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Augmented Reality in Primary Education since students' visions

La Realidad Aumentada en Educación Primaria desde la visión de los estudiantes

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Abstract

Working today with digital resources in the classroom is a reality without the possibility of questioning. In this sense, the incorporation of tools such as Augmented Reality (from now on AR) are reflecting a new way of seeing and understanding the teaching and learning process. Its use for curriculum development is very diverse as well as the different ways of incorporating them, depending on the perspective that teachers have of it. In this sense, this article presents the vision that a group of pre-service teachers have of AR in Primary Education, so that the viability or not of the use of this technology in the learning in this educational level can be clarified. Thus, by using an ex post facto design, by the collection the dates a questionnaire with 30 items has been created, distributed in 6 dimensions, using a Likert type response scale of 5 options. The sample has been composed of N=520 students from the University of Córdoba. The main objective of the research has been: to evaluate the possibilities and potentials offered by different software used for the creation of technological environments under the AR architecture to be used in university formative contexts. The main result achieved reflects the non-existence of differences around the perception that teachers have of the RA in the field of primary education that this is a difficult-to-use tool with students with specific educational support needs and that once dominated would be easy to be incorporated into your teaching action.

Keywords: Augmented reality, primary education, pre-service teaches, learning, classroom methodology, curricular development.

Resumen

Trabajar hoy con recursos digitales en las aulas es una realidad sin posibilidad de cuestionamiento. En este sentido la incorporación de herramientas como la Realidad Aumentada, están reflejando una nueva forma de ver y entender el proceso de enseñanza y de aprendizaje. En este sentido, este artículo presenta la visión que un grupo de profesores en formación tienen de la Realidad Aumentada en la Educación Primaria de modo que se pueda esclarecer la viabilidad o no de la utilización de esta tecnología en el aprendizaje en este nivel educativo. Así, mediante el empleo de un diseño ex post facto, se ha creado un cuestionario conformado por 30 ítems, distribuidos en 6 dimensiones, empleando una escala de respuesta tipo Likert de 5 opciones. La muestra ha estado compuesta por N=520 maestros en formación de la Universidad de Córdoba. El objetivo principal de la investigación ha sido: evaluar las posibilidades y potencialidades que ofrecen diferentes softwares utilizados para la creación de entornos tecnológicos bajo la arquitectura de la Realidad Aumentada para ser utilizados en contextos formativos universitarios. El principal resultado alcanzado refleja la no existencia de diferencias en torno a la percepción que los maestros tienen de la RA en el ámbito de la educación primaria, que esta es una herramienta de difícil uso con alumnado con necesidades específicas de apoyo educativo y, que una vez dominada, sería fácil de ser incorporada a su acción docente.

Descriptores: Realidad Aumentada, educación primaria, maestro en formación, aprendizaje, metodología de aula, desarrollo curricular.

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1. Introduction

Education today implies a 180-degree turn compared to past decades. The methodologies, the curricular designs, the resources and the profile of the student and the teacher have evolved as the society has been growing (Marín-Díaz, 2017a).

In this sense, the development that Information and Communication Technologies (ICT) have experienced as well as their imbrication with educational action, have precipitated their presence in the classroom and in the academic life of students and teachers.

Digital resources have come to stay in the classrooms, reason for which it is necessary to know, as education professionals and those responsible for the educational act, to incorporate them into the teaching practice, if believing that this element can benefit the learning process of the student (Cuevas *et al*., 2019). Therefore, the aim is to present and have a perspective of ICT, and understand that their first advantage is to improve and facilitate the student's learning process. On the other hand, it can be considered that the educational act will be in continuous growth and improvement.

In the last decade the presence of Augmented Reality (AR) has been growing. It has its origins from Virtual Reality (VR), and it has been used in education for more than a decade, although its presence in Primary Education is gradually becoming more evident, it is quite sparse in terms of inclusive education (Marín-Díaz 2020).

On the following pages this article presents the relationship of AR in Primary education. The purpose is to analyze the situation in which today this technology can lead to educational and inclusive scenarios (Marín-Díaz, 2016, 2017a). In short, the aim is to answer the following question: can AR be a viable tool for the learning development in primary school.

