RESEARCH REPORT

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A pilot study on gamified and conventional e-quizzes reinforcing human histology among first-year medical and physiotherapy students

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Abstract

The present retrospective, descriptive, and quasi-experimental study aimed to explore students' perceptions of traditional teaching combined with gamified and nongamified e-tests for postlecture reinforcement. Midterm knowledge retention and academic performance were also analyzed. The study was conducted from February 2021 to May 2022, involving a single group of first-year medical and physiotherapy students enrolled in equivalent core subjects on human histology at the University of Las Palmas de Gran Canaria (ULPGC). Lectures were supplemented with gamified Quizizz (QQ) or nongamified Moodle questionnaires (MQ) after lecture ($t0$) and 30 days later ($t30$). From 171 attendees, 162 volunteers *were surveyed on their perceptions on the* experience. Furthermore, 97 volunteers participated in the DOCENTIA-ULPGC survey on the students' satisfaction, and 123 participants individually answered 20 QQ and 20 MQ. Data were analyzed using the program Jamovi 2.3.24. The survey on volunteers' perception comprised 11 Likert items and 3 numerical scale items. The former showed acceptable internal consistency (ω-McDonald, 0.70) and validity (KMO, 0.58). Both types of e-questionnaires facilitated learning and motivated pre-reading contents but QQs were preferred. Reinforced lectures were rated higher than those unreinforced. Volunteers expressed higher overall satisfaction though DOCENTIA-ULPGC survey than the prepandemic control group. Average scores peaked at $t0$ with higher MQ rates. At $t30$, MQ and QQ scores were acceptable and similar. Participants' outcomes in the final exam tended to improve compared to the prepandemic control group, but without statistical significance. In summary, gamified and nongamified e-quizzes enhanced the student satisfaction and motivation and facilitated midterm knowledge retention.

KEYWORDS
gamification, histology education, teaching methodology, university education, virtual quizzes

INTRODUCTION

The use of e-learning platforms has become widespread in universities to complement traditional teaching methods in the classroom. These platforms, such as Moodle, are likely useful tools for formative assessment. They allow teachers to provide feedback and guidelines to students, enabling them to regulate their own learning process. Consequently, students could gradually prepare themselves for the final summative assessment, which certifies the overcoming of the learning objectives.

Research in cognitive psychology has revealed that using questionnaires after lecture is more effective for retaining knowledge than simply reviewing contents again.[1] Moreover, repeating questionnaires with feedback on the results and at sufficiently spaced intervals can enhance long-term knowledge retention.[1] Additionally, maintaining attendance, awareness, and curiosity is crucial for the learning process. In this regard, the gamification methods incorporate game elements into the educational environments to make them more attractive for the learning process.

Previous studies on gamified e-quizzes (e.g., kahoot!) were mainly conducted during the Covid-19 pandemic. In general, they improved some aspects on the formative assessments such as the student's satisfaction, engaging, and motivation.[2,3] The literature on health science education supported these results,[4-10] and some authors have suggested to increase its implementation.[11,12] The prevalence of a digital native student body at the university may have contributed to these outcomes. However, conventional e-learning platforms remains as an alternative to gamified platforms pending of analysis to confirm or refine these results. Furthermore, studies on the influence of gamification in the mid- and long-term knowledge retention and in the academic performances are lacking to date.[12] These previous studies also revealed diverse and contradictory results. Thus, most of the publications on knowledge retention were designed at very short-term (questionnaires immediately before and after lecture). Many authors showed significant improvement between the pretest and posttest data[5,9] while others indicated similar results to those obtained with traditional teaching methods.[10] Similarly, some publications reported significant improvement of the knowledge retention[9] or certain tendency to improvement without statistical significance.[5,13] To date, a recent publication has reported evidence of enhanced long-term knowledge retention (15 weeks) with gamification in comparison to the traditional teaching methods.[4]

Currently, first-year university students normally have previous experience with non-gamified e-learning platforms during their pre-university education, which makes it intriguing to examine the efficacy of such platforms as tools for formative and summative assessments. In fact, comparative studies contrasting gamified e-quizzes with nongamified versions for repeating testing are lacking as also suggested other authors.[5]

The student's satisfaction influences their learning process and provides valuable insight to educators regarding the learning environment they have designed, thus fostering the continuous improvement advocated by the European Higher Education Area (EHEA). Accordingly, the DOCENTIA procedure is implemented in the Spanish universities to meet the quality standards of the EHEA and for the national accreditation of university teachers. This procedure uses, among other sources, institutional student's satisfaction surveys conducted every academic year. These surveys assess the activities of every university teacher based on the following factors: teaching planning, teaching delivery, results, and an overall evaluation. The utility of these surveys has been widely discussed due to potential biases. However, recent studies have demonstrated minimal or no influence of them on the survey results.[14] The present study uses the institutional DOCENTIA-ULPGC surveys as a supplementary tool for evaluating the overall student experience.

