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Game-based learning and gamification in initial teacher training in the social sciences: an experiment with MinecraftEdu

Ramón Cózar-Gutiérrez[1*] and José Manuel Sáez-López[2]

* Correspondence:
Ramon.Cozar@uclm.es
[1]Faculty of Education of Albacete,
University of Castilla-La Mancha,
02071 Albacete, Spain
Full list of author information is
available at the end of the article

Abstract

This study analyzes the application of game-based learning and gamification using MinecraftEdu, which allows for an exploration of the possibilities regarding immersive learning environments. We analyze the contributions of second-year university students who are pursuing a degree in Primary Education and are enrolled in a subject entitled Social Sciences II: History and Teaching at Castilla-La Mancha University. On four scales, we detail descriptive data and statistical inference through a quasi-experimental design using a Wilcoxon test and a sign test. The instruments provide content and construct validation based on data triangulation as a strategy. Despite the fact that participants consider video games as non-essential tools in an educational context, they value the fact that game-based learning through immersive environments allows for learning that involves a higher level of activity and engagement of the students. Interest level, educational innovation and motivation are valued positively and show statistically significant improvements.

Keywords: Game-based learning, Interactive learning environment, Pedagogical issues, Primary education, Teaching/learning strategies

Introduction

Preparing students for learning a new culture imposed by our virtual era (Adell and Castañeda 2012) is a challenge for educators and it forces us to rethink the goals of education (European Commission 2013; Mishra et al. 2011). From our perspective—that of our initial training of future teachers—we must address this change by developing training activities that include the most suitable opportunities and strategies for successful acquisition not only of teaching skills (Esteve et al. 2014a) but also those fundamental to resolving problems and situations in the digital world. Digital learners, or digital natives, have grown up in a technological and digital environment (Palfrey and Gasser 2008) and their prevalence is recognized by the growing expansion of ICT (Esteve et al. 2014b).

In recent years, the changes experienced since the creation of the European Higher Education Area have generated new educational formulas geared towards active and dynamic learning designs and teaching methods that are student-centred and linked to the availability and use of technologies that can be integrated into the classroom. Some teachers and education policies interested in introducing innovative strategies have not

hesitated to add video games to the long list of possible tools and resources (Gómez 2014). The *NMC Horizon Report: 2014 Higher Education Edition* (Johnson et al. 2014) identifies the emerging technologies that are bound to have a significant impact on learning, teaching and creative thinking in higher education. The aforementioned report targets gaming and gamification as technologies whose impact on university education will arrive in two to three years. The edition of this report, which analyzes the major trends and emerging innovations that may affect elementary and secondary education environments, also identifies games and gamification along with emerging technology implementation in the medium term (2–3 years).

From our perspective as teacher trainers, we decided to investigate and analyze opinions about emerging technologies that use gamification and game-based learning in initial training for future teachers, as well as the real presence of these key trends in university training contexts. To do so, we relied upon the implementation of MinecraftEdu (http://minecraftedu.com), the educational version of the popular virtual world Minecraft.

Theoretical framework

According to Kapp (2012), "Gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems" (p. 10). It is a method used to create a meaningful and motivating experience through the integration of mechanical play in non-recreational environments and applications. Thus, game-based learning refers to the use of games to enhance the learning experience, while maintaining a balance between content and gaming and its application in the real world. With the introduction of gaming, the methodology was renamed digital game-based learning (Prensky 2001). Van Eck (2006) sets out three aspects to the use of this approach in the classroom: a) the use of commercial titles—motivating and attractive games that can be used for educational purposes, but which require trained teachers and curriculum planning so as not to lose sight of the pedagogical approach; b) the so-called 'serious game'—those specially developed to educate, train and inform (Michael and Chen 2006); c) games built by the students themselves that therefore develop problem-solving skills, programming and game design. Gertrudix and Gertrudix (2013) add one more aspect: d) gamification process integration in educational activities mediated by technology. Despite the differences between concepts, we agree with Kapp's (2012) statement, "when you get right down to it, the goals of both are relatively the same. Serious games and gamification both are trying to solve a problem, motivate, promote learning and using game-based thinking and techniques" (p. 16).

