teaching and tools most used inside and outside the classroom

Variable		Kahoot	Storytelling	Augmented reality	Flashcards	Classcraft	Classdojo
Years of experience	S.S	$X^2 = 29.805$	L.R. = 26.347	L.R. = 24.909	$X^{2=}40.152$	$X^2 = 38.379$	$X^2 = 33.062$
		D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12
		P.V = 0.003*	P.V = 0.010*	P.V = 0.015*	P.V = 0.000*	P.V = 0.000*	P.V = 0.001*
	M.A	KTc = −0.143	KTc = −0.161	KTc = −0.100	KTc = −0.222	KTc = −0.105	KTc = −0.073
	A.P	≤10 & 1 (csr = −3.1)	≤10 & 1 (csr = −2.5)	≤10 & 1 (csr = −2.0)	≤10 & 1 (csr = −3.9)	≤10 & 1 (csr = −2.9)	≤10 & 1 (csr = −3.2)
		≤10 & 5 (csr = 2.1)	≤10 & 4 (csr = 3.0)	≤10 & 1 (csr = 1.9)	≤10 & 4 (csr = 4.0)	≤10 & 2 (csr = 4.0)	≤10 & 2 (csr = 3.9)
		[≥11–≤20] & 2 (csr = 2.0)	[≥21–≤30] & 1 (csr = 1.9)	[≥21–≤30] & 2 (csr = −2.8)	[≥21–≤30] & 1 (csr = 2.4)	≤10 & 5 (csr = 1.9)	≤10 & 3 (csr = 2.1)
		[≥11–≤20] & 4 (csr = −2.1)	[≥21–≤30] & 4 (csr = −2.0)		[≥21–≤30] & 4 (csr = −2.7)	[≥11–≤20] & 2 (csr = −2.7)	[≥11–≤20] & 1 (csr = 2.2)
		≥31 & 1 (csr = 3.9)			≥10 & 1 (csr = −3.8)	[≥21–≤30] & 2 (csr = −2.9)	[≥11–≤20] & 2 (csr = −2.9)
					≥10 & 5 (csr = −2.2)	[≥21–≤30] & 4 (csr = 2.0)	[≥21–≤30] & 4 (csr = 2.4)

[1] S.S. (Statistical Significance), M.A. (Measure of Association) y A.P. (Association Patterns), X^2 (Chi-square), L.R. (Likelihood Ratio), D.F. (Degrees of Freedom), KTc (Kendall's Tau-c), csr (Corrected Standardized Residuals), & (and)

[2] Years of Experience, ≤10 (less than or equal to 10 years), [≥11–≤20] (equal to or more than 11 and less than or equal to 20 years), [≥21–≤30] (equal to or more than 21 and less than or equal to 30 years) y ≥31 (equal to or more than 31 years)

[3] response scale between 1 and 5, where 1 is not at all and 5 is a lot

[4] *P.V. (*p* Value) < 0.05; csr (≥1.96 and ≤ −1.96)

Table 5 Relationship between the workplace and the tools most used inside and outside the classroom

Variable		Minecraft	Storytelling	Augmented Reality	Flashcards	Classcraft
Workcenter	S.S	L.R. = 30.445	L.R. = 18.756	L.R. = 49.308	X^2 = 24.033	L.R. = 24.640
		D.F. = 8	D.F. = 8	D.F. = 8	D.F. = 8	D.F. = 8
		P.V = 0.000*	P.V = 0.015*	P.V = 0.000*	P.V = 0.002*	P.V = 0.000*
	M.A	KTc = − 0.081	KTc = − 0.039	KTc = − 0.100	KTc = − 0.032	KTc = − 0.085
	A.P	Public & 1 (csr = − 2.5)	Concerted & 1 (csr = 3.5)	Public & 1 (csr = − 3.1)	Public & 3 (csr = − 1.9)	Public & 1 (csr = − 2.3)
		Public & 3 (csr = 1.9)	Concerted & 3 (csr = − 2.0)	Public & 4 (csr = 2.5)	Public & 5 (csr = 2.2)	Public & 3 (csr = 2.4)
		Public & 4 (csr = 2.4)	Private & 1 (csr = − 2.0)	Concerted & 1 (csr = 5.6)	Concerted & 1 (csr = 2.4)	Concerted & 1 (csr = 3.8)
		Concerted & 1 (csr = 3.6)	Private & 4 (csr = 2.0)	Concerted & 4 (csr = − 2.8)	Concerted & 2 (csr = − 2.0)	Concerted & 4 (csr = − 3.2)
		Concerted & 4 (csr = − 2.0)		Private & 1 (csr = − 3.0)	Private & 1 (csr = − 2.2)	Private & 2 (csr = 2.1)
		Private & 2 (csr = 3.3)		Private & 3 (csr = 2.9)	Private & 3 (csr = 3.5)	

