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Article

Gamification of Assessments in the Natural Sciences Subject in Primary Education

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Abstract

The type of tests used most by Primary Education teachers in the Spanish education system is traditional examinations, despite not fulfilling the educational qualities that pedagogy and the Spanish law prescribe for assessment processes. In this study, an assessment test has been designed by applying game-design elements to examinations of the Natural Sciences subject of Spanish Primary Education, considering the potential games have for learning at school. A sample of 217 teachers divided into two groups was studied. Teachers who agreed to apply gamification in class were included in the experimental group and teachers who declined to apply gamification were included in the control group. Both groups answered a questionnaire on their perception of how each type of assessment influenced different didactic aspects. The comparison of the traditional assessment model and the game-based model revealed that the gamified exam presented notable advantages associated with increased motivation and increased capacity of the assessment activity to continuity the learning process beyond the school context.

Keywords

Primary Education • Examinations • Educational Assessment • Natural Sciences • Gamification

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The reform of the Spanish education system that was promoted by the Organic Law 8/2013 for the Improvement of the Quality of Education (2013), involved restructuring how science is taught in Primary Education. A specific subject was created under the title of Natural Sciences, which was given a core character (compulsory for students from all the autonomous communities). This new didactic situation brought with it the need to generate relevant knowledge in its planning, classroom performance and assessments. The research presented in this paper creates knowledge about the assessment of this subject in this new educational context.

Assessment is a process in which information is obtained through systematic instruments to make judgements based on references (assessment criteria), verify the degree of development of competencies and make decisions accordingly (Sánchez-Rivas, 2013, p. 143). From this perspective, many different tasks have the potential to provide data to assess students' learning. However, traditional examinations are the most commonly used tests for assessment in science subjects in Primary Education (Gómez, Monteagudo & López, 2012; Gómez, Rodríguez & Miralles, 2015; Miralles, Gómez & Sánchez, 2014).

Despite Spanish teachers' excessive use of examinations, pedagogy insists on the need to diversify assessment tools (Antivi, 2005; Perrenoud, 2004;). Specifically, there is a warning about the urgency of reducing the prevalence of conventional examinations (Arribas, Manrique, & Taberero, 2016; Calvo & Mingorance, 2010; Trevitt, Brenan & Stocks, 2012;). The main argument put forward relates to the inability of this tool to comply with the educational nature that all assessment tasks in Primary Education should have (Pérez, 2013; Vila & Esteve, 2002).

“Comprehension, expression, the ability to relate facts, application or memory are among the cognitive abilities that teachers assess; but it is the latter that acquires greater prominence in examinations [...]. Therefore, teaching and learning in classrooms maintain a memory-based and repetitive profile” (Monteagudo, Molina & Miralles, 2015).

The Spanish education legislation positions itself along the same lines and states that assessment cannot be extracted from the educational process. Teachers cannot design a task that serves only for assessment purposes. All tasks, including assessment, should promote student learning (Bartolomé, Martínez & Tellado, 2014). Otherwise, they have no place in the curriculum at this stage. A large number of science teachers share this pedagogical idea (Hernández, 2010; Vilanova *et al.*, 2017). Our paper studies teachers' perception of new mechanisms and game-based assessment tools considering these positions.

The transformation of teaching and learning tasks into games is known as gamification (Werbach & Hunter, 2012). Its aim in Primary Education is to promote students' commitment to their own learning process and create a classroom climate conducive to meaningful learning (Gaitero, Domínguez & Santaren, 2016).

Several research papers conclude that gamified activities fulfil their purpose in class, especially by improving the didactic elements linked to the willingness of students to learn (Gros, 2014; Lacasa, 2011; Marín-Díaz, López-Pérez & Maldonado-Berea, 2015; Revuelta & Esnaola, 2013; Villalustre & Moral, 2015). From the pedagogical point of view, Sánchez-Rivas (2016) and Gértrudix and Gértrudix (2013) agree in affirming that children learn better through games. Gee (2004) explains that a gamified task helps students to increase

their dedication when faced with challenges that are sometimes complex until they reach the goal set by the game. This is possible thanks to intrinsic motivation processes and the feeling of having experienced a fun process.

