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Application of the ubiquitous game with augmented reality in Primary Education

Aplicación del juego ubicuo con realidad aumentada en Educación Primaria

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ABSTRACT

Augmented reality (AR) immersion enables virtual objects and real environments to coexist and encourage experimentation with phenomena that are not possible in the real world. Augmented reality is generating new opportunities for the development of ubiquity within educational environments. The objective of this study was to analyze the impact that the integration of ubiquitous game approaches with augmented reality has on learning. A quasi-experimental study was carried out with 91 sixth-grade primary school students; the learning scenario was designed and the augmented reality application "WallaMe" was selected for use in five sessions of a didactic unit in Art Education. Through pretest and postest procedures, academic performance and information search skills were evaluated, and, a Likert scale analyzed the motivation and collaboration variables among the students. The results showed that the experimental group obtained statistically significant improvements in the academic performance of the subject, motivation, in the search for, and analysis of, information, level of fun and collaboration. The conclusion is that the dynamic activities managed in the intervention, which made use of augmented reality and localization, benefit teaching-learning processes, and encourage innovation and improvement through educational technology.

RESUMEN

La inmersión de la realidad aumentada (RA) propicia la coexistencia de objetos virtuales y entornos reales que permiten la experimentación con fenómenos que no son posibles en el mundo real. La realidad aumentada está generando una nueva oportunidad de crecimiento de la ubicuidad en los entornos educativos. El objetivo de este estudio es analizar el impacto que tiene sobre el aprendizaje la integración educativa de los enfoques de juego ubicuo con realidad aumentada. Se realizó un estudio cuasi experimental con 91 alumnos de sexto curso de Educación Primaria, se diseñó el escenario de aprendizaje y se seleccionó la aplicación de realidad aumentada «WallaMe», que fue utilizada en cinco sesiones de una unidad didáctica del área de Educación Artística. Mediante el procedimiento de pretest y postest se evaluaron el rendimiento académico y las habilidades de búsqueda de información, y una escala Likert analizó las variables motivación y colaboración entre los estudiantes. Los resultados mostraron que el grupo experimental obtiene mejoras estadísticamente significativas en la motivación hacia el aprendizaje, el rendimiento académico de la materia y en la competencia digital. En definitiva, se concluye que las actividades dinámicas manejadas en la intervención, que hacen uso de realidad aumentada y localización, aportan beneficios en los procesos de enseñanza aprendizaje, y propician una innovación y mejora educativa con el uso de la tecnología educativa.

KEYWORDS | PALABRAS CLAVE

Mobile learning, classroom, basic education, search strategies, learning processes, education, educational technology, educational trends.
Aprendizaje móvil, aula, educación básica, estrategias de búsqueda, procesos de aprendizaje, enseñanza, tecnología educativa, tendencia educacional.

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1. Introduction

The use of game-based learning (Squire, Giovanetto, Devane, & Durga, 2005) as an educational enhancer has grown in recent years, and numerous studies have demonstrated the success of these practices in fomenting the capacity to reason (Bottino, Ferlino, Ott, & Tavella, 2007), leadership skills, collaboration (Zhao & Linaza, 2015) and motivation to learn in primary education. However, the results from using the game-based augmented reality (AR) application in classroom contexts has not been researched as widely, even though the link between AR and the classroom is a hot topic in educational science literature. There are few theoretical or conceptual works that explain the complex relation between the characteristics of rapid technological, and occasionally, revolutionary evolution, its potential for education and learning, and its integration in teaching activities (Cabero & Marín, 2018). We believe the research presented here is a novel and singular contribution. In line with Knaus (2017:64), teachers need to understand the potential of digital media, software and algorithms in order to use them in a rational, didactic way, seeing them as resources and not merely ends in themselves. Some researchers and teaching professionals (Cantillo, Roura, & Sánchez, 2012; Brazuelo, Gallego, & Cacheiro, 2017) have questioned the use of virtual games in the concept and practice of education through mobile and ubiquitous devices. All the studies consulted here state that the use of games and AR can only be justified if their application is didactic, and if it promotes creativity, collaboration and reflection. Creativity is the key dimension highlighted for years by researchers such as Perez-Rodriguez, & Delgado-Ponce (2012: 33). Other researchers (Koring, 2016) conclude that children learn a lot from playing games with other children, thus ideally, digital media should be used by children to play in groups, so that they can engage in, and reflect on, the play they generate.

From this educational perspective, AR-based apps can be used to initiate didactic interactions in towns and cities, and in settings such as museums and places of cultural interest for situated educational activities that motivate users. These developments drive the relocation of teaching away from the school center and move the student away from reality towards immersive scenarios (Dunleavy, Dede, & Mitchell, 2009; Bronack, 2011).