Numerous investigations have focused on the influence of video games in education (Barab et al. 2007; Barab et al. 2010; Blunt 2007; Gee 2004; Kafai 1998; Prensky 2001; Squire and Jenkins 2003). Many of these studies agree that statistically significant improvements in terms of increased motivation and task commitment and enjoyment are connected with video games (Cebrián 2013). Revuelta and Guerra (2012) provide a list of educational learning processes that favour the inclusion in classrooms of the game: a motivating and flattering performance element, the use of edutainment, the acquisition of or use of skills for problem solving, socialization and cooperation, increased concentration, personal autonomy, close teacher-student relationship, a multi-area and multi-

tasking tool, the ability to interact, the assimilation and interconnection of content, the development of values, the simulation of situations, improved decision-making, and immediate feedback.

We also found less positive reviews. For Blunt (2007) "there is not enough research to determine the relationship between video games and learning" (p. 2). De Freitas and Oliver (2006) argue that "although a number of frameworks exist that are intended to guide and support the evaluation of educational software, few have been designed that consider explicitly the use of games or simulations in education" (p. 262). De-Marcos et al. (2014) state that "there are drawbacks to their use for educational purposes associated with educational content, transfer of learning, assessment, potential problems of teacher involvement or technical infrastructure" (Borrás et al. 2014, p. 2). And others like Akkerman et al. (2009), and Moshirnia and Israel (2010) in the article by Young et al. (2012) agree that when it comes to integrating gaming in areas such as the present one (history) "adding text or historical information to gaming is not enough to foster learning" (p. 80). Overall, despite the criticism, it is undeniable that video games are technological tools that are fully integrated into society (Revuelta and Guerra 2012). As for incorporation into classrooms, a 2012 study by the Spanish Association of Games indicates that 67 % of Europeans and 58 % of Spaniards consider the use of entertainment software in general and video games in particular as educational tools as something beneficial (aDeSe 2012; Marín and Martín-Párraga 2014). The report also states that 30.9 % of Spanish elementary teachers acknowledge having used video games in their teaching, mainly in subjects like maths, science and Spanish. Moreover, 79.2 % of teachers believe that video games' great teaching capacity and their introduction in the classroom can function as a stimulating teaching method (aDeSe 2012, p. 32). However, they also state that due to a lack of information and guidance regarding the possibilities of applying video games in schools (75.9 %), there should be more support from the public administration to provide resources and facilitate the realization of this type of activity (64.4 %) and, in general, the centres are not adapted (poor Internet connections, lack of computers, etc.) for this type of activity (63.4 %).

In this regard, the need to promote adequate initial ICT training of future teachers (derided in the curriculum) has led us to train students enrolled in the Social Sciences II: History and Teaching subject in the second year of their master's degree in Primary Education course in the Faculty of Education of Albacete, University of Castilla-La Mancha, Spain. By following a TPACK model as an intervention approach, we have educated them in the pedagogical integration of video games for the teaching of historical and artistic content. To do this, we relied upon the use of MinecraftEdu (http://minecraftedu.com), the educational version of the popular virtual world Minecraft. This is an immersive environment that responds to the sandbox model, with its own educational community composed of teachers and programmers, and with a set of specific tools for the development of educational activities within the environment personalized by and adapted to different educational levels and subject areas (Gertrudix and Gertrudix 2013).

Method

The study makes use of the survey technique and the questionnaire as a tool, consistent with the objectives of the investigation. We propose four scales. Scales 1 and 2 are

adapted studies on MinecraftEdu by Sáez-López and Domínguez (2013) to analyze the level of knowledge about game-based learning and gamification. Scale 3, entitled "Active Learning", contains four questions present in Hiltz et al. (2000). Scale 4, "Fun", consists of five questions adapted from Laros and Steenkamp (2005).

In addition to the descriptive data, we proceed to evaluate results from statistical inference. Data are analyzed through a quasi-experimental design with a Wilcoxon test and sign test. The significance level α is 0.05. The calculated reliability coefficient using Cronbach provides a 0.73 value at different levels, always greater than 0.6, which is considered acceptable (Hair et al. 1998). Also, an exploratory factor analysis was performed using the principal component method for determining the most significant different elements and factors on the various scales considered.

From the data triangulation approach (Cohen et al. 2000), and to give greater consistency and validity to the study, we only accepted and interpreted significant improvements if they had been met in the two tests applied, i.e., in the Wilcoxon test and the sign test. This triangulation, implemented by using different analyses, test and quantitative and qualitative (open question) data, allows us to determine that there is evidence to support the validity of the results and minimize error variance (Goetz and LeCompte 1988).

