Revista Latinoamericana de Tecnología Educativa, 22(2)
https://doi.org/10.17398/1695-288X.22.2.135

RELATEC Revista Latinoamericana de Tecnología Educativa

Received: 2023-02-03
Reviewed: 9 junio 2023
Accepted: 15 junio 2023

Authors' addresses:

[1] Departamento de Educación. Facultad de Lenguas y Educación. Universidad de Nebrija. Calle de Sta. Cruz de Marcenado, 27, 28015 Madrid (España)

[2] Departamento de Didáctica de las Lenguas, Artes y Educación Física. Facultad de Educación – Centro de Formación del Profesorado. Universidad Complutense de Madrid. Calle del Rector Royo-Villanova, 1, 28040 Madrid (España)

[3] Centro Singular de Investigación en Química Biológica y Materiales Moleculares (CIQUS). C/ Jenaro de la Fuente s/n, Campus Vida, Universidad de Santiago de Compostela, 15782 Santiago de Compostela (España)

E-mail / ORCID

sdelgadoro@nebrija.es

https://orcid.org/0000-0003-3731-2510

sicarras@ucm.es

https://orcid.org/0000-0002-4950-669X

rebeca.garcia.fandino@usc.es

https://orcid.org/0000-0002-5274-3928

ARTICLE

Degree of acceptance of digital evaluation systems adapted to the use of educational technological resources based on Augmented Reality

Grado de aceptación de los sistemas de evaluación digitales adaptados al uso de recursos tecnológicos educativos basados en Realidad Aumentada

Santiago Delgado-Rodríguez[1], Silvia Carrascal-Domínguez[2] and Rebeca García-Fandiño[3]

Abstract: The use of immersive technologies, especially Augmented Reality (AR), is presently one of the main technological trends in the field of education. Some studies carried out in recent years in this field highlight that traditional evaluation systems continue to be used and raise the possibility of using adapted evaluation systems. This research, based on primary sources of information, seeks empirical evidence regarding the need to use digital evaluation systems adapted to technological resources in Science subjects and in stages of Compulsory Secondary Education. The methodology used is quantitative research based on the design and statistical analysis of the responses given by students to a questionnaire created *ad hoc*, administered to assess an AR educational resource used in class to explain a key concept in connection with the subject. The results obtained through the exploratory factorial analysis of the students' answers reveal, as a latent construct, a high level of acceptance of the digital evaluation system used. The analysis of the data obtained in this study allows us to establish the hypothesis that a digital evaluation system adapted to the use of an immersive AR technological resource can generate a positive impact on the students' learning process.

Keywords: Educative Technology, Augmented Reality, Evaluation, Sciences, Secondary Education.

Resumen: El uso de las tecnologías inmersivas, especialmente la Realidad Aumentada (RA), es una de las principales tendencias tecnológicas en el ámbito educativo actual. Algunos estudios recientes, realizados durante los últimos años en este campo, destacan que, los sistemas de evaluación utilizados siguen siendo de corte tradicional y plantean la posibilidad de utilizar sistemas de evaluación adaptados. Esta investigación, basada en fuentes primarias de información, busca evidencias empíricas sobre la necesidad de utilizar sistemas de evaluación digitales, adaptados a recursos tecnológicos, en asignaturas de Ciencias y en etapas de Educación Secundaria Obligatoria. La metodología utilizada es de corte cuantitativo y se ha basado en el diseño y análisis estadístico de las respuestas ofrecidas por los estudiantes a un cuestionario creado ad hoc, administrado para que valorasen un recurso educativo de RA utilizado en clase para la explicación de un concepto clave de la asignatura de Ciencias. Los resultados obtenidos a través del análisis de las respuestas ofrecidas por los estudiantes, revelan un elevado nivel de aceptación del sistema de evaluación digital utilizado. El análisis de los datos obtenidos en este estudio permite establecer la hipótesis basada en que un sistema de evaluación digital, adaptado al uso de un recurso educativo tecnológico e inmersivo de RA, puede generar un impacto positivo sobre el proceso de aprendizaje de los estudiantes.

