Capacitación en

Realidad Aumentada & Inmersiva 3D

Estado del Arte

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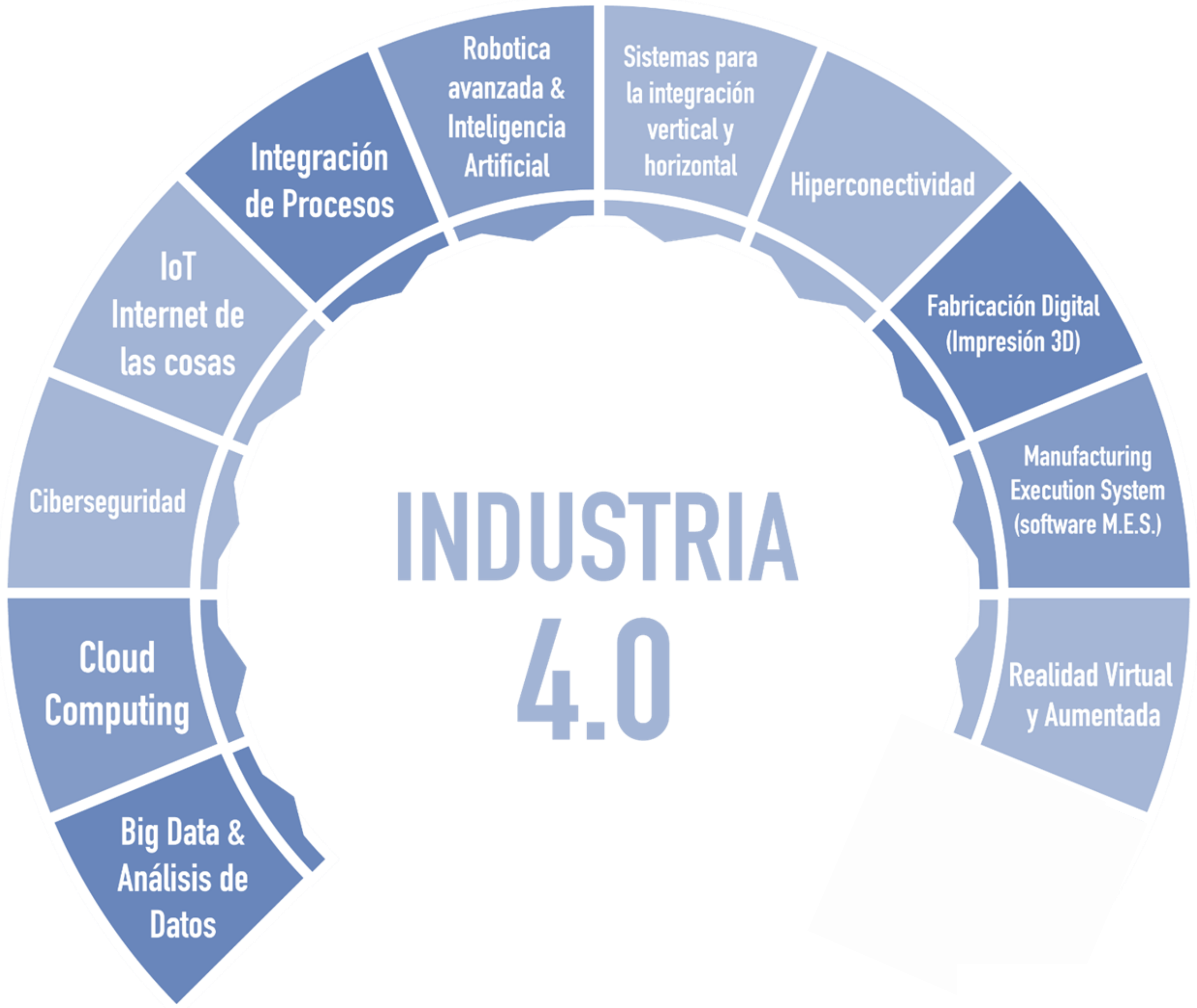


Formación 4.0

Smart Mining

Construcción 4.0

Formación

4.0

Realidad

Aumentada

The New York Times

Pokémon Go Brings Augmented Reality to a Mass Audience

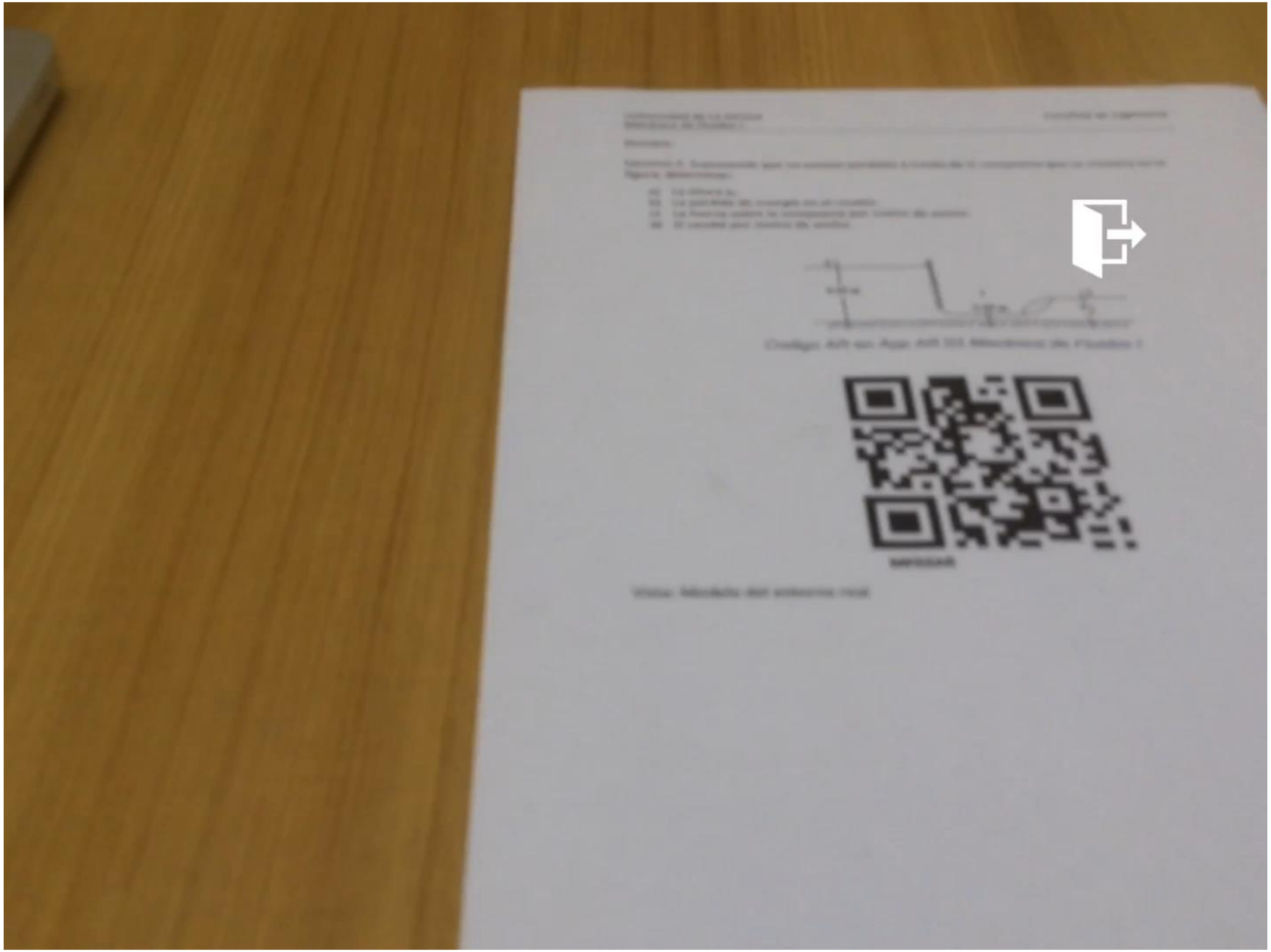
Give this article 228

Diego Escudero, 24, and Kay Collins, 22, played Pokémon Go in San Francisco on Sunday. Jason Henry for The New York Times

By Nick Wingfield and Mike Isaac
July 11, 2016

SAN FRANCISCO — There are video games that go viral

The New York Times (2016)
https://www.nytimes.com/2016/07/12/technology/pokemon-go-brings-augmented-reality-to-a-mass-audience.html



Ver Video

Motivación

Industria

4.0

… AR forma parte del gran abanico de tecnologías relacionadas con la industria 4.0 y la transformación digital

(Vidal-Balea et al., 2020)

Forbes

3 Ways Manufacturers Can Win In The Industry 4.0 Revolution

Anise Madh Forbes Councils Member
Forbes Business Council COUNCIL POST | Membership (Fee-Based)

Nov 1, 2022, 07:30am EDT

Anise Madh is the CEO of LeanSwift, a global leader in eCommerce and mobile solutions for Infor M3.

GETTY

Industry 4.0—also known as the Fourth Industrial Revolution—has ushered a monumental shift in the global manufacturing industry, and it's rapidly changing how companies operate. This strategy expands on existing automation technologies and processes to include the Internet of Things (IoT), machine learning (ML), cloud and edge computing, augmented reality (AR) and more.

Forbes (2022)

https://www.forbes.com/sites/forbesbusinesscouncil/2022/11/01/3-ways-manufacturers-can-win-in-the-industry-40-revolution/?sh=18ad6d341e9e

ABC (2021)

https://www.abc.es/economia/abci-fabrica-40-conecta-realidad-virtual-y-aumentada-202106220124_noticia.html

→ ABC → **Economía**

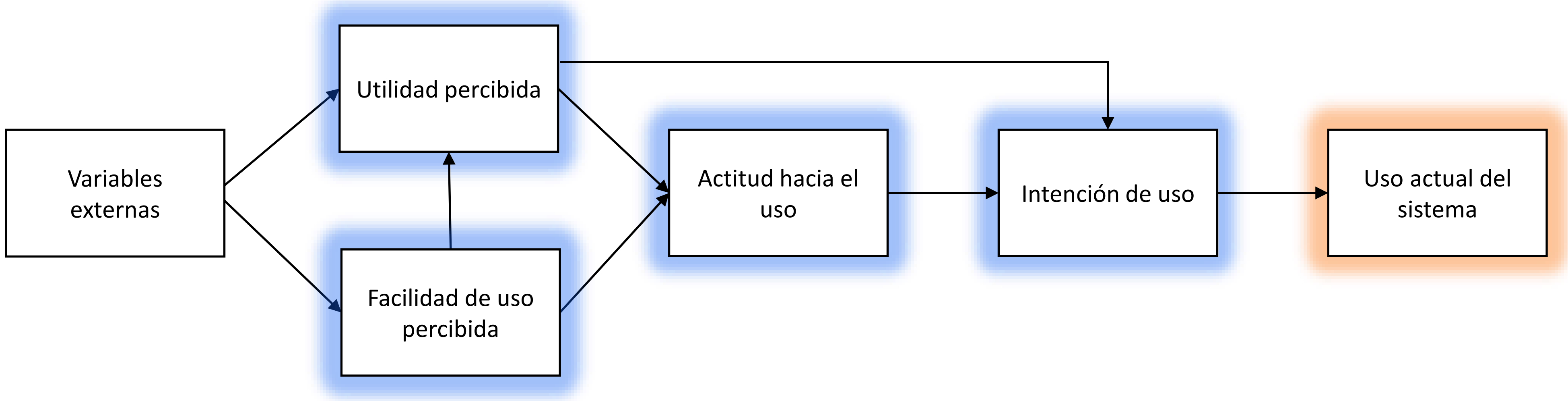
La fábrica 4.0 se conecta a la realidad virtual y aumentada

Diseño, identificación de errores, mantenimiento, formación... la industria española empieza a explorar las muchas posibilidades de estas tecnologías

Aceptación Tecnológica

Modelo de Aceptación Tecnológica **TAM**

(Davis, 1986)



Estado del arte

del uso de la tecnología de

realidad aumentada *en educación en*

ingeniería

RQ$_5$ | *¿Qué grado de interactividad presentan las aplicaciones de realidad aumentada utilizadas?*

4 **Interacción en tiempo real.** El alumno puede interactuar en una simulación donde los estímulos generan respuestas complejas.

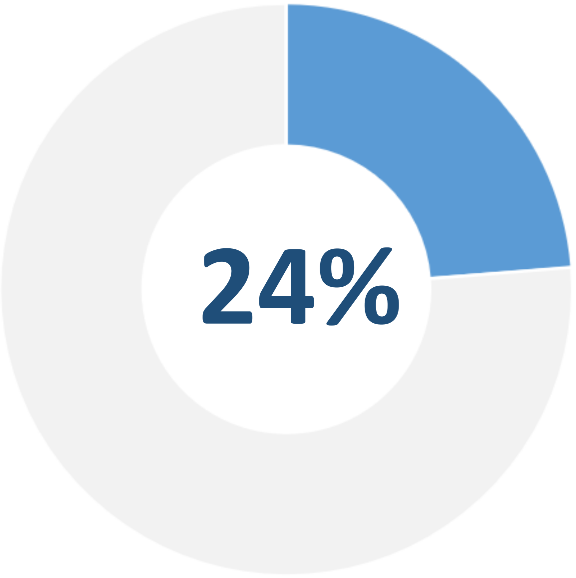
3 **Interacción compleja.** El alumno puede manipular objetos gráficos para analizar su comportamiento.

2 **Interacción limitada.** Las aplicaciones consideran una interacción simple con el alumno. A modo de ejemplo preguntas sencillas para que el alumno responda.

1 **Pasiva.** La interacción es directa y unidireccional. El alumno es un mero receptor de información, leyendo texto en una pantalla, viendo gráficos o ilustraciones, entre otros.

(Aqel, 2013)

RQ$_5$ | *¿Qué grado de interactividad presentan las aplicaciones de realidad aumentada utilizadas?*



N = 42 apps

4 **Interacción en tiempo real.** El alumno puede interactuar en una simulación donde los estímulos generan respuestas complejas.

3 **Interacción compleja.** El alumno puede manipular objetos gráficos para analizar su comportamiento.

2 **Interacción limitada.** Las aplicaciones consideran una con el alumno. A modo de ejemplo preguntas sencillas para que el alumno responda.

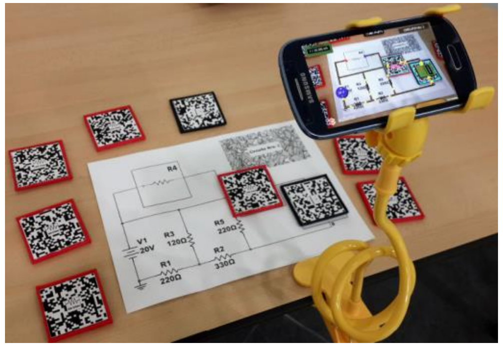
1 **Pasiva.** La interacción es directa y unidireccional. El alumno es un mero receptor de información, leyendo texto en una pantalla, viendo gráficos o ilustraciones, entre otros.

(Aqel, 2013)

RQ$_5$ | *¿Qué grado de interactividad presentan las aplicaciones de realidad aumentada utilizadas?*

Virtual Circuits

(Lucas et al., 2018)



4 **Interacción en tiempo real.** El alumno puede interactuar en una simulación donde los estímulos generan respuestas complejas.

3 **Interacción compleja.** El alumno puede manipular objetos gráficos para analizar su comportamiento.

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(Aqel, 2013)

Augmented Reality and Engineering Education: A Systematic Review

Alejandro Álvarez-Marín, *Member, IEEE* and J. Ángel Velázquez-Iturbide, *Senior Member, IEEE*

***Abstract*—Augmented reality (AR) for learning is a relevant topic that has recently received considerable attention. However, the current literature lacks a survey of AR-based educational approaches and experiences in the specific field of engineering studies. Five research questions were addressed: RQ1) engineering studies where AR is used; RQ2) types of educational activities where AR is used; RQ3) evaluation of its impact on students and instructors; RQ4) relevant characteristics of AR apps; and RQ5) their degree of interactivity. Regarding RQ1, it is concluded that AR has been mainly used in technical drawing, electronics, and construction. Concerning RQ2, AR apps have assisted in lectures, exercise classes, and laboratories. However, the preferred educational activity varies for each discipline. Regarding RQ3, it has been found that AR apps have been evaluated with respect to students' or instructors' perceptions and students' academic performance. In general, the perceptions are positive, but students criticize some technical elements. Moreover, academic performance is increased in most studies. Finally, regarding RQ4 and RQ5, AR apps do not achieve the highest levels of functional characteristics and have low degrees of interactivity. The systematic review indicates that there is plenty of room for the future use of AR in engineering studies, but each engineering area must identify adequate educational purposes. It is also recommended to assess apps through objective measures, more structured constructs, and validated scales. Finally, higher functional characteristics and interactivity should be encouraged to exploit the full potential of AR.**

***Index Terms*—Augmented reality (AR), engineering education, learning technologies, systematic review.**

I. Introduction

IN the recent past, emerging technologies have offered new opportunities to enhance education. Specifically, the use of computers in the classroom can improve students' experiences and increase their academic achievements. One of such technologies is augmented reality (AR) [1], where virtual and real objects are integrated in real time, often in a 3-D

real objects in the real world [2]. AR applications (apps) can show virtual objects by using a marker that acts as a spatial reference [3]. Typically, AR apps are offered as mobile apps, although they may also rely on alternative wearable devices, such as head-mounted displays (HMDs), Oculus Rift, or HTC Vive, which provide a wider field of view and lower latency. In addition, current HMD devices can be combined with other tracker systems, such as eye-tracking systems, or motion and orientation sensors [4]. Augmentation is not limited to the sense of sight, but it can be provided for other senses, such as hearing or touch. Finally, some AR apps allow for the removal of real objects from the perceived environment [5].

AR apps have been increasingly used in the last decade. Therefore, a growing number of experiences and user experiments in different areas have been reported, including education [6]. Until now, systematic reviews on AR use in education have been conducted both in general [7]–[11] and specific fields, most notably in medicine (in particular, in the training of surgical procedures [12]–[16]). Systematic reviews are also available on the use of AR in industrial maintenance operations [2] and the usability of AR apps [6].