Our work draws on previous research (Kim, Kim, Khera & Getman, 2014; Marín-Díaz, López-Pérez & Maldonado-Berea, 2015; Marín-Díaz & Requena, 2016;) that identifies didactic aspects that can be improved as a result of applying gamification strategies in basic education. These aspects are based on (1) optimisation of class time, (2) student performance, (3) motivation and (4) ubiquity of learning. There is also an additional element of improvement, which has a direct bearing on all the previous ones: (5) the teacher's professional satisfaction.

Although no references to research on the application of gamification in the assessment of science in Primary Education have been found, its inclusion in class is a reality. Proof of this is the teaching experiences (Lester *et al.*, 2014; Martín del Pozo, 2015) or the analysis of games as didactic resources for teaching scientific concepts (Ouariachi, Olvera-Lobo & Gutiérrez-Pérez, 2017; Sterman *et al.*, 2015; Wu & Lee, 2015).

Despite its qualities, gamification has little presence in schools. This is clear from the study conducted by Vaillant (2013) for UNICEF, which shows that only 1.5% of teachers admit to implement video games in class. In the same vein, Dussel and Quevedo (2010) show that four out of every five teachers have not considered using gamifying elements in their educational interventions. Compared to teachers, students stress that play is their favourite activity and affirm that it is also the action they learn most from (Riemer & Schrader, 2015). Briefly, gamification is a marginal didactic strategy in our schools, despite the potential games have for learning and being the activity students prefer most.

Although gamification is not currently a predominant resource in class, more and more teachers are introducing it as a methodological innovation (Fernández, 2015). Considering the opinions of the next generation of teachers, their view of the future points to a growing implementation.

As didactic potential in class, future teachers see gamification as another methodology to be implemented within educational institutions (...). As a motivating element to encourage learning in class, they are fully convinced that gamification will be a very stimulating tool for students, as they believe that students would work with greater enthusiasm (Aznar-Díaz *et al.*, 2016).

This situation makes it advisable to deepen into the incorporation of gamification in traditional didactics. To this end, we have designed an assessment test based on transforming the examinations of the curriculum of Natural Sciences in Primary Education into a game. Our research focuses on analysing the implementation of this gamified assessment through teacher perception and comparing it with an assessment process based on traditional examinations.

Research Objectives

This paper aims to provide knowledge about the perception of science teachers in Primary Education concerning the application of a gamified assessment tool, specifically in relation to the effective use of class

time, student motivation and performance. It also looks at ubiquity, i.e. the potential of the resource to continue improving learning after the end of the assessment session. Finally, it also studies the professional satisfaction of teachers who gamify different traditional aspects of their didactic intervention. Given these claims, the following research questions are posed:

- 1) Does the gamification of a traditional examination improve any aspects of didactics in the Natural Sciences subject?
- 2) Does a gamified examination contribute to the students' learning process beyond the classroom without the presence of a teacher?
- 3) Does the gamification of traditional didactic elements in the field of science have a positive impact on the teachers' professional satisfaction?

With these questions in mind, the conjectural response begins to take shape through these work hypotheses (H) and their corresponding dependent (DV) and independent (IV) variables.

H1. The use of gamified examinations (IV) improves the perception that science teachers have of the effective use of class time (DV1), the motivation with which students face assessments (DV2) and their performance (DV3) compared to traditional examinations.

H2. The use of gamified examinations (IV) allows students to continue learning even outside the classroom (DV4) more so than with traditional examinations.

H3. The use of gamified examinations (IV) contributes to a higher degree of satisfaction among science teachers (DV5) compared to traditional examinations.

A similar gamified examination model was provided to all the teachers participating in the study and implemented in public education centres in the only one Spanish autonomous community to reduce the incidence of confounding variables. The aim was to reduce differences in the allocation of classroom resources, the curricular structure of scientific subjects and class ratios. Precisely for this reason, the research period was limited to one school year.

Methods

Participants

This research aims to describe the variables defined for a population made up of Primary Education teachers who teach the Natural Sciences subject in Primary Education centres in a Spanish province. The Statistical Unit of the Department of Education of the Junta de Andalucía (Spain) provided information on the population. Based on the data provided by the education authority, a non-probabilistic sampling was carried out, determined by the ease of access through the corporate emails of the educational centres.