[1] S.S. (Statistical Significance), M.A. (Measure of Association) y A.P. (Association Patterns), X^2 (Chi-square), L.R. (Likelihood Ratio), D.F. (Degrees of Freedom), KTc (Kendall's Tau-c), csr (Corrected Standardized Residuals), & (and)

[2] Workcenter, Public (Public Center), Concerted (Concerted Center) and Private (Private Center)

[3] response scale between 1 and 5, where 1 is not at all and 5 is a lot

[4] *P.V. (p Value) < 0.05; csr (≥ 1.96 and ≤ -1.96)

Table 6 Relationship between the age of the teacher and the didactic functionality of gamification

Variable		Gamification and digital competence	Gamification and learning outcomes	Gamification and available resources	Gamification and educational innovation	Gamification and positive teacher	Gamification and teacher preparation
Age	S.S	L.R. = 25.559	L.R. = 38.979	L.R. = 24.557	L.R. = 27.934	L.R. = 25.538	L.R. = 25.061
		D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12
		P.V = 0.010*	P.V = 0.000*	P.V = 0.017*	P.V = 0.006*	P.V = 0.012*	P.V = 0.015*
	M.A	KTc = − 0.043	KTc = − 0.142	KTc = − 0.027	KTc = − 0.064	KTc = − 0.069	KTc = − 0.067
	A.P	[≥ 31–≤ 40] & 1 (csr = 2.0)	≤ 30 & 2 (csr = − 1.9)	[≥ 31–≤ 40] & 1 (csr = − 2.0)	≤ 30 & 4 (csr = − 2.6)	[≥ 41–≤ 50] & 3 (csr = − 2.9)	≤ 30 & 5 (csr = 1.9)
		[≥ 41–≤ 50] & 3 (csr = − 2.2)	[≥ 41–≤ 50] & 1 (csr = − 1.9)	[≥ 41–≤ 50] & 5 (csr = 1.9)	≤ 30 & 5 (csr = − 2.4)	≥ 51 & 2 (csr = 2.9)	[≥ 31–≤ 40] & 3 (csr = 2.7)
		≥ 51 & 2 (csr = 3.5)	≥ 51 & 1 (csr = 3.9)	≥ 51 & 2 (csr = 3.2)	[≥ 41–≤ 50] & 3 (csr = 2.5)	≥ 51 & 3 (csr = 2.3)	≥ 51 & 4 (csr = 3.4)
			≥ 51 & 5 (csr = − 3.1)		≥ 51 & 4 (csr = − 2.9)	≥ 51 & 5 (csr = − 2.6)	

[1] S.S. (Statistical Significance), M.A. (Measure of Association) y A.P. (Association Patterns), X^2 (Chi-square), D.F. (Degrees of Freedom), KTc (Kendall's Tau-c), csr (Corrected Standardized Residuals), L.R. (Likelihood Ratio), & (and)

[2] Age, ≤ 30 (less than or equal to 30 years), [≥ 31–≤ 40] (equal to or more than 31 and less than or equal to 40 years), [≥ 41–≤ 50] (equal to or more than 41 and less than or equal to 50 years) y ≥ 51 (equal to or more than 51 years)

[3] response scale between 1 and 5, where 1 is not at all and 5 is a lot

[4] *P.V. (*p* Value) < 0.05; csr (≥ 1.96 and ≤ − 1.96)

observed in the gamification and digital variable, whereas age increases, the valuation in the use of this activity decreases. This pattern is repeated with gamification and positive teachers. At intermediate ages this assessment stabilizes.