Palabras clave: Tecnología Educativa, Realidad Aumentada, Evaluación, Ciencias, Educación Secundaria.

1. Introduction

The social systems in which we currently live are based on the use of technologies that facilitate almost unlimited access to information. Information is an essential element in a modern society, and its interpretation allows generating knowledge. Therefore, it can be considered that the information society has generated a knowledge society. The objective interpretation of information and the ability to share it easily using available technological resources as complementary tools are generating what some experts in the field of education call a learning society (Cabero et al., 2016).

Hence, the acquisition of skills and strategies that are characteristic of the digital era is of paramount importance in a learning society. This objective is one of the primary challenges and difficulties currently faced by individuals in terms of their digital competence. The significance of this challenge has been further highlighted during the COVID-19 pandemic, where the utilization of digital resources became indispensable in both society at large and in the field of education, enabling the continuation of distance learning processes. The lasting effects of this reliance on digital tools are still evident. Consequently, there has been a substantial increase in investments in educational technology, driving significant advancements in technological development as a whole. Notably, these advancements are prominent in immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) (Pelletier et al., 2021).

Recent research, such as the one conducted by Alalwan et al. (2020), suggests that teachers show a greater predisposition to use educational technological resources based on AR than to use VR. These investigations conclude that the use of this technology in educational contexts is appropriate. All of this positions AR as an educational resource with high potential for use in teaching and learning processes.

One of the main advantages of AR lies in its ability to visualize both physical phenomena and concepts associated with a high level of abstraction. Thus, this technology facilitates the interpretation of complex phenomena, those that require visualizing a three-dimensional component, and is also very useful for simulating or recreating educational spaces that are safer than real ones, such as laboratory environments (Akçayır, Akçayırb, Miraç, & Akif, 2016; Cai, Chiang, Sun, Lin, & Lee, 2017; Fombona & Pascual, 2017; Herpich, Fernanda da Silva, & Rockenbach, 2021; Tarng, Ou, Lu, Shih, & Liou, 2018).

AR is a technology with significant potential for implementation in education mainly because it can increase student motivation, thus leading to improvements in their academic results. All this gives AR high potential for use in different subjects and educational levels (Cabero-Almenara, Barroso-Osuna, Llorente-Cejudo, & Fernández, 2019; Han, Jo, Hyun, & So, 2015; Kim, Hwang, Zo, & Hwansoo, 2014).

The development of skills and strategies acquired through learning based on the use of educational technological resources cannot be achieved without the design and implementation of active methodologies that efficiently and effectively integrate the use of these educational resources. For some years now, educational experts such as Livingstone (2012) have even hypothesized that when evaluating these students' results with objective tests and traditional exams, the effects on academic performance may not only remain unchanged but may also worsen, making them counterproductive. In fact , until now, innovative methodologies incorporating specific assessment systems adapted to the use of new technological resources have not been used. Instead, evaluations have been based on the use of evaluation systems considered traditional (Bacca et al., 2014; Brown et al., 2020, and Nieto, 2016).

In this context, it is necessary to adjust traditional evaluation systems to align them with the characteristics of new active methodologies that incorporate educational technological resources. However, there is currently a lack of specific criteria to achieve these objectives, despite a clear consensus among institutions on the importance of defining exactly how evaluation systems should be implemented in virtual teaching and learning environments. Most research conducted in this field has primarily focused on evaluating e-learning programs, leaving a significant gap in the literature. Therefore, there is a legitimate and well-founded need to conduct research based on primary sources of information in order to determine the appropriateness of specific applications, methodologies, and distinct features of digital evaluation systems adapted to the use of educational technologies, particularly immersive technologies like AR (Alkhattabi, 2017; Cabero-Almenara, Barroso-Osuna, Llorente-Cejudo, & Fernández, 2019; Fombona & Pascual, 2017; Prendes, 2015).

