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Situated Learning and Education: Development and Validation of the Future Teacher Attitudes Scale in the Application of Augmented Reality in the Classroom

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Abstract: This research article focuses on the design and validation of a questionnaire to analyse future teachers' perceptions of professional skills through the use of Augmented Reality (AR) in higher education, specifically for students in the field of Educational Sciences. The sample consisted of 575 students of Early Childhood Education, Primary Education and Pedagogy during the academic year (2021/2022). The focus of this study is to authenticate a questionnaire that measures the influence of Augmented Reality (AR) on aspects such as situated learning, motivation, and the necessary instructional preparations for the successful integration of AR within classroom educational encounters. The questionnaire is an online Likert-type scale developed based on three dimensions: situated learning, motivation and training. The data were analysed using the Statistical Package for the Social Sciences (SPSS) version 25 and JASP 0.17.1. The questionnaire met the standards recommended for validation. However, improvements to the instrument are suggested. In conclusion, validation of instruments is necessary to gain a rigorous understanding of the impact of new learning environments.

Keywords: *Augmented reality, effective learning experience, innovation, motivation, situated learning.*

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Introduction

Recognizing the need for more explicit research gaps and comprehensive rationale, the current context demands a clear trajectory for professional development. This trajectory hinges upon the recognition of the indispensable role played by educational experiences intertwined with digital resources within the learning journey.

Augmented reality (AR) has garnered substantial attention over the past decade, emerging as an exhilarating avenue that seamlessly incorporates these resources into educational settings and intelligent formative ecosystems. This fusion empowers aspiring educators to discern their digital requirements and competencies, fostering a world-class education enhanced by state-of-the-art technologies such as Augmented reality (AR), Virtual reality (VR), Extended reality (ER), or Mixed reality (MR).

The existing literature underscores how the diversification of internet-based information utilization, facilitated through multimedia resources, e-learning, and blended learning approaches, has significantly propelled the adoption of these technological tools. The advent of emerging technologies, particularly AR and VR, has demonstrated significant advancements in comprehending highly abstract subjects and content domains (Cabero Almenara et al., 2018; Cabero-Almenara et al., 2022).

However, in order to enhance the robustness of this narrative and its academic contributions, it is crucial to further illuminate the specific gaps in research and expound upon the rationales that underscore the significance of these developments. This will undoubtedly fortify the scholarly foundation and broaden the scope for future inquiries in this dynamic field. In recent decades, numerous international reports have highlighted the importance of certain digital

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training tools, including the use of the internet, e-learning, b-learning, and now the impact of new technologies, such as augmented reality (AR) and virtual reality (VR) (Adams Becker et al., 2018; Alexander et al., 2019; Brown et al., 2020; Ministry of Social Rights and the 2030 Agenda, 2023; World Economic Forum, 2022). In educational contexts, scholars have shown great interest in exploring the identification, meaning and consequences of app use (Abich et al., 2021; Saltan & Arslan, 2017; Van Krevelen & Poelman, 2010). Their findings have pointed to notable positive effects, including increased motivation, higher levels of engagement, meaningful learning experiences, and improved teaching skills (Bockholt, 2017; Díaz-Noguera et al., 2019, 2022).

Several authors have emphasized the necessity of enhancing techniques and ensuring their accessibility (Akçayir & Akçayir, 2017; Hantono et al., 2016). Consequently, a substantial body of evidence now supports the significant impact of AR on education (Garzón et al., 2019). As a result, further research becomes imperative to understand how future educators can effectively integrate these technologies into their teaching careers.

Literature Review

Elevating Learning Significance via Augmented Reality

According to the ideas of the American theorist Ausubel et al. (1983), significant learning involves a process in which students link new information (versionist) with their existing knowledge, leading to a reorganisation and reconstruction of both types of information. This concept is consistent with the principles of constructivist psychology, where learners actively construct their understanding by integrating new experiences with their prior knowledge.

In contrast, situated learning takes a different approach, starting from real-life practical situations that require active and deliberate engagement by students. In this model, knowledge is seen as situated as it emerges in specific contexts, influenced by activity, environment, culture and social interactions with others. Achieving situated learning requires the use of thoughtful and experiential teaching and learning strategies that can transform everyday classroom practices.

It is important to emphasize that the situated learning paradigm goes beyond mere task completion; rather, it fosters a sense of social practice within a community context. Students become active participants within a supportive learning community, enabling them to understand the subject matter in a more meaningful and contextualised way.

