




Article

Augmented Reality in Higher Education: An Evaluation Program in Initial Teacher Training

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Abstract: One of the emerging technologies that have sparked greater interest in pedagogical contexts is augmented reality. This paper aims to assess the impact, practices and attitudes that are generated from augmented reality in the initial training of future teachers, and the presence of these practices in a university training context. The study was carried out with 87 trainee primary teachers. Information was obtained by applying the Wilcoxon test. The qualitative data obtained in open questions were also triangulated. It is emphasized that students do not habitually use this resource at the university, and that with these practices there is sometimes a certain amount of distraction, and even of time being wasted. From the data analyzed, we also highlight that once the availability of resources, class planning and initial teacher training are overcome, augmented reality provides benefits and advantages centered on pedagogies that allow for greater enthusiasm on the part of the students, with significant advantages in creativity, innovation, participation, and especially in the motivation of participants. Coinciding with recent research, our results underline the need for initial training so as to be able to design and apply practices with augmented reality in teaching, and to take advantage of the aforementioned benefits.

Keywords: educational technology; augmented reality; teacher training; social sciences; applied research

1. Introduction

In the current information society, coherent training is necessary to provide a response to the presence of technologies and processes of social transformation. Therefore, in contemporary classrooms, oriented towards active and dynamic approaches, a methodological change is needed to allow for an adaptation and integration of material resources towards the acquisition of 21st century competencies.

Therefore, it is necessary to highlight the importance of the initial training of future teachers, because to carry out these changes requires the development of training activities that include the most suitable spaces and strategies for the proper acquisition of teaching skills [1]. It is essential that future teachers have adequate training for the challenges of the 21st century, and that they have knowledge of emerging technologies in educational contexts and acquire the necessary skills to be able to design and develop educational activities to exploit the potential of the technologies. This is an issue of current interest on an international level [2–4]. Analysis of the knowledge of trainee teachers is considered crucial to be able to direct initial training programs for teachers [5]. A large number of articles have analyzed the beliefs and perceptions of trainee teachers in order to understand how these constructs can be used to improve their training [2,6,7]. Pajares [8] and, more recently, Fives and Buehl [6,9],

have shown that actions based on these beliefs can make it possible to create new learning spaces with teachers.

Empirical findings in recent years have provided detailed information on how the learning opportunities presented in training programs have a notable correlation with the knowledge and skills of teachers at the end of their training [10,11]. A recent study by Coll, Pardo and Pérez [12] has shown the close correlation between the methodology employed in university classes and the professional development and skills of graduates. Problem-based learning, teaching practice, and practical knowledge were shown to be among the most influential factors. Similar findings have been made by Hortigüela, Abellá, Delgado & Ausin [13] concerning initial teacher training.

After the creation of the European Higher Education Area, new educational formulas focused on student-centered teaching methodologies have been generated, and the pedagogical use of technologies can contribute considerable support for a more enriching and participatory orientation in the classroom. In the last five years we have seen a proliferation of studies about its impact in teacher training [14], which trace teachers' perceptions regarding the significance of digital literacy skills [15] or measure teachers' ability to develop digital information among their students and promote their communicative skills in this regard [16].

One of the emerging technologies of interest and applicable in educational contexts is augmented reality. The NMC Horizon Report 2018, in its Higher Education edition, identifies emerging technologies which are having a significant impact on learning and teaching in university education [17]. For some years, augmented reality has been recognized as one of the technologies with a higher impact on university education. At the intersection of virtual and physical realities there is an emerging environment known as mixed reality, where digital and physical objects coexist. This hybrid space integrates virtual reality and technologies in the real world in such a way that users cannot distinguish where one world ends or the other one begins. One of the virtual aspects of mixed reality finds the integration of augmented reality that allows user interaction and has significant learning potential [17].

For Azuma [18], augmented reality can be the fusion of a direct or indirect vision of a physical environment (real world), whose elements are combined with digital objects to create a mixed reality in real time. According to this author, augmented reality systems are characterized by three properties: a combination of real and virtual objects in a real environment; the alignment of real and virtual objects with each other; and their interactive execution in real time.