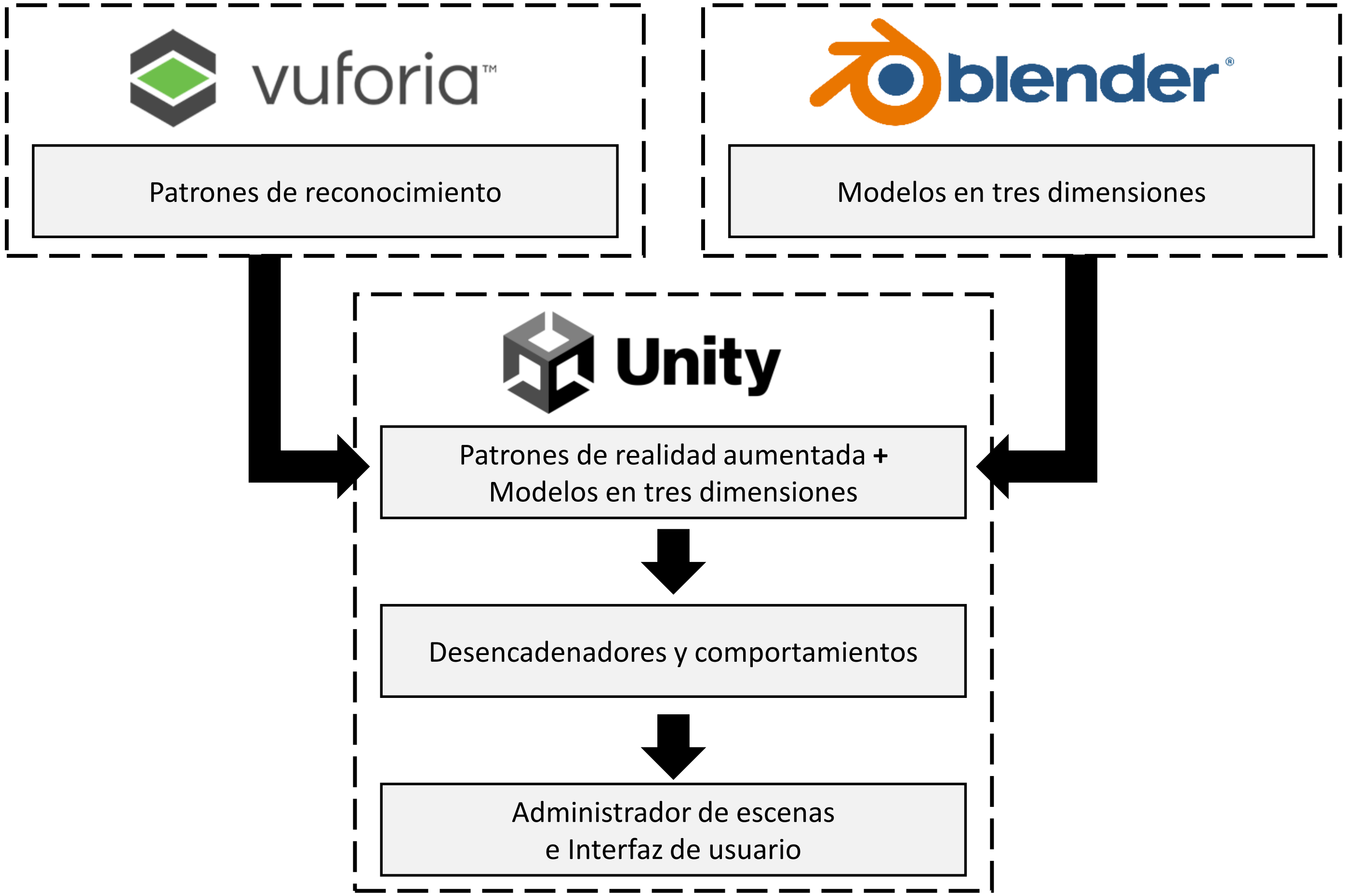
Five systematic AR reviews can be found in broader educational areas. The first study [7] investigates certain factors, such as the uses, advantages, limitations, effectiveness, challenges, and characteristics of AR in educational environments. The primary purpose of AR has been to explain a topic of interest, thus providing additional information. It has been effective in enhancing students' academic performance, motivation, commitment, and positive attitudes. The study also identifies some limitations of the technology, including difficulties in keeping overlaid information, paying too much attention to virtual information, and the consideration of AR

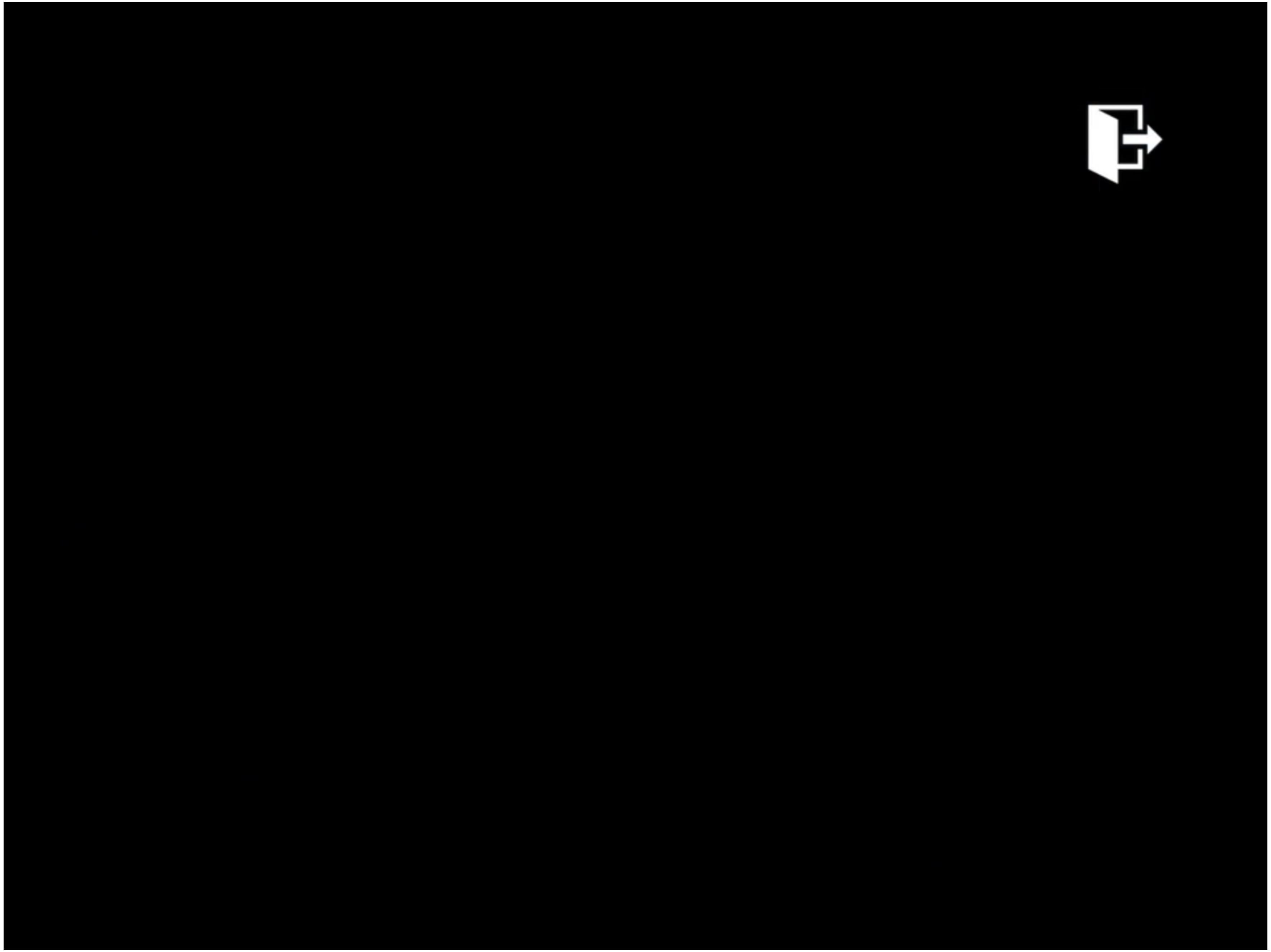
Álvarez-Marín, A., and Velázquez-Iturbide, J.Á. (2021). Augmented reality and engineering education: A systematic review. In IEEE Transactions on Learning Technologies, 14(6), 817-831. doi: 10.1109/TLT.2022.3144356.

WoS Q1

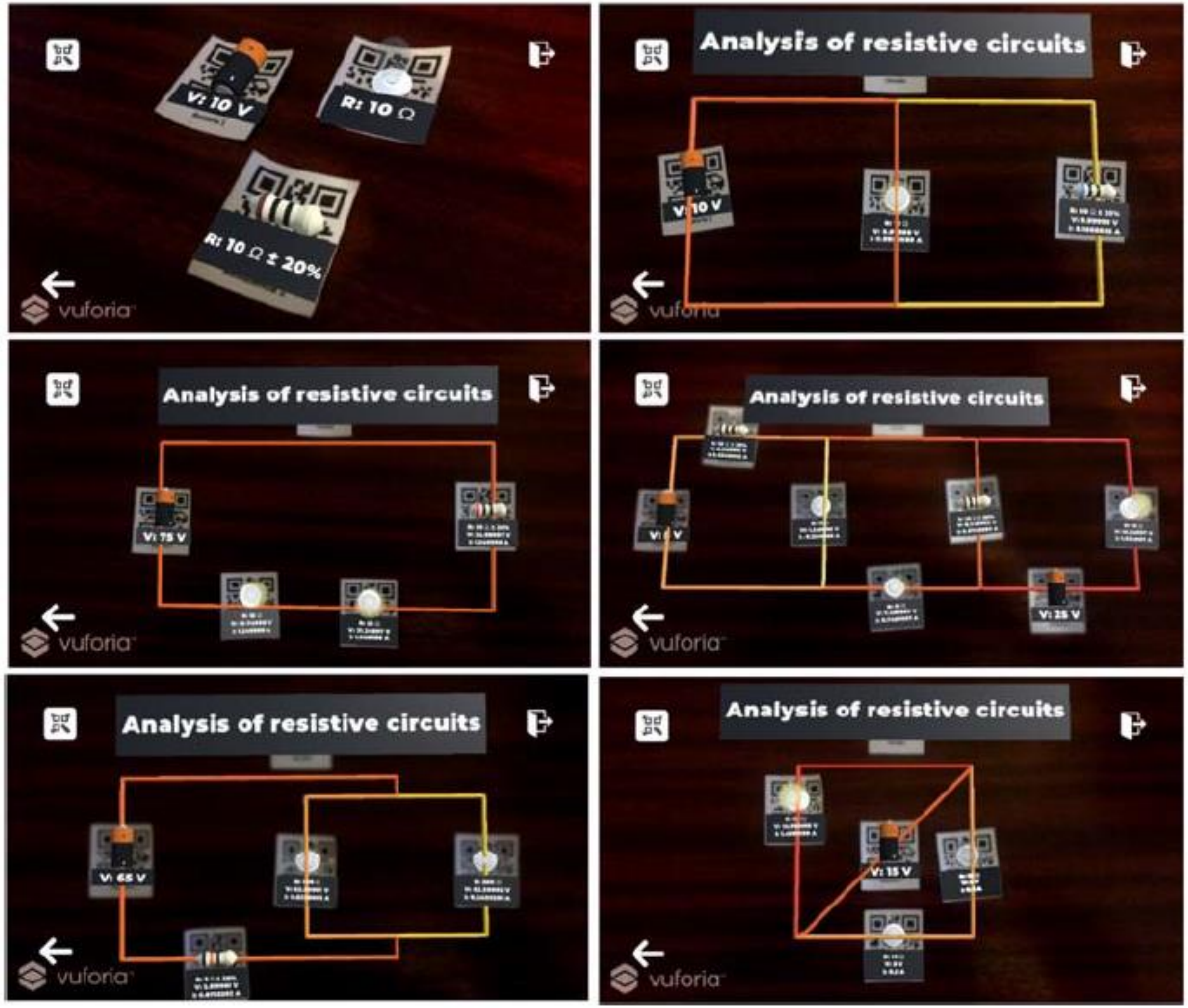
Aplicación de realidad aumentada *desarrollada*

Arquitectura Aplicación Desarrollada





Ver Video



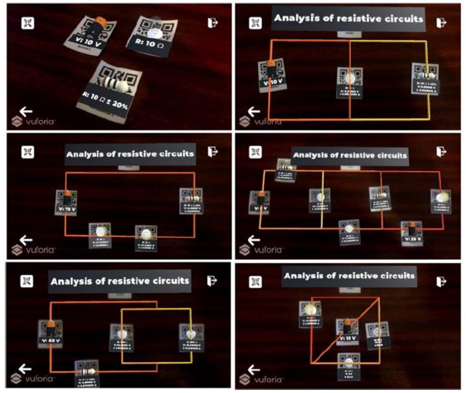
V: 10 V
R: 10 Ω
R: 10 Ω ± 20%
Analysis of resistive circuits
V: 10 V
Analysis of resistive circuits
V: 75 V
Analysis of resistive circuits
V: 25 V
Analysis of resistive circuits
V: 65 V
Analysis of resistive circuits
V: 15 V

Grado Interactividad | Nivel 4

4

Aplicación Desarrollada

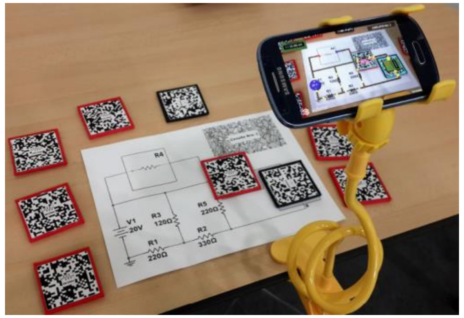
(Álvarez-Marín et al., 2021)



3

Otras Aplicaciones

(Lucas et al., 2018)



Interactive AR App for Real-Time Analysis of Resistive Circuits

Alejandro Álvarez-Marín, *Member, IEEE*, J. Ángel Velázquez-Iturbide, *Senior Member, IEEE*, and Ricardo Campos-Villarroel

***Abstract*—An augmented reality app for real-time analysis of direct current in resistive circuits is presented. The app allows the manipulation of circuit elements and computes the values of voltage and current intensity using the loop method and applying the Kirchhoff's voltage law. The app can be used in theoretical classes and laboratories. The contributions of this paper are two-fold. First, the app has higher levels of interactivity than other apps in the same domain since it allows defining the configuration and the parameters of the circuit. Second, the app performs more complex computations than similar apps in real-time.**

***Index Terms*—Augmented reality, resistive circuits, laboratories, DC analysis.**

I. Introduction

AUGMENTED reality (AR) technology integrates virtual objects, often in three-dimensional models, with real scenarios in real-time [1]. It allows the user to observe objects in the real world while simultaneously delivering additional information, such as virtual object overlays [2] or explanatory instructions [3]. AR is increasingly used in different areas, including education [4]. The use of AR in the classroom can contribute to improving students' experiences. Its implementation in educational processes has achieved more active participation by students [5], increasing their interest and motivation to learn [6]–[8]. This technology has also been shown to increase students' academic performance due to its ability to allow a quick understanding of spatial problems and complex relationships [9]–[11].

Electronics is one of the areas where AR educational apps have been used. Most of the experiences in this area are carried out in laboratories and allow interaction with real electronic boards. Using *targets* (element or marker, which must be recognized by a device such as a *smartphone* or a *tablet*, to identify the position of a virtual object to be projected), it is possible to visualize real electronic components on the boards also additional virtual components. In some cases, it is possible to simulate the behavior of an electronic board with switches as AR elements [12]–[14] or to know the inner wiring of an electronic component by selecting it with a pen pointer [15]. In other cases, apps can guide an electronic board's repair by analyzing its components and then through step-by-step guidance [16].

Besides, there are experiences with electrical circuits designed with symbols. This more straightforward approach allows interpreting standard electrical symbols as *targets*, showing their components in three dimensions and giving an explanatory note for each of them [17]. A more advanced feature is to include switches to analyze the circuit behavior when enabled [18]. Also, electrical circuits can be configured through *targets* representing different components to allow the user to observe the resulting operation [5], [17], [18].

Some apps support electronic equipment analysis. Electrical and electronic components are identified and provide different information types, such as monitoring data, visualization of the internal structure, technical circuit design, and instructions, among others [19].

Usually, the instructor plays a guiding role in laboratory classes [20], either supporting learning as a peer-to-peer guide [21] or providing the conditions to perform simulations [13], [14], [16], [18].

We analyze the degree of interactivity in these AR apps. Aqel [22] proposes four levels to examine the degree of interactivity.

Level I: Passive. The interaction is straightforward and unidirectional. The learner is only a receiver of information,

Álvarez-Marín, A., Velázquez-Iturbide, J.Á., and Campos-Villarroel, R. (2021). Interactive AR app for real-time analysis of resistive circuits in interactive learning environments. In IEEE Revista Iberoamericana de Tecnologías del Aprendizaje, 16(2), 187- 193. doi: 10.1109/RITA.2021.3089917.

WoS *(ESCI)*

Intención de uso *de la aplicación desarrollada*

La actitud hacia el uso se refiere a la evaluación del usuario sobre la conveniencia de utilizar una determinada tecnología.

(Fishbein & Ajzen, 1975)

La intención de uso se define como la probabilidad subjetiva de que una persona utilice un sistema.