In this sense, "with the use of AR, the students will find it easier to relate their previous ideas to new knowledge" (Elizondo Moreno et al., 2018); "with the use of AR, communicative ideas are promoted" (Velázquez et al., 2020); "the learning of the students would be greater if all disciplines use AR" (Alvarado et al., 2019; Cabero-Almenara et al., 2022); "the appeal of AR is that it increases and facilitates learning" (Cuendet et al., 2013; Fowler, 2015); "the use of AR in the classroom promotes an active behaviour among the students" (Bjork et al., 2013); "after the results obtained with the use of AR, other teachers would be motivated to use it in their classrooms" (Lahiri et al., 2015; Lorenzo Lledó et al., 2022; Montenegro-Rueda & Fernández-Cerero, 2022).

Motivation Through Augmented Reality

Motivation is the tendency to make an effort in order to overcome educational tasks with a high degree of difficulty. The main advantage of AR is that it has a motivational effect on the students, who can operate and modify the learning itinerary, becoming active agents of their learning process. That is, AR in university classrooms promotes a motivational improvement (González Pérez & Cerezo Cortijo, 2020; Marín-Díaz & Sampedro-Requena, 2023).

Motivation in education is closely linked to students' freedom to choose their own learning path, which is why the concept of the Personal Learning Project (PLE) was born. The aim is to enable each student to design their own unique learning journey. This emphasis on personalisation has spurred the scientific community to explore projects that enhance learning environments and provide students with access to education based on digital ecosystems and active teaching methods.

In the context of an intelligent classroom environment, it is easier to motivate students. This in turn promotes active learning and contributes to improved learning outcomes. In particular, research conducted through systematic reviews has established a link between self-regulated learning (SRL) and personal learning environments (Tur et al., 2022). This highlights the importance of empowering students to take control of their learning experiences and become self-directed learners, further contributing to their overall educational success.

Thus, "AR makes learning more interesting and exciting" (Prieto Andreu, 2022); "the use of AR makes students more motivated during educational activities" (Rodríguez-Mendoza, 2021); "the use of AR makes it easier to reach different sources and show them immediately to the entire class" (Elizondo Moreno et al., 2018); "with the use of AR, it is possible to explain contents more efficiently" (Velázquez et al., 2020); "I think that AR makes learning more pleasant and interesting" (Iftene & Trandabăt, 2018); and "lectures with AR are more attractive than lectures without AR" (Baturay, 2011; Lorenzo Lledó et al., 2022).

Teaching Through Augmented Reality

Being a competent teacher is related to the social demands in different scopes. This study is focused on digital competences. Recent studies indicate that teachers who use AR present greater digital competence than those who do not use this technology, concluding that the use of VR, for example, may increase the learning of students by 400% (Moreno-Guerrero et al., 2021).

Defining and designing the scope of action for professionals in the development of 21st century skills involves taking into account the Common Digital Competence Framework for Educators (DigCompEdu; Cabero Almenara et al., 2018; Cabero-Almenara et al., 2022), which includes several domains: Domain 1: Professional digital competences: This refers to the digital skills and knowledge required for educators to effectively manage and navigate digital tools, software and devices in their professional practice. Areas 2, 3, 4 and 5: Pedagogical Digital Competences: These areas focus on how educators can integrate digital resources into their teaching methodologies. This includes using digital tools to design engaging and interactive learning experiences, promoting digital literacy among students, fostering critical thinking, and using technology for collaborative learning. Strand 6: Digital literacy for students: This strand emphasises the importance of developing students' digital skills. This includes equipping them with the ability to access, evaluate and use digital information responsibly, fostering digital creativity and preparing them to thrive in the digital world. For future teachers, the Teacher Digital Competence aims to specifically address the following aspects Professional commitment: This involves a teacher's commitment to using digital resources and technologies to enhance the teaching-learning process and achieve educational goals. It includes keeping abreast of technological advances and continuously improving their digital skills. Digital content: Future teachers should be able to create, curate and use digital content that is aligned with the curriculum and meets the learning needs of their students. This includes the use of multimedia, interactive materials and online resources. Using technology for teaching and assessment: Competence in the use of technology extends to both teaching practices and assessment methods.