Table 7 shows the statistically significant relationship between years of experience and functionality. Except for play and learning, the other variables have a negative Kendall's Tau-c coefficient. This indicates that as the years of experience increase, the valuation of the games and learning variable also increases. The interpretation of the coefficient for each of the variables must be conservative, as the absolute value is quite small. The corrected standardized residuals reaffirm these findings. In the case of the game and learning variable, as the years of experience increase, so do the positive evaluations regarding the didactic functionality. The rest of the variables present a different behavior, due to the fact that with the increase in years of experience, the interest in the didactic functionality decreases slightly.

Table 8 shows the relationship between the work center and the variables that showed statistical significance within the didactic functionality section. The intensity of association between the variables is again weak and negative, as shown by the coefficients and signs of Kendall's Tau-c. This indicates that depending on the characteristics of the workplace, the assessment of each of the activities of didactic functionality will fluctuate. Variables such as Gamification and Available Resources. Gamification and Innovation show similar behaviors, both in public and private centers. Variables such as digital gamification and teacher preparation gamification show different behaviors depending on the work center.

6.3 Multivariate Analysis

The HJ-Biplot method is a multivariate graphical representation of the data of an Xnxp matrix, using markers j1,…, jn for the rows and h1,…, hp for the columns (Galindo, 1986).

The markers j1…jn and h1…hp can be superimposed in the same reference system with maximum rendering quality. The presentation of rows and columns with equal goodness of fit facilitates the interpretation of the position, both of the rows and of the columns. This superposition also allows identifying the relationship between row and column markers (Amaro-Martin, 2001; Hernández Sánchez, 2016). The interpretation of the HJ-Biplot is based on a set of rules used in other multivariate statistical reduction techniques such as factor analysis, multidimensional scaling, correspondence analysis, and classic biplots (Díaz-Faes et al., 2013). The geometric understanding of the biplot is based on geometric concepts on a flat representation of Cartesian axes. The application of the HJ-Biplot allows interpreting the distance, in terms of similarity, between the row markers (teachers interviewed) and the proximity of the column markers (variables) in terms of covariation. Interpretation of results must take into account that the more distant the row markers are from the origin (center of gravity of the Cartesian plane), the greater variability will be evidenced by the teachers interviewed. That is, the teachers will have a high quality of representation. Similarly, the order of the orthogonal projections of each of the row markers on a column marker (position of each of the teachers with respect to age, years of experience, or type of device used) reproduces the order of the elements of the starting matrix. This permits an analysis of the positions of the projections of the row markers and ordering them according to their position at the moment of the projection on the column marker.

Another aspect that must be assessed to interpret the HJ-Biplot is the direction of the vectors. This indicates the sense in which the variability of the column markers increases, thus approximating the length of the vector to the standard deviation of age, years of