(Davis, 1993)

Resultados

Item	Media	SD
Actitud hacia el Uso | 1	4,49	0,74
Actitud hacia el Uso | 2	3,95	0,93
Actitud hacia el Uso | 3	4,65	0,65
Actitud hacia el Uso | 4	4,64	0,62
Actitud hacia el Uso | 5	4,33	0,74
Actitud hacia el Uso | Media	**4,41**	**0,55**
Intención de Uso | 1	4,41	0,77
Intención de Uso | 2	4,31	0,82
Intención de Uso | 3	4,36	0,78
Intención de Uso | Media	**4,36**	**0,69**

N = 314 estudiantes (190 on-line; 124 presencial)

2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)

Intention to use an interactive AR app for engineering education

Alejandro Álvarez-Marín[1*] J. Ángel Velázquez-Iturbide[2] Mauricio Castillo-Vergara[3]

1 Departamento de Ingeniería Industrial, Universidad de La Serena, La Serena, Chile
2 Departamento de Informática y Estadística, Universidad Rey Juan Carlos, Móstoles, Madrid, Spain
3 Facultad de Economía y Negocios, Universidad Alberto Hurtado, Santiago, Chile

Abstract

Augmented reality (AR) has been incorporated into educational processes in various subjects to improve academic performance. One of these areas is the field of electronics since students often have difficulty understanding electricity. An interactive AR app on electrical circuits was developed. The app allows the manipulation of circuit elements, computes the voltage and amperage values using the loop method, and applies Kirchhoff's voltage law. This research aims to determine the intention of using the AR app by students. It also looks to determine if it is conditioned by how the survey is applied (online or face-to-face) or students' gender. The results show that the app is well evaluated on the intention of use by students. Regarding how the survey is applied, the *attitude towards using* does not present significant differences. In contrast, the students who carried out the online survey presented a higher *behavioral intention to use* than those who participated in the guided laboratory. Regarding gender, women showed a higher *attitude toward using* and *behavioral intention to use* this technology than men.

Keywords: Augmented reality; technology acceptance; engineering; education.

Index Terms: Applied computing --- Education --- Interactive learning environments.

1 Introduction

AR is a technology that has been incorporated in different areas, one of which is education, which has been shown to help improve academic performance [1]. In engineering, one of the subjects that this technology applies is electronics. Students find some concepts difficult to understand, such as electricity, since they cannot visualize how it works [2].

One of the complex elements for understanding is the behavior

circuits. The acceptance of technology seeks to explain its use and is related to the *behavioral intention to use* [4]. Likewise, studies carried out in RA have determined that the *attitude toward using* positively influences the *behavioral intention to use* [5], [6].

It is also interesting to determine if the intention to use this technology depends on whether the student was instructed to use this technology in a guided laboratory class or an independent instance where they can download the app and practice freely. The above is important because situations where people cannot meet in large numbers (for example, confinement or meeting restrictions by COVID-19), taking these measuring remotely, can be a good alternative.

Finally, it is also useful to determine if gender influences the *behavioral intention to use* this technology. That is due to the historical disparity that women present in this area of engineering education.

2 App Design

An AR app to analyze digital current (DC) in resistive circuits was designed. A resistive circuit may include batteries, light bulbs, and resistors. The app has to choose five types of circuits in serial and parallel. These circuits allow any configuration and simulate current flow when batteries, light bulbs, and resistors are incorporated.

The app allows the user to change the batteries' voltage values and the resistance of light bulbs and resistors. Furthermore, the app calculates in real-time and displays the resulting values of voltage and amperage (Figure 1).

By exhibiting a higher degree of interactivity than existing apps [2], [7], it allows students to practice and experiment with a wide range of electrical circuit configurations.

The app computes the circuit configuration results proposed by using the loop method and applying Kirchhoff's voltage law [8].

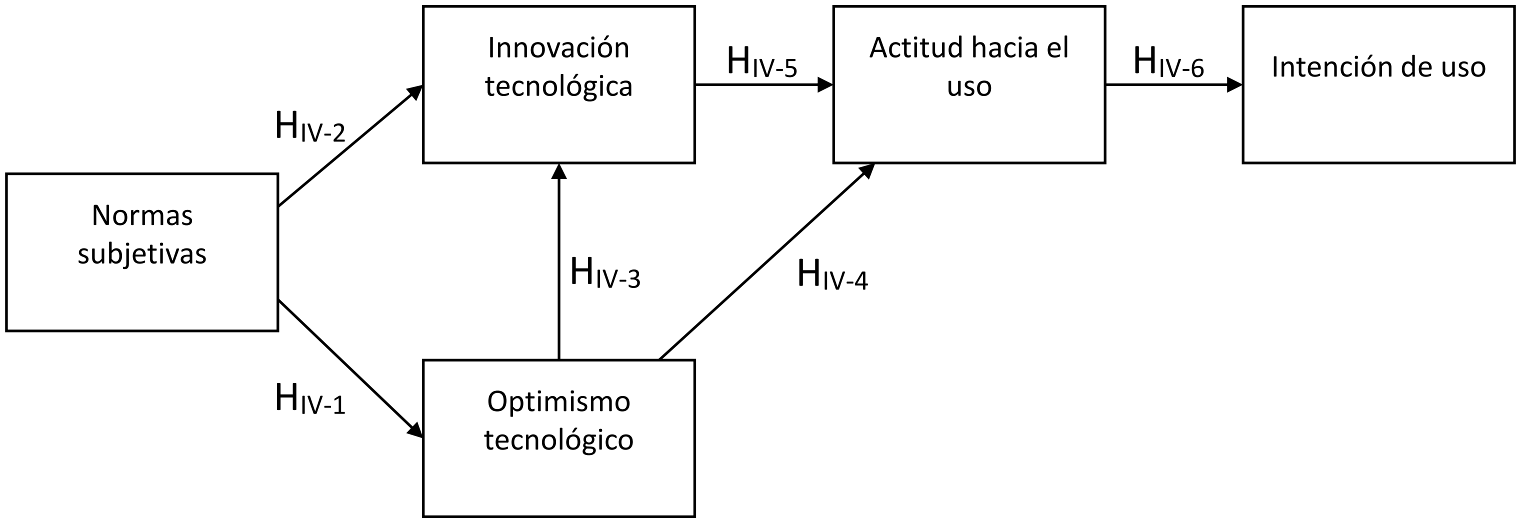
Álvarez-Marín, A., Velázquez-Iturbide, J.Á., and Castillo-Vergara, M. (2020). Intention to use an interactive AR app for engineering education. In 2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), 70-73. doi: 10.1109/ISMAR-Adjunct51615.2020.00033.

Core *A**

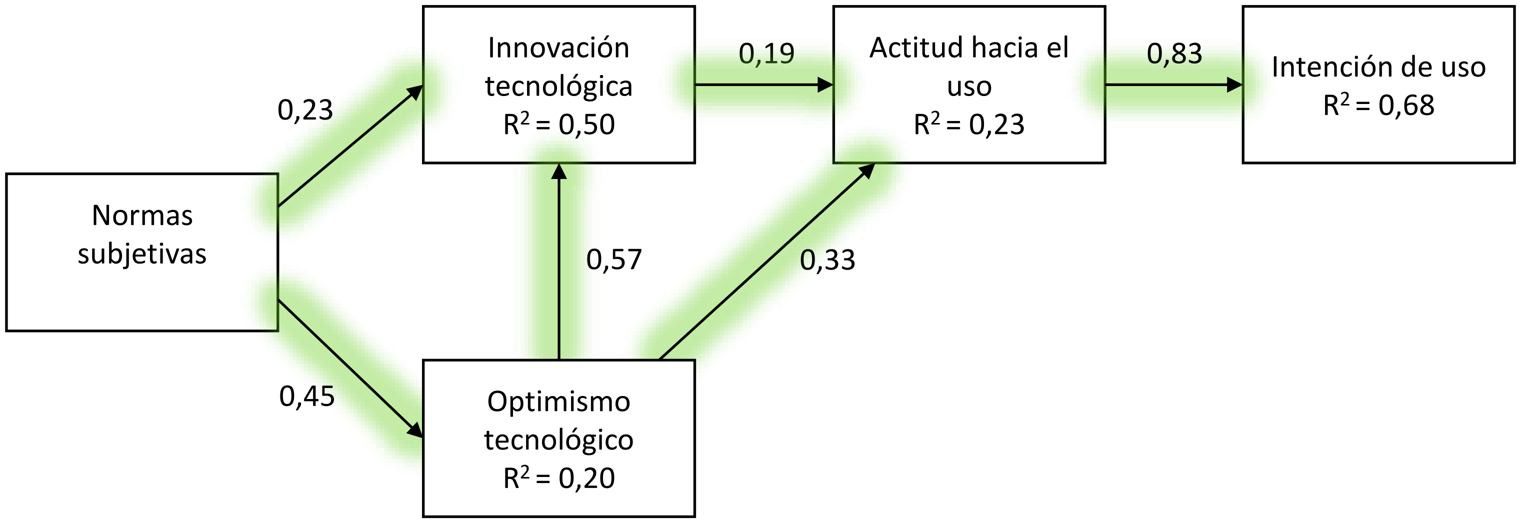
Papel que desempeñan el ***optimismo*** *y la* ***innovación tecnológica***

en la ***aceptación de la tecnología*** *de realidad aumentada en el área de*

educación en ingeniería



N = 173 estudiantes (laboratorio on-line)



Innovación tecnológica
R2 = 0,50
0,19
Actitud hacia el uso
R2 = 0,23
0,83
Intención de uso
R2 = 0,68
0,23
Normas subjetivas
0,57
0,33
0,45
Optimismo tecnológico
R2 = 0,20

INTERACTIVE LEARNING ENVIRONMENTS
https://doi.org/10.1080/10494820.2021.1928710

Routledge
Taylor & Francis Group

Check for updates

The acceptance of augmented reality in engineering education: the role of technology optimism and technology innovativeness

Alejandro Álvarez-Marín [a], J. Ángel Velázquez-Iturbide [b] and Mauricio Castillo-Vergara [c]

[a]Departamento de Ingeniería Industrial, Universidad de La Serena, La Serena, Chile; [b]Escuela Técnica Superior de Ingeniería Informática, Universidad Rey Juan Carlos, Móstoles, Madrid, Spain; [c]Facultad de Economía y Negocios, Universidad Alberto Hurtado, Santiago, Chile

ABSTRACT

This study aims to determine if *technology optimism* and *technology innovativeness* can explain and predict the use of augmented reality in the scope of engineering education. An Augmented Reality app to analyze digital current (DC) in resistive circuits was developed was developed to enhance students' understanding of electricity. The app allows the manipulation of circuit elements, computes the voltage and amperage values using the loop method by applying Kirchhoff's voltage law. A model with the following variables was theoretically conceived: *subjective norms*, *technology optimism*, *technology innovativeness*, *attitude toward using* and *behavioral intention to use*. The study considered a sample of 173 engineering students and was carried out using structural equation modeling. The findings suggest that *subjective norms* have a positive effect on *technology optimism* and *technology innovativeness*. Further, *attitude toward using* was found to depend on a medium range of students' characteristics, such as *technology optimism* and *technology innovativeness*. The results suggest that the academic environment can influence a student's beliefs concerning new technologies. Understanding how the educational environment can affect students' attitudes toward the use of new technologies can help higher education institutions establish policies for their adoption to facilitate the learning process.

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KEYWORDS
Augmented reality; technology acceptance; engineering; education; interactive app

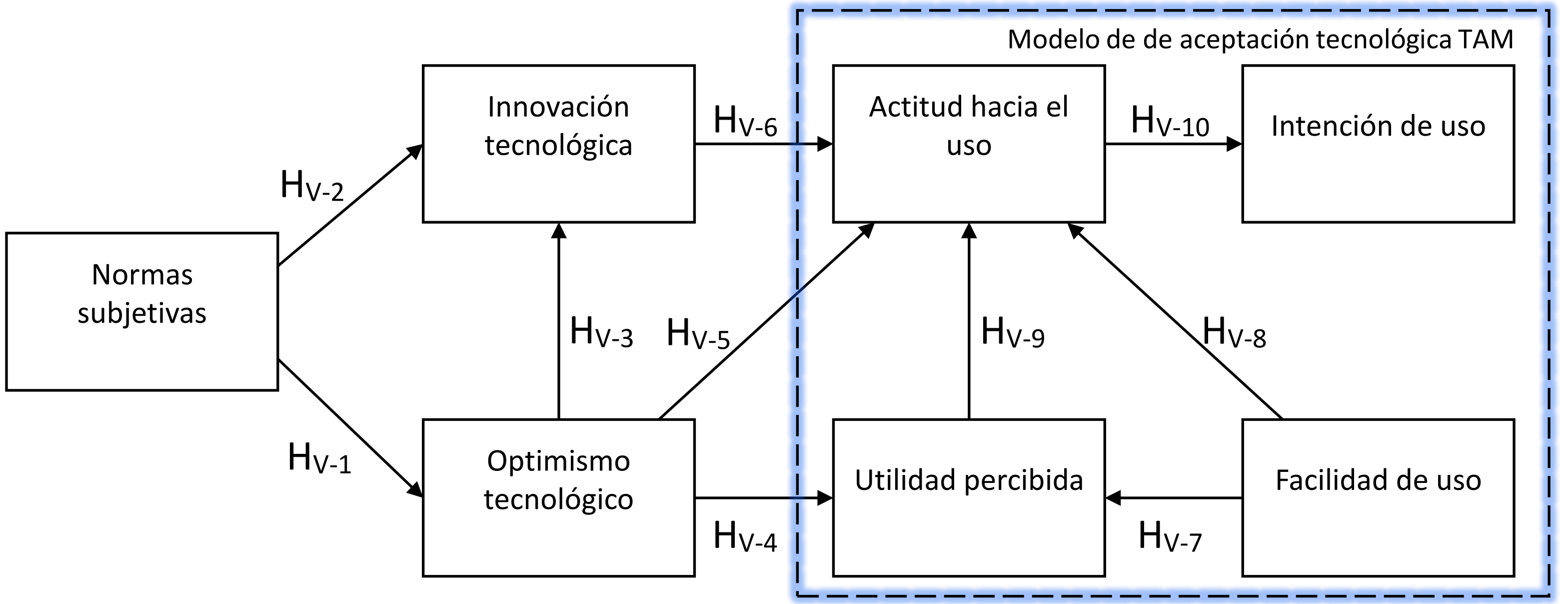
Introduction

Information technology use could be highly beneficial for organizations in achieving their objectives. However, acceptance of these new technologies is necessary to realize the benefits, and the education system is no exception. New technologies can be incorporated into the teaching and learning process to improve students' performance, granting them the opportunity to be more competitive by learning more efficiently and effectively via a student-cantered way of teaching (Al-Maroof & Al-Emran, 2018). However, students' resistance to new technologies poses a challenge in the

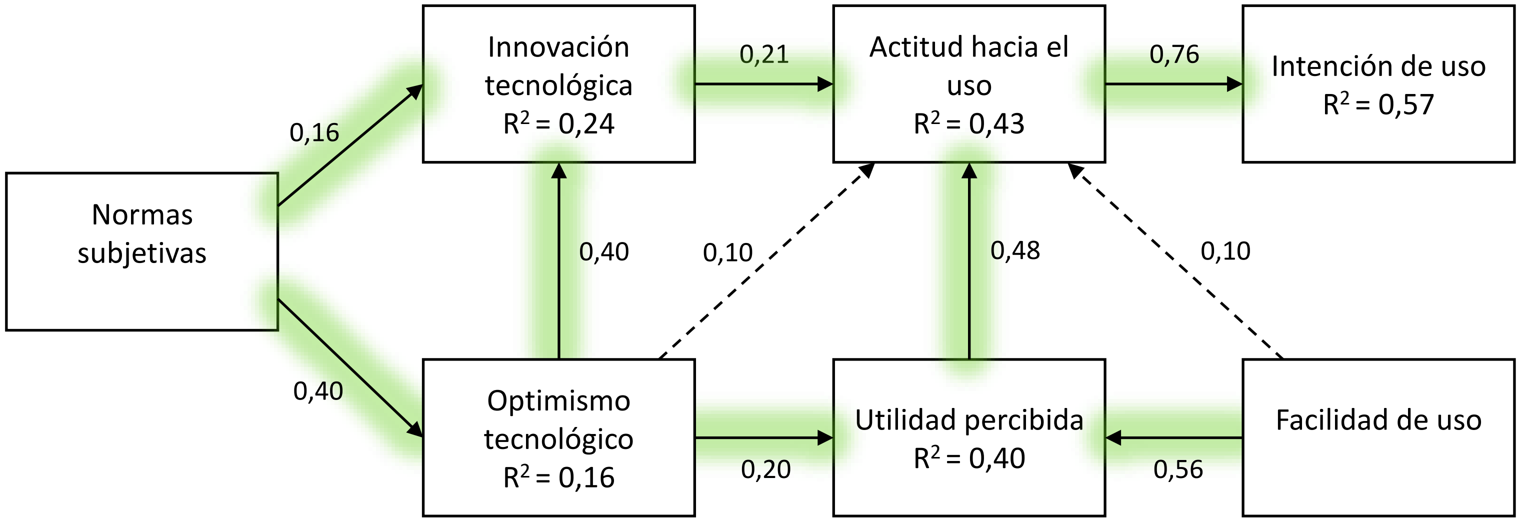
Álvarez-Marín, A., Velázquez-Iturbide, J.Á., and Castillo-Vergara, M. (2021). The acceptance of augmented reality in engineering education: The role of technology optimism and technology innovativeness. In Interactive Learning Environments. doi: 10.1080/10494820.2021.1928710.

WoS Q1

Variables *que pueden* ***explicar*** *y* ***predecir el uso*** *de esta tecnología por parte de los estudiantes de ingeniería*



N = 190 estudiantes (laboratorio presencial)



N = 190 estudiantes (laboratorio presencial)

electronics

Article

Technology Acceptance of an Interactive Augmented Reality App on Resistive Circuits for Engineering Students

Alejandro Álvarez-Marín [1,*], J. Ángel Velázquez-Iturbide [2] and Mauricio Castillo-Vergara [3]

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2 Escuela Técnica Superior de Ingeniería Informática, Universidad Rey Juan Carlos, 28933 Madrid, Spain; angel.velazquez@urjc.es
3 Faculty of Economics and Business, Universidad Alberto Hurtado, Santiago 8340578, Chile; mhcastillo@uahurtado.cl
* Correspondence: aalvarez@userena.cl

Abstract: In this study, we aim to establish the factors that explain the technology acceptance of augmented reality (AR) in students' engineering education. Technology acceptance of AR apps has been insufficiently investigated. We conceive a theoretical model to explain technology acceptance by relating behavioral intention to use with the variables subjective norm, technology optimism, technology innovativeness, perceived ease of use, perceived usefulness, and attitude toward using. An interactive AR app on electrical circuits was designed to assist students to overcome their difficulties in understanding how electricity works. A theoretical model was hypothesized and tested using structural equation modeling. The study was conducted using a sample of 190 engineering students. The results demonstrate the positive effect of technology optimism and technology innovativeness on perceived usefulness and attitude toward using, respectively. Furthermore, they suggest that attitude toward using is influenced by perceived usefulness but not directly by perceived ease of use. This could mean that students would be willing to use this app if they find it useful and not just easy to use. Finally, the results illustrate that attitude toward using firmly explains behavioral intention to use, which is consistent with the findings in previous studies. These results could guide how academics and higher education centers should approach the incorporation of these technologies in classrooms.