Theoretical framework

The present study is anchored in several theories and key concepts:

- Research in cognitive psychology advocates the use of questionnaires after lecture to enhance the knowledge retention with repeated feedback at spaced intervals for long-term retention.
- Gamification enhances the attractiveness of the educational environment for the learning process. Previous studies during the Covid-19 pandemic showed improvements in students' satisfaction, engagement, and motivation with gamified e-quizzes.
- E-learning platforms are widely used in universities to facilitate formative assessments alongside traditional teaching methods. However, there is a gap in the literature concerning comparative studies on the efficacy of gamified and conventional e-questionnaires in the learning process.
- Student satisfaction influences de learning process. Institutional student satisfaction surveys, such as DOCENTIA in Spain, are implemented to assess teaching quality and the overall student experience. They serve as useful tools for self-regulation of the teaching activity and promote continuous improvement.
- Based on these concepts, the theoretical framework of the study focuses on how the integration of e-learning platforms, formative assessment strategies based on cognitive psychology principles, gamification techniques, and student satisfaction contribute to enhancing the learning experience and the academic outcomes in higher education. The study aims to compare the effectiveness of gamified and nongamified platforms in formative assessments and evaluates their effects in the summative assessments while also examining the impact of student satisfaction on the overall educational process.

Aims of this study

The present pilot study addresses certain gaps in the literature by introducing gamified (Quizizz) and nongamified (Moodle) virtual

quizzes to compare their effectiveness in the formative and summative assessment of first-year medical and physiotherapy students. The research questions (RQs) are the following:

RQ 1: Are there differences among the students' perception about traditional teaching and the ones supplemented with gamified and nongamified quizzes? (Lectures supplemented with gamified e-quizzes better than those reinforced with Moodle e-quizzes. Lectures supplemented with any of them better than those unreinforced).

RQ 2: Does the introduction of e-quizzes improve the students' satisfaction with the teaching activity? (Teaching activity in the Docentia-ULPGC survey better rated than in the pre-pandemic years 2015–16 and 2017–18).

RQ 3: Is there any difference in the knowledge retention depending on the type of e-quiz? (Topics reinforced with gamified quizzes better rated than those reinforced with Moodle quizzes).

RQ 4: Does the introduction of e-quizzes improve the academic performance? (Participants' academic performance better than the control group during the pre-pandemic years 2015–16 and 2017–18).

MATERIALS AND METHODS

Study context and design

Contents on cell biology and human histology (HH) are fundamental to all healthcare professions. They are programmed during the first year of the Health Sciences degrees. These contents introduce students into the microscopic structure of the human body to elucidate its molecular, cellular, and tissue components to establish functional and clinical correlations. There is a detailed teaching guide by subject, which outlines the learning objectives, learning activities, contents, and evaluation criteria. These guides and the exam calls are established since the enrollment period. University students usually access to the Moodle virtual campus for their courses through the institutional website (http://www.ulpgc.es). Educators utilize this platform to share learning materials with students and to establish different activities. Theoretical and practical contents involved the traditional expository–participatory teaching method. During the theoretical sessions, instructors present the content using PowerPoint presentations while addressing students' doubts or comments. In laboratory practices, educators encourage guided self-learning by displaying cytological and histological slides on large screen while students individually work on them under the microscope.

The present study was conducted between February 2021 and May 2022 (academic years 2020–2021 and 2021–2022) during the theoretical and laboratory classes. The contents on Cell Biology and HH were similar in the degrees in Medicine and Physiotherapy. Each subject covered 15 weeks: 14 weeks with theoretical classes in large groups (up to 75 students) and laboratory practices in groups of 20–25 students. The last week was dedicated to review teamwork activities. The traditional expository–participatory method was employed to teach Cell Biology contents for the first 4 weeks. During the next 10 weeks, every HH topic was reinforced with alternating individual virtual tests, Moodle quizzes (MQ), or Quizizz questionnaires (QQ). The Quizizz gamified platform was selected over others, such as Kahoot!, because it allowed a higher number of simultaneous participants for free (up to 70 individuals in this study). These e-tests reinforced the learning of each HH content at the end of both theoretical and laboratory classes ($t0$), followed by a single review of each topic after 30 days ($t30$). Participants utilized different electronic devices (mobile phones, PCs, or tablets) to answer a total of 20 MQ and 20 QQ corresponding to the contents on HH (Figure 1). Each quiz consisted of 10–14 multiple-choice questions with a time limit of 10–14 min. The order of questions and response options was randomly programmed. To enhance participation opportunities, the quizzes scheduled for 30 days were developed both in face-to-face and online formats. The alternation of CM and QQ helped to reduce bias from confounding variables, such as the level of complexity of certain content blocks and time-related circumstances.