This research aims to provide answers to the aforementioned questions in order to understand the students' assessment of the use of an immersive educational technological resource based on AR and to determine the level of acceptance of a digital evaluation system adapted to the use of immersive educational technology. To this end, an attitudinal study has been conducted based on the development and validation of an ad hoc questionnaire (Carrascal et al., 2023; Delgado, 2021). The statistical analysis of the students' responses to the questions posed in the aforementioned questionnaire has allowed us to learn their opinion about the use of immersive educational technology for explaining key concepts in the subject. It has also made it possible to determine the main factors that intervene in and support the learning process based on the use of immersive technological resources of AR, as well as to explore other additional factors present in the educational process as a latent construct.

2. Method

The methodology employed in the study is quantitative in nature. It is based on the design and statistical analysis of responses obtained from a specifically created ad hoc questionnaire administered to the selected sample of students.

The main objective of the study is to examine students' assessments regarding the use of an immersive educational technological resource based on AR, aiming to enhance their academic performance. This objective is pursued by analyzing students' responses and specific factors such as motivation levels, acceptance of the technological resource, and comprehension of key concepts taught in class. Additionally, an exploratory analysis of the questionnaire's internal structure is conducted to identify potential underlying factors.

Considering the distinctive characteristics of the study, both general population characteristics and specific features of the participating sample have been taken into account. The sample of student participants (n = 199) consists of fourth-year secondary school students in the subject of Biological and Geological Sciences , drawn from 16 educational institutions, including both public and private schools, located in the region of Cantabria.

The sample was chosen from the group of students who had previously participated in a performance study. All students involved in the attitudinal study had prior experience using an AR application in their Science class, which illustrated a key concept. Therefore, following criteria established by experts like Sáez (2017), the selected sample for the attitudinal study can be considered representative of the population it represents.

In order to collect the participants' opinions on specific aspects related to the methodology and technology used in the classroom, an instrument based on an ad hoc questionnaire was designed. The instrument was custom-designed to be integrated in the research process and was adapted from previous models proposed by other authors to determine both the level of motivation and the degree of acceptance generated in students by using technological resources in educational environments.

On one hand, the Technology Acceptance Model (TAM) was chosen as a reference in order to determine students' level of acceptance of technology in connection with the use of an innovative educational methodology that combines an AR technological resource for explaining key concepts in the subject and an adapted digital evaluation system.,. The TAM, initially proposed by Davis (1989), continues to be utilized in various research studies concerning the applicability of educational technology (Cabrero, Barroso, & Gallego, 2018).

In summary, the TAM model developed by Davis (1989) suggests that individuals who perceive a positive relationship between the use of a technological application and their performance will also increase their acceptance of the application. This, in turn, may lead to an improvement in academic outcomes.

This dimension consists of nine items (five items for the Perceived Utility indicator and four items for the Perceived Ease of Use indicator).

On the other hand, the Instructional Materials Motivation Survey (IMMS) has been adopted as a reference in order to determine the level of motivation evoked in students by the use of an innovative methodology that incorporates the use of an AR technological resource to explain key concepts in the subject, combined with an adapted digital evaluation system.. This survey, proposed by the education expert Keller (2010), aims to estimate attitudes based on student motivation generated during the learning process through the use of technological resources. To achieve this objective, the survey was specifically adapted for the current study.

This dimension, in turn, consists of a total of 13 items (four items for the Attention indicator, three for the Relevance indicator, three for the Confidence indicator, and three others for the Satisfaction indicator). In addition to gathering information on the two aforementioned dimensions of motivation level and degree of acceptance, a third dimension was added to the instrument, initially referred to as the level of understanding. This dimension was represented by a single indicator called Perceived Ease of Understanding Key Concepts, composed of six items.

Overall, the instrument consisted of a total of three dimensions, with seven indicators and 35 items, complemented by categorical variables related to the students and the educational institutions, such as gender, age, geographic location, etc. The questionnaire, administered in an online format, contained questions concerning both the AR application itself and the evaluation system students had used in class. This approach adheres to recommendations for instrument design and fulfills the minimum observation quantity requirement in this type of study (Hair, Black, Babin, & Anderson, 2018).