1.1. State-of-the-art

The Horizon Reports of recent years, especially those issued in 2012 and 2016 (Durral, Gros, Maina, Johnson & Adams, 2012; Johnson, Adams, Cummins, Estrada, Freeman & Hall, 2016) introduces Augmented Reality as an emerging technology which should be normally present in training centers around 2020.

RA has been defined as a system that merges 3 elements: on the one hand the combination of the virtual world with the real one, the instant or immediate interaction with objects and finally the possibility of increasing the real objects by offering 3-dimensional images (Sommerauer & Müller, 2014). Consequently, if it is understood as an element, as pointed out by Fabregat (2012), then it provides the person who uses it a visual guide which will allow the person to perform a more precise task; thus, it should be considered that its use in the academic sphere contributes more than it restricts, since it does not limit the methodology used in the classroom, but power it when presenting the world to the students—in which they live and interact with others daily outside schools — within the walls of the classroom, all from a natural perspective (Prendes, 2015); in this way, observation capacity will be enhanced (Ak-ayir & Ak-ay, 2017). Hence, RA offers the possibility to insert an image or virtual object in a real scenario, allowing to experience in a more vivid and rich way the practice of learning.

This emergence by the Horizon reports, because of its link to the teaching of subjects, has highlighted the various studies conducted since more than a decade ago. Thus, there are studies in areas such as the teaching of mathematics (Sommerauer & Müller, 2014; Rahman Ling & Yin, 2020), Medicine (Ferrer-Torregrosa, Torralba, Jiménez, García & Barcia, 2015), Physics (Chang, Wu & Hsu, 2016), Anatomy (Citardí, Agdetoba, Bigas & Luang, 2016), Education (Barroso & Gallego, 2017; Cozar, del Moya, Hernández, & Hernández, 2015; Luna, Ibañez & Rivero, 2019; Yilmaz, 2016), Second languages (Cruz, 2018), Museums or architecture (Luna, Ibáñez & Rivero, 2019), to mention a few subjects. All of them have emphasized that learning can be achieved more effectively by bringing back

images and text, hence the Cognitive Theory of Multimedia Learning supports a positive view of the application of AR in education (Sommerauer & Müller, 2014).

There is a work by Yilmaz (2016) with children's education students, which showed a greater interest in the contents shown through a book developed with this technology, supporting the playful and rational approach with which the teaching process takes place at this level of education. Also, the RAFODIUM project, (Augmented Reality to Increase Training. Design, Production and Evaluation of Augmented Reality Programs for University Training [EDU2014-57446-P] (http: ://bit.ly/2LiQXc3), developed at the University of Seville (Spain), whose objective is to evaluate the possibilities and potentials offered by different software for the creation of technological environments with AR to be used in university training contexts, and in which this article is focused.

Of all these experiences, as well as the research carried out on AR (Álvarez, Delgado, Gimeno, Martín, Almaraz & Ruiz, 2017; Barroso & Gallego, 2017; Cozar-Gutiérrez & Sáenz-López, 2017; Fracchia, Alonos & Martíns, 2015; Marín-Díaz, 2016, 2017a, 2017 b) have allowed to elucidate a number of advantages of the educational application of AR. These would be: it increases the motivation and interest of the students for their own learning process; it enhances playful learning; it provides the possibility of interacting in real time with reality; it allows to combine cognition with physical experience; it complements perception and interaction with the real world; it stimulates perception and helps to understand abstract concepts and content; it stimulates abstraction; it boosts the development of cognitive, spatial, temporary abilities; It allows to offer information in an improved way; it propitiates conducive immersion experiences in the content, causing intuitive and interactive learning.

However, it also entails a number of disadvantages or problems related with the lack of economic resources to acquire digital resources; availability of Wi-Fi connection; lack of training for the implementation in the classroom; the decisions made have no consequences; it does not develop manual skills; shortage of learning objects created under this architecture; teachers' attitudes towards their curriculum integration; distraction from students; it requires a lot of time for its mastery; difficult to be employed by students (Álvarez *et al.,* 2017; Cabero & Barroso, 2016; Cubillo, Martín, Castro & Colmenar, 2014; Durrall *et al.,* 2012; Gavish, Gutiérrez, Webel, Rodríguez, Peveri, Bockholt & Franco 2015; Marín-Díaz, 2016, 2017a, 2017b).