1.1. Game-based Digital Learning

Klopfer, Osterweil, & Salen (2009: 21) define digital learning games as those aimed at acquiring knowledge and fostering mental habits and understanding that can be useful in the academic context. The mechanics of these games are essential for their effectiveness as bearers of intrinsic motivation and fun (Perrotta, Featherstone, Aston, & Houghton, 2013). The use of GPS-based games is evidently interesting because they change the players' paradigm: users must step outside to achieve their goals and walk around to reach objects and fulfil the objectives that allow them to progress in the game. This is also a good way to combat the sedentary habits that are so prevalent among gamers. Games can promote a higher level of thought, and, positive proof in various studies (Dondlinger, 2007; Steinkuehler, & Duncan, 2008) urges designers of educational games to focus on player/student participation in an environment in which they can experiment with the relations between all objects, resolve a set of problems, actively learn a new literacy and develop critical learning (Gee, 2004).

Several studies insist on the advantages of game-based learning as an environment that stimulates motivation and commitment in students (Blunt, 2007; Greenfield, 2010; Slova ek, Zovki , & Cekovi , 2014), and our research is based on verifying this notion. These practices mean that motivation is an integral part of the pedagogical processes (Aguaded, 2012; Eseryel, Law, Ifenthaler, Ge, & Miller, 2014; Katja, 2012; Liao, 2015). The findings in educational research help determine whether to adopt certain objectives and encourage learning activities that are significant and motivational for the students.

1.2. Exploring augmented reality

Klopfer & Squire (2008: 205) broadly define AR as a situation in which a coherent localization or virtual information is superimposed dynamically on a real-world situation. Cabero & Barroso (2016, 44) describe AR as the combination in real time of digital and physical information using a range of technological devices. The integration of the real and virtual worlds through AR creates an enriching scenario (Bronack, 2011; Cabero & García, 2016; Fombona, Pascual, & Madeira, 2012; Fombona, 2013 Rico & Agudo, 2016; Squire & Klopfer, 2007). Cabero & Barroso (2016) emphasize that any physical space can become a stimulating educational scenario, and that AR reinforces ubiquitous learning through an inspiring learning environment in which the student interacts with objects and manages information.

Some successful experiences in which students have to use portable devices to carry out research, interpret unique location data and provide solutions within an AR-based game environment are: "Environmental Detectives" (Squire & Klopfer, 2007), a game in which students assume the role of environmental engineers and have to solve problems in a real setting. A similar experience is "Mad City Mystery" (Squire & Jan, 2007), in which players have to solve a crime by searching for information in their environment; another is "Frequency 1550", developed by The Waag Society to help students discover medieval Amsterdam (Akkerman, Admiraal, & Huizenga, 2009).

Ubiquitous learning implies the break between formal and informal learning and facilitates a more social way of learning; it presumes that learning "based on the curriculum" gives way to learning "based on problem-solving", now with the student as framework of reference.

The advantages of AR enable detection of locations, monitoring of student status and issuing of task reminders. This dynamic offers alternatives for refocusing student attention. AR technology is easy to incorporate into education as it allows students to use their own devices without the need for extra technologies. Fombona & Vázquez (2017: 335) state that primary school students already own devices that can be used for AR-based activities, since 80% of devices nowadays use the Android operating system and 60% have GPS, which lets students perform geolocation tasks. Barroso & Cabero (2016:165) carried out a detailed study that concluded that AR objects aroused considerable interest in students, technically and aesthetically, as well as for ease of use. This system allows users to work in real time by exchanging comments and provides information that heightens participants' sensation of immediacy. All the AR-related media mentioned so far enable the user to experience interactions with a sense of immersion, which is "the subjective impression that you are involved in a global and realistic experience" (Dede, 2009: 66). All this occurs within a ubiquitous learning scenario expanded by digital mobile media that allow the user to construct and exchange knowledge between the virtual and the physical (Díez & Díaz, 2018). Ubiquitous learning implies the break between formal and informal learning and facilitates a more social way of learning; it presumes that learning "based on the curriculum" gives way to learning "based on problem-solving", now with the student as framework of reference (Burbules, 2014). The various subsets of AR including mobile AR, gameable AR, and multiplayer AR, offer a range of possibilities to support the implementation of these perspectives. Considering the most important characteristics of these AR types, we can classify the educational approach in three categories: Approaches that emphasize student participation via "roles", student interactions with physical locations (ubiquity, collaboration, situated learning, informal learning) and the design of learning tasks (learning in 3D, visualizing the invisible). This study focuses on an intervention that emphasizes learning tasks, ubiquity, collaboration and situated learning, with the use of location and programs such as "WallaMe".

2. Method

2.1. Research design

We based our study on a quasi-experimental design on both a control and an experimental group, including a pretest and postest. The main objective was to analyze the impact on learning of ubiquitous AR game approaches in education; the variables analyzed were: academic performance, student skills in searching for, and analyzing, information, level of fun and collaboration established among the students.

The hypotheses were: The use of AR in ubiquitous settings improves academic performance (H1); the use of AR improves searching and information analysis skills (H2); the use of AR increases motivation and level of fun (H3); the use of AR and ubiquity fosters collaboration (H4). The research was structured around the following dimensions, with the indicators and instruments described for each dimension (Table 1).