In this way the three characteristics are combined: combining the real with the virtual; interacting in real time; and registration in 3D. For Klopfer & Squire [19] (p. 205), augmented reality is a situation in which a real-world context dynamically overlaps with a coherent location, or context-sensitive virtual information. This coexistence of virtual objects and real environments allows experimentation with phenomena that are not possible in the real world [19], interaction with synthetic objects in two and three dimensions in a mixed reality [20], and the development of practices that cannot be implemented in learning environments powered by technology [21].

Other research through meta-analysis [22–31] provides evidence and relevant information on the progress of this emerging technology in teaching/learning processes. Wu, Lee, Chang and Liang [32] detail learning activities related to augmented reality with innovative approaches and active participation with pedagogical approaches quite different from the teacher-centered approach [20,21].

Klopfer and Squire [19] include the need to balance competitive impulses and facilitate downward movements of information in educational activities. Likewise, the results coincide with the advantages of collaboration and management of technology and information as essential skills [19–21]. The integration of virtual and real worlds through the augmented reality creates a rich scenario [21,33–35].

Regarding the existing resources, the potential of mobile augmented reality provides opportunities for designing virtual learning spaces that are learner generated [36]. Mobile devices such as smartphones or tablets offer easier and cheaper access to augmented reality than before [28,37], and appearance in the videogame market of mobile augmented reality games with potentially millions of users [38], such as Pokemon Go [39], have led to the fact that augmented reality is gaining ground in the field of

education. In addition, Fombona and Vázquez [40] state that we have teams capable of performing tasks supported by augmented reality, because 80% of the teams have the Android operating system, and 60% of them have an integrated GPS system, which allows them to perform geolocation tasks.

According to Wu et al. [32], augmented reality provides the possibility of: enabling learning content in 3D perspectives; promoting ubiquitous, collaborative and situated learning; providing a sense of presence, immediacy and immersion of students; visualizing the invisible; and uniting formal and informal learning. The focus in this article was on one key issue—the possible effects of an intervention program in improving teacher training on the knowledge, skills and competencies of trainee teachers [5].

2. Methods

From our position as researchers, and from the application of approaches focused on augmented reality, we set out to understand and analyze the impact, practices and attitudes generated by these emerging technologies and innovations in the initial training of teachers in training, as well as the real presence of these key trends in the university training context.

This study presented an evaluation of the use of augmented reality in initial university teacher training based on data obtained through the survey technique, with a mixed questionnaire as an instrument. This was adapted from Cózar and Sáez's research [41], including items on the scale "Active Learning", with four questions present in Hiltz, Coppola, Rotter & Turoff [42], and the "Fun during learning activities" scale, which consists of five questions adapted from Laros and Steenkamp [43]. The questionnaire was administered before and after the intervention. We worked with related samples comparing this data using non-parametric tests.

The study provided descriptive data, based on an ordinal measurement scale data obtained from the questionnaires. From a pre-experimental design, a Wilcoxon test for related samples is applied, to determine if there are significant differences between pre- and post-intervention measures. In the present study, the level of significance α is 0.05. Reliability calculated through Cronbach's alpha coefficient offers an average of 0.71 at different scales, always greater than 0.6, so it is considered acceptable [44].

From the application of the survey technique, using the mixed questionnaire as an instrument, open questions were raised that allowed students to respond freely. From the data triangulation approach [45], conclusions were drawn based on different analyses, tests and information, which allows us to determine that there is evidence to support the validity of the results and minimize the variance of error [46].

2.1. Participants

The study sample was university students in the 2nd year of the Degree in Primary Education of the Faculty of Education of the University of Castilla-La Mancha. The sample, which is a non-probabilistic and intentional, consisted of 87 individuals. The group was made up of 73.6% female students and 23.4% male students, which turns out to be a representative sample of the gender disparity that exists in teacher studies, in which there is always a greater number of women. The average age was 21 years old (21.08). The group was quite homogeneous because it was made up of students of almost the same age and educational level.

2.2. Intervention

The application was carried out with 3 groups of university students studying to be Primary Education teachers, in the subject entitled 'Social Sciences II: History and History Education'. It was intended that students understood the educational possibilities offered by the sculptures of the Iberian culture, and used the teaching tools and applications to teach these contents. In line with the competences of the degree and the subject, a mandatory practical activity was proposed in which the

participants had to create their augmented reality objects to favor the educational instrumentation of the Iberian cultural heritage of the area.