Keywords: augmented reality; education; engineering; mobile learning; technology acceptance

Citation: Álvarez-Marín, A.; Velázquez-Iturbide, J.Á.; Castillo-Vergara, M. Technology Acceptance of an Interactive Augmented Reality App on Resistive Circuits for Engineering Students. *Electronics* **2021**, *10*, 1286. https://doi.org/10.3390/electronics10111286

Academic Editors: Daniela M. Romano and Vinoba Vinayagamoorthy

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Published: 28 May 2021

1. Introduction

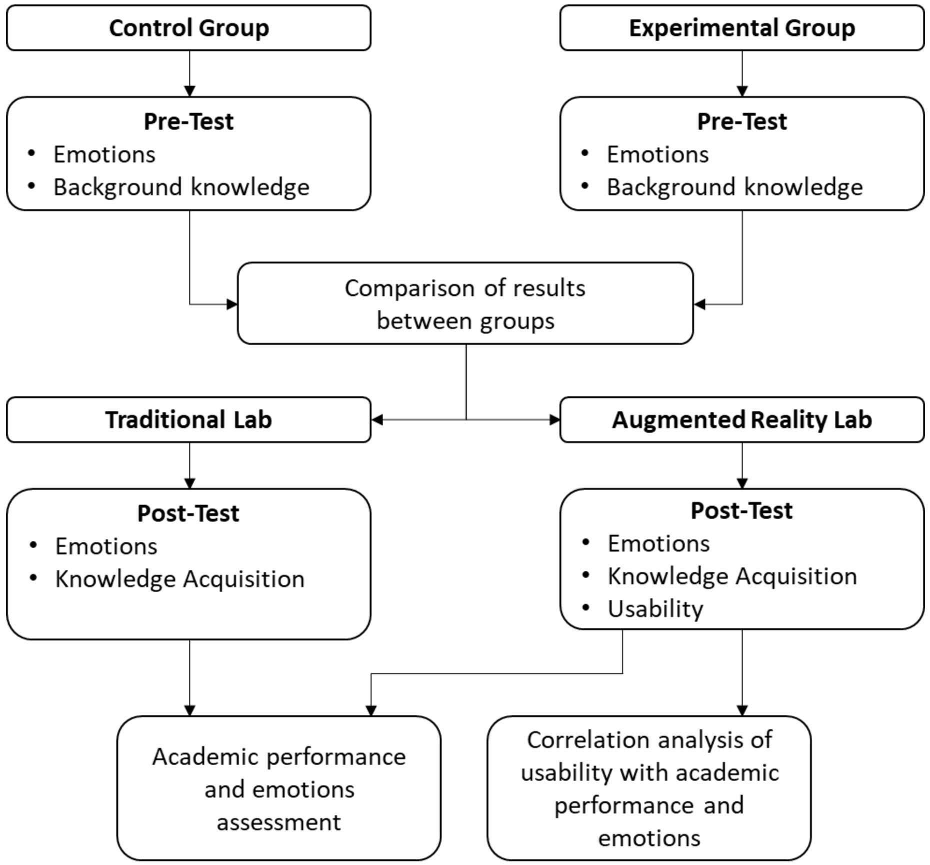
The education sector can benefit significantly by incorporating information technologies and improving the academic performance of students [1,2]. However, students'

Álvarez-Marín, A., Velázquez-Iturbide, J.Á., and Castillo-Vergara, M. (2021). Technology acceptance of an interactive augmented reality app on resistive circuits for engineering students. In Electronics, 10(11), 1286. doi: 10.3390/electronics10111286.

WoS Q2

Realidad aumentada & educación en electrónica:

Usabilidad, desempeño académico y emociones experimentados en el aprendizaje



N = 28 estudiantes (grupo experimental: 18; grupo de control: 10)

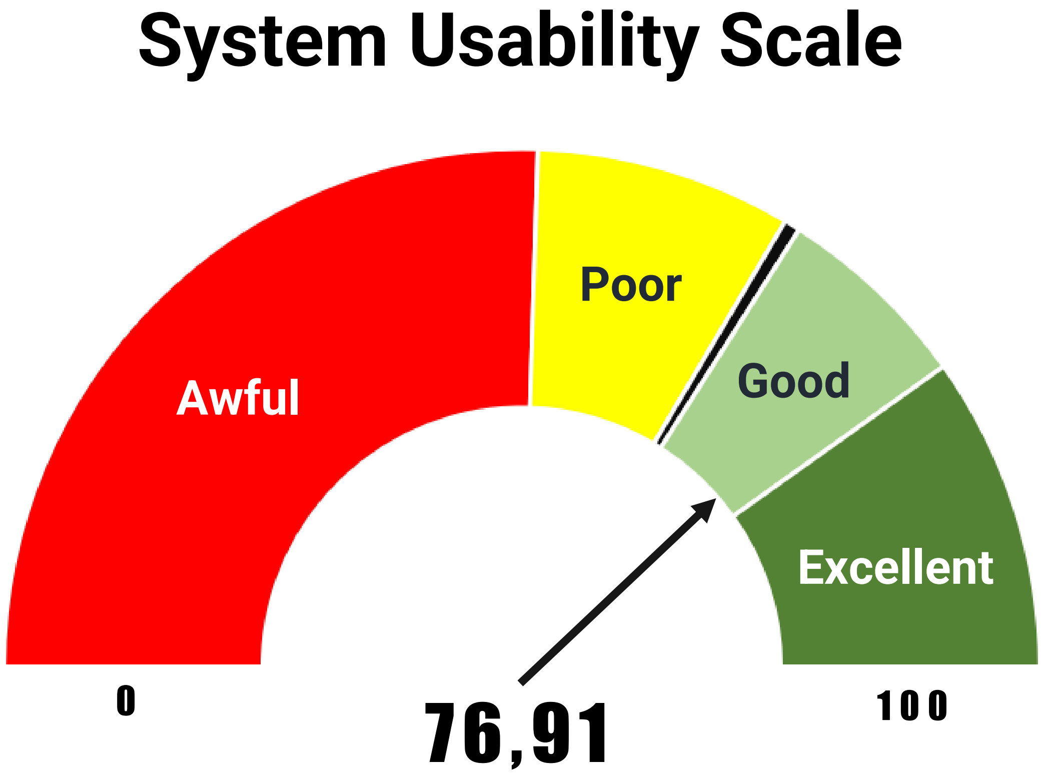
System Usability Scale (SUS)

Uno de los cuestionarios estandarizados más utilizados para evaluar la usabilidad percibida.

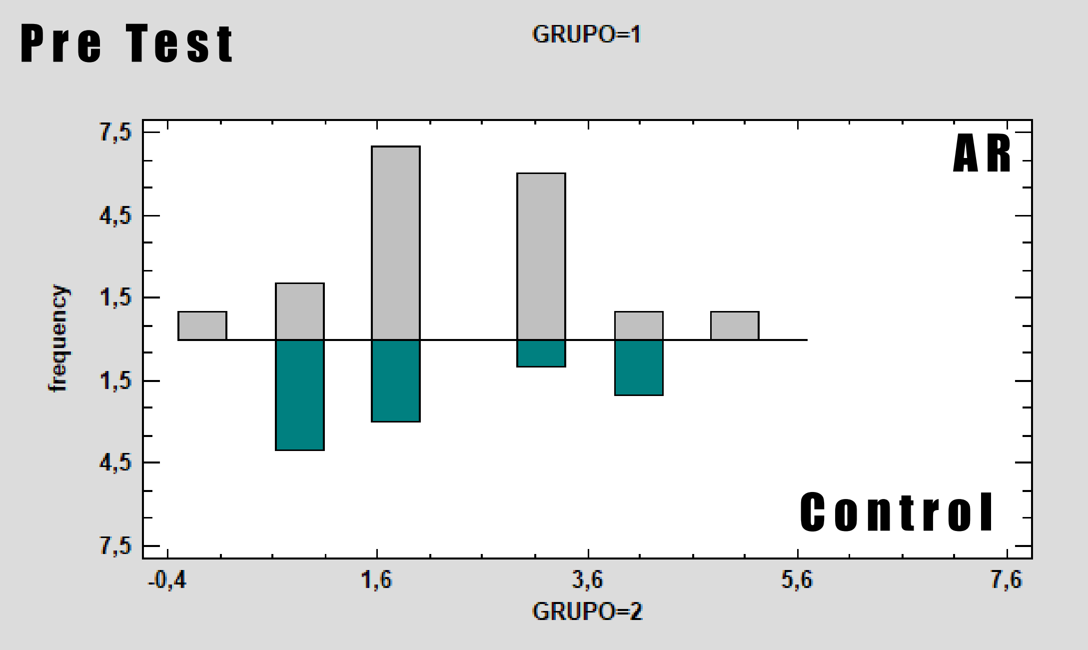
(Lewis, 2018)

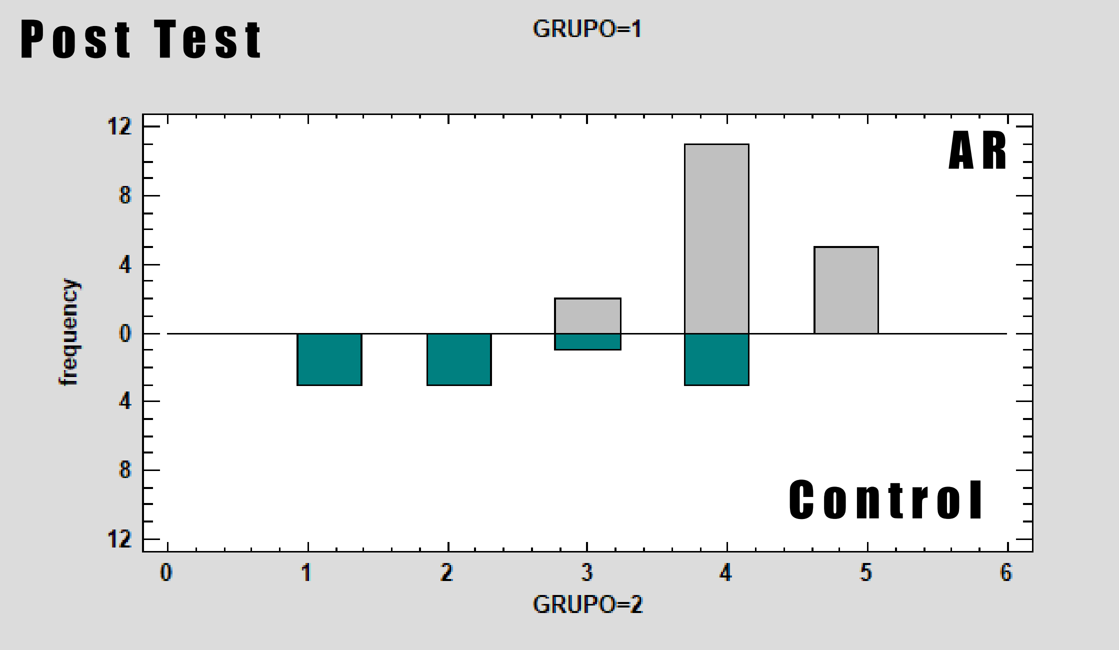
	SUS	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1.	I think that I would like to use this website frequently.	☐	☐	☐	☐	☐
2.	I found the website unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought the website was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need the support of a technical person to be able to use this website.	☐	☐	☐	☐	☐
5.	I found the various functions in this website were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this website.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this website very quickly.	☐	☐	☐	☐	☐
8.	I found the website very cumbersome / awkward to use.	☐	☐	☐	☐	☐
9.	I felt very confident using the website.	☐	☐	☐	☐	☐
10.	I needed to learn a lot of things before I could get going with this system.	☐	☐	☐	☐	☐

Usabilidad


System Usability Scale
Poor
Awful
Good
Excellent
0
76,91
100

Rendimiento Académico





Emociones

Achievement Emotions Questionnaire (AEQ)

Es una escala consistente y validada para medir

emociones en un contexto educacional.

(Paoloni et al., 2014)

Emociones

	Grupo de Control			Grupo Experimental		
	Antes	Después	p-value	Antes	Después	p-value
Ira	2,50	2,80	0,24	2,54	2,94	0,13
Disfrute	3,10	3,00	0,40	2,89	3,24	0,14
Desesperanza	2,65	2,78	0,37	2,86	2,72	0,34
Ansiedad	2,70	3,45	0,03	2,85	3,56	0,01
Vergüenza	3,30	3,07	0,34	4,11	2,89	0,00
Emociones positivas	3,43	3,13	0,17	3,34	3,33	0,41
Emociones negativas de activación	2,83	3,11	0,18	3,17	3,13	0,44
Emociones negativas de desactivación	2,83	2,78	0,44	2,99	2,72	0,19

Received: 11 January 2023 | Revised: 28 June 2023 | Accepted: 17 July 2023

DOI: 10.1002/cae.22670

RESEARCH ARTICLE

WILEY

Augmented reality and education in electronics: Relationship between usability, academic performance, and emotions experienced in learning

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Funding information
Government of the Region of Madrid, Grant/Award Number: S2018/TCS-4307; Research Department of the University of La Serena, Grant/Award Numbers: PR2111014, TTP221103

Abstract

Students often find difficult to understand the concepts and working details of electricity because its mechanisms of operation are invisible. The visualization of electricity through an augmented reality (AR) app could assist students in understanding these concepts more intuitively and in improving their academic achievement. Due to the lack of studies on AR apps for electricity education, this study aimed to investigate the effects of an interactive AR app designed for teaching electrical circuits on students. The study investigates its impact on students' academic performance, explores its influence on their emotions, and examines the relationship between the perceived usability of the app and the student's learning outcomes and emotional experiences. The study was conducted in an electromagnetism laboratory with the participation of 28 engineering students. The findings revealed that the students who used the augmented reality application presented a better academic performance than those who participated in the traditional laboratory. Except for the students in the experimental group feeling less shame, there were no discernible variations between the students' feelings in the two groups. Anxiety increases in both groups. The AR application proved to have usability rated as good, but it was not evident that it correlated with academic performance, or the emotions students experienced. Only one relationship was determined between the perceived consistency of the system and hopelessness.

KEYWORDS
augmented reality, emotions, engineering education, learning technologies, usability

Álvarez-Marín, A., Paredes-Velasco, M., Velázquez-Iturbide, J.Á., and Poblete-Castro, J.C (2023). Augmented reality and education in electronics: Relationship between usability, academic performance, and emotions experienced in learning. In Comput. Appl. Eng. Educ., 1-11. doi: 10.1002/cae.22670.

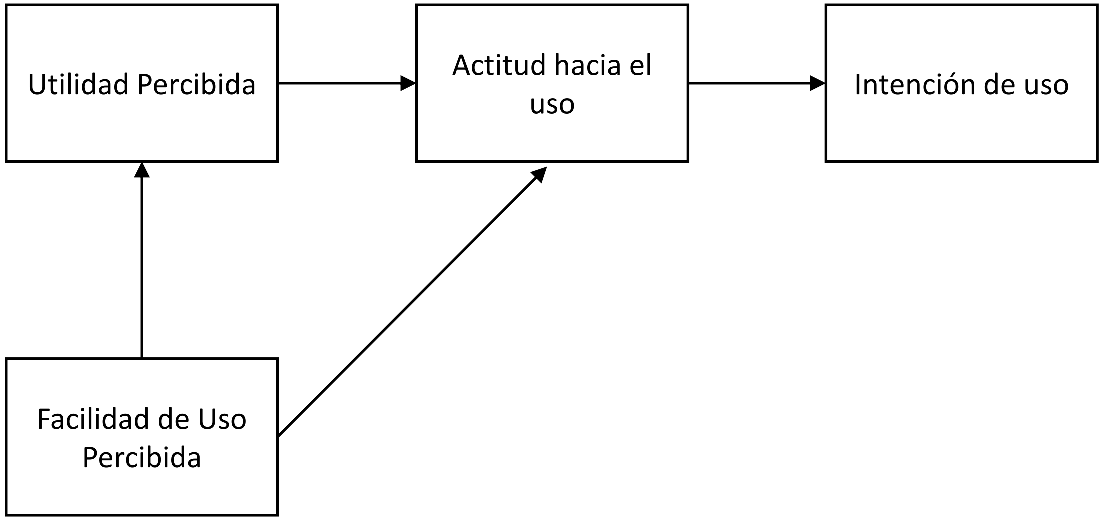
WoS Q2

El rol moderador de la Estética

y la Calidad de la Información

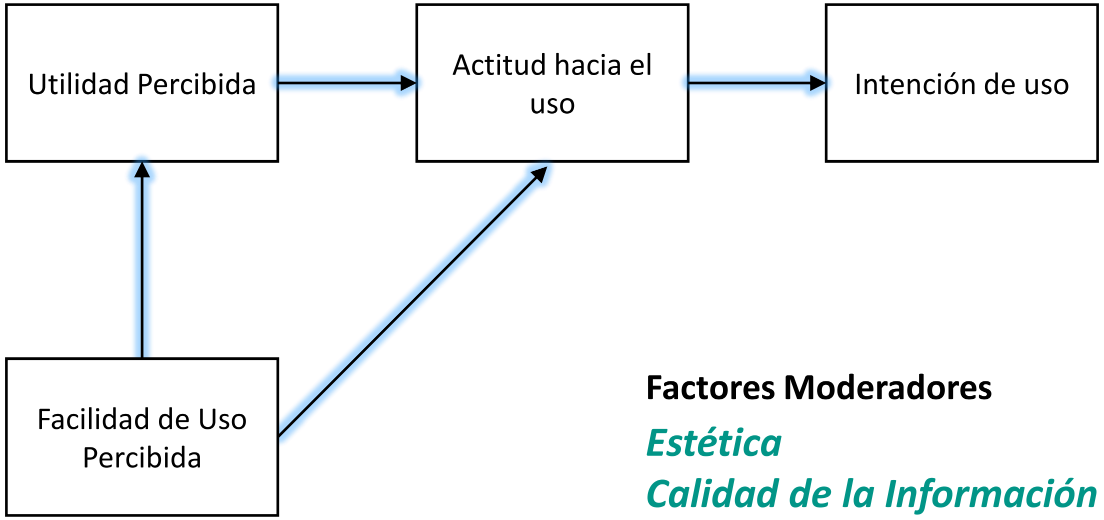
para la aceptación de la realidad aumentada