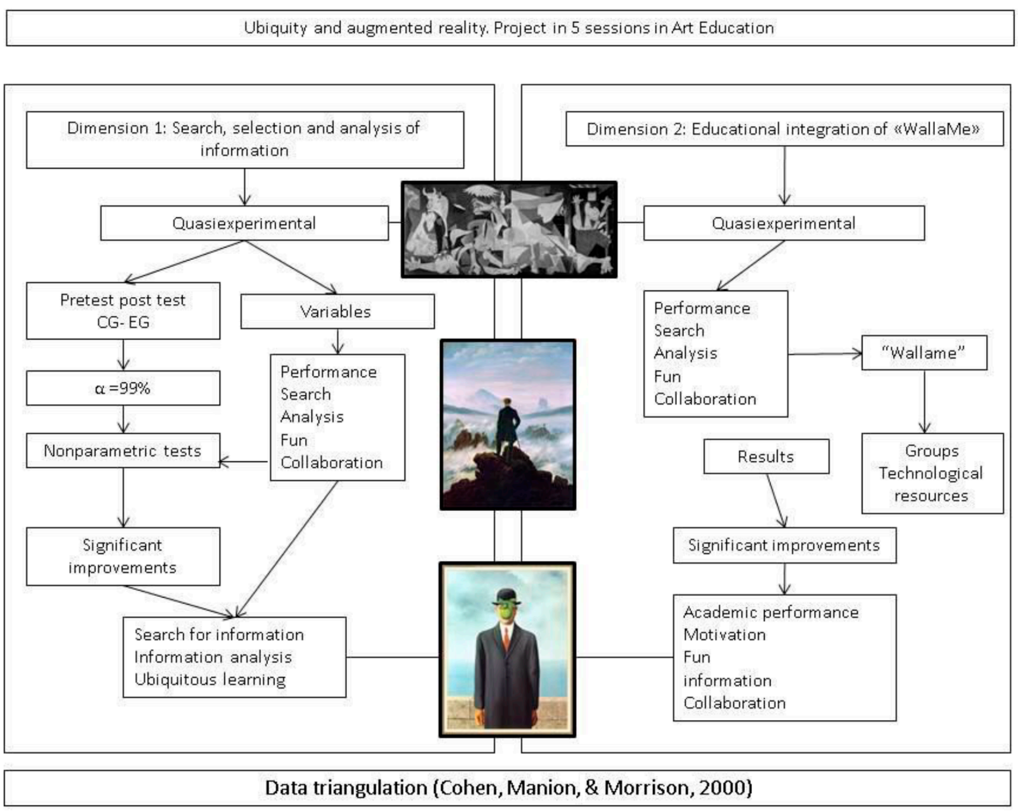
Table 1. Dimensions, indicators and instruments

Dimensions	Indicators	Instruments	Analysis
Dimension 1: Search for, selection and analysis of, information	Academic performance	Tests	Descriptive analysis Wilcoxon test Mann-Whitney U test
	Search for information		
	Analysis of information		
	Level of fun		
	Collaboration		
Dimension 2: Educational use of “WallaMe”	Academic results		
	Motivation		
	Level of fun		
	Search for information		
	Collaboration		

2.2. Participants

This research was developed in a public Primary Education school in the Autonomous Community of Madrid, and it was applied to all the students in sixth grade (91 students) who attended Art Education classes. The experimental group consisted of 69 students, who searched for information using technological devices (Dimension 1) with the “WallaMe” app during five sessions that were part of a didactic unit on “Art in Europe” (Dimension 2).

Figure 1. Research design



The control group was formed of 22 students in a class that studied the same unit but using a textbook and "traditional" forms of teaching, with an expositional approach and teacher-centered focus. The sampling was non-probabilistic and intentional. The experimental group had 34 girls and 35 boys; the control group had 13 girls and 9 boys. The pretest control for knowledge of "Art in Europe" in the two groups showed that both sets of students had the same level of knowledge.

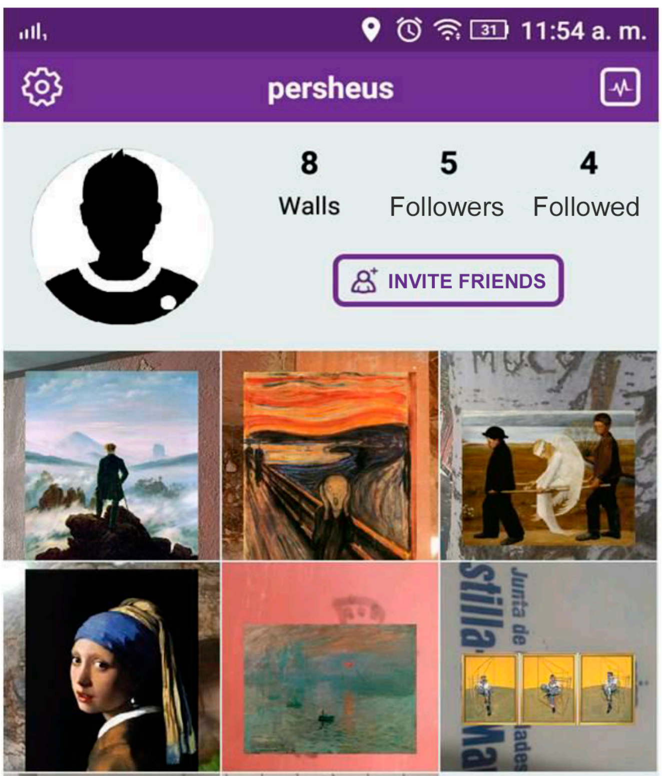
2.3. Intervention process

Based on the conceptual definition described in the theoretical section of this article (Mathews, 2010; Rosenbaum, Klopfer, & Perry, 2007; Squire & Jan, 2007; Squire & Klopfer, 2007), the analysis of the tools and intervention centered on the application of game- and situation-based learning. The categories that framed the analysis and application were:

- Approaches that emphasize student interactions with physical locations.
- Approaches that emphasize the design of learning tasks.