The wording of the questions or items was done taking into account the criteria and recommendations established by educational experts such as Sáez (2017) for the design of this type of questionnaire. In this regard, when drafting the initial version of the questionnaire, several fundamental issues were considered. In addition to collecting students' opinions, the administration of the questionnaire also aimed at assessing students' attitudes towards the use of an innovative methodology based on the utilization of an AR resource and an adapted evaluation system to improve their understanding of key concepts in the subject. According to authors like Sáez (2017), attitude can be considered as a construct that can be observed directly and objectively, since attitude, as a psychological trait, is acquired and structured through practice, and individuals respond in specific ways to concrete stimuli.

In order to obtain information in connection with students' attitudes, an attitudinal scale was used, allowing each student to rate their responses using a structured scoring system within intervals on the scale. Specifically, a Likert-type attitudinal scale was utilized, graded with response intervals from 1 to 5, where 1 represented complete disagreement and 5 represented complete agreement. The selection of the number of response options for the questions took into account that a higher number of responses would lead to greater reliability in the scale. However, considering the context and educational level of the participating student sample, it was also important to avoid including an excessive number of response options that could exceed the students' ability to discriminate when responding.

In consultation with teachers, it was also determined that a maximum completion time of 20 minutes should be established for the questionnaire, providing students with sufficient time to respond calmly to all the questions.

To ensure the content validity of the ad hoc instrument, two approaches were employed. Firstly, a review of relevant literature regarding dimensions and indicators was conducted (Davis, 1989; Keller, 2010). Secondly, a content validity analysis was performed through expert judgment. A group of 10 experts with experience in instrument design and data analysis, representing various fields of expertise, was selected. The initial version of the questionnaire, comprising 26 items, was sent to the panel of expert judges for review and analysis (Table 1).

Table 1. Structure of the instrument sent to the group of experts for their review and analysis.

Dimensions	Indicators	Items
Degree of motivation	Attention	1-4
	Trust	5-7
	Satisfaction	8-10
	Relevance	11-13
Level of acceptance of AR technology	Perceived Usefulness	14-17
	Perceived Ease of Use	18-20
Degree of understanding of key concepts	Perceived Ease of Understanding Key Concepts	21-26

The "Expert Competence Coefficient" or "K Coefficient" was utilized to determine with precision the level of expertise of the judges who were asked to analyze the initial attitudinal questionnaire Once the experts' responses to the questions were analyzed, and following the criterion established by authors like Cabero and Barroso (2013), whereby the opinions of experts with an Expert Competence Coefficient (K) below 0.8 (k<0.8) should not be considered, the evaluations provided by nine out of the initial 10 experts were ultimately taken into account (Table 2).

The "Aiken V coefficient" was utilized to assess the analyses conducted by the selected group of expert judges on the set of 26 items proposed in the initial version of the questionnaire,. Proposed by Aiken (1980), this coefficient has been employed in recent years in research studies across various fields such as psychology, medicine, and education (Sáez-López, Román-González, & Vázquez-Cano, 2016).

Table 2. Expert Competence Coefficient (K) values obtained

Expert	Knowledge Coefficient (Kc)	Argumentation Coefficient (Ka)	Expert Competence Coefficient (K)
1	0,90	1,00	0,95
2	0,90	0,90	0,90
3	0,80	0,80	0,80
4	0,80	1,00	0,90
5	0,60	0,70	0,65
6	0,90	0,90	0,90
7	0,80	1,00	0,90
8	0,80	1,00	0,90
9	0,80	1,00	0,90
10	0,90	1,00	0,95

The conclusions and results obtained from analyzing the responses and recommendations provided by the experts align with the analysis of the data obtained

RELATEC Revista Latinoamericana de Tecnología Educativa

from the judges' evaluations. Therefore, taking all this into account, the initial version of the questionnaire was modified following the recommendations and criteria set forth by the experts, resulting in a revised and corrected questionnaire structured in three dimensions, seven indicators, and a total of 35 items:

- Dimension: Level of Motivation. Indicators: Attention (items 1-7), Confidence (items 8-11), Satisfaction (items 12-16), and Relevance (items 17-21)

- Dimension: Level of Acceptance of AR Technology. Indicators: Perceived Utility (items 22-26) and Perceived Ease of Use (items 27-30)

- Dimension: Level of Understanding Key Concepts. Indicator: Perceived Ease of Understanding Key Concepts (items 31-35)

The attitudinal study aimed to answer the following fundamental questions: first, whether the use of an innovative methodology based on AR technology and an adapted evaluation system can have an impact on motivation and the level of acceptance of technology, and second, whether the use of AR technology as a complementary educational resource enhances students'understanding of key concepts in science subjects.