Efecto Moderador



N = 190 estudiantes (laboratorio presencial)

Efecto Moderador



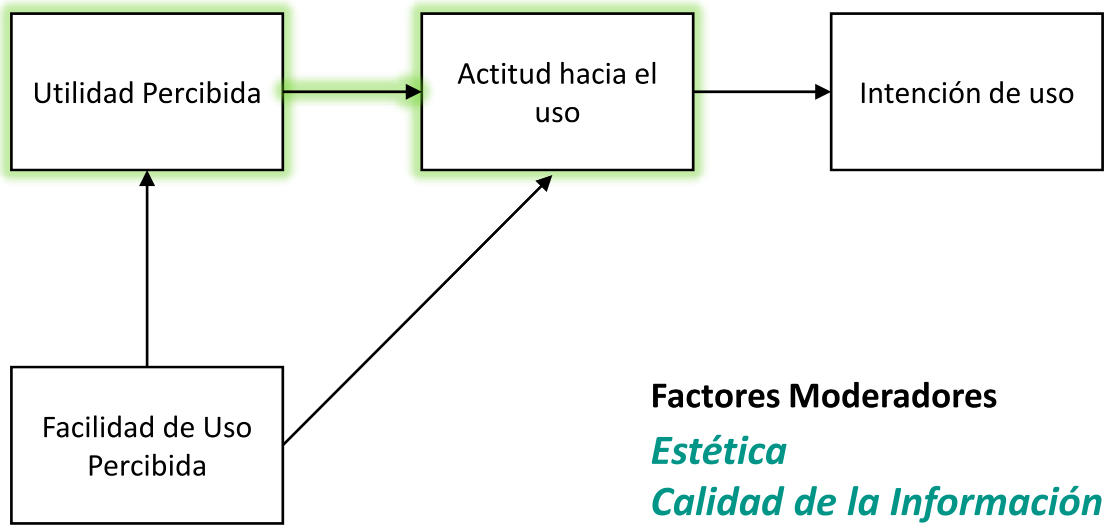
Factores Moderadores

Estética

Calidad de la Información

N = 190 estudiantes (laboratorio presencial)

Efecto Moderador



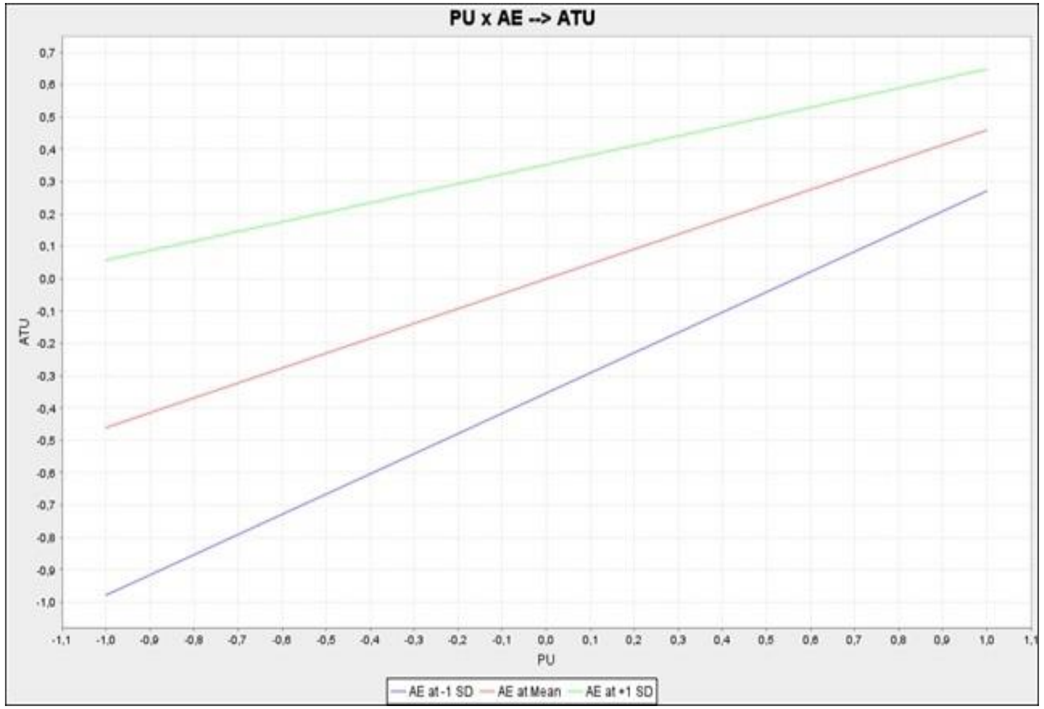
Factores Moderadores

Estética

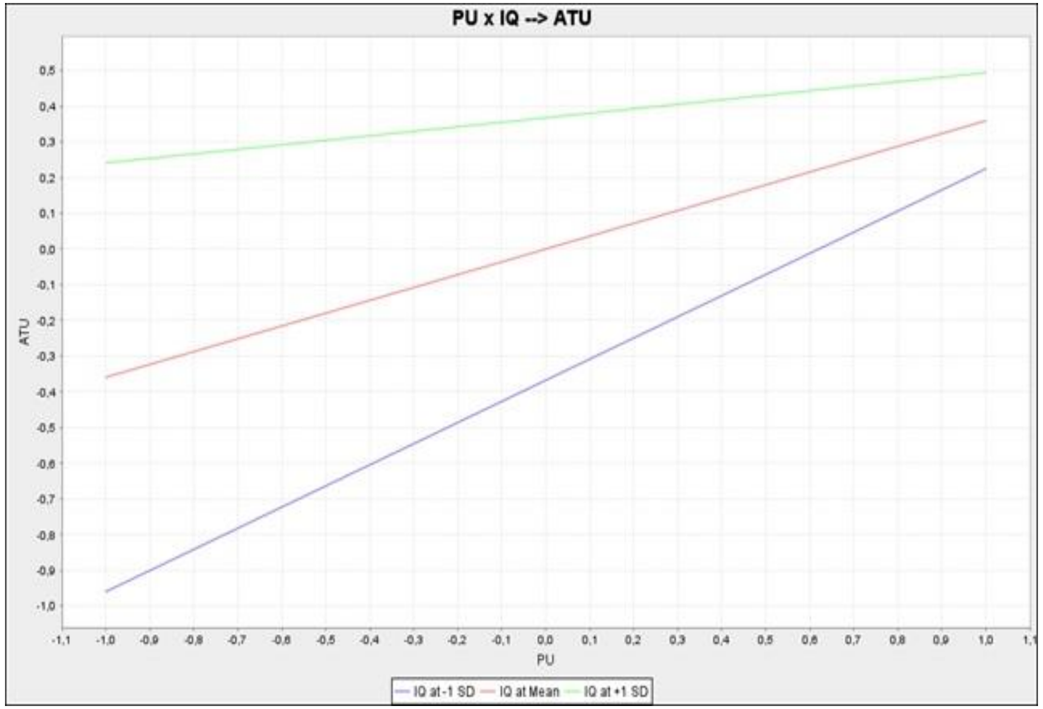
Calidad de la Información

N = 190 estudiantes (laboratorio presencial)

Efecto Moderador

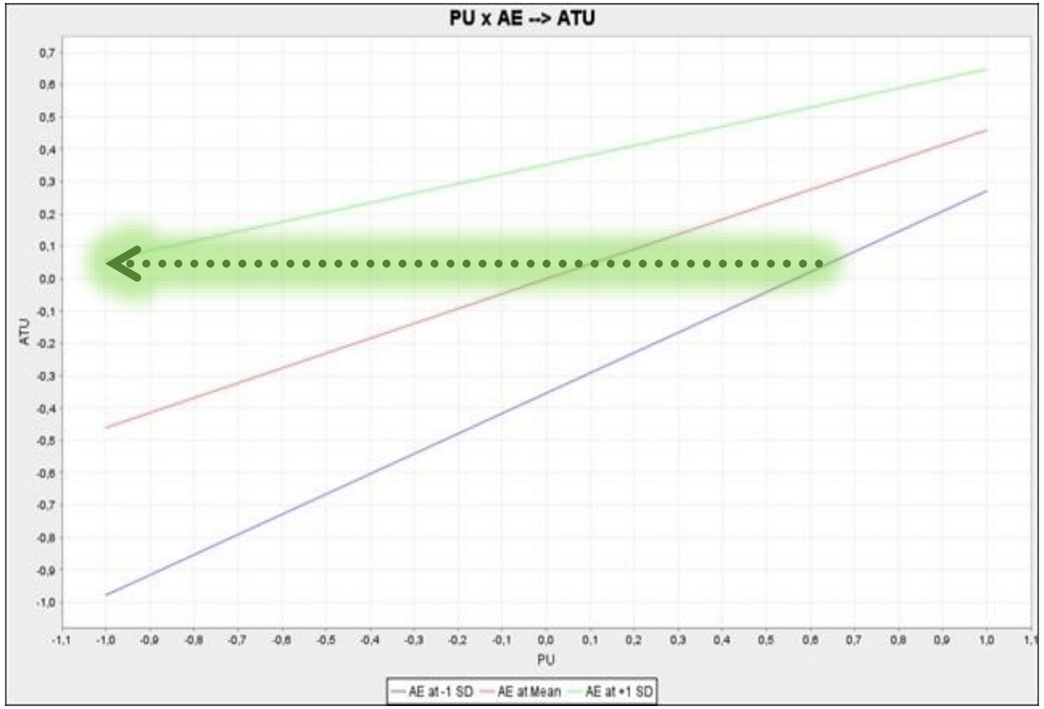


The moderating effect of aesthetics

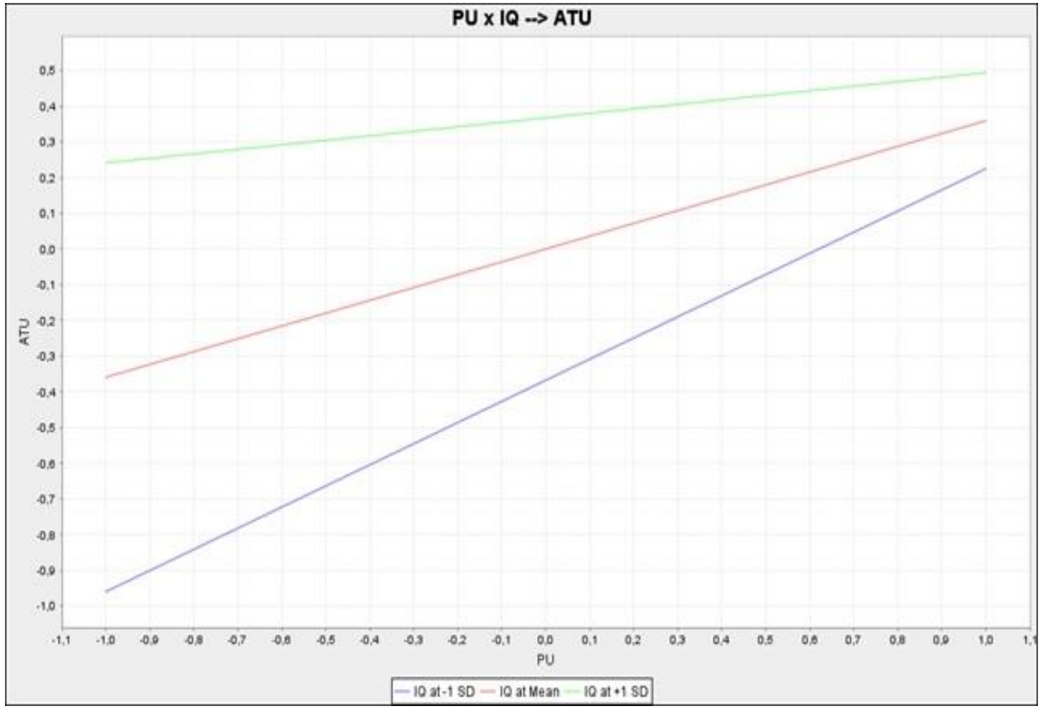


The moderating effect of information quality

Efecto Moderador

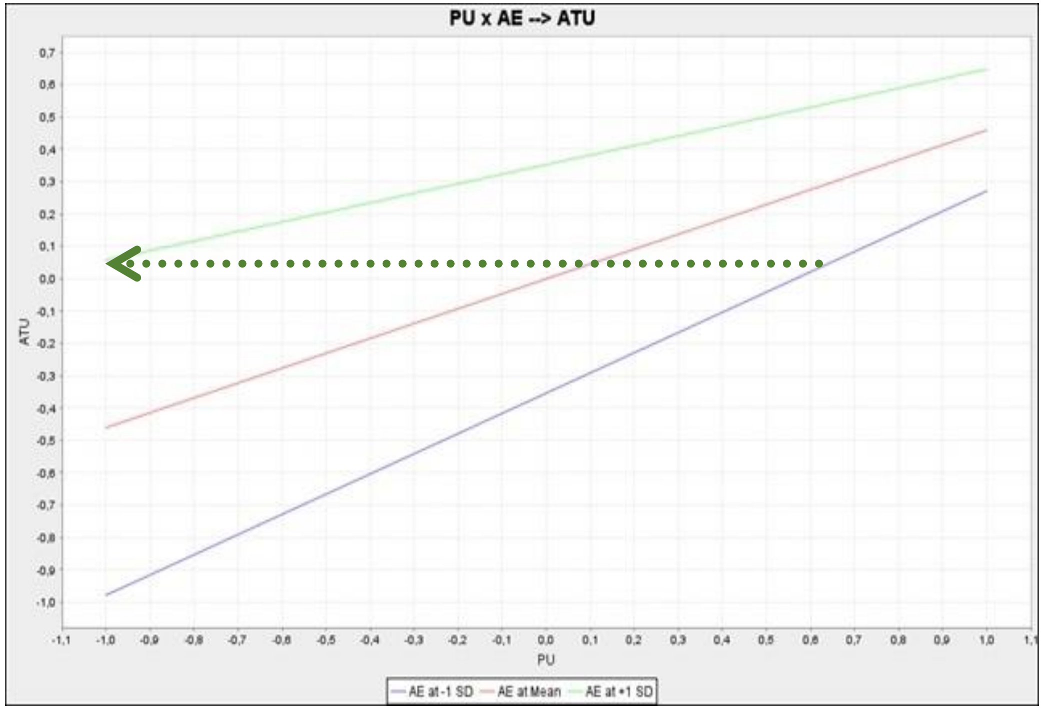


The moderating effect of aesthetics

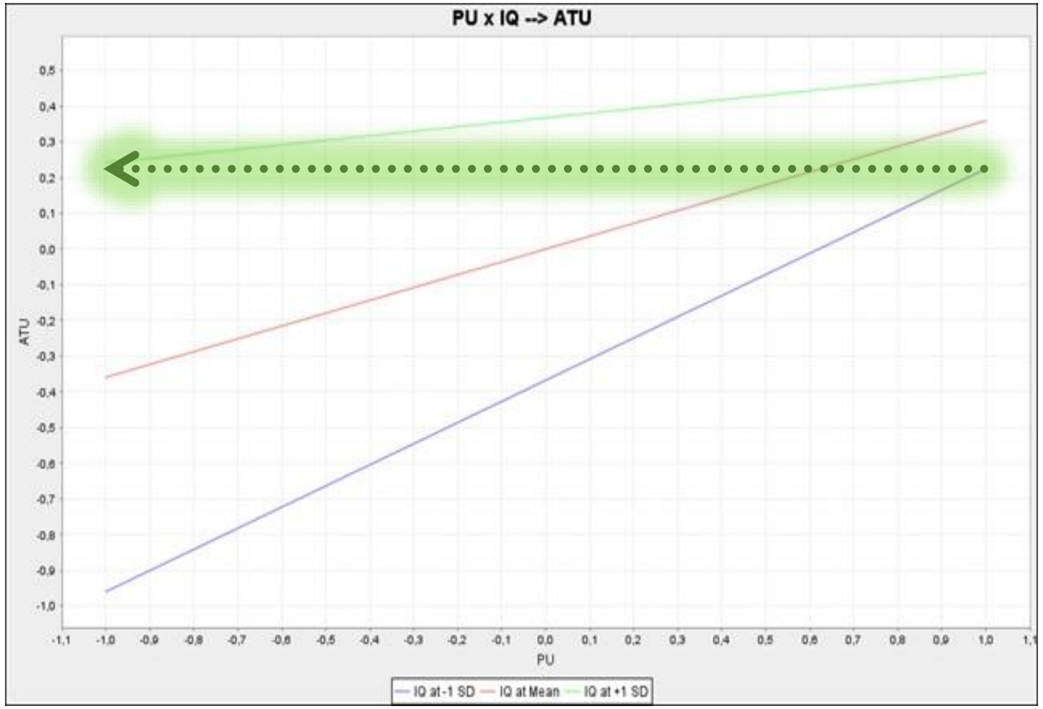


The moderating effect of information quality

Efecto Moderador



The moderating effect of aesthetics



The moderating effect of information quality

INNOVATIONS IN EDUCATION AND TEACHING INTERNATIONAL
https://doi.org/10.1080/14703297.2023.2267509

Routledge
Taylor & Francis Group

The moderating role of aesthetics and information quality for acceptance of augmented reality

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[a]Department of Industrial Engineering, Universidad de La Serena, La Serena, Chile; [b]Department of Computing and Statistics, Rey Juan Carlos University, Madrid, Spain; [c]Faculty of Economy and Business, Universidad Alberto Hurtado, Santiago, Chile; [d]Faculty of Engineering and Architecture, Universidad Central, La Serena, Chile

ABSTRACT

This study explores the moderating role of aesthetics and information quality on the technological acceptance of augmented reality. A technology acceptance model with the following variables was used: perceived ease of use, perceived usefulness, attitude towards using, and behavioural intention to use. Analysis was conducted by using structural equation modelling and a participation of 90 engineering students. Participants used an augmented-reality app for electrical resistive circuits, which works as a virtual laboratory. The app allows manipulating circuit elements and computing voltage and amperage values using the loop method, applying Kirchhoff's voltage law. The results suggest that aesthetics and information quality influence attitudes towards use. These findings show the importance of aesthetics and information quality in accepting augmented reality apps; therefore, designers and developers should consider these factors. This type of study has not been investigated previously.