The individual virtual tests allowed content reinforcement, formative self-assessment to track mid-term progress, and preparation for the final exam, which had a similar format. Participants received the percentage of correct answers automatically through the mentioned virtual tools. Additionally, the institutional Moodle platform facilitated sharing of learning materials with students, the establishment of virtual forums for doubts and comments, the creation of

Topics for Moodle	t0	t30	Topics for Quizizz	t0	t30
Histology processing	1	1	Microscopy	1	1
Covering epithelium	2	1	Glandular epithelium	2	1
Connective tissue proper	2	1	Adipose tissue	2	1
Blood	2	1	Cartilage tissue	2	1
Bone tissue	2	1	Types of ossification	2	1
Squeletal muscle	2	1	Cardiac and smooth muscles	2	1
Nervous tissue (Peripheral N. S.)	2	1	Nervous tissue (Central N. S.)	2	1

FIGURE 1 Human histology topics reinforced by e-quizzes at $t0$ and $t30$. The number of e-tests at $t0$ and at $t30$ are shown. Most topics had 2 e-tests at $t0$ corresponding to theoretical and laboratory sessions.

linking access to MQ and QQ, and the creation of the offline final exam. The study was completed with a final exam (ordinary call), which was scheduled around 5–6 weeks after ending the contents (Figure 2). Thus, this study used a mixed-method design over time (Figures 1 and 3).

Ethical concerns

The present study was conceived as an experience to enhance the students' learning process within the context of voluntary formative assessment. The students were informed that their decision to participate or not would have no implications on their final exam grade. The study was fully integrated into the regular teaching activity and met the ethical standards promoted by the declaration of Helsinki. The students provided their consent to participate in the study prior to voluntarily submitting the online survey and e-quizzes. The volunteers were also informed on their rights to access, rectify, oppose, and cancel their data, in accordance with the Spanish Organic Law 7/2021, of May 26, on the protection of personal data. Throughout the study, the anonymity of the participants was ensured through the strictly confidential handling of personal data.

Participants, instruments, and scales of measurements

From 171 class attendees, a sample of 162 volunteers, 100% newcomers, and 72.22% female, completed an anonymous survey on their perceptions of the experience (Figure 4). Additionally, 97 volunteers participated in the institutional DOCENTIA-ULPGC survey, which gauged students' satisfaction with the teaching activity (Figure 5). These data were compared to those of a prepandemic control group ($n = 100$). Furthermore, 123 volunteers answered over 50% of the proposed e-quizzes to be included in the analysis. These participants were 100% newcomers, 69% females, and 100% had previous experience in gamified quizzes during their pre-university education. Moreover, the participants' scores in the final exam ($n = 116$) were compared to those of a random sample ($n = 122$) from a prepandemic control group. The sample size for a finite population of 171 individuals, error margin of 5%, confidence level of 95%, and probability of answer of 50% were fixed to 120 according to specific calculators available online (https://www.questionpro.com). The dependent variables on the students' perception ($n = 162$) and the knowledge retention ($n = 123$) were studied according to minimum sample size requirements.

The instruments and scales used to measure the dependent variables in this study are shown in Figure 3. The students' perception of the experience was measured using an anonymous online survey. This survey comprised 14 items: 11 rated on a 5-point Likert scale and 3 on a 0–10 numerical scale (Figure 4). The Likert items were adapted from previous studies by other authors in this field.[5,6] The responses ranged from strongly disagree to strongly agree, including a "neutral" midpoint as in previous studies.[7] Furthermore, the students' satisfaction was measured using the institutional DOCENTIA-ULPGC survey (Figure 5). This survey assessed three factors (F) or dimensions: teaching planning (F1), teaching delivery (F2), and results (F3), along with a global evaluation (FG) of these three factors. Summarized statistical results (sample size, mean, and standard deviation) were available on the institutional website for educators. This survey used 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). As control group, the prepandemic years 2014–2015 and 2017–2018 were chosen due to their proximity and substantial number of surveyees ($n = 100$). Moreover, both groups showed the same subjects, teaching guides, and instructors.
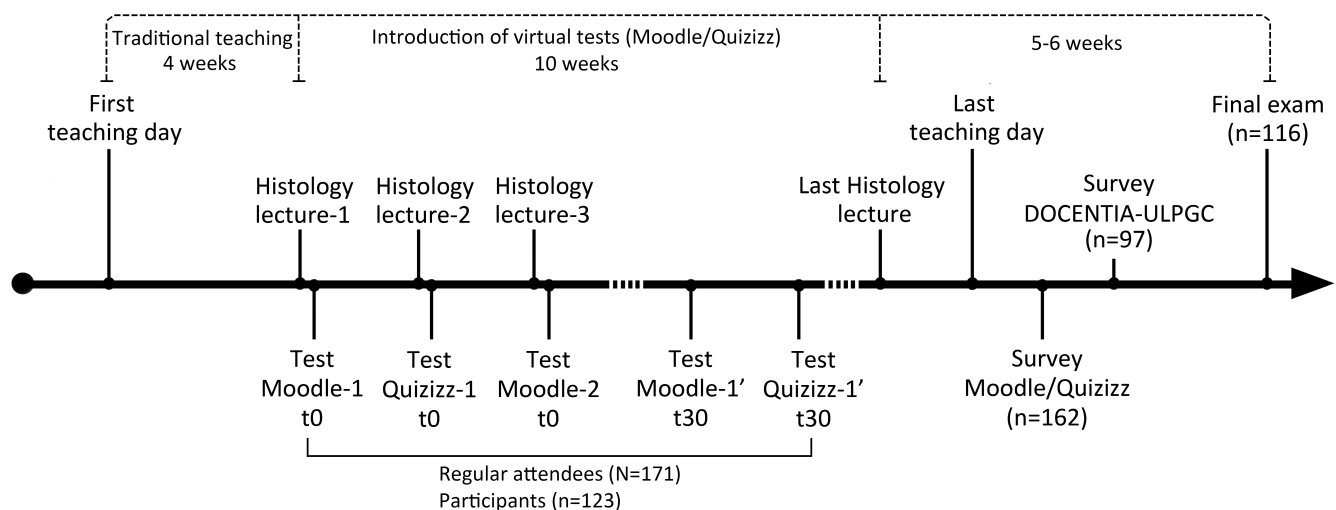