The internal consistency and reliability of the instrument were assessed by analyzing the students' answers to the questionnaire. Cronbach's Alpha procedure, recommended by experts such as Hair, Black, Babin, and Anderson (2018) for polytomous scales, was employed for that purpose. Upon analyzing the results and interpreting the instrument's overall Cronbach's Alpha value, an excellent value of 0.980 (Cronbach's Alpha) was obtained. This exceeds the criterion set by authors like Sáez (2017), indicating that the instrument demonstrates strong internal consistency, as the Cronbach's Alpha value is ≥ 0.9.

It is worth noting the excellent partial values obtained for each of the dimensions comprising the instrument: level of motivation, level of acceptance of AR technology, and level of understanding of key concepts. All of them show high Cronbach's Alpha values of ≥ 0.9.

3. Results

Following the criteria of relevant experts such as Hair, Black, Babin, and Anderson (2018), an Exploratory Factor Analysis (EFA) was conducted to determine construct validity and to establish possible relationships between variables and dimensions or factors (Carrascal et al., 2023; Delgado, 2021). The use of this type of analysis is justified as one of the objectives of the attitudinal study was to explore the internal structure of the questionnaire through its main components and determine the presence of other underlying factors.

The coefficients of the correlation matrix were examined in order to verify the suitability of using this spific statistical analysis, , confirming the relationships between variable pairs. Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy were employed, yielding a value of 0.000 ($p < 0.05$) for the former and 0.956 (p > 0.5) for the latter. This confirmed that all conditions were met for conducting an EFA.

Subsequently, after confirming the necessary conditions, a Factor Analysis was performed using the Principal Component Method, where the first factor explained the majority of variance in the variables. After determining the first factor, the remaining factors were selected from the remaining variability. Due to the complexity of interpreting factors, as they correlate with multiple variables, a Varimax rotation was applied to ensure that each selected factor was strongly represented by a specific set of variables, facilitating interpretation in theoretical terms. Initially, four main factors were obtained through this method.

Considering the evidence from the data analysis presented in Table 3, it was determined that extracting only three main factors was appropriate. This number of factors was considered sufficient as it significantly reduced the initial number of factors and accounted for nearly 70% of the total variance.

Table 3. Principal factors and total explained variance. Delgado (2021).

Componente	Autovalores iniciales			Sumas de extracción de cargas al cuadrado			Sumas de rotación de cargas al cuadrado		
	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado
1	21,361	61,033	61,033	21,361	61,033	61,033	11,453	32,722	32,722
2	1,774	5,068	66,101	1,774	5,068	66,101	9,563	27,324	60,046
3	1,072	3,063	69,165	1,072	3,063	69,165	3,191	9,119	69,165
4	1,039	2,967	72,132						
5	,829	2,367	74,499						
6	,787	2,248	76,747						
7	,739	2,111	78,858						
8	,622	1,778	80,636						
9	,542	1,549	82,185						
10	,535	1,528	83,714						
11	,514	1,468	85,182						
12	,471	1,346	86,527						
13	,414	1,182	87,709						
14	,353	1,010	88,719						
15	,346	,988	89,708						
16	,322	,921	90,628						
17	,321	,918	91,547						
18	,290	,830	92,377						
19	,267	,764	93,140						
20	,232	,664	93,804						
21	,230	,657	94,461						
22	,222	,634	95,095						

Componente	Autovalores iniciales			Sumas de extracción de cargas al cuadrado			Sumas de rotación de cargas al cuadrado		
	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado
23	,208	,595	95,690						
24	,205	,585	96,275						
25	,180	,513	96,788						
26	,164	,470	97,258						
27	,163	,465	97,723						
28	,138	,395	98,118						
29	,121	,347	98,465						
30	,116	,331	98,796						
31	,107	,305	99,101						
32	,096	,274	99,375						
33	,084	,239	99,614						
34	,071	,203	99,817						
35	,064	,183	100,000						

Taking into account the criteria established by relevant measurement experts such as Abad et al. (2011), extracting more factors than necessary can result in a single variable representing multiple factors, although the appropriate structure is generally maintained. On the other hand, the choice of three main factors is justified, as selecting a fourth factor would not significantly improve the model fit and would introduce greater complexity for interpretation. Recommendations from experts such as Lorenzo-Seva and Ferrando (2013) suggesting that each factor should be represented by at least two theoretically related items were considered to interpret the obtained factors.