KEYWORDS
Augmented reality; engineering education; mobile learning; technology acceptance; virtual labs

Introduction

Augmented reality (AR) is an interactive technology that is often used for innovative device applications and has been widely adopted in educational contexts (Sahin & Yilmaz, 2020). AR is a technology whose function is to 'augment' normal perception by superimposing virtual objects onto an agent's visual field. Currently, AR studies include research on the phenomenology of augmented experiences, the metaphysics of virtual objects, and different ethical issues associated with AR systems, including

Álvarez-Marín, A., Velázquez-Iturbide, J.Á., and Castillo-Vergara, M. and Acuña-Opazo, C. (2023). The Moderating Role of Aesthetics and Information Quality for Acceptance of Augmented Reality. In Innovations in Education and Teaching International. doi: 10.1080/14703297.2023.2267509.

WoS Q3

Mejoras

en la AR app

Circuito

Batería 1

Resistencia 1

Circuito

Batería 1

Resistencia 1

Circuito

Batería 1

Resistor 1

Ver Video

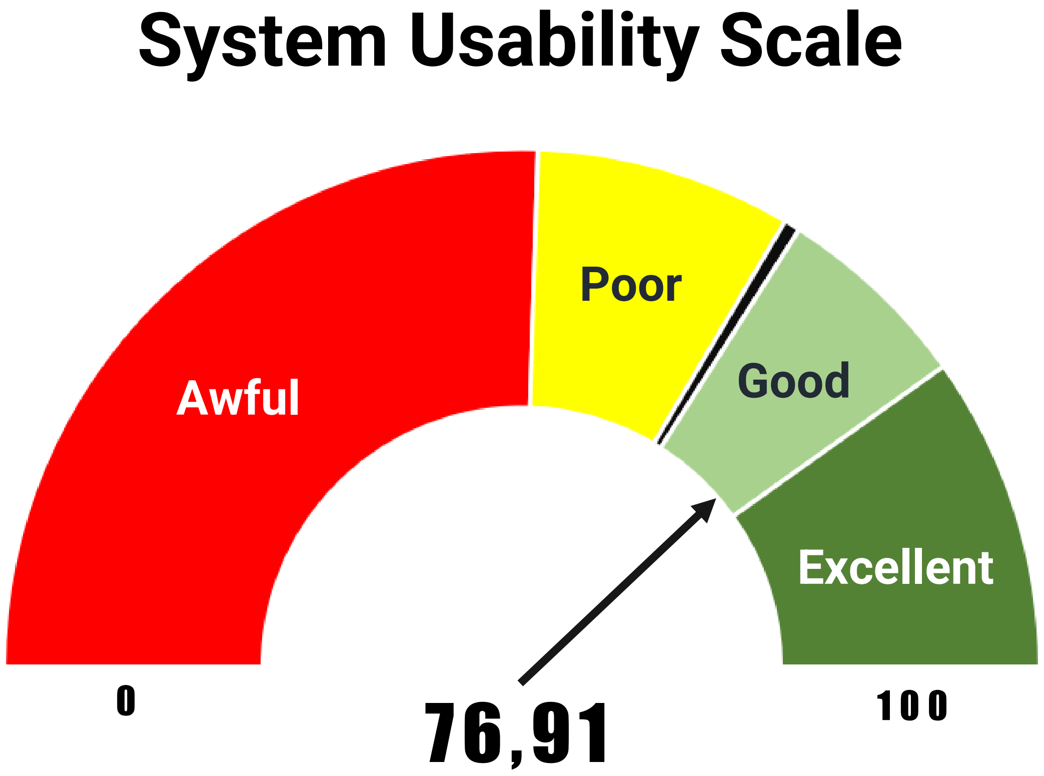
Realidad aumentada & educación en electrónica:

Usabilidad, desempeño académico y emociones experimentados en el aprendizaje

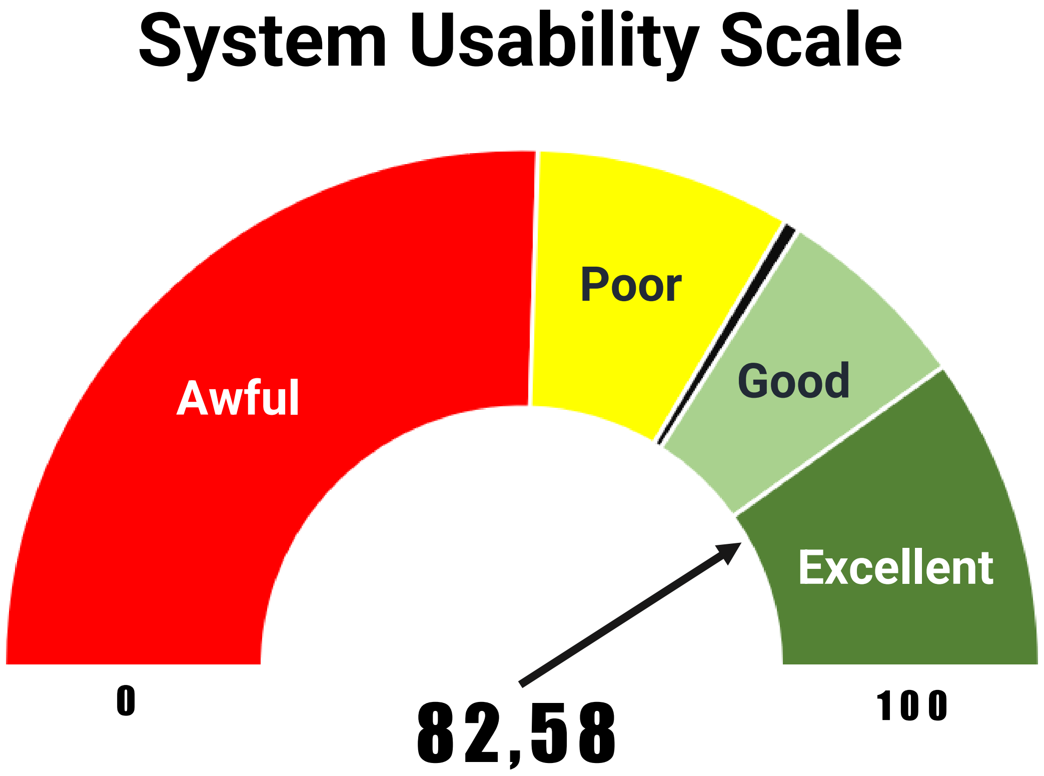
[2]

N = 64 estudiantes (grupo experimental: 31; grupo de control: 33)

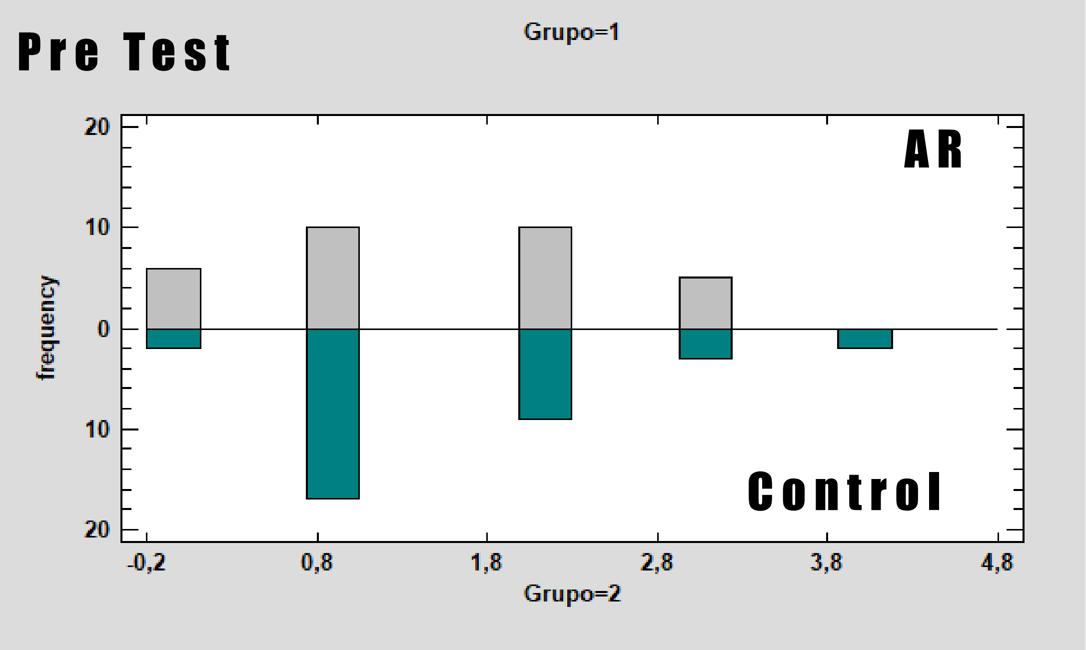
Usabilidad

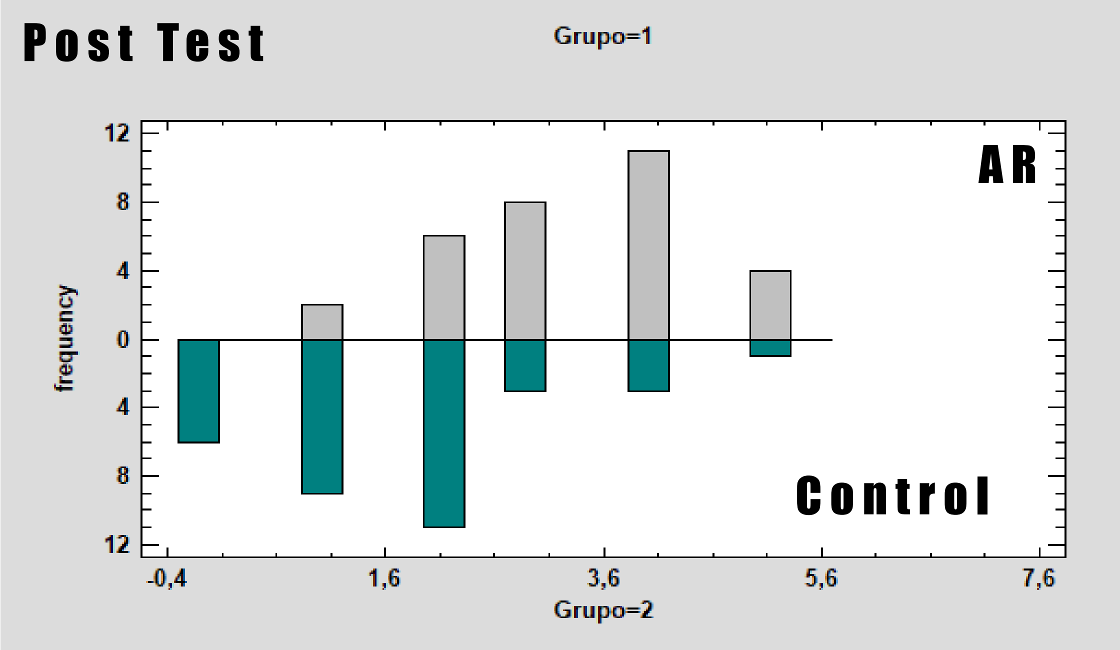

System Usability Scale
Poor
Good
Awful
Excellent
0
76,91
100

Usabilidad


System Usability Scale
Poor
Awful
Good
Excellent
0
82,58
100

Rendimiento Académico





Emociones

		Grupo de Control (GC)		Grupo Experimental (GE)		GC vs GE
		Media	SD	Media	SD	p-value
Antes	Ira	2,92	0,81	2,56	0,87	0,05
	Disfrute	3,45	1,00	3,39	0,88	0,36
	Desesperanza	3,32	1,18	2,95	1,31	0,12
	Ansiedad	2,82	0,96	2,72	1,06	0,35
	Vergüenza	4,06	1,09	3,94	1,24	0,40
	Emociones positivas	3,50	0,79	3,58	0,76	0,34
	Emociones negativas de activación	3,27	0,59	3,07	0,88	0,15
	Emociones negativas de desactivación	3,15	0,92	2,87	1,07	0,13
Después	Ira	3,64	0,93	1,97	1,05	0,00
	Disfrute	2,48	0,94	3,82	0,95	0,00
	Desesperanza	3,66	0,60	2,28	1,05	0,00
	Ansiedad	4,08	0,78	2,66	1,23	0,00
	Vergüenza	3,62	0,74	2,32	1,07	0,00
	Emociones positivas	2,47	0,89	3,84	0,93	0,00
	Emociones negativas de activación	3,78	0,65	2,32	0,96	0,00
	Emociones negativas de desactivación	3,66	0,60	2,28	1,05	0,00