FIGURE 2 Study design in a time scale. Traditional teaching of cell biology contents was scheduled for 4 weeks. Then, Histology topics were reinforced with e-tests in alternating order (Moodle-1, Quizizz-1, etc.) at the end of both theorical and laboratory sessions (*t*0), followed by a single review of each topic (Moodle-1′, Quizizz-1′) after 30 days (*t*30). *N*, population size; *n*, sample size.

*RQs	Dependent variables	Instruments and scales	Study design	Sample
RQ1	Students' perception	Survey on students' perception 5-point Likert scale of 11 items + 0-10 numerical scale of 3 items.	Retrospective, descriptive, transversal.	First-year medical and physiotherapy students, academic years 2020-21 and 2021-22 (n=162).
RQ2	Students' satisfaction	DOCENTIA-ULPGC survey 5-point Likert scale of 18 items.	Retrospective, descriptive, transversal.	First-year medical and physiotherapy students, academic years 2020-21 and 2021-22 (n=97). Control: Pre-pandemic years 2014-15 and 2017-18 (n=100).
RQ3	Knowledge retention	Virtual tests (Moodle vs Quizizz) Percentage of correct responses.	Retrospective, quasi-experimental in one group.	First-year medical and physiotherapy students, academic years 2020-21 and 2021-22 (n=123).
RQ4	Academic performance	Final exam (ordinary call) Percentage of correct responses	Retrospective, descriptive, transversal.	First-year medical and physiotherapy students, academic years 2020-21 and 2021-22 (n=116). Control: Pre-pandemic years 2014-15 and 2017-18 (n=122).

FIGURE 3 Details of the study design. RQs, research questions.

Nº	Items
1	Quizizz facilitates my learning on the subject.
2	Moodle facilitates my learning on the subject.
3	Quizizz motivates to real in advance the contents before class.
4	Moodle motivates to real in advance the contents before class.
5	Quizizz creates a fun atmosphere.
6	Moodle creates a fun atmosphere.
7	There is enough time to resolve the Quizizz questionnaires.
8	There is enough time to resolve the Moodle e-questionnaires.
9	The electronic devices and internet work properly during the Quizizz questionnaires.
10	The electronic devices and internet work properly during the Moodle questionnaires.
11	In general, I prefer Quizizz questionnaires than Moodle questionnaires.
12	Score your experience during lectures supplemented with Quizizz questionnaires in a scale from 0 to 10.
13	Score your experience during lectures supplemented with Moodle questionnaires in a scale from 0 to 10.
14	Score your experience during the traditional lectures, in absence of Moodle or Quizizz questionnaires, in a scale from 0 to 10.

FIGURE 4 Survey on the students' perception on the experience. The first 11 items used a 5-point Likert scale. Responses ranged from strongly disagree to strongly agree, including a neutral midpoint. Items 12, 13, and 14 rated on a 0–10 scale.

Statistical analyses

Data were collected in the Moodle and Quizizz platforms and downloaded as Excel files. Afterwards, they were transferred to the statistic program Jamovi 2.3.24.[15] The level of statistical significance was set at $p < 0.05$. Quantitative data were presented as mean$\pm$standard deviation ($\pm$SD). The effect size (f) was also considered using the Cohen's d or the rank of biserial correlation, depending on whether the data met normality criteria or not, respectively.

The survey on the students' perceptions on the experience included 11 items rated on a 5-point Likert scale (Figure 4), which showed acceptable internal consistency (ω-McDonald, 0.70) and validity (KMO, 0.58). Subsequently, a descriptive statistical analysis of the data was conducted (Figure 6). The Likert items were analyzed using the frequency distribution of responses given by participants. A qualitative scale of satisfaction and its percentage were established: satisfied (values 4 and 5), "neutral" (value 3), and unsatisfied (values 1 and 2) for each Item (Figure 7). Numerical scale items ranged from 0 to 10 and data were compared using one-tailed Wilcoxon rank test for paired samples since data did not meet normality criteria.