The variables that correlated most strongly with each of the aforementioned factors were studied for the purpose of assigning them names. The results obtained from the analysis allow naming the factors (components) as follows:

- First Factor: Level of motivation
- Second Factor: Degree of acceptance of AR technology
- Third Factor: Degree of acceptance of adapted digital assessment system

A detailed examination of the students' ratings was conducted by means of a descriptive analysis of the questionnaire items. The thorough analysis of the data obtained from the students' responses reveals mean scores above the theoretical average of the scale in all three dimensions of the questionnaire.

Students believe that the regular use by teachers of immersive technological resources based on AR would enhance their academic performance, primarily because they perceive a greater ease in understanding key concepts explained by their teachers compared to using textbooks or even non-immersive technologies.

Similar evaluations were also obtained for the adapted digital method employed to assess the students' acquired knowledge, indicating that students consider the use of this system as necessary and complementary to the utilization of immersive technological resources like AR to improve both their academic performance and their grades.

Therefore, after analyzing the items, the questionnaire's functionality to detect and determine students' opinions regarding the use of an innovative educational methodology based on the combination of AR resources and an adapted digital assessment system has been confirmed.

To further delve into the analysis of the students' ratings, homogeneity in the responses to each item was also examined. The obtained data serve as an indicator of the reliability of these ratings, establishing the instrument's relevance in identifying the most robust aspects related to the use of an educational resource based on AR technology and an adapted digital assessment system as essential pillars of an innovative educational methodology.

It is worth noting that the analysis of the data obtained from the students' responses revealed low standard deviations concerning their ratings, both for individual items and the overall average. This indicated a moderate homogeneity in the responses, reflecting a clear uniformity in the students' opinions regarding the use of the specific innovative educational methodology employed in this study.

In conclusion, the analysis of the students' responses confirms the functionality of the questionnaire as a valid instrument to collect their opinions. Additionally, it enables determining the most robust and vulnerable aspects of using a specific innovative educational methodology based on the use of technological resources for educational and assessment purposes, which were fundamental objectives of this study.

4. Conclusions

The analysis of the data obtained in this study on the factorial structure of the questionnaire administered to students reveals the existence of a factor related to the degree of acceptance of digital assessment systems adapted to the use of educational technological resources based on AR, which overall was positively valued by the study participants. The data confirm that the set of three factors, consistingof the level of motivation, the degree of technological acceptance, and the degree of acceptance of an adapted digital assessment system, represents best the data structure as a construct (Carrascal et al., 2023; Delgado, 2021).

These findings suggest the need to incorporate adapted assessment systems as part of educational methodological strategies that are based on the use of educational technology in general and immersive resources based on AR in particular. This finding is consistent with the hypothesis proposed by digital technology experts like Livingstone (2012), suggested in reports published by international organizations (OECD, 2015) and upheld by educational experts such as Nieto (2016) and Blázquez, Alonso, and Yuste (2017) in terms of enabling a positive effect produced by the use of an innovative methodology in combination with a digital and adapted assessment system, thus inducing profound methodological changes that favor the improvement of teaching and learning processes in Science subjects. These changes are based on the acquisition of specific skills and strategies related to the educational technological resource that cannot be effectively and efficiently achieved or quantified with traditional assessment systems.

The main contribution of this research lies in empirically validating the central hypothesis of the theoretical model proposed. This hypothesis is based on the assumption that the use of an innovative educational methodology that combines the use of an immersive AR resource and an adapted digital assessment system leads to improvements and gains in the learning process of secondary school Science students.