In dimension 1, the analysis centered on the students' ability to search for, select and analyze information using their mobile phones, thus, ubiquitous learning. The 5 sessions in Art Education were aimed at learning about works of art in Europe. The students were organized individually and later in groups, to carry out searches for information relating to the paintings in different countries, analyzing artistic styles, historical context, the artists, and social and cultural repercussions (Figure 1). Dimension 2 consisted of an intervention in the 5 sessions of the "Art in Europe" unit. Here the students had to download the free "WallaMe" app to their phones (Figure 2).

Figure 2. Use of «WallaMe» for works of art. Mobile phone version



Then, in groups, they went to the school playground to locate images of some of the most important paintings in European art history. Once they had captured the images, the students had to work in groups to find the following data: title of each painting, name of the artist, country of origin, historical and social context, style of painting used, description of the style and interpretation of the work. Instructions and materials were provided to help students structure their work and carry out the tasks on computers with an Internet connection in the classroom. Once completed, the final session consisted of a discussion to check the answers (name of painting, artist, style). We worked with interesting historical and artistic concepts while also learning about the geography of Europe, and we developed digital competences in a task that required continuous information searching.

When both groups had concluded the 5 sessions, a postest was carried out to evaluate academic performance in relation to the content imparted in the didactic unit. A questionnaire was also distributed to both groups, with a 1-5 Likert scale, to analyze the variables of motivation, commitment, level of fun and collaboration.

In both dimensions, the students searched for, and analyzed, information relating to the artistic content in the unit. The curricular structure complied with current education legislation: Content, assessment criteria and learning standards. Content is designed to foment the creative process: purpose of the painting, search for information (bibliographical and internet). Planning, work to be developed by analyzing works of art from various countries. The assessment criteria included: 1) Being able to distinguish the fundamental differences between fixed images and images in motion, classifying them according to the patterns learnt; 2) Ability to approach reading, analysis and interpretation of art and images that are fixed and in motion, in their historical and cultural contexts, understanding their meaning and social function in a critical way, and being able to produce new visual compositions based on the knowledge acquired; 3) Responsible use of information and communication technologies to search for, create and disseminate images that are fixed and in motion.

The following learning standards were established: Classification of fixed and moving images according to a range of criteria; Critical assessment of messages transmitted by the images; Development of good habits for ordering, correct usage and careful maintenance of the material and instruments used in their artistic creations; Demonstration of creativity and initiative in their artistic productions; Active participation in group tasks; Assessment of the compositions produced; Handling simple computing programs for sound and treatment of digital images (size, brightness, color, contrast…) that contribute to the development of the creative process.

2.4. Analysis and results

2.5. 3.1. Dimension 1: Search for, and analysis of, information and works of art

A comparison of the data for the control and experimental groups yielded the results for the students who carried out searches for information using a conventional approach based on the textbook, and for those who used electronic devices and mobile phones with AR.

2.5.1. Pretest and postest. Wilcoxon test and sign test

Given that both sets of students had the same initial level of competence in the subject, the analysis of the postest is of particular interest as it presents a significant difference in the scores according to the treatment used. The results from the Wilcoxon test and the sign test, with a significance of 0.01, indicate a statistically significant improvement in various factors, thus, the research hypothesis regarding better academic performance, improved information search and analysis skills, level of fun and collaboration, is proven correct (Table 2).

Table 2. Wilcoxon test and sign test. Experimental group samples

	Mean		Wilcoxon		Sign test	
	Pretest	Postest	Z	Sig.	Z	Sig.
Academic performance	3.05	3.91	-5.513	.000	-5.215	.000
Information search	3.33	4.25	-5.575	.000	-6.086	.000
Information analysis	3.26	3.85	-4.248	.000	-3.276	.001
Level of fun	3.35	3.87	-4.144	.000	-3.528	.000
Collaboration	3.37	3.81	-3.472	.001	-2.969	.003

2.5.2. Control group and experimental group

The scores showed a statistically significant improvement in the experimental group over the control group following treatment assignment. The students who performed the activity using electronic devices and ubiquitous learning scored higher in the variables analyzed than the control group that worked with the textbook (Table 3).