To virtualize the augmented reality scenes, the Autodesk 123d Catch application was used, which is simple to operate and allows pictures to be taken and images to be captured that will later become a 3D object in .obj format, which can be converted into an augmented reality scene using Aumentaty Author, or imported it into .dae with SketchUp, so that it can be visualized in these tools to create educational digital objects that do not have a 3D engine (Figure 1).



Figure 1. Students working on capturing artworks in the museum.

It focuses on the application towards an active, autonomous and collaborative role that students had in creating the resources for their subsequent design and development of future pedagogical activities. Working groups of 4 students were created, the teacher providing, through the virtual space, a script that detailed the competencies, objectives, tasks and specific support material for each of the tools to be used.

Students worked for 3 weeks on their projects, under the supervision of the teacher, choosing the images to virtualize, expanding the related content and developing their own materials for future educational uses. The projects focused on archaeological collections of Iberian art housed in the Provincial Museum of Albacete (Figure 2). At the end of the generation of augmented reality scenes, and the educational design that each group planned, the results were presented in an evaluation session.

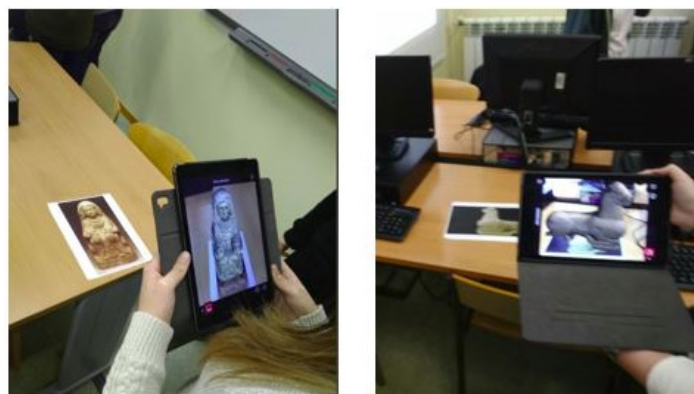


Figure 2. Students using augmented reality in the classroom to study artworks and design educational materials.

3. Results

3.1. Descriptive Analysis

In the analysis of scale 1 augmented reality in initial teacher training (Table 1) it can be verified that the majority of the students contribute intermediate or positive assessments regarding the consideration of this approach as essential in the training of future teachers, and on the importance of initial university training in augmented reality. The items that achieved the highest level of acceptance were those that related augmented reality in initial teacher training, the need for knowledge of technologies, and interaction throughout the process (Items 1.1, 1.2 and 1.3). This descriptive analysis highlights that students do not usually work with this resource in the university (Item 1.4).

Table 1. Scales and items in the questionnaire, descriptive analysis and Wilcoxon test.

Items	% Pre-Test					% Post-Test					<i>p</i>
	1	2	3	4	<i>Md</i>	1	2	3	4	<i>Md</i>	
AR in Initial Training											
1.1. Knowledge of technologies	0	2.3	36.8	60.9	4	0	2.3	69	28.7	3	0
1.2. Initial training	3.4	5.7	66.7	24.1	3	0	1.1	70.1	28.7	3	0.06
1.3. Interaction is beneficial.	3.4	16.1	57.5	23	3	0	4.6	67.8	27.6	3	0.02
1.4. Worked at University	33.3	50.6	13.8	2.3	2	33.3	43.7	21.8	1.1	2	0.54
1.5. Designed activities	52.9	33.3	11.5	2.3	1	23	47.1	28.7	1.1	2	0
1.6. I know tools	32.2	39.1	24.1	4.6	2	5.7	29.9	57.5	6.9	3	0
Benefits of AR											
2.1. Creativity	1.1	4.6	47.1	47.1	3	0	2.3	35.6	62.1	4	0.03
2.2. Collaboration	2.3	6.9	57.5	33.3	3	0	2.3	52.9	44.8	3	0.03
2.3. Communication	0	3.4	41.4	55.2	3	1.1	9.2	59.8	29.9	3	0.01
2.4. Educational skills	0	3.4	49.4	47.1	3	0	0	62.1	37.9	3	0.51
2.5 Innovation	12.6	24.1	57.5	5.7	3	2.3	0	36.8	60.9	4	0
2.6. Motivation	14.9	21.8	54	9.2	3	1.1	1.1	36.8	60.9	4	0
2.7. To learn	5.7	8	63.2	23	3	0	2.3	77	20.7	3	0.12
2.8. Central themes	2.3	14.9	69	13.8	3	0	11.5	60.9	27.6	3	0.02
2.9. Interesting	1.1	6.9	39.1	52.9	4	0	0	37.9	62.1	4	0.06
2.10. Participation	1.1	2.3	31	65.5	4	0	0	40.2	59.8	4	0.77
Learning with AR											
3.1. I like it	2.3	18.4	54	25.3	3	0	5.7	55.2	39.1	3	0.02
3.2. I'm excited	2.3	25.3	47.1	25.3	3	2.3	3.4	63.2	31	3	0.01
3.3. It motivates me	2.3	14.9	43.7	39.1	3	1.1	2.3	43.7	52.9	4	0.01
3.4. I'm comfortable	6.9	19.5	50.6	23	3	2.3	6.9	70.1	20.7	3	0.06