Table 7 Relationship between years of experience and didactic functionality

Variable		Games and learning	Gamification and digital competence	Gamification and learning outcomes	Gamification and available resources	Gamification and educational innovation	Gamification and positive teacher	Gamification and teacher preparation
Years of experience	S.S	$X^2 = 44.372$	L.R. = 33.055	$X^2 = 31.101$	$X^2 = 35.459$	$X^2 = 50.746$	L.R. = 27.928	L.R. = 25.417
		D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12	D.F. = 12
		P.V = 0.000*	P.V = −0.001*	P.V = 0.000*	P.V = 0.000*	P.V = 0.000*	P.V = 0.006*	P.V = 0.013
	M.A	KTc = 0.069	KTc = −0.056	KTc = −0.065	KTc = −0.034	KTc = −0.097	KTc = −0.076	KTc = −0.095
	A.P	≤10 & 4 (csr = 2.0)	≤10 & 2 (csr = −2.9)	≤10 & 1 (csr = −2.8)	≤10 & 2 (csr = −2.8)	≤10 & 1 (csr = −2.9)	≤10 & 1 (csr = −2.0)	≤10 & 3 (csr = −2.2)
		[≥21–≤30] & 5 (csr = 2.8)	≤10 & 5 (csr = 2.1)	≤10 & 2 (csr = −2.4)	[≥11–≤20] & 2 (csr = 3.1)	≤10 & 5 (csr = 4.3)	≤10 & 5 (csr = 2.3)	≤10 & 5 (csr = 2.5)
		≥31 & 1 (csr = −4.5)	[≥11–≤20] & 3 (csr = 2.0)	≥31 & 1 (csr = 3.5)	[≥11–≤20] & 5 (csr = −1.9)	[≥11–≤20] & 1 (csr = 3.2)	[≥11–≤20] & 5 (csr = −2.4)	[≥11–≤20] & 1 (csr = 2.5)
			[≥11–≤20] & 5 (csr = −2.8)	≥31 & 5 (csr = −2.2)	[≥21–≤30] & 5 (csr = 2.5)	[≥11–≤20] & 5 (csr = −4.3)	≥31 & 1 (csr = 2.1)	[≥21–≤30] & 3 (csr = 2.0)
			[≥21–≤30] & 2 (csr = 2.8)		≥31 & 5 (csr = −2.1)	≥31 & 1 (csr = 2.0)		≥31 & 4 (csr = 2.2)

[1] S.S. (Statistical Significance), M.A. (Measure of Association) y A.P. (Association Patterns), X^2 (Chi-square), L.R. (Likelihood Ratio), D.F. (Degrees of Freedom), KTc (Kendall's Tau-c), csr (Corrected Standardized Residuals), & (and)

[2] Years of Experience, ≤10 (less than or equal to 10 years), [≥11–≤20] (equal to or more than 11 and less than or equal to 20 years), [≥21–≤30] (equal to or more than 21 and less than or equal to 30 years) y ≥31 (equal to or more than 31 years)

[3] response scale between 1 and 5, where 1 is not at all and 5 is a lot

[4] *P.V. (*p* Value) < 0.05; csr (≥1.96 and ≤ −1.96)

Table 8 Relationship between the workplace and didactic functionality

Variable		Gamification and digital competence	Gamification and learning outcomes	Gamification and available resources	Gamification and educational innovation	Gamification and positive teacher	Gamification and teacher preparation
Workcenter	S.E	$X^2 = 18.226$	$X^2 = 23.113$	L.R. = 32.671	L.R. = 39.924	L.R. = 26.256	L.R. = 325.715
		D.F. = 8	D.F. = 8	D.F. = 8	D.F. = 8	D.F. = 8	D.F. = 8
		P.V = 0.020*	P.V = 0.003*	P.V = 0.000*	P.V = 0.000*	P.V = 0.001*	P.V = 0.001*
	N.S	KTc = −0.061	KTc = −0.040	KTc = −0.076	KTc = −0.132	KTc = −0.024	KTc = −0.055
	P.A	Private & 1 (csr = 3.2)	Concerted & 5 (csr = −2.4)	Public & 3 (csr = 2.6)	Public & 1 (csr = 2.6)	Public & 2 (csr = −2.7)	Public & 1 (csr = −3.3)
		Private & 4 (csr = −1.9)	Private & 1 (csr = 2.9)	Public & 5 (csr = −2.4)	Public & 5 (csr = −3.8)	Concerted & 2 (csr = 3.3)	Private & 1 (csr = 6.8)
			Private & 5 (csr = −2.1)	Concerted & 2 (csr = 2.5)	Public & 3 (csr = 3.3)	Private & 1 (csr = 4.5)	
				Private & 1 (csr = 3.4)	Concerted & 2 (csr = 2.6)		
				Private & 3 (csr = −2.2)	Private & 1 (csr = 2.7)		