Table 3. Mann-Whitney U test. Independent samples

	Mean		Mann-Whitney	
	Control	Experimental	U	Sig.
Academic performance	3.27	3.91	348.5	.000
Information search	3.68	4.25	388.5	.000
Information analysis	3.14	3.85	356	.000
Level of fun	3.23	3.87	402	.000
Collaboration	3.23	3.81	425	.001

2.6. Dimension 2: Using "WallaMe" in an educational context: a case in primary education

In this dimension, we analyzed the intervention with the "WallaMe" app in Art Education. A quasi-experimental design was constructed since it was impossible to work with a random sample due to ethical or logistical considerations. A pretest was carried with the experimental group (O1), a program (X) and a postest (O2). The control group had a pretest (O1) and a postest (O2).

This design ensures control over the majority of sources and is more accessible in educational settings. In short, a pretest and postest were carried out, and there was also a control group, so, various non-parametric tests were run due to this being a cautious research proposal. The experimental group consisted of 69 students at three centers that had uploaded "WallaBe" to their mobile phones for 5 sessions of a didactic unit called "Art in Europe". There was also a control group of 22 students who studied the same unit but used a textbook and a "traditional" form of teaching. The sampling was non-probabilistic and intentional, hence the quasi-experimental design. Although it was assumed that the number of students in the experimental group was sufficient to render it normal, a conservative approach was favored, with the running of non-parametric tests (Wilcoxon test and Mann-Whitney U test), with a significance level (α) of 0.01.

2.6.1. Pretest and postest: Wilcoxon test and sign test

An exploratory analysis of the data was performed; the low values in the preliminary test suggested that the students in both groups had the same initial levels. It was in the postest that scores varied, to indicate significant differences in the values according to the treatment applied. The Wilcoxon and sign tests values, with a significance of 0.01, indicate a statistically significant improvement, thus the research hypothesis is proven in terms of better academic results, greater motivation, level of fun, stronger information search skills and collaboration (Table 4).

Table 4. Wilcoxon test and sign test. Experimental group samples

	Mean		Wilcoxon		Sign test	
	Pretest	Postest	Z	Sig.	Z	Sig
Academic results	3.39	4.01	-4.015	.000	-3.776	.000
Motivation	3.30	4.48	-6.240	.000	-6.326	.000
Level of fun	3.13	4.14	-5.449	.000	-4.576	.000
Information search	3.41	4.09	-4.433	.000	-3.946	.000
Collaboration	3.25	4.07	-4.140	.000	-4.166	.000

2.6.2. Control group and experimental group

As well as the data that established that there was a variation, with an increase in student scores following application of the treatments assigned, the experimental groups showed a statistically significant improvement in relation to the control group.

Table 5. Mann-Whitney U test. Independent samples

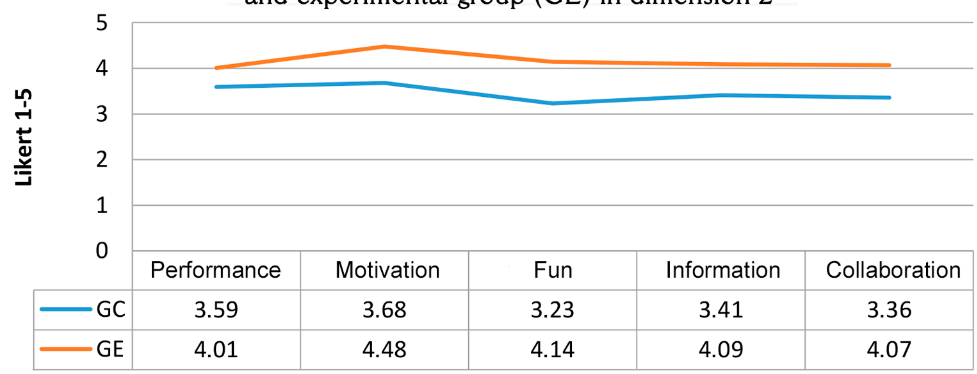
	Mean		Mann-Whitney	
	Control	Experimental	U	Sig.
Academic results	3.59	4.01	532	.000
Motivation	3.68	4.48	367.5	.000
Level of fun	3.23	4.14	362.5	.000
Information search	3.41	4.09	464.5	.004
Collaboration	3.36	4.07	440	.002

The students who carried out the activity with "WallaMe" got better results for the variables analyzed than the control group that worked with textbook and via direct teacher instruction (Table 5).

There was a statistically significant improvement in the dependent variables analyzed, with greater incidence of motivation and level of fun, which emphasizes the active nature of the intervention applied (Figure 3).

The improvement in academic performance indicated in the test of the didactic unit on Art Education is appreciated in the control group values of 3.32 in the pretest and 3.59 in the postest, against 3.39 in the experimental group's pretest (similar to the GC) and 4.01 in the postest (an improvement on the GC postest score). Both groups begin with similar scores in the pretest, but the learning processes lead to an improvement in the postest score for the experimental group, which exceeds 4 points. Based on the data from this statistical analysis, the trend and improvement are statistically significant when the intervention that is the object of this study was applied.