The comparative analysis of the DOCENTIA-ULPGC surveys was carried out according to previously described procedure.[16] The

Factors	Items
F1	**TEACHING PLANNING**
F1.1	The teacher mentions the teaching guide.
F1.2	The learning materials elaborated and recommended by the teacher are useful to develop individual and group activities.
F1.3	The amount of work in this subject corresponds to what is described in the teaching guide.
F1.4	The classes are according to what is described in the teaching guide.
F1.5	The teacher offers supporting documents to the contents.
F2	**TEACHING DELIVERY**
F2.6	The teacher uses didactic resources properly.
F2.7	The teacher proposes activities to foster autonomous learning
F2.8	The teacher resolves doubts and questions clearly.
F2.9	Most of the learning activities described in the teaching guide have been made.
F2.10	The teacher checks the understanding of the subject during the classes.
F2.11	The teacher provides monitoring and advice on the learning activities and works.
F3	**RESULTS**
F3.12	The teacher informs about the evaluation criteria at the beginning of the subject.
F3.13	The evaluation process meets the tests and criteria described in the teaching guide.
F3.14	The evaluation process meets the contents and competences worked during the course.
F3.15	The learning objectives of the subject have been reached.
F3.16	The teacher's work is contributing to reach the objectives of the subject.
F3.17	The proposed timing in the teaching guide corresponds to the work done to achive the objectives of the subject.
F3.18	In general, I am satisfied with this teacher's work.
FG	**OVERALL EVALUATION (F1 + F2 + F3)**

FIGURE 5 DOCENTIA-ULPGC survey. This Likert survey has 5 response options: (1) Totally disagree; (2) Somewhat disagree; (3) Agree; (4) strongly agree; (5) Totally agree.

summarized statistical data for each factor (sample size, mean, and standard deviation) of experimental and control groups were compared using a one-tailed t-test for independent samples, using various online statistical applications: GraphPad quickcals (www.graphpad.com), StatsKingdom (www.statskingdom.com) and social science statistics (www.socscistatistics.com).

The sequence of CM and QQ scores at $t0$ and $t30$ was compared using the t-student for paired samples if the data met the assumptions of normality, according to Kolmogorov–Smirnov's test, and homoscedasticity using Levene's test. Alternatively, the Wilcoxon rank-sum test for paired samples was employed instead. Finally, the participants' scores on the final exam ($n = 116$) were compared with those of a random sample from control pre-pandemic courses ($n = 122$). The nonparametric Mann-Whitney U test for independent samples was employed since data did not meet the assumptions of normality and homoscedasticity. Additionally, the proportion of pass rates in both groups was compared using the chi-squared test.

Items	n	Mean	Median	SD
1	162	4.32	4.00	0.65
2	162	4.07	4.00	0.68
3	162	3.64	4.00	0.89
4	162	3.64	4.00	0.88
5	162	3.48	4.00	1.17
6	162	3.20	3.00	1.12
7	162	3.84	4.00	1.01
8	162	3.73	4.00	0.98
9	162	4.12	4.00	0.83
10	162	3.38	3.00	0.92
11	162	3.80	4.00	1.14
12	162	7.90	8.00	1.42
13	162	7.13	7.00	1.65
14	162	5.45	6.00	1.97

FIGURE 6 Descriptive analysis of answers to the survey on e-tests. n, sample size; SD, standard deviation.

Items	R	n	Satisfaction (%)
1. Quizizz facilitates my learning on the subject.	1	---	
	2	1	Unsatisfied (0.62)
	3	13	Neutral (8.02)
	4	81	Satisfied (91.36)
	5	67	
2. Moodle facilitates my learning on the subject.	1	---	
	2	1	Unsatisfied (0.62)
	3	29	Neutral (17.90)
	4	89	Satisfied (81.48)
	5	43	
3. Quizizz motivates to read in advance the contents before class.	1	2	
	2	12	Unsatisfied (8.64)
	3	56	Neutral (34.57)
	4	65	Satisfied (56.79)
	5	27	
4. Moodle motivates to read in advance the contents before class.	1	1	
	2	13	Unsatisfied (8.64)
	3	57	Neutral (35.19)
	4	64	Satisfied (56.17)
	5	27	
5. Quizizz creates a fun atmosphere	1	---	
	2	5	Unsatisfied (3.09)
	3	32	Neutral (19.75)
	4	63	Satisfied (77.16)
	5	62	
6. Moodle creates a fun atmosphere	1	6	
	2	15	Unsatisfied (13.00)
	3	68	Neutral (42.00)
	4	57	Satisfied (45.00)
	5	16	
7. There is enough time to resolve the Quizizz questionnaires.	1	7	
	2	33	Unsatisfied (24.00)
	3	34	Neutral (20.99)
	4	52	Satisfied (54.32)
	5	36	
8. There is enough time to resolve the Moodle questionnaires.	1	12	
	2	34	Unsatisfied (28.39)
	3	45	Neutral (27.78)
	4	52	Satisfied (43.83)
	5	19	
9. The electronic devices and internet work properly during the Quizizz e-questionnaires.	1	3	
	2	16	Unsatisfied (11.73)
	3	32	Neutral (19.75)
	4	64	Satisfied (68.52)
	5	47	
10. The electronic devices and internet work properly during the Moodle e-questionnaires.	1	4	
	2	14	Unsatisfied (11.11)
	3	40	Neutral (24.69)
	4	68	Satisfied (64.20)
	5	36	
11. In general, I prefer Quizizz questionnaires than Moodle questionnaires.	1	9	
	2	10	Unsatisfied (11.73)
	3	40	Neutral (24.69)
	4	49	Satisfied (63.58)
	5	54	

FIGURE 7 Survey on the students' perceptions. Frequency distribution of responses given by participants ($n = 162$). The responses (R) correspond to the following levels of agreement: (1) strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

RESULTS

RQ 1: Are there differences among the students' perceptions of traditional teaching and those supplemented with gamified and non-gamified quizzes? (Lectures supplemented with gamified e-quizzes better than those reinforced with Moodle e-quizzes. Lectures supplemented with any of them better than those unreinforced).