Values: 1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly agree.

The second part, related to the benefits of augmented reality, also obtained positive values especially in relation to the potential of augmented reality in the development of creativity, collaboration, innovation, motivation, participation and interest that it arouses in students (Items 2.1, 2.2, 2.5, 2.6, 2.9 and 2.10). The participants expressed more doubts in the descriptive analysis by providing intermediate values regarding educational competencies and learning of the curricular contents and central themes (Items 2.4, 2.7 and 2.8).

Finally, in the third part of the questionnaire, which refers to learning with augmented reality and its components related to fun, there were considerably high values and agreement with the fact that augmented reality is attractive and motivating (Items 3.1, 3.3 and 3.4), and exciting, 30% of the sample (Item 3.2).

Therefore, the values presented in the scales are quite positive for most of the items except those that refer to the contents and pedagogical issues when working with augmented reality, with greater skepticism or neutrality in the answers.

3.2. Statistical Inference: Wilcoxon Test

Regarding statistical inference, one non-parametric test, the Wilcoxon test, was applied to analyze related samples and assess the data obtained in the pre-test post-test in the mentioned pre-experimental design described in the present study. Significant improvements were obtained regarding the valuation of work with applications based on augmented reality in the university. Although after the activity the students valued that knowledge of technologies such as augmented reality was essential to train future teachers (1.1), in a lower proportion than before the intervention, several positive outcomes were derived from the results. Thus, interaction with augmented reality was beneficial in initial teacher training (1.3), and the intervention showed them how to design activities with augmented reality in educational contexts and how to learn about various tools that allow the design of educational activities (Items 1.5 and 1.6)

With statistically significant improvements, the advantages of creativity, collaboration, communication, motivation and innovation of augmented reality were appreciated (Items 2.1, 2.2, 2.3, 2.5, and 2.6). Also appreciated was that the central issues were addressed successfully (Item 2.8). In addition, statistically significant improvements were obtained in relation to students' enthusiasm, fun, and motivation in these practices (Items 3.1, 3.2, and 3.3)

It should be noted that in other items there were no significant improvements because the pre-test values regarding attitudes related to augmented reality were already quite high and remained high in the post-test. However, the intervention led to: improvements in work (although not significant in these items); the design and knowledge of tools that allow the design of approaches with augmented reality; and the assessment of the possibilities of motivation and their importance in educational innovation processes.

It is interesting to note that during initial university training the importance of working on augmented reality has not been seen to be significant (or hardly significant at all), and other items related to curricular issues, educational competencies and work in the university (Items 1.2, 1.4, 2.4 and 2.7) do not present statistically significant differences, so the null hypothesis is accepted in these cases. It can be interpreted that students are skeptical in their educational implantation even though they perceive and highlight numerous benefits of the integration of the mentioned resources.

3.3. Qualitative Analysis: Open Questions

From the application of the survey technique, using the mixed questionnaire as an instrument, open questions were raised that allowed students to respond freely. The frequencies provided by the subjects in each of the 5 questions raised were numbered and counted:

1. A. What technological tools do you consider essential today in educational contexts?
2. A. And in the future?
3. A. What do you think might be the strengths of the use of augmented reality in the classroom?
4. A. And the weaknesses?
5. A. What tools or programs do you know related to augmented reality?
6. A. What problems or obstacles do you perceive when implementing augmented reality in educational contexts?