Figure 3. Results from the control group (GC) and experimental group (GE) in dimension 2



3. Discussion

The results analysis enables us to compare our data with those of other authors, in relation to the impact of the approach proposed in our study regarding location and AR in educational settings. These resources can involve the students much more and can support learning in specific contexts. In line with the results of this research, other studies state that learning with localization and AR offers benefits for, and improvements in, learning processes (Bronack, 2011; Mathews, 2010; Rosenbaum, Klopfer, & Perry, 2007; Squire & Jan, 2007; Squire & Klopfer, 2007), and fosters student motivation (Bressler & Bodzin 2013; Cózar-de-Moya, Hernández, & Hernández, 2015; Han, Jo, Hyun, & So, 2015). A range of studies have evaluated ubiquity together with technological elements and AR within different contexts and areas (Huang, Sun, & Li, 2016; Kim & Han, 2014: Pendit, Zaibon, & Abubakar, 2015), and they emphasize the advantages they provide for interaction and motivation, which reflects the results in our study.

Other experiences in primary education highlight interaction, the creation of local, significant materials for students (Diego-Obregon, 2014), with curricular content and collaborative work (Ramirez

& Cassinerio, 2014), and with works and projects centered on an environment-focused education (Kamarainen, Metcalf, Grotzer, Browne, Mazzuca, Tutwiler, & Dede, 2013). These studies and experiences from other countries present significant evidence that the use of AR and ubiquity in educational settings yields substantial improvements, as do the findings of our research.

This study is in line with other authors, in that AR-related learning activities often lead to innovative approaches that involve participative simulations (Wu, Lee, Chang, & Liang, 2013). Our study shows that the nature of these educational approaches differs considerably from the teacher-centered approach (Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Squire & Jan, 2007). This study corroborates the coherence of the approach proposed by Klopfer & Squire (2008: 203-228) that emphasizes the need to balance competitive impulses and facilitate the decentralized flow of information in educational activities. The results in our study demonstrate the advantages of collaboration and the importance of technology and information management as essential skills (Kerawalla & al., 2006; Klopfer & Squire, 2008; Squire & Jan, 2007).

4. Conclusions

Although there are numerous theoretical studies on the potential for, and design of, AR apps, there is less research on the effects of AR-based game scenario design on improvements in learning, in other words, how this can be used in everyday classroom contexts.

Overall, it is considered that the resources and approaches analyzed are beneficial for pedagogical practice, and there are enough suitable projects and media available to design and develop educational activities. By triangulation of the data (Cohen, Manion, & Morrison, 2000) and the results in the two dimensions analyzed, we can conclude that:

1) The use of mobile devices and ubiquity in the search for information relevant to Art Education improved academic achievement and competence in information search and analysis (Dimension 1, Table 2, Table 3).

2) The approaches based on ubiquitous learning, AR and information search contributed to an increase in the level of fun and the potential for collaboration between students (Dimension 1, Table 2; Table 3).

3) There are statistically significant improvements in academic performance when activities are applied in the school setting, as in the case detailed in dimension 2 (Table 4, Table 5; Figure 3).

4) There are statistically significant improvements in motivation, level of fun, information search skills and collaboration. The pedagogical use of ubiquitous AR in a project on European painting was successful as a case study, and the results present numerous advantages (Table 4; Table 5).

It is evident that an incorporation of this type requires resources, infrastructure and good internet connection, and adequately trained teachers for this pedagogical design to be integrated. However, as this study shows, when these are all in place, the evidence and advantages are clear. The apps currently on the market that use location and AR are clearly designed for gaming and entertainment, yet with some exceptions, and by well-planned design, they can be used to develop activities and projects that offer considerable advantages, as various studies have described and which our own study verifies.

In the case explored here, we emphasize the values that show statistically significant improvements in educational performance, motivation, level of fun, information search skills and student collaboration. This case has shown that game-based, dynamic activities that use localization and AR offer pedagogical benefits and represent an opportunity for success in enabling innovation in education through the application of emerging technologies.

References

Aguaded, I. (2012). Media proficiency, an educational initiative that cannot wait. [La competencia mediática, una acción educativa inaplazable]. *Comunicar*, *39*, 07-08. https://doi.org/10.3916/C39-2012-01-01

Akkerman, S., Admiraal, W., & Huizenga, J. (2009). Storification in history education: A mobile game in and about medieval. *Computers & Education*, *52*(2), 449-459. https://doi.org/10.1016/j.compedu.2008.09.014

Barroso, J., & Cabero, J. (2016). Evaluación de objetos de aprendizaje en realidad aumentada: Estudio piloto en el Grado de Medicina. *Enseñanza & Teaching*, *34*(2), 149-167. https://doi.org/http://doi.org./10.14201/et2016342149167

Blunt, R. (2007). Does game-based learning work? Results from three recent studies. In *Interservice/Industry Training, Simulation & Education Conference (I/ITSEC)* (pp. 1-11). Florida, USA: NTSA.