The descriptive statistical analysis (Figure 6) revealed the predominance of a median value of 4 out of 5 in most of the Likert items (from 1 to 11). These data indicated a positive perception of the experience. Only items 6 "Moodle creates a fun atmosphere" and 10 "The electronic devices and internet work properly during the Moodle e-questionnaires" had a median value of 3. Some relevant aspects of the formative assessment, such as items 1 to 4 on learning process and motivation, were perceived equally positive using MQ or QQ and with similar values of the SD.

The proportion test (Figure 7) indicated that most participants found QQ and MQ useful for their learning process (QQ, 91.36%; MQ, 81.48%) and motivating for pre-reading contents (QQ, 56.79%; MQ, 56.17%). Students preferred QQ (63.58%), which was considered the funniest (QQ, 77.16%; MQ, 45.00%). Despite scheduling similar time assignments, the students expressed higher satisfaction with the time allocated for QQ (54.32%) compared to MQ (43.83%). Moreover, most of the surveyees expressed satisfaction with the technical support available for completing the questionnaires (QQ, 68.52%; MQ, 64.20%).

The median values of items 12 to 14 (Figure 6) indicated a positive perception of the experience and established a clear order of preference: QQ (8/10), MQ (7/10), and the traditional expository-participatory method alone (6/10). The one-tailed Wilcoxon rank test for paired samples showed significant differences between the mean ratings of QQ (7.9 ± 1.42) and MQ (7.13 ± 1.75) with a medium effect size ($p < 0.001$; $f = 0.52$). Furthermore, lectures supplemented with QQs rated significantly higher compared to those unreinforced (5.45 ± 1.97), showing a large effect size ($p < 0.001$; $f = 0.90$). Interestingly, lectures supplemented with MQs also rated significantly higher compared to those unreinforced ($p < 0.001$; $f = 0.77$). Thus, the students' preference for gamified tests was significant. These data supported the acceptance of the hypotheses generated by the RQ1.

RQ 2: Does the introduction of e-quizzes improve the students' satisfaction with the teaching activity? (Teaching activity in the Docentia-ULPGC survey better rated than in the pre-pandemic years 2015–16 and 2017–18).

	Planning (F1) (n) mean ± SD	Delivery (F2) (n) mean ± SD	Results (F3) (n) mean ± SD	Overall evaluation (n) mean ± SD
Control	(97) 3.85 ± 0.95	(98) 3.94 ± 1.06	(96) 3.48 ± 0.95	(97) 3.75 ± 0.99
Experimental	(97) 4.1 ± 0.91	(97) 4.02 ± 0.97	(92) 3.96 ± 0.97	(95) 4.03 ± 0.95
t-test	p= 0.0628	p= 0.583	*p < 0.001	*p= 0.024
d-Cohen (f)	0.27	0.08	0.5	0.29

FIGURE 8 Comparative analysis of DOCENTIA-ULPGC surveys. Experimental group: academic years 2020–21 and 2021–22. Control group: academic years 2014–15 and 2017–18. Asterisks (*) show significant differences in F3 and in the overall evaluation.
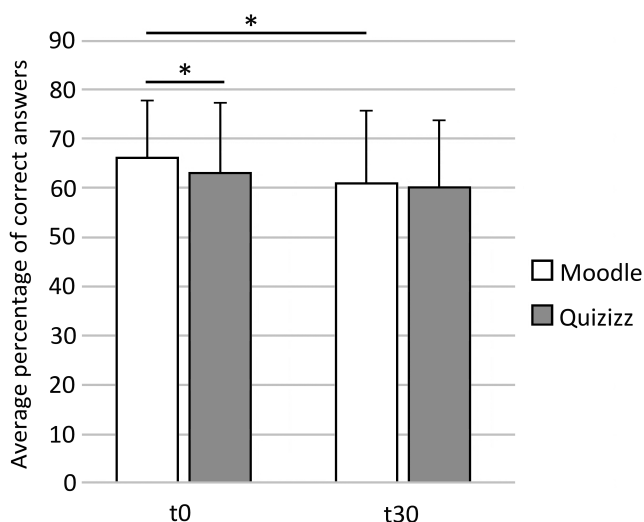
FIGURE 9 Graphic on the timeline sequence (t=days) of scores obtained in e-test (Moodle and Quizizz). Asterisks (*) show significant differences.
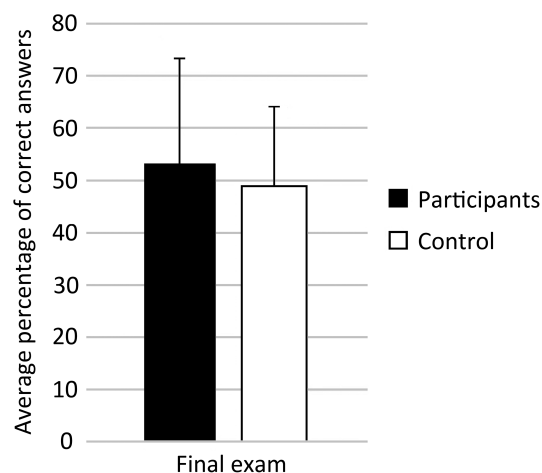