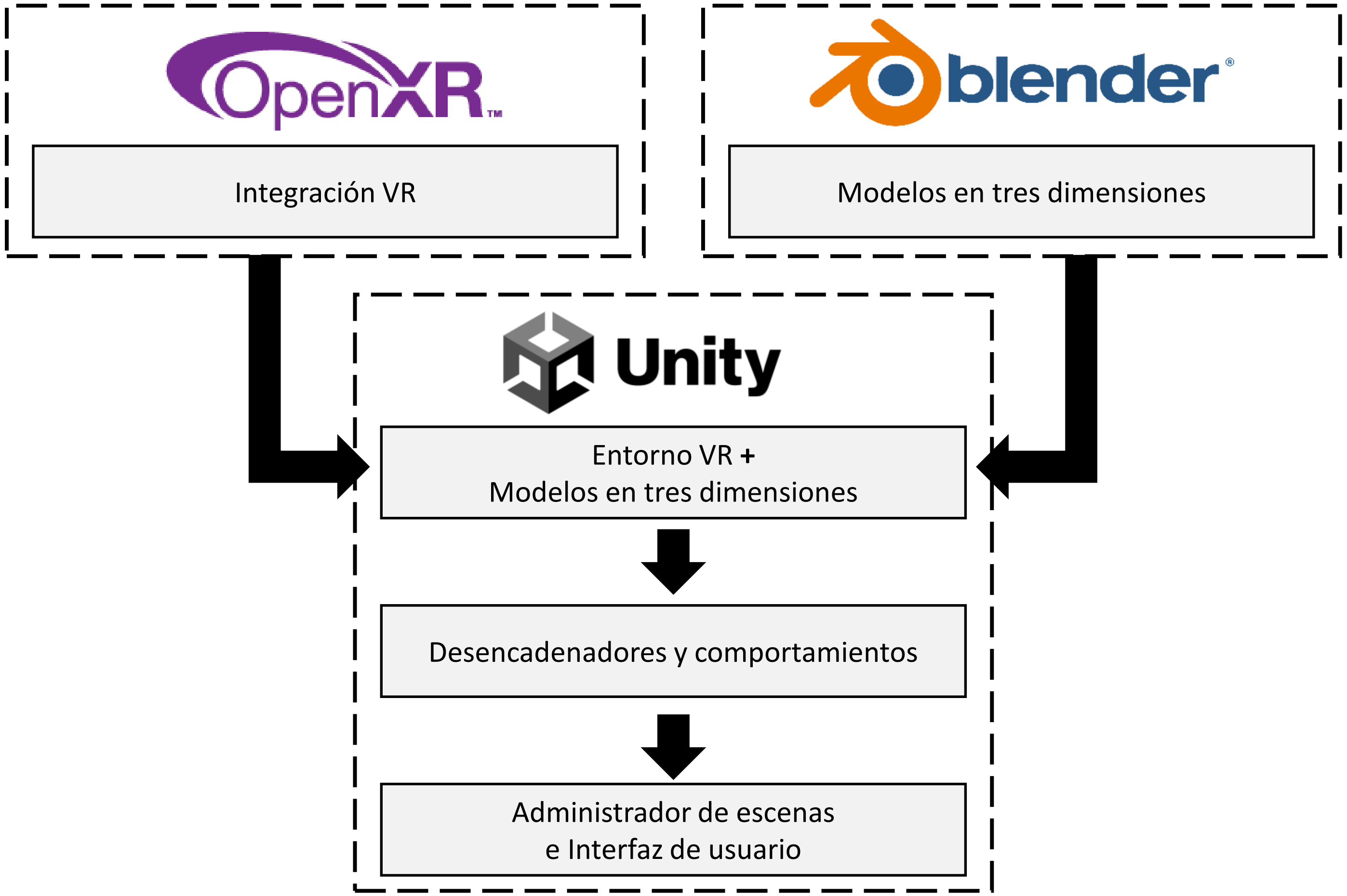
Correlación Usabilidad

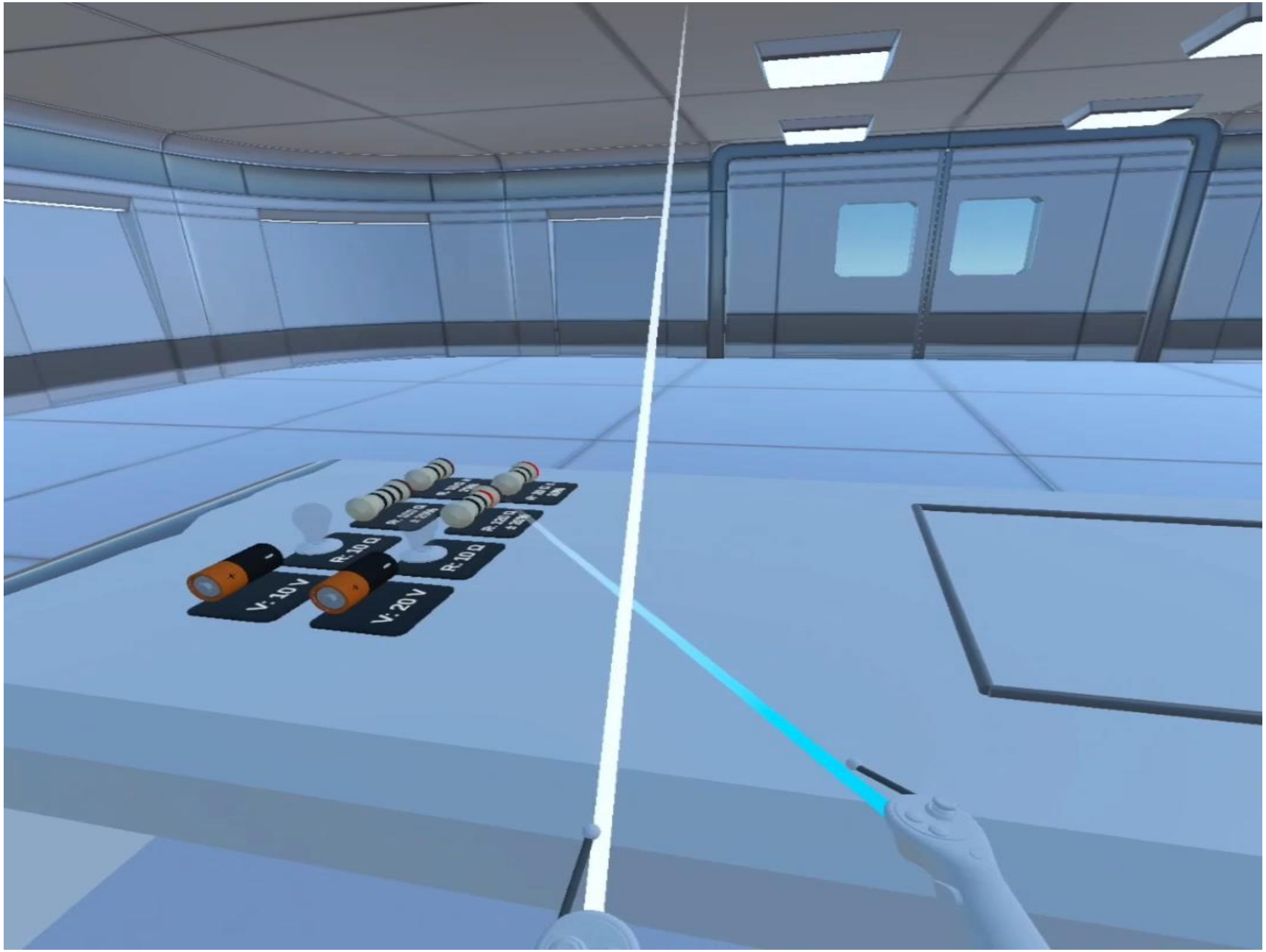
con rendimiento académico y emociones

Variable	Correlación	p-value
Rendimiento académico	0.24	0.19
Ira	-0.52	0.00
Disfrute	0.69	0.00
Desesperanza	-0.59	0.00
Ansiedad	-0.55	0.00
Vergüenza	-0.68	0.00
Emociones positivas	0.68	0.00
Emociones negativas de activación	-0.59	0.00
Emociones negativas de desactivación	-0.62	0.00

Realidad

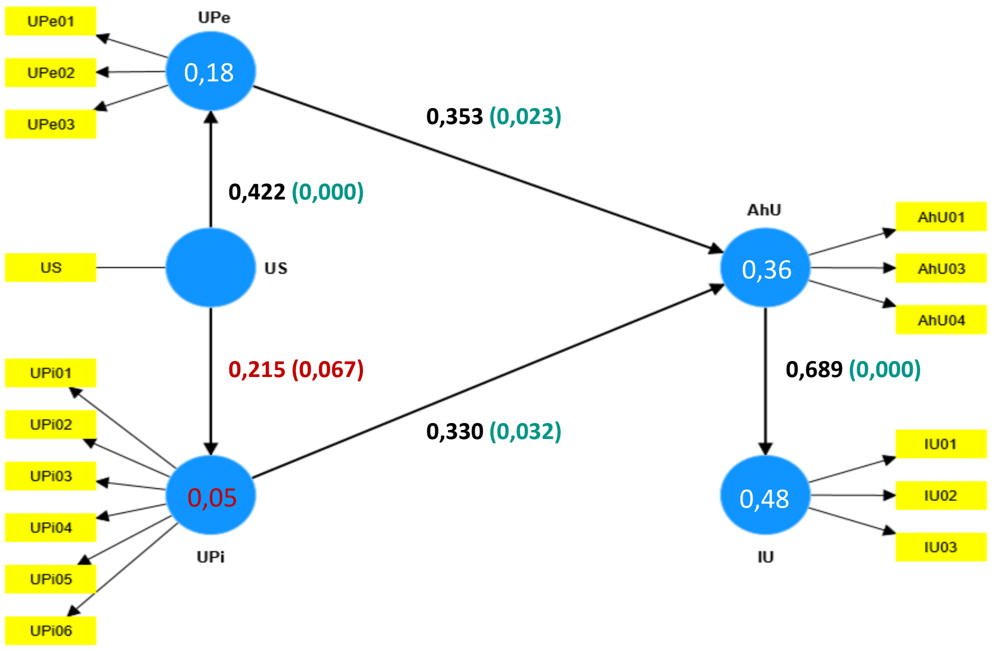
Virtual


OpenXR
Integración VR
blender
Modelos en tres dimensiones
Unity
Entorno VR +
Modelos en tres dimensiones
Desencadenadores y comportamientos
Administrador de escenas
e Interfaz de usuario



Ver Video

SEM



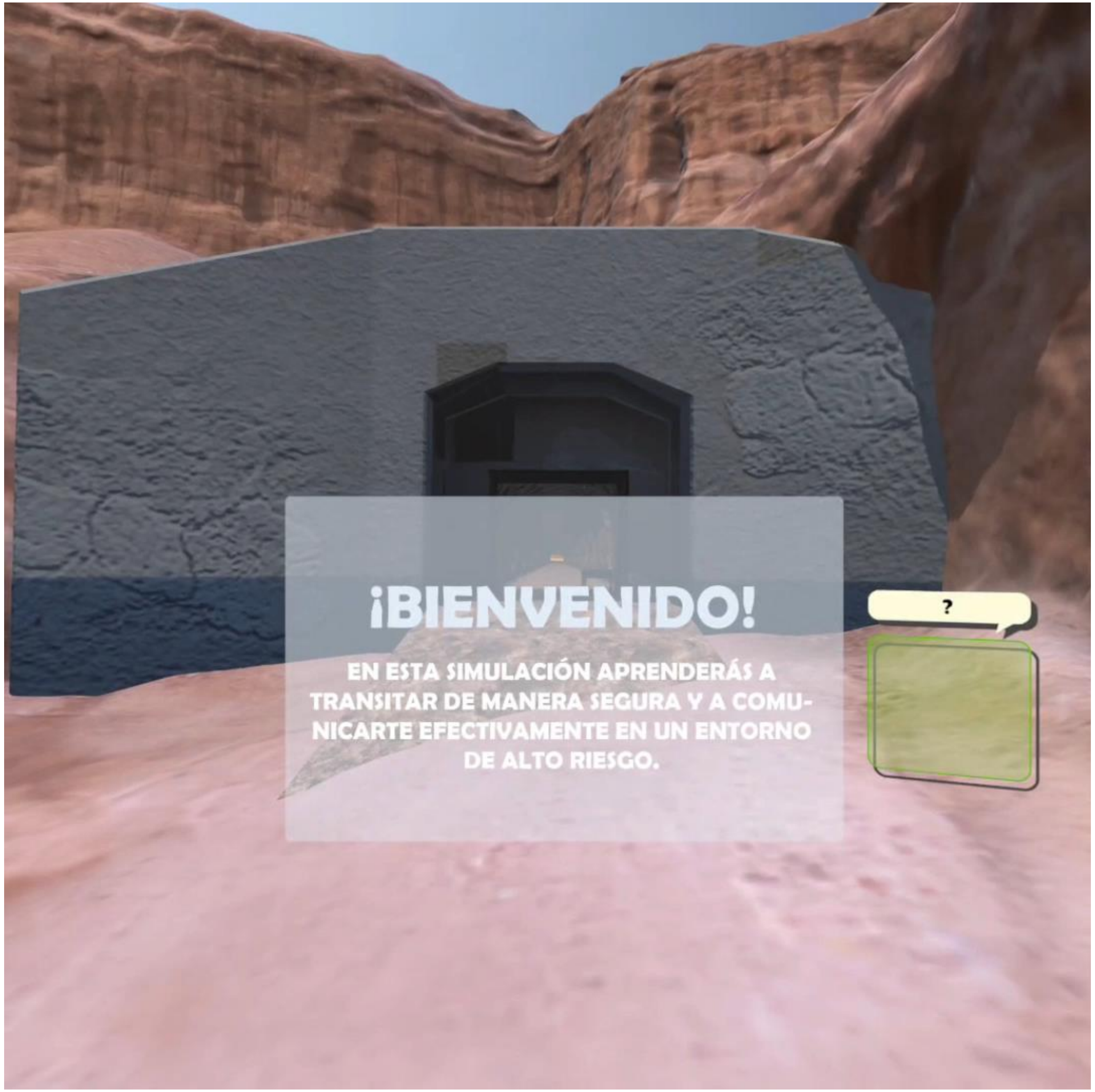
fsQCA

	Solución		
Configuración	*1*	*2*	*3*
Sexo			●
Usabilidad	●		⊗
Utilidad Percibida Estudio	●	●	⊗
Utilidad Percibida Industria		●	⊗
Actitud hacia el Uso	●	●	●
Consistency	*0.976476*	*0.978927*	*0.984166*
Raw Coverage	*0.748319*	*0.855179*	*0.0799225*
Unique Coverage	*0.0276844*	*0.135815*	*0.0038119*

Overall solution consistency	0.96827
Overall solution coverage	0.887946

Smart

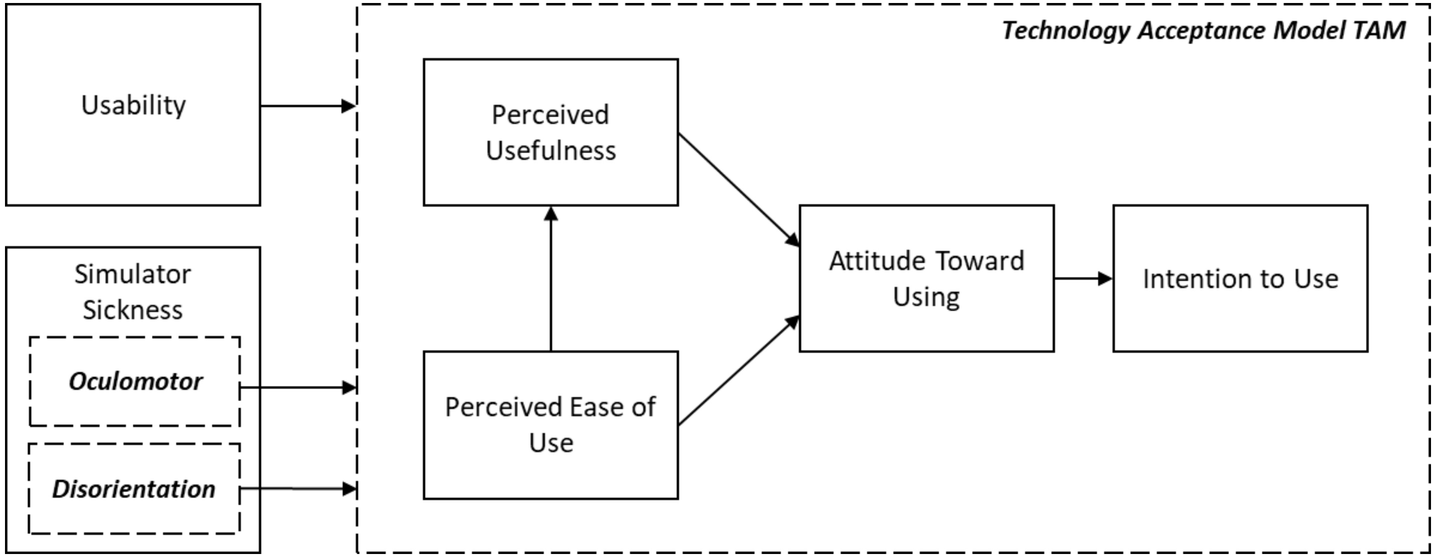
Mining


¡BIENVENIDO!
EN ESTA SIMULACIÓN APRENDERÁS A TRANSITAR DE MANERA SEGURA Y A COMUNICARTE EFECTIVAMENTE EN UN ENTORNO DE ALTO RIESGO.
?

Ver Video

Smart

Mining



Estudio Preliminar

Spearman Rank Correlations						
Correlation *P-Value*	OCU	DIS	VRSQ	SUS	ATU	BIU
OCU						
DIS	0,7351 *0*					
VRSQ						
SUS			-0,318 *0,0146*			
ATU			-0,2923 *0,0247*	0,3329 *0,0106*		
BIU			-0,3277 *0,0118*	0,4168 *0,0014*	0,7008 *0*	