Bottino, R.M., Ferlino, L., Ott, M., & Tavella, M. (2007). Developing strategic and reasoning abilities with computer games at primary school level. *Computers & Education*, *49*(4), 1272-1286. https://doi.org/10.1016/j.compedu.2006.02.003

Brazuelo, F., Gallego, D., & Cacheiro, M.L. (2017). Los docentes ante la integración educativa del teléfono móvil en el aula. *Revista de Educación a Distancia*, *52*, 1-22. https://doi.org/10.6018/red/52/6

Bressler, D.M., & Bodzin, A.M. (2013). A mixed methods assessment of students' flow experiences during mobile augmented reality science game. *Journal of Computer Assisted Learning*, *29*(6), 505-517. https://doi.org/10.1111/jcal.12008

Bronack, S.C. (2011). The role of immersive media in online education. *Journal of Continuing Higher Education*, *59*(2), 113-117. https://doi.org/10.1080/07377363.2011.583186

Burbules, N. (2014). El aprendizaje ubicuo: Nuevos contextos, nuevos procesos. *Entramados*, *1*, 131-133. https://bit.ly/2SOhHah

Cabero, J., & Barroso, J. (2016). The educational possibilities of augmented reality. *Journal of New Approaches in Educational Research*, *5*(1), 44-50. https://doi.org/10.7821/naer.2016.1.140

Cabero, J., & García, F. (2016). *Realidad aumentada*. Madrid: Síntesis.

Cabero, J., & Marín, V. (2018). Blended learning y realidad aumentada: Experiencias de diseño docente. *RIED*, *21*(1), 57-74. https://doi.org/10.5944/ried.21.1.18719, https://doi.org/10.5944/ried.21.1.18719

Cantillo, C., Roura, M., & Sánchez, A. (2012). Tendencias actuales en el uso de dispositivos móviles en educación. *La Educ@ción Digital Magazine*, *147*, 1-21. https://bit.ly/2znGXZy

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education*. New York: Routledge. https://bit.ly/2BdCnOz

Cózar, R., De-Moya, M., Hernández, J., & Hernández, J. (2015). Tecnologías emergentes para la enseñanza de las ciencias sociales. Una experiencia con el uso de realidad aumentada en la formación inicial de maestros. *Digital Education Review*, *27*, 138-153. https://bit.ly/2V4Ford

Dede, C. (2009). Immersive interfaces for engagement and learning. *Science*, *323*(5910), 66-69. https://doi.org/10.1126/science.1167311

Diego-Obregon, R. (2014). Realidad aumentada en documentos e imágenes. *Aula de Innovación Educativa*, *230*, 65-66. http://bit.ly/2Q1fCTw

Díez, E., & Díaz, J.M. (2018). Ubiquitous learning ecologies for a critical cyber-citizenship. [Ecologías de aprendizaje ubicuo para la ciberciudadanía crítica]. *Comunicar*, *54*, 93-103. https://doi.org/10.3916/C54-2018-05

Dondlinger, M.J. (2007). Educational video games design: A review of the literature. *Journal of Applied Educational Technology*, *4*(1), 21-31. https://bit.ly/2BzU9M3

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology*, *18*(1), 7-22. https://doi.org/10.1007/s10956-008-9119-1

Eseryel, D., Law, V., Ifenthaler, D., Ge, X., & Miller, R. (2014). An investigation of the interrelationships between motivation, engagement, and complex problem solving in game-based learning. *Educational Technology & Society*, *17*(1), 42-53. https://bit.ly/2FK8jhI

Fombona, J. (2013). La interactividad de los dispositivos móviles geolocalizados, una nueva relación entre personas y cosas. *Revista Historia y Comunicación Social*, *18*, 777-788. https://doi.org/10.5209/rev_HICS.2013.v18.44007

Fombona, J., Pascual, M.J., & Madeira, M.F. (2012). Realidad aumentada, una evolución de las aplicaciones de los dispositivos móviles. *Píxel-Bit*, *41*, 197-210. https://bit.ly/2rpWSTS

Fombona, J., & Vázquez-Cano, E. (2017). Posibilidades de utilización de la geolocalización y realidad aumentada en el ámbito educativo. *Educación*, *1*(20), 319-342. https://doi.org/10.5944/educxx1.19046

Gee, J.P. (2004). *Lo que nos enseñan los videojuegos sobre el aprendizaje y el alfabetismo*. Málaga: Aljibe. https://bit.ly/2BJioqw

Greenfield, P.M. (2010). Video games revisited. In Van-Eck, R. (Ed.), *Gaming and cognition: Theories and practice from the learning sciences* (pp. 1-21). Hershey, PA: IGI Global. https://doi.org/10.4018/978-1-61520-717-6.ch001

Han, J., Jo, M., Hyun, E., & So, H.J. (2015). Examining young children's perception toward augmented reality-infused dramatic play. *Educational Technology Research and Development*, *63*(3), 455-474. https://doi.org/10.1007/s11423-015-9374-9

Huang, C.S.J., Yang, S.J.H., Chiang, T.H.C., & Su, A.Y.S. (2016). Effects of situated mobile learning approach on learning motivation and performance of EFL students. *Journal of Educational Technology & Society*, *19*(1), 263-276. http://bit.ly/2Q0oNDT

Kamarainen, A.M., Metcalf, S., Grotzer, T., Browne, A., Mazzuca, D., Tutwiler, M.S., & Dede, C. (2013). EcoMOBILE: Integrating augmented reality and probeware with environmental education field trips. *Computers & Education*, *68*, 545-556. https://doi.org/10.1016/j.compedu.2013.02.018

Katja, F. (2012). Mobiles Lernen in der Schule. In Laufer., J., & Röllecke, R. (Eds.), *Chancen digitaler Medien für Kinder und Jugenlichen* (pp. 53-59). München: Koepadverlag.