[1] S.S. (Statistical Significance), M.A. (Measure of Association) y A.P. (Association Patterns), X^2 (Chi-square), L.R. (Likelihood Ratio), D.F. (Degrees of Freedom), KTc (Kendall's Tau-c), csr (Corrected Standardized Residuals), & (and)

[2] Workcenter, Public (Public Center), Concerted (Concerted Center) and Private (Private Center)

[3] response scale between 1 and 5, where 1 is not at all and 5 is a lot

[4] *P.V. (p Value) < 0.05; csr (≥ 1.96 and ≤ -1.96)

experience, and type of device used. The cosine of the angle formed between two vectors shows the correlation between the variables. The acute angles indicate a positive correlation, and the right and obtuse angles show a null and negative correlation, respectively.

The statistical analysis was carried out with the Multbiplot software in the programming environment focused on matrices. The data occupy a X308×4 matrix that has the 308 teachers interviewed in the rows and the four social and gamification variables in the columns. Thus, for each row i (teacher) and each column j (variable), a value xij appears in the data matrix, which is the value of that teacher j for each variable i. The data have been standardized by columns due to the plurality of units of measurement of the variables. Teachers with representation quality lower than 400 have not been represented in the factor graphs.

7 Impact and Collaboration Analysis Plane 1–2

Figure 3 shows the factor plot of plane 1–3 resulting from the HJ-Biplot analysis (explained inertia 83.93%). The vectors represent the analyzed variables. The dots represent the teachers interviewed. The left and right part of the second factorial axis shows interesting behaviors in relation to the three formed clusters. The right part mainly groups the teachers of cluster 1. These teachers are distinguished by their relative youth (age and years of experience) as well as by the low application of gamification devices and resources (opposite direction to the vectors). In contrast, the left part of this second factorial axis contains almost all the teachers from clusters 2 and 3. It also contains the variables age, years of experience, devices used, and resources used. The variables have a strong and direct relationship, as evidenced by the large acute angle they form. This indicates that, in general terms, the teachers of clusters 2 and 3 are characterized by a combination of years of experience, age, and application of gamification devices and resources. Refining this relationship, it is observed that age and years of experience are more present in cluster 2, while the use of gamification devices and resources is more present in cluster 3.

8 Conclusions and Discussion

Gamification developed through tools or in immersive environments can generate greater motivation for learning in primary education children, as well as commitment, enthusiasm, and participation in their academic training. But to achieve all these training advantages in the first years of schooling, primary education teachers must be trained in gamification. Based on the results shown in this study, such training is not typically received by Spanish teachers, either through their initial university training or by continuing education among veteran teachers.

Various studies highlight the importance of motivation in gamified implementations (Agüero Contreras et al., 2020; Bell, 2017; Chalkiadaki, 2018; Mitchell et al., 2020; AUTHOR; Wichadee & Pattanapichet, 2018; Zainuddin et al., 2020). Motivation is the variable with the greatest presence in research with game-based interventions, so it can be said that there is significant agreement in the academic community regarding the importance and presence of motivation in playful interventions, and in applications. technologies (Chalkiadaki, 2018).

The commitment and enthusiasm of the students that is detailed in this study is also detailed in recent research (Bell, 2017; Fernández-Rio et al., 2020; Furdu et al., 2017; Halloluwa et al., 2016; López-Faican & Jaen, 2020).

Regarding the implications for theory, methodology and pedagogical practice, it is important to highlight the abundant educational research in the context of elementary education. The literature has detailed the importance of teacher training and the problems that a lack of training can cause (Furdu et al., 2017; Kasinathan et al., 2018; Zainuddin et al., 2020). The variable related to the teaching experience in these studies is also detailed, so that an agreement and coherence is maintained with the contributions detailed in the present investigation.

Our study shows that veteran teachers tend to avoid this instructional design approach, presumably due to their lack of training, the time required to put it into practice in the classroom, or difficulties in accommodating the school curriculum to this approach. Among younger teachers, this behavior is less pronounced. Of the nonprobabilistic study sample, 67.9% stated that they were attracted to gamification, and 87.4% stated that they considered continuous training in digital teaching competence in the subject to be necessary. In other words, the teachers themselves see the need to receive training on this approach to instructional design, but only 6.8% reported having received training in their initial education; the rest had undertaken continuous education in this area or participated in innovation programs.