Participants

The study population if formed by university students in the second year of their master's degree in Primary Education course in the Faculty of Education of Albacete, enrolled in the Social Sciences II: History and Teaching subject. The research sample is not probabilistic or intentional and consists of 89 individuals. Evidence from the quasi-experimental design was applied as related samples were linked to a pre-test and post-test design.

The experimental group consists of 75.3 % females and 24.7 % males, which turns out to be a representative sample of gender disparity existing in teacher studies, in which there are always more women. The average age is 21 years. The group is quite homogeneous because the students are almost all the same age and educational level.

Results

Descriptive analysis

In the analysis of scale 1, "Game-based Learning in Initial Training", we can see that most students bring positive assessments regarding the consideration of this approach as essential in training future teachers, and regarding the importance in initial university training to work with immersive environments, with positive values (agree or strongly agree) higher than 95 %. The benefits of 3D interactive gaming environments in initial teacher training also get positive values from over 90 % of the sample. As for initial training and skills in this field, just under a quarter of the sample had worked with video games and gamification in college applications; similar values are seen related to how to design video game activities in educational settings.

With regard to scale 2 "Gamification in Educational Contexts", we would point out that 100 % of the students assess creativity with positive values (agree or strongly agree). Over 97 % of students also emphasize the collaborative advantages, skills

development and educational innovation. And finally, more than 94 % indicate that communication, interaction and motivation in learning processes are positive aspects.

Regarding "Active Learning", scale 3 highlights that 100 % of the students provide positive values regarding the view that the gamification approach allows the subject to be more interesting. Over 96 % of the sample believes that game-based learning permits active participation and that students ultimately learn. And more than 80 % consider that engaging with the content is better using this approach.

Finally, on scale 4 "Fun", over 90 % of the participants say that they were happy, motivated and enjoyed the activity, and more than 80 % felt relaxed and comfortable in the process.

Therefore, the values shown on the scales are quite positive, close to 90 % on most items except those referring to the experience of students in working with gamification and game-based learning and applications in college (item 1.4) and the ability to design video game activities in educational settings (1.5). These obtained values close to only 25 % of the sample.

Statistical Inference: Wilcoxon test and sign test

With regard to statistical inference, non-parametric tests were applied to test samples to evaluate related data from the pre-test post-test quasi-experimental design (as in the above description of the present study). Significant improvements were considered made only if the value was less than 0.05 in both the Wilcoxon test and the sign test (Table 1).

Significant improvements are obtained with regard to the evaluation of work based on video games and gamification in college applications. Students value work with higher positive results after the activity. Therefore, it is important to work games and gamification into initial training at university to enhance their future professional performance. Although the descriptive analysis highlighted that about 80 % of the students do not know how to design video game activities in educational settings, involvement in the activity has resulted in a significant improvement in this regard. Moreover, the experience has allowed the students to study various technologies to design approaches to gamification and game-based learning (items 1.4, 1.5 and 1.6).

With regard to scale 2 "Gamification in Educational Contexts", the Wilcoxon test and the sign test found significant improvements with regard to educational improvement as students believe that game-based learning through MinecraftEdu encourages educational innovation processes (item 2.5). In addition, the motivation of students is also enhanced, i.e., working with MinecraftEdu increases motivation in learning processes (item 2.6).

Note that with respect to other items significant improvements are not seen since the pre-test values related to attitudes on gamification were already quite high and so the post-test results were very similar at close to 90 %, as detailed in the descriptive analysis. However, the intervention has led to improvements in the work, knowledge and creation of tools for designing gamification and game-based learning approaches, assessing the possibilities of motivation and its importance in educational innovation processes.

Exploratory factor analysis

We proceeded to carry out an exploratory factor analysis in the studied dimensions. It was verified to be appropriate to conduct factor analysis of the data provided by the