Teachers should use digital tools and platforms to effectively deliver content and accurately assess student progress. Overall, the development of these competencies will enable educators to adapt to the evolving digital landscape and equip students with essential skills to thrive in the digital age. The integration of technology in education opens up (a) new possibilities for engaging, personalized and effective learning experiences, (b) evaluation tools, data treatment, and student empowerment through technology; and (c) accessibility, reduction of the digital divide, attention to the digital and literacy needs of the students, communication, responsible use, general well-being, and problem solving (Redecker & Punie, 2017). According to different authors, “training is required to teach with AR” (Shavelson et al., 2019); “the teacher must obtain basic training before using AR” (Yip et al., 2019); “the proposal of activities through AR is difficult without previous training” (Campos Retana, 2021); “without sufficient training, teachers do not feel comfortable using AR in the classroom” (Zimmerman et al., 2005); “teachers demand a more specific preparation about AR in order to use this technology adequately in their professional future” (Pettersson, 2018).

Methodology

Research Design

The aim of the present study was to develop and validate a questionnaire about the evaluation of a learning experience using AR in higher education, specifically for bachelor and master´s students in the field of education sciences. The following sections are presented below: sample and data collection, data analysis and instrument.

Sample and Data Collection

To carry out the validation, a non-probabilistic convenience sampling was conducted among the students who participated in the learning experience with AR. A total of 575 students participated in the study (women = 87 %; men = 13 %). The students were distributed in the degrees of pedagogy (36 %), early childhood education (44 %) and primary education (20 %).

Data Analysis

The data were analysed using the Statistical Package for Social Sciences (SPSS) v.25 and JASP 0.17.1 software. In order to attain the proposed objective, the psychometric properties of the questionnaire were verified (Weadman et al., 2022). To calculate the reliability, McDonald's Omega (ω) was used, as it provides better consistency than Cronbach’s alpha (α) by performing the calculation from the factor loadings (Hayes & Coutts, 2020), and Cronbach’s alpha was employed for each of the dimensions of the instrument. Lastly, an exploratory factor analysis (EFA) and a confirmatory factor analysis (CFA) were conducted.

Instrument

An instrument was developed to evaluate the educational experience carried out, which was aimed at future education professionals. The instrument was designed to determine the valuation of situated learning, motivation and training required for the implementation of teaching experiences using AR. Based on this objective, a first questionnaire was created with four sociodemographic questions about the characteristics of the study population:

- Gender: dichotomous question (female/male).
- Age: multiple-choice question (18-20 years/ 21-24 years and >25 years).
- Degree: multi-choice question (pedagogy, primary education and early childhood education).
- Year: multiple-choice question (1/2/3/4).

Moreover, a block was created with 48 Likert questions, whose scores ranged from 1 (totally disagree) to 5 (totally agree). These questions were based on three dimensions: situated learning, motivation and training.

Firstly, with the aim of cleansing the questionnaire, the instrument was subjected to an expert judgement, which was performed with two researchers from the Department of Research Methods and Diagnosis in Education of the University of Seville (Spain). These researchers were asked about:

- Appropriateness: to evaluate the convenience of the item, both in its dimension and in the questionnaire in general.
- Relevance: to assess the importance and significance of the item for the research objectives.
- Clarity: to evaluate the correct drafting for the target population.