FIGURE 10 Graphic on the participants' average score in the final exam compared to the control group in the pre-pandemic courses 2015–16 and 2017–18.

The results factor of the DOCENTIA-ULPGC evaluates three subfactors: the evaluation process (Figure 5: F3.12 to F3.14), the educational objectives (Figure 5: F3.15 to F3.17), and an overall assessment (Figure 5: F3.18). The control group rated these subfactors within a range of 3.35 to 3.58 out of 5, while the experimental group scored them between 3.87 and 4.05 over 5. The summarized data from the DOCENTIA-ULPGC surveys of the experimental and control groups (pre-pandemic courses) were compared using a one-tailed t-test (Figure 8).

A trend toward improvement (without statistical significance) was observed in the factors F1 (teaching planning) and F2 (teaching delivery). Moreover, surveyees expressed significantly higher satisfaction with the teaching results ($p<0.001$; $f=0.50$) and with the overall educator's evaluation ($p=0.024$; $f=0.29$) than the control group. These data supported the acceptance of the hypothesis generated by the RQ2.

RQ 3: Is there any difference in the knowledge retention depending on the type of e-quiz? (Topics reinforced with gamified quizzes better rated than those reinforced with Moodle quizzes).

The sequence of average scores obtained in MQ and QQ at $t0$ and $t30$, as well as for the final exam at ($t60$–120) showed a gradual decrease in knowledge retention over time (Figure 9). The scores peaked at $t0$, with MQs (66.01 ± 11.61) achieving higher rates than QQs (62.80 ± 14.41) with a medium effect size ($p=0.004$; $f=0.25$). At $t30$,

both MQ (60.81 ± 14.75) and QQ (60.34 ± 12.35) scores were acceptable and decreased significantly (MQ: $p<0.001$; $f=0.39$; QQ: $p=0.03$; $f=0.2$). Interestingly, the difference between MQ and QQ scores at $t30$ was not significant, with a very small effect size ($f=0.03$). These data supported the rejection of the hypothesis generated by the RQ3.

RQ 4: Does the introduction of e-quizzes improve the academic performance? (Participants' academic performance better than the control group during the pre-pandemic years 2015–16 and 2017–18).

The ordinary examination calls were scheduled approximately 5–6 weeks after the last histology lecture (Figure 2). The participants' scores (52.88 ± 20.38) were compared to those of a control random sample (48.89 ± 15.30) from previous pre-pandemic courses using a one-tailed t-test for independent samples. The same subjects, teaching guides, and educators were applied in both groups. A slight improvement in the participants' average scores was observed (Figure 10). There was also a higher proportion of pass rates among the participants (55.17%) compared to the control group (46.72%). However, these differences did not reach statistical significance. These data supported the rejection of the hypothesis generated by the RQ4.

DISCUSSION

Positive perception of the experience and improved the students' satisfaction in the DOCENTIA-ULPGC surveys.

The survey on the students' perception included a "neutral" midpoint option in the Likert scale, which could admit additional interpretations, including no opinion and unsure.[17] To avoid misinterpretation, only values in terms of satisfaction (4, 5) and unsatisfaction (1, 2) were discussed here (see Figure 7).

In general, this study revealed the participants' preference for gamified questionnaires for formative assessment. This was according to most of studies on this field.[4,5,6,7,18] Interestingly, the present study revealed a valuable 81% of participants who also considered Moodle tests to facilitate their learning. Furthermore, both types of e-questionnaires similarly motivated students to pre-read materials before class (see Figure 7, items 3 and 4). These data were particularly relevant considering that the questionnaires were voluntary and had no impact on the summative assessment of the subject. On the contrary,[6] reported minor student's interest in e-quizzes provided by institutional e-learning platforms for formative assessment. Differences in the study design and geographical aspects could play a role in these discrepant results.