These findings provide empirical evidence and fill the current gap in the literature identified by authors such as Alkhattabi (2017), Cabero-Almenara et al. (2019) and Fombona and Pascual (2017) regarding the specific features that should characterize active educational methodologies based on immersive technological resources and the need to incorporate digital assessment systems integrated in these methodologies.

The level of difficulty involved in designing, developing, and implementing an innovative educational methodology based on the use of technological resources requires carrying out complementary studies in order to expand the data obtained through this research process. Further studies should include Confirmatory Factor Analysis (CFA) with the main objective of verifying the degree of fit of the model proposed in this study with additional results.

In this regard, it is worth noting that due to the intrinsic characteristics of these types of studies, the complexity in their design, the access to the groups of students that make up the selected sample, etc., the research has been conducted exclusively in educational centers located in the region of Cantabria. The data obtained in this study should be compared with data obtained from its implementation in other territories, with other samples of students and in different educational centers.

5. References

Abad, F., Olea, J., Ponsoda, V., y García, C. (2011). *Medición en ciencias sociales y de la salud.* Síntesis.

Aiken, L. (1980). Content Validity and Reliability of Single Items or Questionnaires. *Educational and Psychological Measurement, 40*(4), 955-959. https://doi.org/10.1177/001316448004000419

Akçayır, M., Akçayırb, G., Miraç, H., y Akif, M. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior, 57*, 334-342. https://doi.org/10.1016/j.chb.2015.12.054

Alalwan, N., Cheng, L., Al-Samarraie, H., Yousef, R., Alzahrani, A., y Sarsam, S. (2020). Challenges and Prospects of Virtual Reality and Augmented Reality Utilization among Primary School Teachers: A Developing Country Perspective. *Studies in Educational Evaluation, 66*(100876). https://doi.org/10.1016/j.stueduc.2020.100876

Alkhattabi, M. (2017). Augmented Reality as E-learning Tool in Primary Schools' Education: Barriers to Teachers' Adoption. *International Journal of Emerging Technologies in Learning, 12*(2), 91-100. https://doi.org/10.3991/ijet.v12i02.6158

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., y Kinshuk. (2014). Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *Educational Technology & Society, 17*(4), 133–149.

Blázquez, F., Alonso, L., y Yuste, R. (2017). *La evaluación en la era digital.* Síntesis.

Brown, M., McCormack, M., Reeves, J., Brooks, C., Grajek, G., Alexander, B., Bali. M., Bulger, S., Dark, S., Engelbert, N., Gannon, K., Gauthier, A., Gibson, D. Gibson, R., Lundin, B. Veletsianos, G., y Weber, N. (2020). *2020 EDUCAUSE Horizon Report, Teaching and Learning Edition .* Louisville, CO: EDUCAUSE. https://library.educause.edu

Cabero, J., y Barroso, J. (2013). La utilización del Juicio de Experto para la evaluación de TIC: El Coeficiente de Competencia Experta. *Bordón. Revista de Pedagogía, 65*(2), 25-38. https://doi.org/10.13042/brp.2013.65202

Cabero, J., Barroso, J., y Gallego, Ó. (2018). La producción de objetos de aprendizaje en realidad aumentada por los estudiantes. Los estudiantes como prosumidores de información. *Revista Tecnología, Ciencia y Educación*(11), 15-16. Obtenido de https://tecnologia-ciencia-educacion.com/index.php/TCE/article/view/221

Cabero, J., Leiva, J., Moreno, N., Barroso, J., y López, E. (2016). *Realidad Aumentada y educación. innovación en contextos formativos* (1ª ed.). Octaedro.