The items were valued with a score of 1 to 3 for each of the proposed criteria. The items that obtained a score below 2 were discarded. To assess the concordance between researchers, Krippendorff's Alpha was calculated (Krippendorff, 2004). A concordance of 0.83 was obtained, indicating a high degree of agreement (Krippendorff, 2004).

```
Krippendorff's Alpha Reliability Estimate


             Alpha      Units    Obsrvrs      Pairs
Nominal      ,8315   159,0000     2,0000   159,0000

Judges used in these computations:
 Pablo    Jesús

Examine output for SPSS errors and do not interpret if any are found

------ END MATRIX -----
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Figure 1. Krippendorff's Alpha Results

After performing the expert judgement, 24 items were selected, which were distributed among the mentioned dimensions (See Table 1):

Table 1. Dimension and Corresponding Items

DIMENSION	ITEMS
MOTIVATION (MOT)	MOT1 I prefer the teachings that are taught with AR. MOT2 I concentrate better when my teacher uses AR. MOT3 I can participate more in the classes when my teacher uses AR. MOT4 The use of AR increases my motivation during the educational activity.
SITUATED LEARNING (SL)	SL1 I believe that AR can be a good complement to support teaching. SL2 The use of AR increases my efficiency as an educator. SL3 I like using AR technology in my classes. SL4 I have a positive attitude toward the use of AR in teaching. SL5 I think that AR makes learning more pleasant and interesting. SL6 With the use of AR, the students will find it easier to relate their previous ideas to new knowledge. SL7 With the use of AR, communication skills are promoted. SL8 The use of AR in the classroom promotes an active behaviour among the students. SL9 The classes with AR are more attractive than the classes without AR. SL10 The use of materials with AR help me to better understand the subject matter. SL11 The advantages are greater than the disadvantages in the use of AR. SL12 My experience with the use of AR was very favourable. SL13 After the results obtained with the use of AR, I can motivate my colleagues to use it in their classrooms.

Table 1. Continued

DIMENSION	ITEMS
TRAINING (TRA)	TRA1 The teacher must obtain a basic training before using AR.
	TRA2 The proposal of activities through AR is difficult without previous training.
	TRA3 I would like to obtain more specific training in AR in order to adequately use it in my professional future.
	TRA4 I believe that training is necessary for teaching with AR.
	TRA5 Familiarising oneself with AR from an early age will make learning easier in this scope.

The questionnaire was administered using Google forms at the end of the educational experience with AR. This educational experience was framed within a teaching innovation project. The students completed the questionnaire anonymously.

Results

Exploratory Factor Analysis

Firstly, a Bartlett's sphericity test was performed (see Table 2). This test was significant ($p < 0.01$), indicating that the data were adequate for the realisation of a factor analysis (García-Jiménez et al., 2000). Kaiser-Meyer-Olkin's adequacy measure was also calculated (see Table 2), obtaining KMO = 0.944, which showed that the factor analysis was pertinent, as it was considered within the higher category (García-Jiménez et al., 2000).

Table 2. KMO and Bartlett's Sphericity Tests

Kaiser-Meyer-Olkin's measure of sampling adequacy		.943
Bartlett's sphericity test	Approx. Chi-squared	7838.004
	df	231
	Sig.	.000

Then, the exploratory factor analysis by principal components was conducted, with the aim of determining the validity of each factor (see Table 3). It was verified that the communalities of all factors were over 0.5 (Beavers et al., 2013). Oblimin was used as the rotation method, since it is assumed that the items are correlated with each other (Lloret-Segura et al., 2014). Items that were more closely related to a dimension other than the one theoretically proposed were eliminated. Therefore, a new exploratory factor analysis was performed discarding items MOT4, AS3 and AS5.

Table 3. Exploratory Factor Analysis of the Selected Items

	Component			% cumulative variance explained
	1	2	3	
MOT1	.567		.704	46.484
MOT2			.858	
MOT3			.790	
MOT4	.716		.653	
SL1	.765	.530		55.86
SL2	.640			
SL3	.789			
SL4	.790			
SL5	.815		.516	
SL6	.693			
SL7	.634			
SL8	.766			
SL9	.761			
SL10	.609			
SL11	.772			
SL12	.680			
SL13	.772			
TRA1		.857		60.812
TRA2		.797		
TRA3	.655	.624		
TRA4	.531	.649		
TRA5	.638	.582		

Extraction method: principal component analysis.
Rotation method: Oblimin with Kaiser normalisation.