Table 1 Scales and items, descriptive analysis, Wilcoxon test and y signs test

Scales	Items	1	2	3	4	W. T.	Sig T.
1. Game-based Learning in Initial Training	1. A game-based learning approach is essential to train future teachers.	0	1.1 l	53.9	44.9	.076	**.041**
	2. It is important to work in immersive environments in the initial university training	0	4.5	66.3	29.2	.155	.371
	3. Interactive 3D gaming environments are beneficial in initial teacher training.	1.1	6.7	76.4	15.7	.504	.755
	4. I have worked with applications based on video games and gamification in college.	20.2	52.8	27	0	**.027**	**.005**
	5. I know how to design video game activities in educational settings.	31.5	43.8	24.7	0	**.009**	**.008**
	6. I am familiar with various tools for designing gamification and game-based learning approaches through technology.	9	27	57.3	6.7	**.000**	**.000**
2. Gamification in Educational Contexts	1. The gamification approach enhances the development of creativity.	0	0	41.6	58.4	.065	.153
	2. Working on immersive environments facilitates collaborative advantages.	0	2.2	69.7	28.1	.776	1.00
	3. Communication and interactions improve through game-based learning.	0	4.5	50.6	44.9	.130	.212
	4. The focus of game-based learning enables the development of skills in educational settings.	0	2.2	66.3	31.5	.052	.086
	5. The game-based learning approach through MinecraftEdu encourages educational innovation processes.	0	2.2	55.1	42.7	**.000**	**.000**
	6. Working with MinecraftEdu increased motivation in learning processes.	0	5.6	50.6	43.8	**.000**	**.000**
3. Active Learning	1. We can learn much factual material through game-based learning.	0	2.2	82	15.7	.333	.749
	2. The central issues and contents are identified through a gamification approach.	0	19.1	71.9	0	.569	.185
	3. With a gamification approach, the subject is more interesting.	0	0	41.6	58.4	.206	.532
	4. Participation is active when applying game-based learning.	0	3.4	39.3	57.3	.189	.291
4. Fun	1. I was happy.	0	4.5	68.5	27	.088	.222
	2. I enjoyed the activity.	0	9	65.2	25.8	.181	.312
	3. I was excited.	0	16.9	60.7	22.5	.335	1.00
	4. I was motivated.	1.1	5.6	44.9	48.3	.062	.229
	5. I was relaxed and comfortable.	1.1	16.9	57.3	24.7	.313	.350

Values 1 = Totally disagree, 2 = Disagree, 3 = Agree, 4 = Totally agree
Bold data indicates value less than 0.05

Kaiser-Meyer-Olkin analysis (close to 0.8 in the four scales) and the Bartlett test of sphericity (all significant, 0.000). The extraction method is the principal component analysis and the rotation method was Varimax with Kaiser normalization. Therefore, we checked the underlying structure of the data matrix by analyzing the interrelationships of variables and using the information collected to explain the interrelationships. The factors were interpreted from estimated correlations with the same variables of the study. These refer to various approaches described in the study and are structured in a coherent way.

Table 2 Scale 1 Rotated matrix

	Component	
	1	2
Focus		.662
Initial training		.734
Beneficial		.679
Worked on	.813	
I can design	.841	
I know	.836	

Principal component analysis. Rotation method: Varimax with Kaiser normalization

On scales 3, "Active Learning", and 4, "Fun", only a rotated factor was obtained, so it was not necessary to proceed to data reduction. On scale 1 in Table 2 based on initial teacher training game learning, two factors explain 59.418 % of the total variance obtained.

Factor 1 is "attitudes to game-based learning" and refers to the ability and management presented by the participants with regard to the gamification approach as present today in emerging technologies. Factor 2 is "training benefits", and bears a relation to the advantages of the approach of game-based learning in teaching and learning processes in university contexts for the initial training of future teachers.

Moreover, for scale 2 "Gamification in Educational Contexts", three factors explain 73.526 % of total variance obtained (Table 3).

Factor 1 refers to motivation and innovation in respect of the aforementioned practices. The second factor points to collaborative and creative possibilities and the third factor refers to developed skills, with special emphasis on communicative elements.

Qualitative analysis: open questions

Implementing the survey technique using a mixed questionnaire as the tool, there are open-ended questions to which allow students can respond freely. Frequencies are numbered and recorded in each subject of the questions, which provide elements and factors relevant to the study. They function to strengthen and reaffirm values obtained in the quasi-experimental design and the descriptive analysis.

Answers to the question "In your view, what programs or applications offer a game-based learning approach?" highlight that, after the intervention, several subjects greatly

Table 3 Scale 2 Rotated matrix

	Component		
	1	2	3
Creativity		.836	
Collaboration		.787	
Communication			.792
Competences			.842
Innovation	.852		
Motivation	.884		

Principal component analysis. Rotation method: Varimax with Kaiser normalization

valued the Minecraft application for educational purposes in the context of game-based learning (Fig. 1).