The answers provide elements and factors of interest to the study, reinforcing and reaffirming values obtained in the pre-experimental design and in the descriptive analysis. In relation to question 1.A, the technological tools that were mentioned the most frequently were computers and laptops (43) tablets (26), interactive whiteboards (16), Moodle (15), and to a lesser extent, robotics (6), augmented reality (5), and other applications and tools. Therefore, the subjects do not consider augmented reality

a resource that is being applied in the classroom today. When asked about technological tools of the future (Item 2.A), the subjects contributed robotics (39), virtual reality (26), augmented reality (26), and 3D printers (22). So, they clearly do consider augmented reality as a resource for the future.

When asked about the strengths of augmented reality (Item 3.A), the high number of frequencies that highlight motivation and student interest (75) is surprising. To a lesser extent, responses related to collaboration (11) and creativity (8) are highlighted. On the other hand, when consulting the weaknesses, it was emphasized that a lot of time is wasted and distraction is a problem (29), there is a lack of teacher training (25), and the economic cost of resources could be high (19).

The tools or programs that subjects recognized as related to augmented reality (Item 5.A) were mainly QR codes (21), *Aumentaty* (20), *Aurasma* (11), and *ARCrowd* (4). The obstacles perceived by the subjects for the integration of augmented reality (Item 6.A) were lack of resources (24), lack of teacher training (23), and traditional teaching practices (11).

In short, after detailed intervention, the subjects have acquired certain notions related to the use of augmented reality for educational purposes, so they can provide a valuable opinion. The agreement of the motivation factor in the quantitative and qualitative data is evident. It is interesting that this resource is conceived as an emerging technology for the future.

From an interpretation and analysis in the present study, the need for initial training to design, apply and develop these practices in teaching is highlighted. This factor obtained the greatest number of frequencies together with the distraction that the integration of these resources can cause in the classroom. This distraction factor can disturb or disadvantage the students' learning process, so an assessment in this regard is proposed in future studies. The availability of resources and the lack of time in class are also other factors valued as difficulties that may arise when considering this approach.

4. Discussion

On the potential of the use of augmented reality in educational contexts, Radu [30], Akçayir and Akçayir [22] and Bacca, et al. [23], among others, discuss positive effects with a better understanding of the contents, consistent with Items 1.5 and 2.8 which highlight that the central themes are learned with the effective design of learning activities. Radu [30] also details advantages in the collaboration and motivation of students, which we have also highlighted significantly in the present study (Items 3.1, 3.2, 3.3 and 3.A).

Radu [30] mentions, on the other hand, some problems present in certain educational experiences, highlighting that the predominance of "tunnel" attention in certain activities, usability difficulties, inefficient integration in the classroom and learning differences are appreciated. We do not agree so much with regard to usability, but we concur with the fact that inefficient integration in the classroom can occur, something that some participants in this study have highlighted in different responses (Items 2.4, 4A and 6A).

Fombona and Pascual [26] highlight, in their research, that these practices promote greater performance in student learning, linked to their creative, motivational and recreational potential, and the power of the immersive sense of experience. We agree with the constructs related to recreational approaches and motivation, although not so much with the improvements in academic performance that the aforementioned authors highlight.

Cabero and Barroso [47] carried out an analysis of published studies on this technology and concluded that augmented reality facilitates the understanding of complex phenomena and concepts; promotes contextualization and enrichment of information; allows the individualization of training and adaptation to different types of intelligences; offers students the ability to interact by manipulating real objects; it favors ubiquitous and contextualized learning by converting any physical space into a stimulating academic setting; facilitates the development of a constructivist teaching/learning methodology; promotes the development of graphic skills through the perception of spatial content and 3D objects; it favors learning through practice (experiential learning) and increases motivation with very positive values of satisfaction, as well as improving academic results. We agree with the authors

on the variables related to motivation, fun and the possibilities of manipulation and management in pedagogical activities.

Fombona and Pascual [26] detail other weaknesses in the educational context of this resource, which focus on: the reluctance of the educational use of augmented reality; the difficulty of using the initial interfaces; the necessary learning times for the teacher (necessary training), and the legal gap related to their use in educational centers, despite the fact that educational laws try to promote ICT in their articles and subsequent decrees. The possible loss of interest inherent in passing fashions is also highlighted as a risk. Several of these problems are also appreciated from our study, especially regarding the need for resources and the need for teacher training.