Table 4 presents the structure matrix excluding the items mentioned above. As all the items were found to have a higher correlation with the theoretical dimension and to have a higher cumulative variance, these items were used for the confirmatory factor analysis.

Table 4. Exploratory Factor Analysis of the Selected Items

	Component			**% cumulative variance explained**
	1	2	3	
MOT1	.578		.687	45.821
MOT2			.877	
MOT3			.804	
SL1	.770			55.803
SL2	.640			
SL3	.799		.503	
SL4	.800			
SL5	.825			
SL6	.698			
SL7	.631			
SL8	.761			
SL9	.764			
SL10	.614			
SL11	.771			
SL12	.677			
SL13	.807			
TRA1		.839		61.417
TRA2		.822		
TRA4	.531	.651		

Extraction method: principal component analysis.
Rotation method: Oblimin with Kaiser normalisation.

Confirmatory Factor Analysis

Firstly, the model fit measures are presented (see Table 5). The Comparative Fit Index (CFI) reached a value of 0.986 and Tucker-Lewis Index (TLI) was 0.984, indicating that the model is valid (Tanaka, 1993). Furthermore, the root mean square error of approximation (RMSEA) and the standardised root mean square residual (SRMR) were below 0.1 and below 0.8, respectively (see Table 6), thus the model has an acceptable fit (Sakib et al., 2022). However, the RMSEA value is slightly above the generally accepted values (<0.08), which may indicate some model misspecification. On the other hand, Table 6 shows the results of the MFI, which offers values with greater stability between different sample sizes (McDonald, 1989).

Table 5. Additional Measures of Fit

Index	**Value**
Comparative Fit Index (CFI)	.986
Tucker-Lewis Index (TLI)	.984
Bentler-Bonett Non-normed Fit Index (NNFI)	.984
Bentler-Bonett Normed Fit Index (NFI)	.984
Parsimony Normed Fit Index (PNFI)	.857
Bollen's Relative Fit Index (RFI)	.982
Bollen's Incremental Fit Index (IFI)	.986
Relative Noncentrality Index (RNI)	.986

Table 6. Additional Measures of Fit

Metric	**Value**
Root mean square error of approximation (RMSEA)	.096
RMSEA 90% CI lower bound	.091
RMSEA 90% CI upper bound	.102
RMSEA p-value	.000
Standardised root mean square residual (SRMR)	.072
Hoelter's critical N (α = .05)	109.522
Hoelter's critical N (α = .01)	117.783
Goodness of fit index (GFI)	.987
McDonald's fit index (MFI)	.500
Expected cross validation index (ECVI)	

Table 7 presents the results of the confirmatory analysis. All items were significant (*p* <.01) and obtained a saturation of over 0.3.

Table 7. Confirmatory Factor Analysis

Factor	Indicator	Estimate	Std. Error	z-value	p	95% Confidence Interval Lower	95% Confidence Interval Upper
MOT	MOT1	0.839	0.025	33.091	< .001	0.790	0.889
	MOT2	0.669	0.027	24.414	< .001	0.616	0.723
	MOT3	0.709	0.029	24.793	< .001	0.653	0.765
AS	AS1	0.863	0.014	60.295	< .001	0.835	0.891
	AS2	0.664	0.023	29.319	< .001	0.620	0.709
	AS3	0.855	0.013	67.704	< .001	0.830	0.880
	AS4	0.888	0.011	77.843	< .001	0.866	0.911
	AS5	0.897	0.010	89.417	< .001	0.877	0.916
	AS6	0.746	0.020	37.106	< .001	0.706	0.785
	AS7	0.645	0.023	27.956	< .001	0.600	0.691
	AS8	0.814	0.019	43.689	< .001	0.777	0.850
	AS9	0.848	0.015	55.212	< .001	0.818	0.878
	AS10	0.600	0.027	22.142	< .001	0.547	0.653
	AS11	0.790	0.016	48.481	< .001	0.758	0.822
	AS12	0.636	0.023	28.176	< .001	0.592	0.680
	AS13	0.809	0.016	51.495	< .001	0.778	0.840
TRA	TRA1	0.918	0.024	38.816	< .001	0.872	0.964
	TRA2	0.511	0.032	16.221	< .001	0.449	0.573
	TRA4	0.925	0.024	37.828	< .001	0.877	0.973

The situated learning dimension showed a strong correlation with the other two dimensions: .66 with training and .72 with motivation. Training and motivation obtained a moderate correlation (.32). Regarding the results of the CFA and EFA, it can be concluded that the distribution of the items was valid.

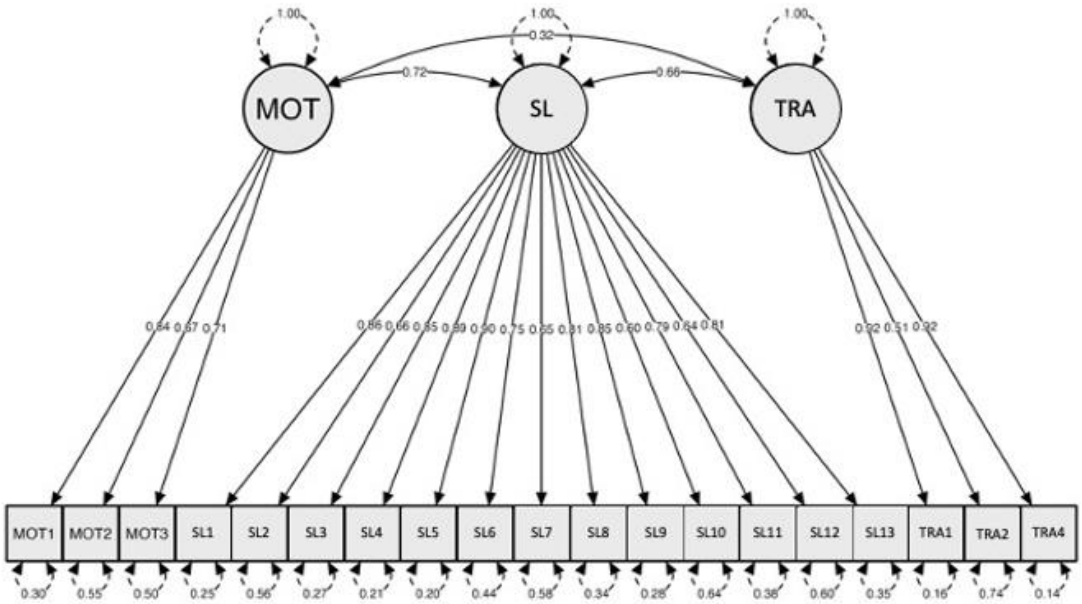

Figure 1. Confirmatory Factor Analysis

Reliability

McDonald's ω and Cronbach's α were used to calculate the reliability of the instrument (see Table 8). The results indicate that the instrument has an adequate internal consistency (Molina-Achury et al., 2016). However, with values above 0.9, the situated learning dimension could indicate redundancy in one of its items (Campo-Arias, 2006).

Table 8. Analysis of the Reliability of Each Dimension and Total Reliability Using McDonald's ￼ and Cronbach's A

Dimension	McDonald's	Cronbach's α
Motivation	.743	.734
Situated Learning	.932	.931
Training	.781	.764

Discrimination Index

Lastly, the item-total correlation index is presented. As can be observed in Table 8, all items, except for item TRA2, reached values above 0.36, indicating that the items have an excellent discrimination power (Nunnally & Bernstein, 1995). Item TRA2 (0.243) should be revised for the final version of the questionnaire, although it can be maintained (Nunnally & Bernstein, 1995).