Of the population of 4994 Primary Education teachers (Language Arts, Mathematics and Science) in Malaga (Spain), 2310 teachers who taught the subject of Natural Sciences during the 2016/2017 school year made up

the population of this study. This group received a formal invitation to take part in the study. Collaboration was sought from teachers who regularly used traditional examinations. A second communication was sent to the teachers who accepted to collaborate, asking whether they would be willing to gamify their assessment following the indications provided by the research team. Participants who responded positively became part of the experimental group and subjects who responded negatively formed the control group.

The final sample of this study included 217 Natural Sciences Primary Education teachers. Participants were divided into an intervention group that used gamification (n = 90) and the traditional assessment group who used a written exam (n = 127). Both females (n = 175) and males (n =42) were included. This is a usual gender proportion of the population of Primary Education teachers with a majority of females. Regarding other personal variables, all the age ranges defined in the questionnaire were represented in the sample, with the majority of teachers aged between 35 and 45 years. All the teachers were working in public schools.

Table 1
Structure of the Questionnaire

<i>Areas of interest</i>	<i>Definition</i>	<i>Items</i>
Effective use of class time	VD1: Optimisation of times and tasks during the assessment classroom session	1-4
Motivation	VD2: Students' emotional acceptance of the assessment perceived by the teachers	5-8
Performance	VD3: Students' learning process during assessment perceived by the teachers	9-12
Ubiquity	VD4: Generalisation of learning involved in the assessment to contexts outside of school	13-16
Satisfaction	VD5: Teachers' personal perception of the didactic effectiveness of the assessment	17-20

Table 2
Guidelines to Design Gamified Examinations

Component	Gamification
Name	“Modify the verb and the noun” it is no longer an “examination”. Now, they “play a Trivial quiz”.
Presentation	Design the task as if it were a competition, exempt from negative connotations. This would contribute to reducing standard tension (negative emotion) of a traditional examination.
Rules	Change how the rules are presented. They can, obviously, not be copied or made in a group (it would not be useful for individual assessment), but it is the competition format and the agonistic component (instead of teacher imposition) that encourages students to comply with the rules of the game.
Support	The examination shall not be printed unlike traditional examinations. A computer presentation will be used instead. The questions are projected in slides and accompanied by images or short video sequences.
Challenge	The challenge for students is to achieve the greatest possible number of correct answers. Each correct answer will yield one point for their particular score.
Prize	The student who gets the highest score will receive a gift. Their feat will also be posted on the class blog (or bulletin board), thus providing additional public recognition.
Verification	Everyone is involved in the correction process. One student assesses another, following the teacher's explanations of the content of each question. This explanation is of great interest, as it has a direct utility: the student needs knowledge to fulfil his or her role as an assessor. Trivial thus gains added value by becoming more of an educational rather than just an assessment activity.

Source: The author

Instruments

To collect data on the areas of interest for the research, we used a questionnaire of 20 items with a five-choice Likert response format (5=always, 4=often, 3=sometimes, 2=little, 1=never), grouped in the following scales: Effective use of class time, Motivation, Performance, Ubiquity and Satisfaction. Each of these areas of interest corresponds to a dependent variable identified in the hypotheses (Table 1).

The study was carried out in schools over one academic year, and it was adapted to the programmes of each context. Teachers who were part of the control group received the research questionnaire with the instruction to complete it after applying a traditional examination (composed of multiple-choice or essay questions, and in written format). Teachers in the experimental group were given a series of guidelines to gamify the examination, which affected the design (Table 2) and the application of the assessment test (Table 2).

Table 3
Guidelines to Apply Gamified Examinations

Phase	Action
Preparation	The teacher or students (in higher grades) prepare a set of multiple-choice questions. This process can be done through a collaborative Google Drive or Dropbox document. Once the questions have been designed, the teacher (or the group in charge) will select fifteen questions and create a computer presentation (with tools such as Impress or PowerPoint). Each slide will contain a question and answer options. It is advisable to present the rules of the Trivial on the first slide.
Presentation	The question must be answered in writing and within the established time frame, which will be about thirty seconds after having given a reasonable amount of time to ensure a comprehensive reading. Copying is not allowed. People who speak during the Trivial will have one point subtracted from their score.
Development	Once the rules have been clarified, the projection of the slides containing the questions begins, through a projector. The students write their answers in the notebook (this record allows the teacher to have data of interest for continuous evaluation). Once the game is over, students exchange notebooks in order to correct the answers marked by their partner.
Completion	The correction process arouses great interest. It is the right moment for the teacher to reinforce the contents involved in the question asked. Each correct answer is one point and will serve to determine the winner. A team competition can also be held, grouping individual scores.