Answers to the question "In your view, what are the strengths of using gamification in the classroom?" (Fig. 2) essentially highlight motivation, to the extent that it is the value with the highest frequency across the qualitative part of the study. Other listed strengths are interest, meaningful learning and participation. To a lesser extent, other elements such as creativity, attention, cooperation, fun and active approach are mentioned.

Answers to the last question "In your view, what are the weaknesses of using gamification in the classroom?" mainly highlight the need for teacher training in design, implementation and development of these practices in their teaching profession. Teacher training and distraction are the factors with the highest frequency. The distraction factor can disrupt or hinder the students' learning processes, so an evaluation of this issue is proposed for future study. The availability of resources and lack of time in class are also considered difficulties that may arise when implementing this game-based learning approach (Fig. 3).

Discussion

From the data triangulation and results analysis, the following points can be concluded.

1. The sample group positively values training on game-based learning and gamification approaches during initial training to become teachers (scale 1) (3AB). Only a small number of students know and have worked on these concepts before (items 1.4, 1.5, 1.6 of Table 1), and so a boost in university training is necessary. Integration into the curriculum was proposed, which also coincides with findings from other studies (Aldrich 2004; Blunt 2007; Young et al. 2012).

2. The training has significantly favoured knowledge of, attitudes on and the application of game-based learning and gamification (Wilcoxon test, sign test). Students know and value Minecraft in pedagogical contexts with statistically significant improvements (scale 1, scale 2, 1AB). The obstacles to overcome are mainly the need for teacher training and the avoidance of distraction, which may have an effect on the application of these approaches.

Fig. 1 In your view, what programs or applications offer a game-based learning approach
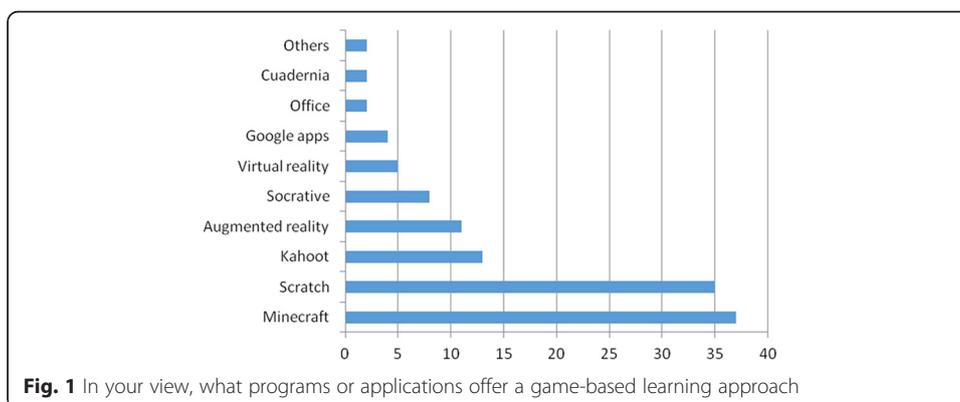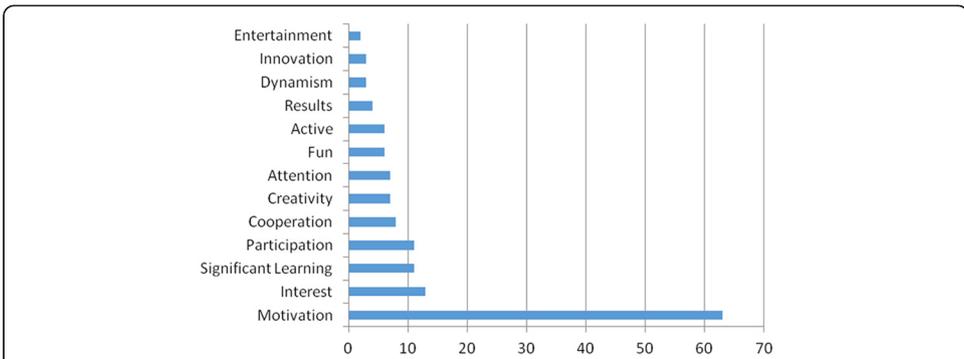
Fig. 2 In your view, what are the strengths of using gamification in the classroom?

3. Game-based learning and gamification enable educational innovation processes (1.5, scale 2, 2AB) and greatly increase student motivation (scale 1.6, scale 2, 2AB). This is in line with what it is proposed in other studies (Blunt 2007; Gee 2007; Greenfield 2010), in which the importance of increased engagement is underlined. However, we agree with Eseryel et al. (2014), who state that motivation must be combined with contents and pedagogical approaches to enable a better integration in school.