Kerawalla, L., Luckin, R., Seljeflot, S., & Woolard, A. (2006). 'Making it real': Exploring the potential of augmented reality for teaching primary school science. *Virtual Reality*, *10*(3), 16-174. https://doi.org/10.1007/s10055-006-0036-4

Kim, H., & Han, S. (2014). A framework for the automatic 3D city modeling using the panoramic image from mobile mapping system and digital maps. 2014 ieee virtual reality (vr). https://doi.org/10.1109/VR.2014.6802087

Klopfer, E., Osterweil, S., & Salen, K. (2009). *Moving learning games forward*. Cambridge, MA: The Education Arcade. https://bit.ly/2XbN90z

Klopfer, E., & Squire, K. (2008). Environmental detectives: The development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, *56*(2), 203-228. https://doi.org/10.1007/s11423-007-9037-6

Knaus, T. (2017). Pädagogik des digitale: Phänomene, Potentiale, Perspektiven. In Eder, S., Mikat, C., & Tillmann, A. (Eds.), *Software takes command* (pp. 40-68). München: Kopaed. https://bit.ly/2Gxjr0L

Liao, T. (2015). Augmented or admented reality? The influence of marketing on augmented reality tecnologies. *Information Communication & Society*, *18*(3), 310-326. https://doi.org/10.1080/1369118X.2014.989252
Mathews, J.M. (2010). Using a studio-based pedagogy to engage students in the design of mobile-based media. *English eaching: Practice and Critique*, *9*(1), 87-102. https://bit.ly/2TXdSf5
Pendit, U.C., Zaibon, S.B., & Abubakar, J.A. (2015). Digital interpretive media usage in cultural heritage sites at yogyakarta. *Jurnal Teknologi*, *75*(4), 71-77. https://doi.org/10.11113/jt.v75.5069
Pérez-Rodríguez, M.A., & Delgado-Ponce, A. (2012). From digital and audiovisual competence to media competence: Dimensions and indicators. [De la competencia digital y audiovisual a la competencia mediática: Dimensiones e indicadores]. *Comunicar*, *39*, 25-35. https://doi.org/10.3916/C39-2012-02-02
Perrota, C., Featherstone, G., Aston, H., & Houghton, E. (2013). Game-based learning: Latest evidence and future directions. https://bit.ly/2GQIRHh
Ramírez, V., & Cassinerio, S. (2014). *Realidad aumentada-trabajo cooperativo; nivel inicial*. Buenos Aires: Innovación y Educación. http://bit.ly/2JD3ua4
Rico, M.M., & Agudo, J.E. (2016). Aprendizaje móvil de inglés mediante juegos de espías en Educación Secundaria. *RIED*, *19*(1), 121-139. https://doi.org/10.5944/ried.19.1.14893
Rodewald, E.M. (2017). Profilklasse, 'Smart Gaming'. In Gross, F., & Röllecke, R. (Eds.), *MedienPädagogik der Vielfalt-Integration und Inklusion*München: . Kopaed. https://amzn.to/2tunWki
Rosenbaum, E., Klopfer, E., & Perry, J. (2007). On location learning: Authentic applied science with networked augmented realities. *Journal of Science Education and Technology*, *16*(1), 31-45. https://doi.org/10.1007/s10956-006-9036-0
Slovacek, K.A., Zovki , N., & Cekovi , A. (2014). A Language games in early school age as a precondition for the development of good communicative skills. *Croatian Journal of Education*, *16*(1), 11-23. https://bit.ly/2Nc4uBM
Squire, K., Giovanetto, L., Devane, B., & Durga, S. (2005). From users to designers: Building a self-organizing game-basedlearning environment. *TechTrends*, *49*(5), 34-42. https://doi.org/10.1007/BF02763688
Squire, K., & Jan, M. (2007). Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology*, *16*(1), 5-29. https://doi.org/10.1007/s10956-006-9037-z
Squire, K., & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences*, *16*(3), 371-413. https://doi.org/10.1080/10508400701413435
Steinkuehler, C., & Duncan, S. (2008). Scientific habits of mind in virtual worlds. *Journal of Science Education and Technology*, *17*, 530-543. https://doi.org/10.1007/s10956-008-9120-8
Wu, H.K., Lee, S.W.Y., Chang, H.Y., & Liang, J.C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, *62*, 41-49. https://doi.org/10.1016/j.compedu.2012.10.024
Zamora-Manzano, J.L., & Bello-Rodríguez, S. (2017). Dispositivos móviles como herramienta de aprendizaje en el mundo del Derecho. In Pérez-Fera, M., & Rodríguez-Pulido, J. (Eds.), *Buenas prácticas docentes del profesorado universitario* (pp. 139-152). Barcelona: Octaedro.
Zhao, Z., & Linaza, J.L. (2015). La importancia de los videojuegos en el aprendizaje y el desarrollo de niños de temprana edad. *Electronic Journal of Research in Educational Psychology*, *13*(2), 301-318. https://doi.org/10.14204/ejrep.36.14108