Source: The author

Teachers who were part of the experimental group filled out the research questionnaire after the assessment test had been designed and applied in class. Two sixty-minute sessions (S) were convened, with predefined actions for each:

S1. The first design action focused on choosing the most appropriate type of questionnaire given the nature of the study. The research team focused efforts towards defining the structural elements of the questionnaire, such as areas of interest, number of items, writing style, rating scale or presentation format.

S2. The second action focused on designing each item.

The resulting questionnaire was subjected to the expert consultation system and revised on the basis of the results obtained in a pilot test, which made it possible to adjust the tool, thus achieving a high degree of validity with regard to the aim of the survey.

Similarly, the reliability of the questionnaire was analysed using Cronbach's Alpha coefficient. The score achieved was 0.91, which allowed us to establish the internal consistency of the tool (Mateo, 2012).

Once the questionnaire design process was completed, it was digitised using the Google Drive application for forms. Participants were presented with the questionnaire via a mobile application (Figure 1), and it was also sent to them by email.

Data analysis focused on comparing the mean scores of the experimental and control groups. To this end, two phases (P) were established.

P1. In a first phase, an initial exploratory analysis was carried out to facilitate the subsequent presentation and interpretation of results by means of univariate descriptive analysis and the refinement of the data matrix, grouping the mean scores according to their correspondence with the independent variable. This also made it easier to contrast the value that each pedagogical model reached in the item.

A mean score in each dependent variable was calculated based on the summation of the scores in the items included in each scale.

P2. In a second phase of the bivariate analysis, the mean scores of the experimental and the control group were compared using the Student t-test for independent samples. To this end, an analysis of the parametric assumptions of the sample was previously applied to ensure confidence in the results.

Design and Procedure

From a methodological point of view, the aim and the nature of the objectives suggested focusing the methodology along the lines of a two-group survey design, using the questionnaire as a tool to collect information and compare scores between the groups.

Based on the scheme proposed by Cohen and Manion (2002), three phases (PH) were articulated to structure the process in a survey study and organise the actions carried out by the research group.

PH1. Approach. This phase began with an analysis of the possibilities of implementing a gamified examination and its potential in the field of science didactics in Primary Education.

PH2. Didactic intervention and data collection. The research team gamified a traditional examination and designed an implementation procedure. The team ensured, both in the process and in the final result, that:

1. The gamified assessment provided the teacher with information similar to that obtained from a traditional examination of the content learned.

2. Students would have to answer questions individually, without the possibility of elaborating a group answer.
3. The feedback received by the students and their families was similar to what a traditional examination would provide.

In short, it was an attempt to preserve the essence of the examination, but changing its presentation and format from a traditional perspective to game.

The research team designed a mobile application to provide teachers with educational resources for the assessment on which this research focused. It also contained the instructions to apply the assessment test that we propose, thus ensuring uniformity in the procedure; in addition to the actual research questionnaire.

This application was sent to the subjects making up the sample through a QR code (see Graph 1). This application is public and can be downloaded free of charge from the Google Play Store.



Graph 1. QR code for the download of the research application

Source: The authors

PH3. Data analysis and reflection. The ultimate aim of this research was to improve didactics in the field of science. For this reason, once the data analysis was carried out using the SPSS software (version 22), meetings were organised to reflect on the results. The conclusions contained in this paper stemmed from this joint interaction of the research team.

Results

Table 4 shows the results of the initial exploratory analysis focused on the mean scores of the control (traditional) and experimental (gamified examination) groups in each item of the questionnaire. The comparison of mean scores showed that, in general, gamified examinations obtain higher values than traditional ones. The differences found in the scales of the questionnaire regarding students' motivation compared to the assessment test and the continuity of their educational character outside the classroom (ubiquity) were particularly remarkable. Also, worthy of mention are the differences in favour of the gamified examination seen in items 1 (on the effective use of the session), 12 (on student performance) and 17 (on professional satisfaction).