Table 8. Item-Total Correlation of the Items of the Questionnaire

	Corrected total correlation of the elements
MOT1	.544
MOT2	.416
MOT3	.460
SL1	.762
SL2	.595
SL3	.742
SL4	.778
SL5	.812
SL6	.669
SL7	.576
SL8	.714
SL9	.748
SL10	.519
SL11	.701
SL12	.535
SL13	.717
TRA1	.562
TRA2	.243
TRA4	.618

Discussion

AR is a teaching and learning methodology that offers many teaching possibilities. It is particularly relevant for the training of education professionals (Cabero Almenara et al., 2018; Cabero-Almenara et al., 2022). For this reason, the validation process of a tool is offered. The aim of this presentation is to offer an instrument that serves as a starting point for other researchers for the evaluation of training, motivation and the development of situated learning using AR. It is important to share the items that require modification and aspects that could be improved in the model. Providing this data could contribute to the decision making of other researchers. In addition, the instrument is shared so that it can be refined and adapted by other researchers. A democratic and democratising vision of science is adopted (Ordóñez Sedeño, 2023).

The results of our study show that augmented reality (AR) is an effective tool for university teaching. The results indicate that the use of AR in the classroom enhances situated learning, motivation and the training necessary for successful integration into educational encounters (Bockholt, 2017; Díaz-Noguera et al., 2022). In addition, students were found to have a positive attitude towards the use of AR in the classroom.

The focus of this study is to authenticate a questionnaire that measures the influence of Augmented Reality (AR) on aspects such as situated learning, motivation, and the necessary instructional preparations for the successful integration of AR within classroom educational encounters. Although our results are promising, further research is needed to broaden the scope of this topic and explore other variables that may affect the use of AR in university education.

The theoretical dimensions considered have a strong impact on the professional development of future teachers, which is consistent with the design of some instruments that have been developed to diagnose digital teaching competencies in other countries (Santana-Valencia & Chávez-Melo, 2022).

Augmented Reality arouses great interest in the scientific community due to its emerging nature, therefore we must continue to investigate the use that is made in the university community in particular with the aim of being able to show all its possibilities in the training field, in this sense research has been developed such as those of (Bacca et al., 2014; Wu et al., 2013). The questionnaire presented helps to answer questions already existing in the scientific literature on Augmented Reality, such as the following: What impact does it have on teaching practices, as specified in the items presented, students express that learning is meaningful, attractive and easy to use, this statement coincides with the results of other research (Blas Padilla et al., 2019; Martínez Pérez et al., 2021), without forgetting the cognitive skills, abilities and ease of learning. We cannot forget that the scenarios that are configured with the incorporation of this tool support the processes of communication and cooperative work (Moreno Martínez & Leiva Olivencia, 2017). In addition, higher education aimed at future teachers should stand out for the promotion of creativity and critical thinking, in this sense there are also agreements with our results and those achieved by (Marín Díaz, 2017; Poce et al., 2019).

Conclusion

The design of this instrument, as was previously mentioned, has a strong impact on the educational development of future teachers. The items related to situated learning, such as "the learning of the students would be better if all disciplines used AR" (item TRA2), were replaced in the final version of the questionnaire with the following item: "in order to adequately follow the activities conducted with AR, previous training is necessary". The aim is to continue improving and cleansing the questionnaire, removing items that could be redundant and incorporating other dimensions with their corresponding items, in order to comprise, in a broader manner, the evaluation of teachings with AR and their impact on teacher training. Similarly, we did not provide data about other hypotheses that consider the evaluation of the students, the