There are numerous investigations (Anak & Kim, 2021; Fernández-Oliveras, et al., 2021; Gurjanow et al., 2019; Kekuluthotuwage & Fernando, 2017; Plump & LaRosa, 2017; Ståhl et al., 2019; Tan Ai Lin et al., 2018; Tóth et al., 2019; Wichadee & Pattanapichet, 2018) that analyze applications, resources in the implementation of gamification in elementary education, generally coinciding with our study on the benefits of using these tools, as well as the importance of teacher attitudes, due to who are gradually becoming familiar with its use. The great presence and effectiveness of the Kahoot application is also highlighted (Tan Ai Lin et al., 2018; Tóth et al., 2019; Wichadee & Pattanapichet, 2018) coinciding with the results of our study.

An important conclusion of this study is that among teachers who were attracted by gamification, only 43.5% use the interactive Kahoot/Socrative test as a training application, despite recognizing that the educational applicability of gamification depends on the positive attitude of the teaching staff as well as digital teaching competence and the availability of resources, time, and preparation. This result is also relevant despite the fact that 75% of the sample considers that gamification improves collaborative learning and learning results.

The interactive Kahoot test and Flashcards are the most used tools among teachers under 30 years of age and the least used among those over 51. The rest of the variables show similar behaviors. These results corroborate the hypothesis that the age of the teacher is a determining factor in the use of gamified tools.

The type of work center also clearly determines the use of these training resources. Educational centers maintained entirely with public funds, that is, public educational centers, use Minecraft, Classcraft, Augmented Reality, and Flashcards to a greater extent than private centers. Private centers use Augmented Reality and Flashcards at a medium level, and concerted centers use such tools infrequently. Thus, we conclude that the use of gamification in primary school is not related to the economic capacity of educational centers; the use of these tools depends exclusively on the teaching decision.

The type of educational center (public, concerted, private) does show important differences in terms of the assessment of the use of digital gamification and the relationship between gamification and teacher training, and it is logical that this is the case. Concerted and private centers support the quality of their teaching in all aspects that, at least theoretically, are related to teaching innovation and the use of ICT in educational processes.

Through multivariate analysis we confirmed the findings on the determining role played by the teacher. The HJ-Biplot method confirms the relationship between years of experience, age, devices used, and resources used, detected with descriptive and bivariate analyses. In addition, it spatially shows the closer relationship between the first two variables and the last two, revealing that teacher seniority is a conditioning factor when it comes to the use of certain resources or devices in the classroom.

In short, the results show that teachers positively value the need for continuous training in teaching digital competence in terms of gamification and working in these environments; however, in practice only around 30% of teachers actually use gamified tools. The most used are Kahoot, Socrative, and Plicker. Regarding the didactic functionality, the teachers in this study consider that gamification provides numerous collaborative and innovative advantages and fosters the development of skills, although the availability of resources and teacher intentionality regarding application are key.

8.1 Limitations and Recommendations for Future Study

The research is limited to a sample of Spanish teachers. It would be desirable that further studies in different socio-educational contexts could help to refute, clarify, or confirm these results. Likewise, the characteristics of teachers, students, families, and socio-educational contexts should be analyzed to define their influence on the adoption or not of this type of gamified apps in primary education.

Appendix

Delphi Phase. Final Round of Experts (n = 17).