Cabero-Almenara, J., Barroso-Osuna, J., Llorente-Cejudo , C., y Fernández, M. (2019). Educational Uses of Augmented Reality (AR): Experiences in Educational Science. *Sustainability, 11*(18). https://doi.org/10.3390/su11184990

Cai, S., Chiang, F.-K., Sun, Y., Lin, C., y Lee, J. (2017). Applications of augmented reality-based natural interactive learning in magnetic field instruction. *Interactive Learning Environments, 25*(6), 778–791. https://doi.org/10.1080/10494820.2016.1181094

Carrascal, S., Delgado-Rodríguez, S., y Garcia-Fandiño, R. (2023). Design, Development and Validation of an Educational Methodology Using Immersive Augmented Reality for STEAM Education. *Journal of New Approaches in Educational Research, 12*(1), 19-39.

https://doi.org/10.7821/naer.2023.1.1250

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340. https://doi.org/10.2307/249008

Delgado, S. (2021). *Diseño, desarrollo y validación de un modelo metodológico educativo basado en software inmersivo de Realidad Aumentada como recurso didáctico. Mejora en el aprendizaje de ciencias en Educación Secundaria* (Tesis Doctoral). Universidad Camilo José Cela, Madrid, España. www.ucjc.edu

Fombona, J., y Pascual, M. (2017). La producción científica sobre Realidad Aumentada, un análisis de la situación educativa desde la perspectiva SCOPUS. *EDMETIC, Revista de Educación Mediática y TIC, 6*(1), 39-61. https://doi.org/10.21071/edmetic.v6i1.5807

Hair, J., Black, W., Babin, B., y Anderson, R. (2018). *Multivariate Data Analysis* (8th ed.). Cengage Learning, EMEA.

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

Herpich, F., Fernanda da Silva, P., y Rockenbach, L. (2021). Efecto de las interacciones de estudiantes de ciencias con laboratorios virtuales de realidad aumentada para el desarrollo de visualización espacial. *Revista Latinoamericana De Tecnología Educativa - RELATEC, 20*(2), 29-47. https://doi.org/10.17398/1695-288X.20.2.29

Keller, J. (2010). *Motivational Design for Learning and Performance. The ARCS Model Approach.* Springer.

Kim, K., Hwang, J., Zo , H., y Hwansoo, L. (2014). Understanding users' continuance intention toward smartphone augmented reality applications. *Information Development, 32*(2), 161-174. https://doi.org/10.1177/0266666914535119

Livingstone, S. (2012). Critical reflections on the benefits of ICT in education. *Oxford Review of Education, 38*(1), 9-24.

Lorenzo-Seva, U., y Ferrando, P. J. (2013). Factor 9.2: A comprehensive program for fitting exploratory and semiconfirmatory factor analysis and IRT models. *Applied Psychological Measurement*, 37(6), 497–498. https://doi.org/10.1177/0146621613487794

Nieto, E. (2016). El papel de las tecnologías en el desarrollo de los aprendizajes y en la mejora del rendimiento académico. En M. Rodríguez, E. Nieto, y R. Sumozas, *Las tecnologías en educación. Hacia la calidad educativa* (pp. 17-33). Síntesis.

Organización para la Cooperación y el Desarrollo Económicos. (2015). *Students, Computers and Learning: Making the Connection.* PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264239555-en

Pelletier, K., Brown, M., Brooks, D., McCormack, M., Reeves, J., Arbino, N., Bozkurt, A., Crawford, S., Czerniewicz, L., Gibson, R., Linder, K., Mason, J., y Mondelli, V. (2021). *2021 EDUCAUSE Horizon Report, Teaching and Learning Edition.* Boulder, CO: EDUCAUSE Publications. https://library.educause.edu

Prendes, C. (2015). Realidad Aumentada en educación: Análisis de experiencias prácticas. *Píxel-Bit. Revista de Medios y Educación*(46), 187-203. https://doi.org/10.12795/pixelbit.2015.i46.12

Sáez, J. (2017). *Investigación educativa. Fundamentos teóricos, procesos y elementos prácticos* (1ª ed.). UNED.

Sáez-López, J., Román-González, M., y Vázquez-Cano, E. (2016). Visual programming languages integrated across the curriculum in elementary school: A two year case study using "Scratch" in five schools. *Computers & Education, 97*, 129-141. https://doi.org/10.1016/j.compedu.2016.03.003

Tarng, W., Ou, K.-L., Lu, Y.-C., Shih, Y.-S., y Liou, H.-H. (2018). A Sun Path Observation System Based on Augment Reality and Mobile Learning. *Mobile Information Systems , 2018*, 1-10. https://doi.org/10.1155/2018/5950732