The prevalence of psychological distress among university students in health professions were found to be around 27% worldwide, and on a rise.[19,20] The learning climate was associated with resilience and protection against mental issues.[19] Apparently, volunteers in the present study preferred the gamified quizzes because they created a more enjoyable environment (Figure 7, items 5 and 6), which probably promoted social interaction among classmates. Gamification could reduce psychological distress among students, as also suggested by other authors.[7,18] Moreover, possibly the relaxing atmosphere supported by the gamification influenced a perception that the allocated time was more suitable for gamified questionnaires than for Moodle tests (Figure 7, Items 7 and 8), even though the same time was allocated to answer all of them. Moodle questionnaires might also contribute to reducing the students' anxiety related to the final exam since they were similar. In addition, they could be useful for those students presenting more anxiety with the gamified competition[21] or to simplify complex context which were perceived inadequate for gamification by students.[6]

The present study showed that lectures supplemented with any type of questionnaire were preferred over those unreinforced (Figures 4 and 6, items 12 to 14). By contrast, some studies revealed similar students' satisfaction with gamified and paper-based tests.[13] It remains to be determined what the most appropriate level of gamification is for other elements of formative assessment, such as knowledge retention and the potential for improvement through group activities, as suggested by other authors.[5,22]

A previous study analyzed the DOCENTIA-ULPGC surveys on the same subjects and teaching activity (2011–2017) to improve the overall evaluation.[16] The statistical data in the present study (see Figure 8) suggested that introducing e-quizzes was a successful strategy to enhance students' satisfaction in the DOCENTIA-ULPGC surveys. These surveys can be a useful tool for self-regulation of the teaching activities, which is in accordance with the continuous improvement promoted by the EHEA for both promoting teaching quality and preparing national accreditation of university teachers.

E-quizzes maintained mid-term knowledge retention and had a promising influence in the academic performance.

The originality of this study lies in providing an equitable design for the implementation and analysis of gamified and nongamified e-questionnaires. Moreover, this study integrated theoretical and practical contents at 30 days (Figure 1), which was more realistic for evaluating the learning process than considering them separately for integrative knowledge retention.

As expected, knowledge retention decreased over time (see Figure 9) according to its natural evolution. The higher score of MQ at $t0$ suggested that MQ was more effective than QQ for short-term memory, while gamification allowed a more stable mid-term retention at $t30$ (see Figure 9). The distractions inherent in gamification may have had a greater influence on short-term results. Moreover, some authors have described gamification as poorly effective for synthesizing complex contents according to the student's own perception.[6] Therefore, an adequate combination of both types of questionnaires could overcome these situations. For that purpose, it is important to note that most of surveyees expressed satisfaction with the technical support available for completing the e-tests (Figure 7, Items 9 and 10). Interestingly, the results support the usefulness of both types of e-questionnaires for mid-term knowledge retention (30 days). This was a much more realistic timeframe than similar studies, which were designed immediately before and after each lesson. In line with this, Cortés-Pérez et al.[4] demonstrated improvements in gamification (kahoot! and reward cards) for long-term knowledge retention (15 weeks) in physiotherapy students.

Regarding summative assessment, the participants' grades in the final exam showed a tendency to improve but without statistical significance, considering both the scores and the proportion of passing grades compared to the control group in previous courses. These results were aligned with those reported in other studies.[5,13] However, other authors have found significant improvement in academic performance through gamification.[9,23] This diversity of results was likely due to the absence of a standardized design to measure the impact of gamification on pedagogical and academic outcomes.[12]

The main contribution of this article is to reinforce the idea of the improvement of students' satisfaction and learning process by reinforcing theoretical and practical sessions with e-questionnaires in the context of Health sciences courses at the higher education level. Because Moodle and Quizizz are freely available and widely used, the experience can be easily extrapolated.

Limitations of the study

As a pilot study fully integrated into regular teaching activities, the limitations of the present study were the absence of a control group, the self-selection of participants, and the sample size. However, the sample size to measure the dependent variables (Figure 3) was larger than that of most similar studies. Additionally, the population is limited to first-year medical and physiotherapy students at the

ULPGC who attended classes regularly. The alternating order of MQ and QQ was established to reduce bias from variables as the level of complexity of certain contents and time-related circumstances. However, there is a possibility of overlapping certain contents. Despite these limitations, and considering the positive attitudes of the students, this study supports the potential of virtual tests as enhancers of formative assessment.

CONCLUSIONS

The gamified and nongamified e-quizzes complemented traditional teaching methods, resulting in increased participants' satisfaction, motivation, and engagement. This situation was positively reflected in the institutional DOCENTIA-ULPGC surveys on the students' satisfaction with the teaching activity. In addition, both types of e-quizzes contribute similarly to mid-term knowledge retention (30 days) and tend to improve the academic performance of first-year medical and physiotherapy students at the ULPGC. All these data encourage their use in combination to complement traditional teaching methodology for formative assessment. Future studies with a control group and the inclusion of a group modality would be necessary to shed more light on this field.

CONFLICT OF INTEREST STATEMENT
There are no financial or other conflicts of interest to declare.

ETHICS STATEMENT
The study was fully integrated into the regular teaching activity and met the ethical standards promoted by the declaration of Helsinki. The students provided their consent to participate in the study prior to voluntarily submitting the online survey and e-quizzes. They were also informed on their rights to access, rectify, oppose, and cancel their data, in accordance with the Spanish Organic Law 7/2021, of May 26, on the protection of personal data. Throughout the study, the anonymity of the participants was ensured through the strictly confidential handling of personal data.

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