1. Teachers' competences	M	SD
1. Control of tools and technological resources	4.011	0.892
2. Creating digital content in their regular practice of teaching	4.710	0.700
3. Capable of solving problems in different pedagogical situations through technology	4.823	0.501
4. Capable of applying gamification-based activities in the classroom	4.800	0.411
5. The focus of game-based learning enables the development of skills in educational settings	1.112	0.512
6. I am able to use tools and measures for network security	1.034	0.199
2. Tools and programs most widely used inside and outside the classroom	**M**	**SD**
1. A game-based learning approach for training future teachers	4.130	0.789
2. It is important to work in immersive environments in the early stages of teacher training at university	3.810	0.521
3. Working with interactive 3D gaming environments is beneficial in the early stages of teacher training	4.901	0.411
4. I worked with gamification-based apps in my teacher training at university	4.123	0.712
5. I consider that continuous teacher training in digital competence in gamification is necessary	3.902	0.411
6. I have received training in digital competence	3.934	0.515
7. Gamification is beneficial for learning Maths	1.201	0.210

3. Types of digital devices used	M	SD
1. I use programs such as Kahoot, Socrative, Plickers, or similar, to assess my students	3.756	0.610
2. I use programs such as Minecraft or Scratch in my classes	4.723	0.588
3. I use digital storytelling programs or apps	4.713	0.372
4. I use augmented or virtual reality programs or apps	4.942	0.410
5. I use flashcard or study unit apps with programs like Quizlet, or similar	4.661	0.641
6. I use a platform or educational videogames such as Classcraft, or similar	4.934	0.578
7. I use programs such as ClassDojo, Edmodo, or similar, to interact with students and families	4.131	0.763
8. I use other resources or tools (apps, websites, programs, etc.) based on gamification	2.315	0.292
4. Didactic functionality	M	SD
1. The games linked to learning activities foment collaborative learning	3.841	0.478
2. The applicability of gamification in the classroom depends on the level of the teacher's digital competence	4.129	0.611
3. I consider that the use of gamification improves learning outcomes	4.190	0.540
4. The applicability of gamification in the classroom depends on the resources available	3.991	0.551
5. I consider that the use of gamification is innovative in education	3.145	0.451
6. The applicability of gamification in the classroom depends on the teacher's positive attitude	3.345	0.521
7. A proper use of gamification in the classroom requires substantial preparation time		
8. The positive attitude of teachers towards the integration of digital devices is important	2.001	0.241
9. I consider gamification as an innovative strategic initiative	2.087	0.291

Final Questionnaire

General data
Age:
Sex:
Years of educational experience:
Subject in which he/she currently teaches:
Have you participated/coordinated any educational project related to ICT?
Type of School: public or private:
Type of School: urban or rural:
Course/s in which you currently teach: (1–2–3–4–5–6)

Dimensions	Items
1. Teachers' competences	1. Control of tools and technological resources 2. Creating digital content in their regular practice of teaching 3. Capable of solving problems in different pedagogical situations through technology 4. Capable of applying gamification-based activities in the classroom

Dimensions	Items
2. Tools and programs most widely used inside and outside the classroom	1. A game-based learning approach for training future teachers 2. It is important to work in immersive environments in the early stages of teacher training at university 3. Working with interactive 3D gaming environments is beneficial in the early stages of teacher training 4. I worked with gamification-based apps in my teacher training at university 5. I consider that continuous teacher training in digital competence in gamification is necessary 6. I have received training in digital competence
3. Types of digital devices used	1. I use programs such as Kahoot, Socrative, Plickers, or similar, to assess my students 2. I use programs such as Minecraft or Scratch in my classes 3. I use digital storytelling programs or apps 4. I use augmented or virtual reality programs or apps 5. I use flashcard or study unit apps with programs like Quizlet, or similar 6. I use a platform or educational videogames such as Classcraft, or similar 7. I use programs such as ClassDojo, Edmodo, or similar, to interact with students and families
4. Didactic functionality	1. The games linked to learning activities foment collaborative learning 2. The applicability of gamification in the classroom depends on the level of the teacher's digital competence 3. I consider that the use of gamification improves learning outcomes 4. The applicability of gamification in the classroom depends on the resources available 5. I consider that the use of gamification is innovative in education 6. The applicability of gamification in the classroom depends on the teacher's positive attitude 7. A proper use of gamification in the classroom requires substantial preparation time

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Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation [UNED bioethics committee] and with the Helsinki Declaration of 1975, as revised in 2000.

Informed Consent Informed consent was obtained from all participants for being included in the study.

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