Table 4
Mean score grouped by item and type of assessment test

	Traditional Examination		Gamified Examination	
	Mean	SD	Mean	SD
<i>Effective use of the assessment session</i>				
1. Learning during the test	1.54	0.82	3.48	0.94
2. Scarce disruptive demonstration	3.60	1.02	4.48	1.02
3. A good level of attention	3.40	1.03	3.40	0.93
4. The student completing all the tasks envisaged	3.29	1.01	4.05	0.83
<i>Students' motivation in the assessment test</i>				
5. The student remaining calm during the assessment test	1.37	0.58	4.08	1.01
6. The student adopting an active role in the task	1.48	0.68	3.91	1.01
7. The student expressing interest towards the assessment test	2.45	1.04	4.14	0.94
8. The student expressing that the assessment process was enjoyable	1.39	0.66	4.31	0.74
<i>Students' performance in the assessment test</i>				
9. The student successfully applying the knowledge acquired	3.13	1.37	3.31	0.88
10. The students finding solutions to the problems	3.61	1.04	3.66	1.01
11. The result of the learning being proportional to the effort	3.36	1.01	3.45	0.92
12. The development of key competencies	2.87	1.35	4.00	0.90
<i>Continuity of learning outside the classroom (Ubiquity)</i>				
13. The students having done the assessment test at home	1.39	0.62	3.99	1.01
14. The student having done the assessment test on his/her own	1.70	0.82	3.93	1.00
15. The student having showed the assessment test to his/her family	4.03	1.00	4.14	0.94
16. The student having showed the assessment test to his/her peers	2.52	1.43	4.24	0.75
<i>Teachers' professional satisfaction</i>				
17. The assessment test having been fruitful for the students	1.48	0.74	3.47	0.94
18. The assessment being in line with pedagogical innovation	3.59	1.02	3.53	0.98
19. The assessment session having been completed satisfactorily	3.49	1.02	3.40	0.93
20. Quality teacher involvement	3.47	1.00	3.55	1.04

Source: The authors

Figure 2 shows the mean scores in each dependent variable comparing the traditional assessment group with the gamified assessment group.

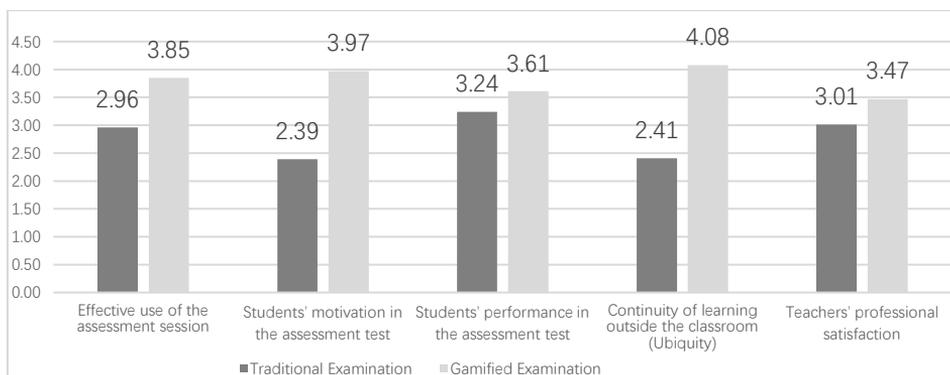


Figure 2. Mean scores in each dependent variable in traditional examination versus gamified examination group

Source: The authors

The mean scores displayed in figure 2 show that teachers perceive improvement in the gamified assessment session in comparison with traditional assessment. In relation to this outcome, it is important to add that the duration of the session was similar in both cases and that the manifestations of disruption are usually very low with the suggested assessment tasks, either gamified or not. The bar chart shows that there is only a small difference in students' performance. There are big differences in relation to ubiquity. The high levels achieved with the gamified assessment show that the students continue to learn at home starting with the challenges proposed in the game. This result is better understood together with high motivation that encourages students to play again with their family at home. Teachers' satisfaction is also slightly higher in the gamified sessions. The analysis of the data provided by descriptive statistics, which showed the existence of differences between traditional and the gamified examinations, recommended comparing the scores in the dependent variables using inferential statistics to determine the possible significance in the variance.