Because of the latter, it can be concluded that implementing AR in classrooms today is a challenge which will be determined by the knowledge, beliefs and skills that teachers at all levels of education have towards it, because providing data in a real environment will imply more work for teachers in designing the classroom methodology and in knowing a lot more about technology. However, there are more advantages than disadvantages in using AR in education.

2. Methodology

The quantitatively cut methodology is based on an *ex post facto* design, which will determine the achievement or not of the established objectives, as well as the confirmation or not of the hypotheses raised (Mateo, 2012).

The objective of this research is based on general objective 1 designed for the project RAFODIUM, which was: to evaluate the possibilities and potentials offered by different software used for the creation of technological environments with Augmented Reality to be used in university training contexts, establishing specific objectives:

1. Determine whether undergraduate college students considered Augmented Reality to have educational value.
2. Set the value of Augmented Reality as a curriculum tool for primary education.

3. Set the possible inclusive value of Augmented Reality.

The starting hypothesis established were:

H1: There are gender differences in the educational value in Augmented Reality of Primary Education for men.

H2: Younger students believe that Augmented Reality can be used as a resource that supports the curriculum development in Primary Education.

An ex post facto study method has been used for the achievement of these objectives and scenarios, thus the objective will be obtained *a posteriori* as pointed out by Mateo (2012).

2.1. Instrument design

For the data collection, a questionnaire created by Marín-Díaz was designed in 2016. This was made up of 31 items. The first three were referring to the identification or dependent variables (gender, age and digital devices that the student has —Tablet, laptop, Smartphone, desktop), the remaining 28 corresponded to the independent variables, which tried to answer the hypothesis of this research.

The response scale of the former was nominal in nature and of the second Likert type, where 1 corresponded to totally disagree and 5 to totally agree.

It was subjected to the Cronbach Alpha (Reliability) test and the Barllett's sphericality test (validity) in order to verify that it continued with the same reliability and validity values obtained by Marín-Díaz (2016), since the sample under study was different.

Having performed Alpha of Cronbach test, it was found that the reliability of the instrument was very high (0.829), taking into account the contributions of Mateo (2012) (see table 1). The aim was also to see that the instrument maintained that reliability, so the same test was carried out taking into account the elimination of the questionnaire items, the result presented an alpha that ranged from 0.835 to 0.809, thus, it can be concluded that the instrument meets the reliability conditions for its use.

Table 1. Cronbach Alpha Study

	Alpha
Item 1 Augmented reality allows the development of primary education	0.812
Item 2 Augmented reality allows the development of inclusive education	0.809
Item 3 Augmented reality enhances creativity	0.813
Item 4 Augmented reality allows collaborative work	0.835
Item 5 Augmented reality allows cooperative work	0.810
Item 6 Augmented reality allows group work	0.810
Item 7 Augmented reality facilitates the real learning of the content	0.811
Item 8 Augmented reality enhances the learning process through experimentation	0.812
Item 9 Augmented reality enhances the learning process by free discovery	0.809
Item 10 Augmented reality can be employed by subjects with visual impairments	0.822
Item 11 Augmented reality can be employed by subjects with motor difficulties	0.810
Item 12 Augmented reality can be employed by subjects with psychological difficulties	0.808
Item 13 Augmented reality can be used by subjects with auditory difficulties	0.813

	Alpha
Item 14 Augmented reality can enhance the cross-sectional teaching of the content	0.810
Item 15 Augmented reality enhances intercultural teaching	0.811
Item 16 Augmented reality facilitates the understanding of curriculum contents	0.808
Item 17 Augmented reality complements the curriculum content explained in class	0.809
Item 18 Augmented reality needs great technological support for its use in the classroom	0.823
Item 19 Augmented reality facilitates communication between students and teachers	0.815
Item 20 Augmented reality facilitates communication between students	0.812
Item 21 Computer skills are needed to use augmented reality	0.815
Item 22 Augmented reality is easy to use by students	0.829
Item 23 The use of augmented reality makes it difficult to acquire the contents	0.809
Item 24 Learning to use augmented reality takes a long time	0.810
Item 25 Augmented reality can be used by subjects with high capacities	0.822
Item 26 Augmented reality enhances multicultural teaching	0.819
Item 27 Augmented reality strengthen the digital gap	0.832
Item 28 Augmented reality can be used to prevent bullying situations	0.826

In order to verify the validity of the instrument's construct, a factorial analysis has been performed, carrying out the Barllett sphericity test (approximate Chi-square 2286.439 and values of significance 0.000), and the Kaiser-Meyer index has been calculated –Olkin (KMO=0.805). The result of the test reflects the existence of 5 factors, which explain 84.548% of the total variance, revealing an optimal balance between the components of the instrument which are representative of the theoretical concept. In this way, it was verified that the Cronbach Alpha test performed on the basis of the dimensions or factors extracted still reflects a high internal consistency of the items: dimension 5 of 0.895; 4 of 0.885; the third with 0.807; the second with an alpha of 0.806 and the first dimension of 0.812.