orientation toward learning, and the effort to attain the proposed goals. The most striking result is that the development of academic and professional competences and the learning process is optimised by the use of AR. Therefore, it is necessary to create tools that make it possible to understand and analyse the impact of the use of AR in the training plans of future teachers. Furthermore, these analyses should be extended to the context of educational centres. In this way, it is possible to know the impact of the use of AR in educational contexts; whether or not it favours the development of skills, knowledge, motivation and attention; the academic performance of students; and satisfaction with the use of this technology (Cabero-Almenara et al., 2022).

The instrument we analysed allows advancing in future studies about the diagnosis of the perceptions toward the use of AR, as well as the use of emerging methodologies. Learning is opening up to new contexts, which therefore gives rise to new learning styles and strategies. Future teachers have the obligation to integrate and consider these new strategies and resources in their educational practice. In this context, the aim of this paper is to learn about new perspectives of special interest in educational research on new learning scenarios in which the entire educational community is involved. Therefore, to know the attitudes, competences and projects developed by students and teachers, through instruments that deepen their educational activity.

This study aims to contribute to the educational initiatives that are carried out by different universities around the world, regarding the effect of different emerging technologies on the design of educational ecosystems, where these technologies play a relevant role. The reduction of team costs and the appearance of mobile devices enable the easy use of these emerging technologies, such as augmented reality, virtual reality and the so-called "extended reality" or "mixed reality", which will help Digital Transformation become a reality.

Recommendations

We consider that studies with these characteristics are necessary for different reasons. For instance, they contribute to developing this field of knowledge, and provide a degree of understanding about this scientific domain and the evolution of this emerging technology. Among its advantages, it is worth highlighting the fact that it favours the acquisition of digital competences and improves skills and abilities, attention and communication, motivation, collaborative work, social participation, creativity, and critical and reflective thinking.

For future research, we suggest that additional studies be conducted to assess the impact of AR on students' assessment, learning orientation and effort to achieve the proposed objectives. Other variables such as students' age, teachers' level of experience and duration of AR use in the classroom can also be explored.

Furthermore, improvements can be made to this study, such as the inclusion of a control group to compare the results with a group that does not use AR. More questions can also be included in the questionnaire to assess students' attitudes towards AR and its impact on learning.

Limitations

The instrument obtained acceptable values, although some indices were low, such as RMSEA, reliability and item TRA2. Therefore, it is necessary to further develop the instrument with new revisions and incorporating the evaluation of new competences and evaluation criteria. The sample was not gender-equitable, with more female students, so this is another limitation to be considered. Prosocial attitude, empathy and other aspects related to emotional intelligence could be incorporated to enrich the evaluation of the application of AR in education. Moreover, among the challenges to overcome in the following research projects, it is important to increase the level of competences and training in the university scope, as well as requesting economic investment to ensure the true integration of these emerging technologies in Higher Education.

Ethics Statements

The participants provided their written informed consent to participate in this study.

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Conflict of Interest

The authors declare no conflict of interest.

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Authorship Contribution Statement

Díaz-Noguera, Martín-Gutiérrez, García-Jiménez, and Hervás-Gómez: Conceptualization, design, analysis, writing. Editing/reviewing, supervision. All authors contributed equally.

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