The results of the Student's t-test performed to compare mean scores between the traditional and the gamified assessment show that the differences are statistically significant. Nevertheless, following the criteria suggested by Tejedor and Etxeberria (2006) for the application of parametric tests, only the results of the comparison in Motivation and Ubiquity are considered valid because other variables are not normally distributed (see Table 5).

Table 5

Results of the Student's t-test and the parametric assumptions in each area of interest

Area of interest	Assessment type	Students t		Shapiro-Wilk		Kolmogorov-Smirnov	
		Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
Effective use of class time	Tradicional	-8.47	0.00	0.96	0.00	0.11	0.00
	Gamified			0.97	0.08	0.11	0.00
Motivation Performance	Tradicional	-36.63	0.00	0.93	0.00	0.16	0.00
	Gamified			0.94	0.00	0.15	0.00
Ubiquity	Tradicional	-4.41	0.00	0.97	0.00	0.10	0.00
	Gamified			0.97	0.06	0.11	0.01
Motivation Performance	Tradicional	-23.58	0.00	0.95	0.00	0.13	0.00
	Gamified			0.94	0.00	0.14	0.00
Ubiquity	Tradicional	-6.25	0.00	0.96	0.00	0.10	0.00
	Gamified			0.96	0.06	0.11	0.00

Source: The authors

Conclusions

In this study, we have deepened into teachers' perception of the two evaluation models used in science teaching in Primary Education: the traditional examination and the gamified examination. In general terms, we can confirm that an assessment based on a game, from the perspective of science didactics, has significant advantages over an assessment with traditional examinations. These conclusions are in line with those obtained in other studies on the use of gamification as a pedagogical strategy (Aguilera, Fúquene & Ríos, 2014; Arias, Bustinza & Djundubaev, 2016; Capell, Tejada & Bosco, 2017).

More specifically, we have found that some of the advantages attributed to gamified teaching also extend to assessment tests in the subject of Nature Sciences. The didactic aspects we are referring to are: “Effective use of class time”, “Motivation” and “Performance”, and they were considered in the first hypothesis of this study.

Optimising the effective use of class time is one of the potentials attributed to gamification in specific literature. The results we have obtained, however, are not sufficient for us to say that there are differences in this regard when a gamified examination is applied. Even though the statistical significance of the difference between the gamified assessment and the traditional assessment was not confirmed, the gamified assessment received a higher score and future studies are needed to confirm this because any type of assessment, including traditional assessment, with high exigency of the task, does not leave space for losing time by the students. However, when drawing attention to item 1, an important difference in learning outcomes during the test is noted. In the traditional examination, students are required to demonstrate the knowledge they have acquired but have no opportunity to learn new things. Traditional examinations lack the educational character that assessment tasks in Primary Education should have. In contrast, gamified examinations provide the option, according to teachers, of learning during the test and, more specifically, in its correction process, which involves the participation of students in a joint assessment process.

Motivation is the didactic component in which more differences have been found. Taking the questionnaire as a reference, the high levels of motivation that teachers perceive in their students when they take the gamified examination contrast with the low range of scores that this variable acquires when evaluated in relation to the traditional examination. Student t-test results confirm the significance of these differences. The contributions of [Kebritchi, M., Hirumi, A., & Bai \(2010\)](#) and [Hamari \(2015\)](#) are in the same line of conclusions, placing motivation as the main advantage of gamified didactic models.

According to [Sánchez-Rivas \(2011\)](#), the positive effect that gamified teaching has on student motivation is due to the fact that the game elements in the activity are in the very nature of childhood. Primary Education pupils like to play, and it is their usual way of learning social skills. Therefore, when traditional didactics takes on the appearance of a game, the interest grows with regards to class.

As for the third didactic aspect studied, "Performance", the descriptive analysis shows that teachers find little differences associated with the type of examination used. This contrasts with the contribution of other scientific work ([González & Mora, 2015](#); [Riemer & Schrader, 2015](#); [Westera, 2017](#)), who find the improvement of learning performance one of the main advantages of the use of gamification as didactic strategy, especially when compared to other more traditional options.

According to our interpretation, the explanation for such dissonance could be found in the fact that the student body presents acceptable levels of performance in traditional examinations (proof of this are the values obtained by this variable in the questionnaire), and there is no qualitative change when students are assessed by means of a gamified examination, with which their performance is maintained.