4. Both approaches develop creativity, collaboration and skills development (scale 2, 2AB) and facilitate active learning, participation and interest, and further enhance the student's fun (scales 3 and 4, 2AB).

Consistent with other recent studies and reports (Sáez-López et al. 2015), this study provides evidence of attitudes, values and perspectives on game-based learning and gamification in university settings, noting that applications with MinecraftEdu enable a number of benefits and advantages centred on pedagogies that allow for greater activity, motivation and involvement of students.

Those training teachers at university must begin to understand that international reports are raising these key trends, which will soon be adopted and will then promote a change in educational practices. Initial teacher training programmes must adapt to the challenges and demands of today's society, by taking into account emerging trends now present in professional settings and soon to be present in the future. Otherwise, reality will surpass training programme designs in higher education.
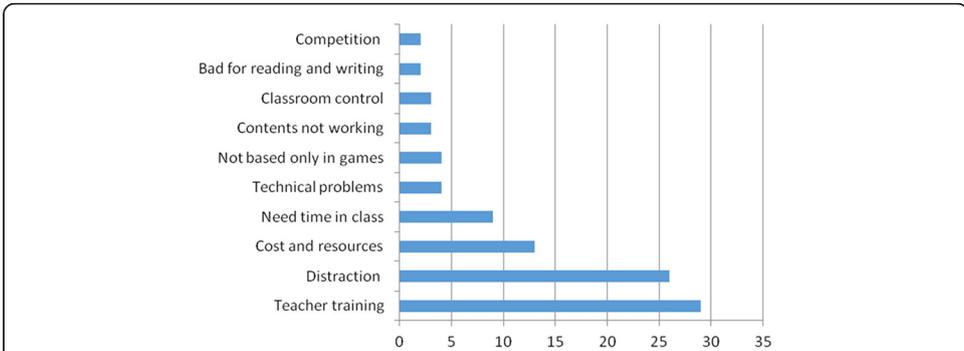
Fig. 3 In your view, what are the weaknesses of using gamification in the classroom?

About the authors
Ramón Cózar Gutiérrez
Ramon.Cozar@uclm.es
ORCID: http://orcid.org/0000-0001-8255-6376
Lecturer, Faculty of Education of Albacete, University of Castilla-La Mancha, Spain
Dr Ramón Cózar Gutiérrez is a lecturer in the Department of History at the Faculty of Education of Albacete, University of Castilla-La Mancha (UCLM), Spain. He is the principal investigator of the research group Labintic_Ab. Laboratory integration of ICT in the classroom (labintic.uclm.es) at UCLM. He is the director of ENSAYOS. Revista de la Facultad de Educación de Albacete and campus coordinator of the master's degree programme in Innovation and Educational Research at UCLM. He has had books and articles published in renowned national and international journals. He has been a visiting scholar at universities in Italy and Portugal and at research centres like the Spanish National Research Council. His research focuses on education and on teaching history, ICT, teaching innovation and teacher training.
Universidad de Castilla-La Mancha
Facultad de Educación de Albacete
Plaza de la Universidad, 3
02071 Albacete
Spain
José Manuel Sáez López
jmsaezlopez@edu.uned.es.
ORCID: http://orcid.org/0000-0001-5938-1547
Lecturer, Faculty of Education, National University of Distance Education, Spain
Dr Jose Manuel Sáez Lopez is an assistant lecturer at the National University of Distance Education (UNED), Spain, and a head teacher at a primary school. He holds a doctorate in Educational Models and ICT from the UNED. His scientific and academic work has been published in 31 peer-reviewed journals (three JCR and five Scopus). His research lines are the integration of educational technology in learning processes, analyzing virtual learning environments, the educational use of interactive video conferencing, methodological strategies and the academic use of Open Access. He is accredited as a "contracted doctor lecturer" by ANECA, the National Agency for Quality Assessment and Accreditation of Spain. He has been recognised as a Microsoft Expert Educator 2014 and Microsoft Innovative Expert 2015.
Universidad Nacional de Educación a Distancia
Facultad de Educación
C/ Juan del Rosal, 14
28040 Madrid,
Spain

Author details
[1]Faculty of Education of Albacete, University of Castilla-La Mancha, 02071 Albacete, Spain. [2]Faculty of Education, National University of Distance Education, 28040 Madrid, Spain.

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