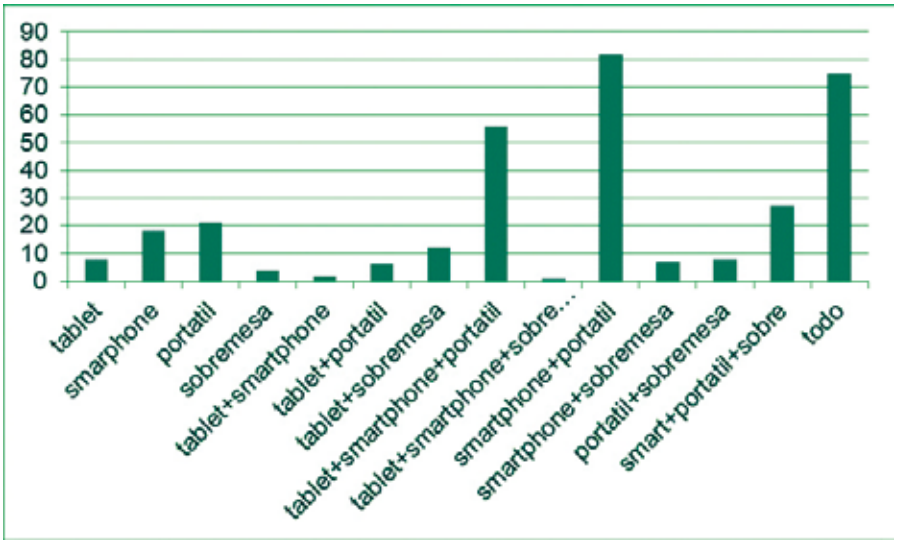
The data achieved have highlighted the validity of the use of this instrument with the sample under study, since they are similar to those obtained by Marín-Díaz (2016).

2.2. Population and sample

The starting population of this study corresponded to the students enrolled in the Degree of Primary Education of the University of Córdoba, taught in the Faculty of Educational Sciences during the academic year 2018-2019, this being 520 students. By incidental sampling, the sample that was finally counted has been 327, taking into account a 5% sample error. From this, 30.9% were men and 69.1% were women. With regard to age, most of the sample is in the age range of 19-20 years, and the lowest in 25-26 years.

Based on the digital devices that the students stated to possess, it was found that 32.51% indicated that they had a smartphone and a desktop computer, and 22.9% had all the indicated digital devices (tablet, smartphone, laptop and desktop), compared to 0.3% that only have tablet, smartphone and desktop computer (see Figure 1).

Figure 1. Student devices



3. Results

3.1. Descriptive study

Participating students fully agree or agree on the educational possibilities that AR has in Primary Education and specifically in the field of inclusive education, highlighting its positive assessment in aspects related to the possibility of enhancing creativity (item 3, 64.2%), the need for computer skills for its use (item 21), and its possibility of being used with the hearing impaired (item 13), 51.4% and 57.7%, respectively.

It is worth mentioning the behavior given to item 4 in which a high percentage of students (16.5%) consider that AR does not allow collaborative work, although 69.1% agree on its possibilities.

However, they disagree or strongly disagree on the assertion that AR can help prevent bullying (item 28, 44.6%) or to strengthen the digital gap (item 27, 42.5%), or that it can be used with visually impaired students (item 10, 29.7%).

3.2. Inferential study

The ANOVA test (n.s.=0.05) based on age has only found significant differences in item 3 (see table 2), referring to the possibility presented by AR to enhance creativity in the student. As can be seen, students aged between 21-22 (M=4.64 DT=.512) and 23-24 years old (M=4.67 DT=.606) consider that AR enhances creativity in Primary Education students versus the other ages (19-20 [M=4.61 DT=0692], 25-26 [M=3.94 DT=1.237] and over 26 years [M=4.29 DT=.736]).