A concordance with the Sáez, Cózar & Domínguez [48] study with elementary students is also highlighted, in which it was detailed that although the students who used augmented reality improved their results with respect to the control group, the differences were not significant, so it cannot be proven that the use of these technological resources completely surpasses the traditional and conventional approaches used in the control group. We also agree with the aforementioned authors on the possibility of active student-centered participation in group content work and manipulation of historical 3D models, as well as motivation and interest in the subjects studied. And we concur with this study concerning the advantage of being able to manipulate artistic works in detail, as we described in the intervention, in order to understand essential artistic expressions in certain cultures.

5. Conclusions

There are several investigations that, with the objective of analyzing the use of augmented reality in educational contexts, provide positive results similar to those found in our study [23,26,30,31,41,47–49]. These results were obtained from an audience with a particular educational background. From the triangulation of data of the results shown, it can be concluded that:

1. The students positively value the approach of initial teacher training that makes use of augmented reality. From a descriptive point of view, augmented reality can be proposed in initial teacher training, highlighting the need for knowledge of technologies and interaction throughout the process (Items 1.1, 1.2 and 1.3). In addition, statistically significant improvements are found when considering the potential of augmented reality to train future teachers (1.3). For the participants, the intervention was useful for designing activities in educational contexts, allowing them to work with various technological tools (Items 1.5 and 1.6).
2. Advantages of augmented reality in the development of creativity, collaboration, innovation, motivation, participation, and interest in students (Items 2.1, 2.2, 2.5, 2.6, 2.9, 2.10 and 3.A) are highlighted with statistically significant improvements in creativity, collaboration, communicative advantages, motivation and innovation (Items 2.1, 2.2., 2.3, 2.5, and 2.6). Particularly, motivation is considered the key and most notable factor in working with this resource (Item 3A).
3. Also appreciated is that the central issues are successfully addressed (Item 2.8) and the intervention with augmented reality has led to learning and significant improvement in the design of educational activities and the possibility of understanding these tools (Items 1.5 and 1.6).
4. The presence of fun and enthusiasm is highlighted by integrating these practices with high values and highlighting the attractive and motivating nature of the mentioned resource (Items 3.1, 3.2, 3.3, 3.4, 3.A and 5.A), with an encouraging 30% of the sample (Item 3.2) and with statistically significant improvements in relation to the enthusiasm and enjoyment of the participants in these practices (Items 3.1, 3.2, and 3.3).
5. It is interesting to note that students do not routinely use this resource in the university (Item 1.4, 1.A). Indeed, they did not even consider augmented reality as a resource with a presence today in classrooms (Item 1.A). However, it is highlighted that it is one of the resources to consider in the future (Item 2.A). Formative action has significantly favored the knowledge, attitudes and application of augmented reality. The students have been able to learn about several resources

and applications with the intervention, especially *Aumentaty*, *Aurasma* and *ARCrowd*, as well as the management of QR codes (Item 5A)

6. It should also be detailed that there are no significant improvements with regard to considering augmented reality in initial training, so students demonstrate certain doubts in this regard (Item 1.2). Other obstacles that stand out are the need for material resources, teacher training, traditional practices and especially some participants commented that with these practices there is some level of distraction and even time being wasted (Items 1.2, 1.4, 4A, and 6A).

Once the availability of resources, class planning and initial and continuous teacher training have been overcome, augmented reality provides a series of benefits and advantages focused on pedagogies that allow greater enthusiasm and motivation of students, taking advantage of the strength of interest that these approaches foster, with advantages when integrating them with active methodologies and always controlling an application that avoids distractions and allows the adequate integration of technology, contents and pedagogy [49].

From training in university contexts, one must begin to understand that international studies and reports are proposing that these key trends be adopted in the short term, leading to a change in practices in educational contexts [50–55]. University education and initial teacher training must adapt to these challenges and the demands of today's society, taking into account the emerging trends that professionals will encounter in their immediate future [56,57].

This study and other studies and reports provide evidence regarding the attitudes, assessments and perspectives of the application of augmented reality in university contexts, the difficulty of proper application, and the essential need for initial training to avoid the barriers and difficulties that would arise when faced with an erroneous pedagogical application. Now is the time to give a strong impetus to educational technology in the initial training of teachers in the university context, otherwise reality will surpass training designs in higher education.

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