We value the level of performance obtained in the gamified examination, considering students' lack of previous experience with gamified examinations. As with teachers, students need to adapt to innovation models

to achieve optimum effective use. After all, they have been doing conventional examinations all their lives, so an immediate adaptation is ambitious, to say the least. It is therefore advisable, for future research on the efficacy of gamified examinations, that the chosen sample has been through an adaptation period to the model before conducting the study.

Without abandoning the performance variable, it should be noted that teachers value the contribution of gamified examinations to the development of key competencies, as shown in item 12 of the questionnaire. This trend is in line with the studies conducted by [Ryder \(2015\)](#) and [Wallace and Priestley \(2017\)](#), which agree that teachers understand that in the field of science, learning competency is much more valuable than the mere acquisition of content that traditional examinations encourage. [Benarroch and Núñez \(2015\)](#) explain this perfectly:

Competent action depends on general and specific knowledge schemes. While the latter may depend on the teaching of the content itself, general knowledge schemes are generally more transversal and require more time to acquire the cognitive procedures necessary to use specific concepts in a flexible, controlled and context-appropriate way.

In a nutshell, and taking the first hypothesis as a reference, we consider that the application of gamified examinations improves teachers' perception of their students' motivation towards assessment tests in the field of science. However, it has not been possible to prove that it increases either the effective use of class time or performance.

The [Delors Report \(1996\)](#) established guidelines for twenty-first-century education. One of the main recommendations was to extend the action beyond the classroom context. Education has to cover all facets of life; it has to be ubiquitous. This aspect has been another of the axes on which our study has focused: the capacity of the assessment task to promote learning outside the classroom.

There are no studies linking the gamification of a science examination to its extension beyond the classroom. However, many research studies demonstrate the potential of scientific learning to find an application in the students' context ([Bennett & Lubben, 2006](#); [King & Ritchie, 2012](#); [King & Ritchie, 2013](#); [Overman *et al.*, 2014](#); [Pilot & Bulte, 2006](#)). Science forms part of life and supports learning beyond the classroom naturally. Gamification has also proven to have great potential in this respect. Based on this relationship, and taking the results obtained on the second hypothesis presented in this study, we conclude that gamified examinations have a great potential to prolong its educational action at the end of the evaluation session. This potential has proved to be higher than with traditional examinations.

We have detected that the competition format and the fact that homework is available on the classroom blog, allows students to repeat the gamified examination at home with their families and peer groups. Traditional examinations only approach the levels of ubiquity of a gamified examination in a parameter reflected in item 15, and it has to do with students showing the examination to their families. In this regard, we must clarify that most teachers who formed the control group (traditional examination) required their students to return the

examination signed by their parents or legal guardians, as a way of ensuring that the family was aware of the mark. This does not happen to the same extent with gamified examinations.

Undoubtedly, the teacher is the fundamental agent in the implementation of didactic innovations such as gamification. We believe that their level of satisfaction may be key to achieving greater implementation in the education system. The third hypothesis of our study was based on knowledge of the degree of satisfaction that teachers expressed about applying one type of examination or another.

Research that considered the opinion of teachers regarding the implementation of innovations coincides in highlighting that education professionals find some reward when they apply a successful innovation in their classes (Díaz-Barriga, 2010; Marcelo, 2013; Medina *et al.*, 2011). In our study, we found differences that invite us to think in the same lines as Lupión-Cobos *et al.* (2017), in that science teachers might also gain professional satisfaction through didactic practices that deviate from traditional models. However, we do not believe that we should say much on the third hypothesis of our study. The results obtained do not make it possible to accept or rule out that gamified examinations contribute to a higher degree of satisfaction on the part of science teachers compared to traditional examinations. This variable will need to be further explored. This reality leads us to recommend further deepening the study into this variable in pursuit of an answer.

In terms of didactics, the conclusions of this research recommend implementing the game as an educational method to improve the assimilation of complex contents and performance of less-attractive school tasks. Other research projects have also been positioned along these lines (Engelhardt & Mazurek, 2014; Blumberg & Randall, 2015; Marín-Díaz & Sampedro-Requena, 2016).

The research process has led us to maintain close contact with the participating teachers, and to learn first-hand about the difficulties they have encountered in implementing a gamified assessment model. In this sense, we recommend the pedagogical training of teachers be updated to consider the implementation of gamified processes in teaching and learning in the science classroom.

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