Table 2. ANOVA considering the age

Dependent variable		(I) age	(J) age	Mean difference (I-J)	Typical error	Sig.	95% confidence interval	
							Lower limit	Upper limit
Augmented reality enhances creativity	Bonferroni	19-20	21-22	-.032	.096	1.000	-.30	.24
			23-24	-.067	.117	1.000	-.40	.26
			25-26	.670*	.179	.002	.16	1.18
			Más de 26	.321	.140	.220	-.07	.72

Dependent variable		(I) age	(J) age	Mean difference (I-J)	Typical error	Sig.	95% confidence interval	
							Lower limit	Upper limit
Augmented reality enhances creativity	Bonferroni	21-22	19-20	.032	.096	1.000	-.24	.30
			23-24	-.036	.132	1.000	-.41	.34
			25-26	.701*	.189	.002	.17	1.24
			Más de 26	.353	.152	.211	-.08	.78
		23-24	19-20	.067	.117	1.000	-.26	.40
			21-22	.036	.132	1.000	-.34	.41
			25-26	.737*	.200	.003	.17	1.30
			Más de 26	.389	.166	.199	-.08	.86
		25-26	19-20	-.670*	.179	.002	-1.18	-.16
			21-22	-.701*	.189	.002	-1.24	-.17
			23-24	-.737*	.200	.003	-1.30	-.17
			Más de 26	-.348	.214	1.000	-.95	.26
		Más de 26	19-20	-.321	.140	.220	-.72	.07
			21-22	-.353	.152	.211	-.78	.08
			23-24	-.389	.166	.199	-.86	.08
				.348	.214	1.000	-.26	.95

M=Media
D.T.=Typical deviation

In view of the gender of the students, the Student T test was conducted (n.s.=0.05), which yields significant differences in items 1, 2, 5, 7, 9, 17, 20 and 21, all in favor of women (see table 3).

Tabla 3. T de Student

	Gender	N	M.	D.T.	F.	p	d de cohen
Ítem 1	Man	101	4.27	.747	.539	.005	-0.34
	Woman	226	4.48	.567			
Ítem 2	Man	101	3.99	.755	0.538	.001	-0.41
	Woman	226	4.25	.560			
Ítem 5	Man	101	3.83	.873	.535	.001	-0.39
	Woman	226	4.14	.756			
Ítem 7	Man	101	4.33	.709	.0.284	.003	-1.97
	Woman	226	4.57	.594			
Ítem 9	Man	101	4.01	.900	.050	.000	-0.50
	Woman	226	4.40	.713			
Ítem 17	Man	101	3.92	.783	1.731	.004	-0.34
	Woman	226	4.16	.663			
Ítem 20	Man	101	4.20	.617	1.786	.003	-0.36
	Woman	226	4.41	.576			

	Gender	N	M.	D.T.	F.	p	d de cohen
Ítem 21	Man	101	4.28	.709	12.145	.002	-0.42
	Woman	226	4.53	.543			

M=Media

D.T.= Typical Deviation

3.3. Correlational Study

The results of the correlational study conducted are presented in terms of the dimensions generated by the exploratory factor analysis carried out.

With respect to dimension 1, there is a high correlation between each other in all items, except for item 27, where there is a good correlation between this and the 20.

In dimension 2, item 28 only has a single correlation to 25. It is significant that the rest of the item only has relationships with two items in the dimension; however, these can be considered very high, since they provide bilateral significance level of 0.01.

Based on dimension 3, there is minor significance as there are only three correlations between item 6 and the other items, and two relationships in item 2 (with item 5 and 6).

The correlational study of dimension 4 reflects how the items have a high relationship behavior, except 22 with the others where there is no correlation.

Finally, dimension 5 shows no correlations between item 18 and the rest of the components of the item, while item 21, except for 18, has a high correlation with all others.

4. Discussion and conclusions

The development of the so-called emerging technologies in the educational field is evolving in the way teaching is taught. In the case of the AR several authors (Barroso & Gallego, 2017; Luna, Ibañez & Rivero, 2019; Moreno & Leiva, 2017) have mentioned the great possibilities it offers to the teaching-learning process.

It is believed that its relevance in the educational field lies in the possibilities it offers to provide digital information in real time, enriching the contents and making interactive learning more participatory in terms of the student of any academic level. With regard to future Primary Education teachers, these aspects are valued positively as are the data contained in the work of Moreno and Leiva (2017) and Garay, Tejada and Castano (2017).

The results obtained in this work have shown that AR can be seen as a tool with the possibility of being employed as a resource in classrooms at this educational level (objective 1); it is also seen as an element that allows to complete the development of the contents (Wu, Lee, Chang & Liang, 2013; Joan, 2015; Rahman, Ling & Yin, 2020), fulfilling the objective of this research.

In relation to the second objective set out (*to establish the value of Augmented Reality as a curriculum tool for primary education*), participants believe that AR enhances training through experimentation (Wei, Weng, Liu & Wong, 2015), as in the work carried out on the subject of Anatomy of the medical degree by Ferrer-Torregrosa, Jiménez-Rodríguez, Torralba-Estelles, Garzón-Farinós, Pérez-Bermejo and Fernández-Ehrling in 2016, where it was stated that the learning of muscle movements had been more successful when experiencing these movements by using RA.

In this matter, the students of the Primary Education Degree think that learning through the free discovery typical of this tool, as well as the transversality that it provides to the curriculum development of the contents, is reinforced (Barroso & Gallego, 2017; Moreno & Leiva, 2017).

The most valued element by students has been creativity, as in Wei *et al.* (2015) y Marín-Díaz (2016, 2017a, 2017b). In this sense, the results obtained make it possible to affirm that it enhances the flexible learning (Munnerly, Bacon, Willons, Steele, Hedberg & Fitzgerald, 2014) and the communication between students, as well as the ability to work collaboratively (Martín-Gutiérrez, Fabiani, Benesova, Meneses & Mora, 2015), reinforcing the curriculum development (Joan, 2015).

Nevertheless, it stresses that participants do not consider that this emerging technology can accentuate the digital gap (objective 3), contrary to the results obtained by Marín-Díaz (2017a, 2017b, 2018), as well as to help prevent bullying (Objective 3).

On the other hand, it must be emphasized that elements such as the need to possess computer skills, as well as having time to learn how to use it, are understood as distorting elements in the positive vision that AR can generate for its use in the primary stage; this suggests that this technology can generate displeasure in teachers in addition to provoking some rejection with the training at this educational level.

The results obtained in this research show that the first two objectives set are met, thus it can be concluded that AR is a tool that once it is fully incorporated into working life it will guarantee its use in the academic work.

Finally, with regard to the third objective (*Setting the possible inclusive value of Augmented Reality*) it has been established that, although they consider it to be a tool that allows the development of inclusive education (Cozar *et al.*, 2015; Marín-Díaz, 2018), it has been found that they do not believe that it can be used entirely with individuals who have visual difficulties, fact that agrees with Marín-Díaz (2017a), or with individuals with motor, psychological or with high abilities, information that is opposed to Cozar *et al.* (2015) and Marín-Díaz (2017, 2018), which reflect the great viability of this tool with individuals with autism or any autism spectrum. It is significant that, both in this study and in the study carried out by Marín-Díaz (2017a, 2017b), this resource can hardly be used with students with visual impairment. On the other hand, they believe that it can enhance both intercultural education and multiculturalism (Marín-Díaz, 2017b, 2018), topics that are part of the inclusive perspective.

With regard to the hypotheses raised, it has been demonstrated that there are no gender differences in the educational value of Augmented Reality in Primary Education, given that only one difference has been found in favor of women as regards the creativity potentiality by this tool in the student; therefore, the starting hypothesis can be rejected.

With regard to the second hypothesis referring to the age of the participants, it should also be rejected because young people at a middle age range are those who see the possibility of this tool at this educational stage.

As a final conclusion to this work, it can be determined that even though AR is a technology that helps and facilitates the understanding of the curriculum content, it is necessary to take a number of measures ranging from the provision of digital resources to centers such as training for teachers regarding its use (Garay, Tejada & Castaño, 2017).

Limitations of the study

The development of the research in the field of Social Sciences and education has as the main limitation the availability of sufficiently large samples, which may allow researchers to generalize the conclusions reached.

However, it is precisely there where lies the worth of this type of work, since it proposes new fields of work and/or study that allow to reject or confirm those achieved in the initial research.

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