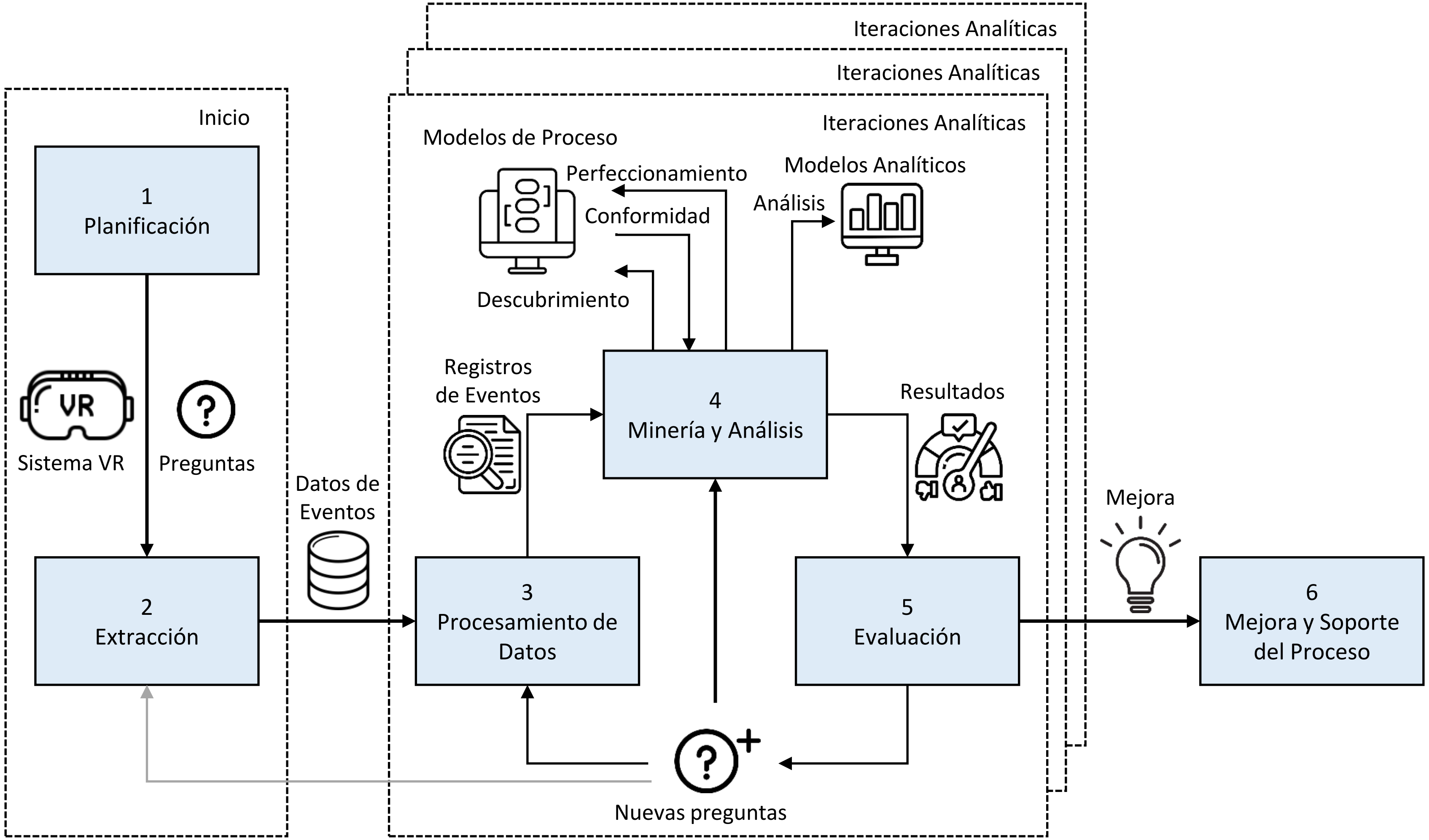
N = 60 estudiantes

Process Mining

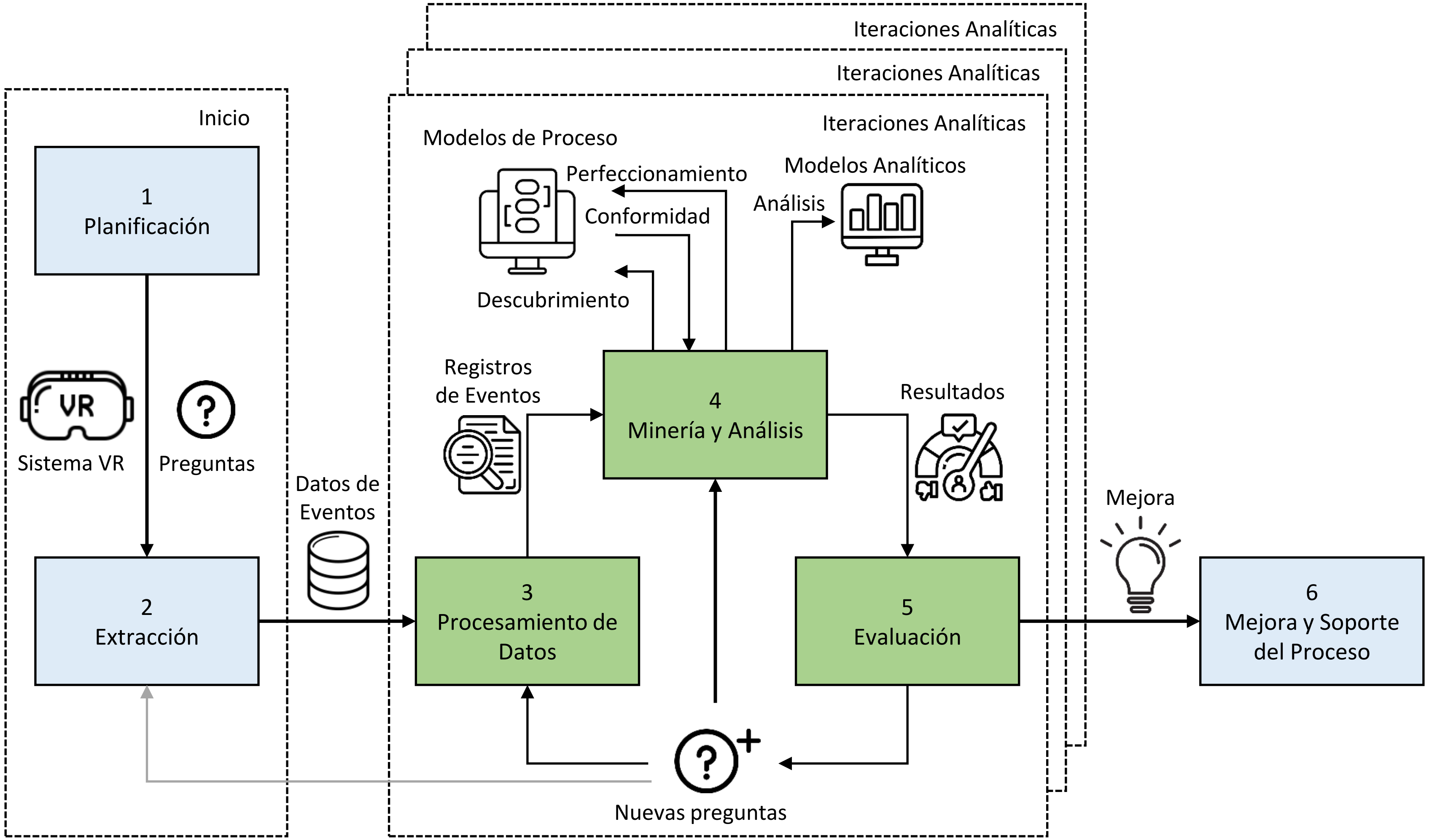
&

Inteligencia Artificial

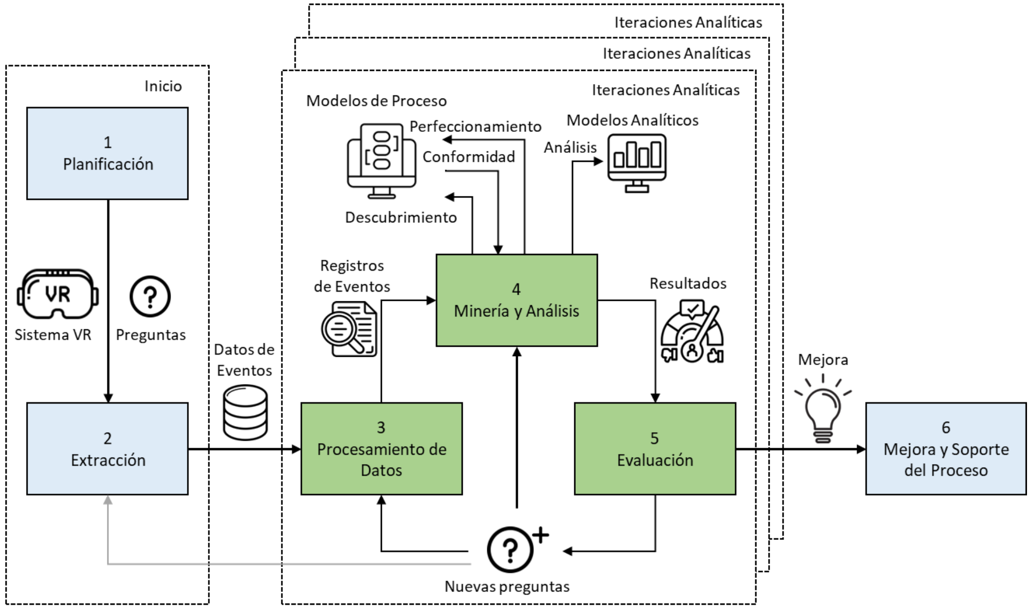
Process Mining



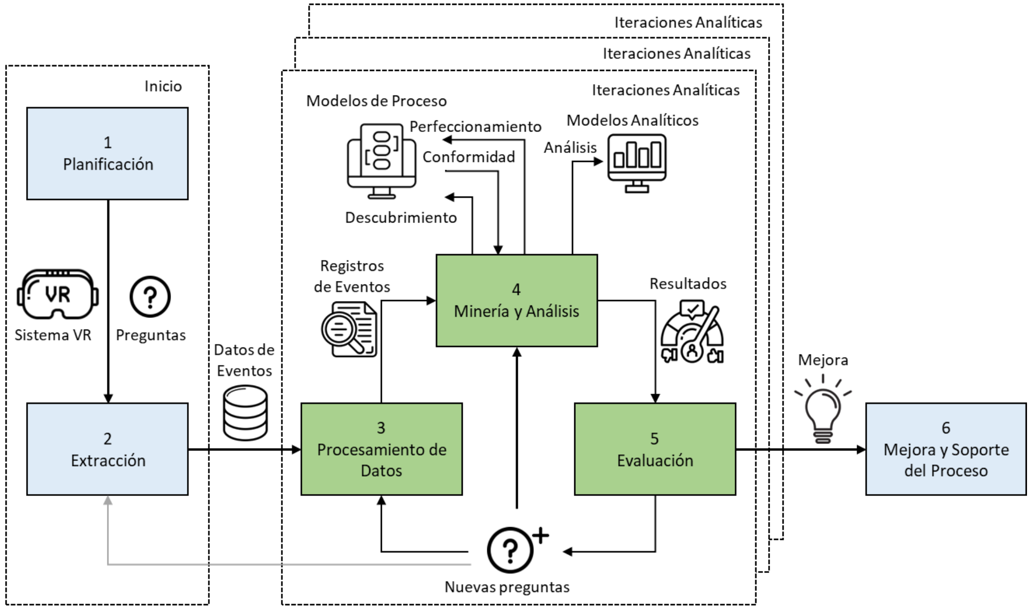
Inteligencia Artificial

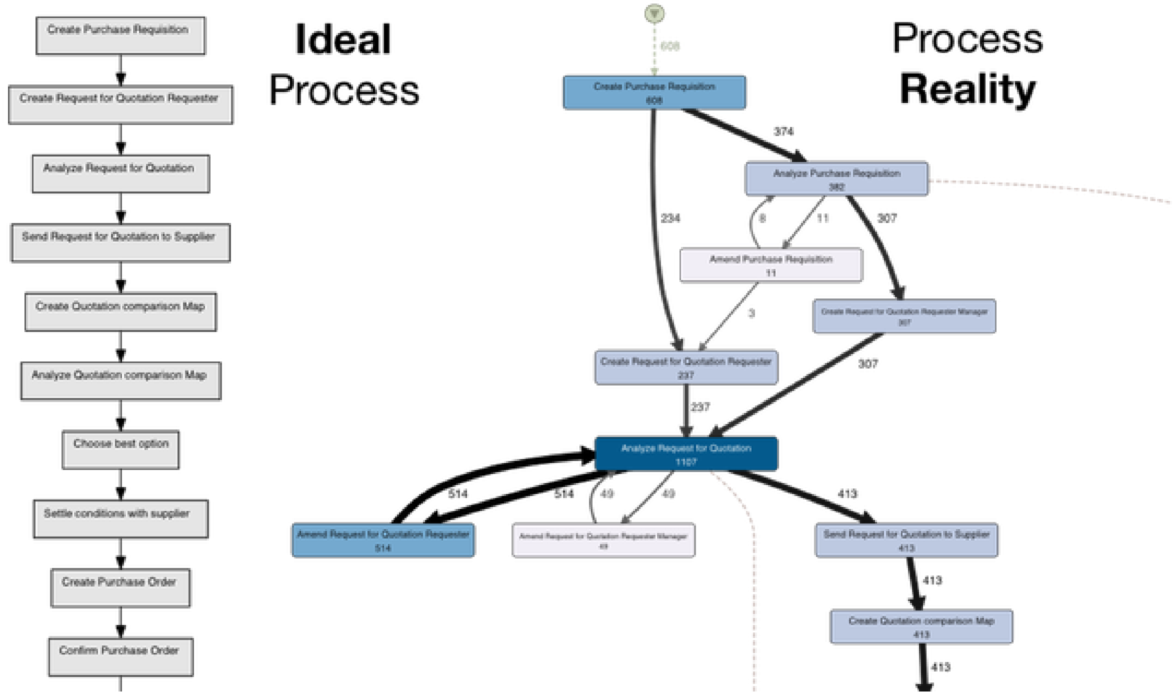


Inteligencia Artificial



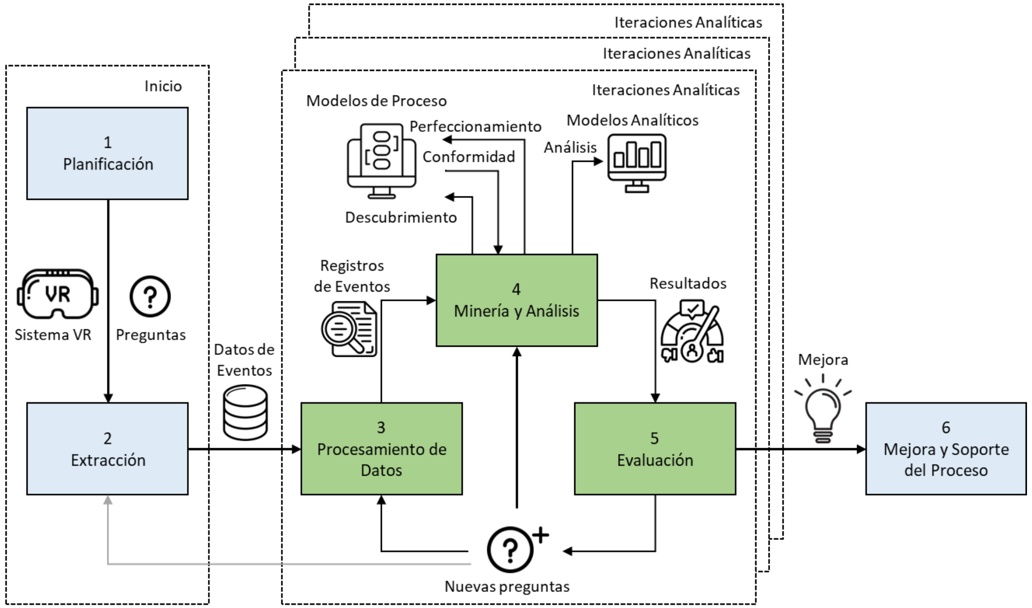
Inteligencia Artificial



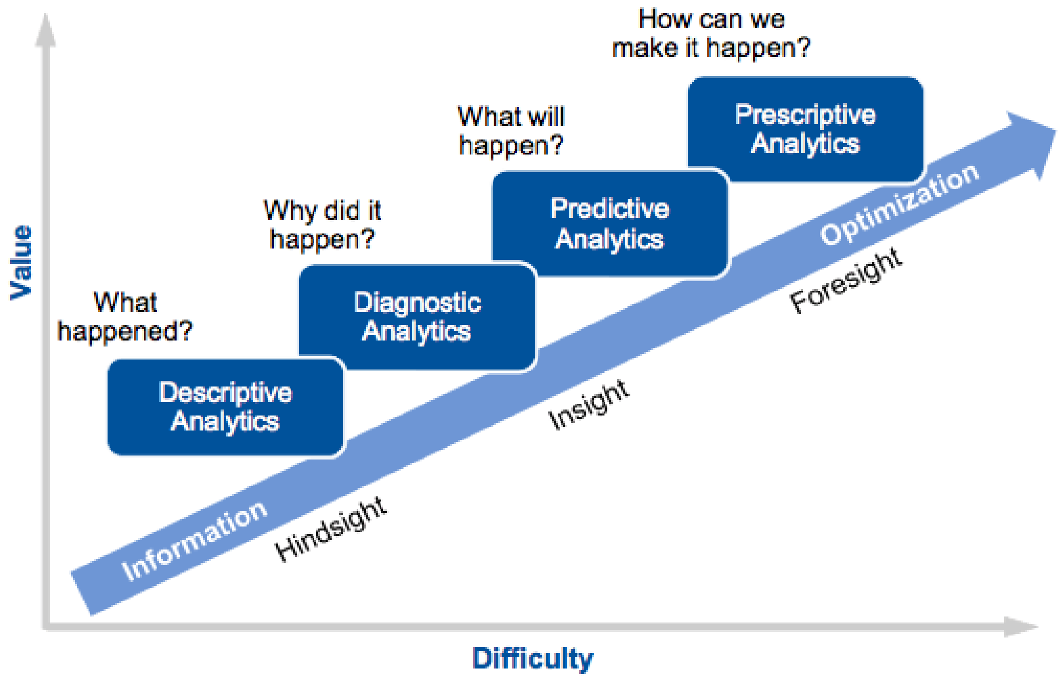


Zulfikar Adamu (2023)
https://www.linkedin.com/pulse/process-mining-construction-industry-ai-opportunities-adamu-phd-7apte/

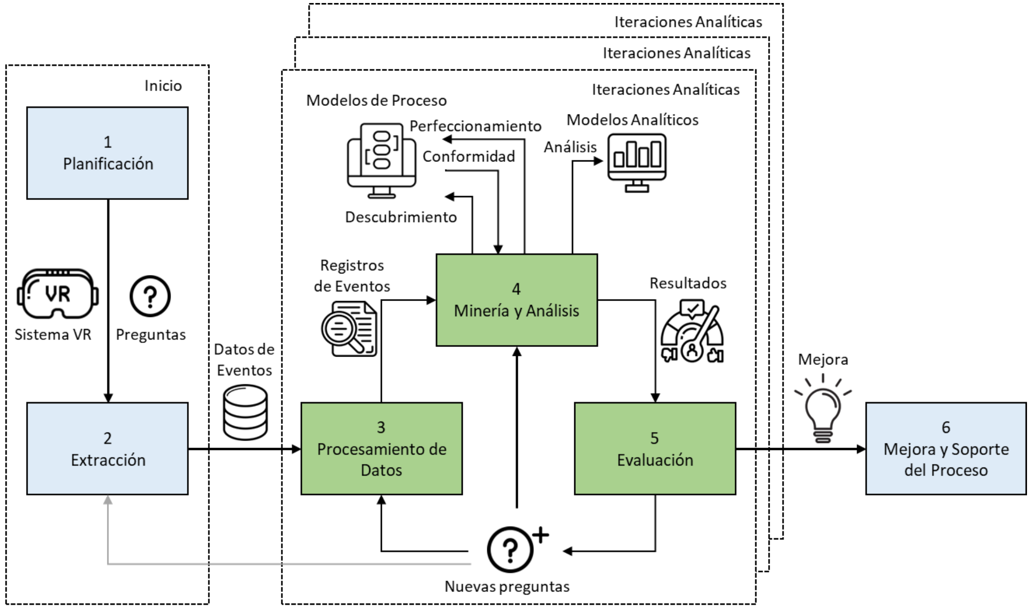
Inteligencia Artificial



Advanced Analytics



Inteligencia Artificial



Optimización | Predicción

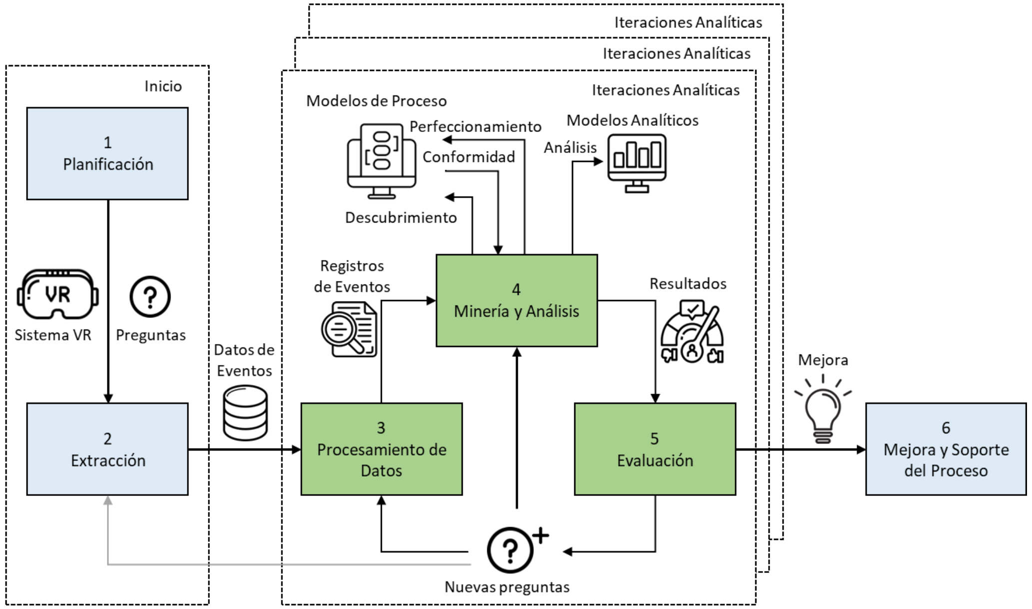
Clustering –Machile Learning

Redes Neuronales – Deep Learning

Algoritmos Evolutivos

Redes Bayesianas

Inteligencia Artificial



Detección de Anomalías

Utilizar técnicas de aprendizaje automático para identificar patrones anómalos en los registros de eventos que podrían indicar problemas o ineficiencias

Predicción de Rendimiento

Aplicar modelos predictivos para anticipar el rendimiento futuro de un proceso y tomar decisiones proactivas

Optimización de Procesos

Emplear algoritmos de optimización para mejorar el flujo de trabajo y la asignación de recursos dentro de un proceso

Descubrimiento de Procesos Complejos

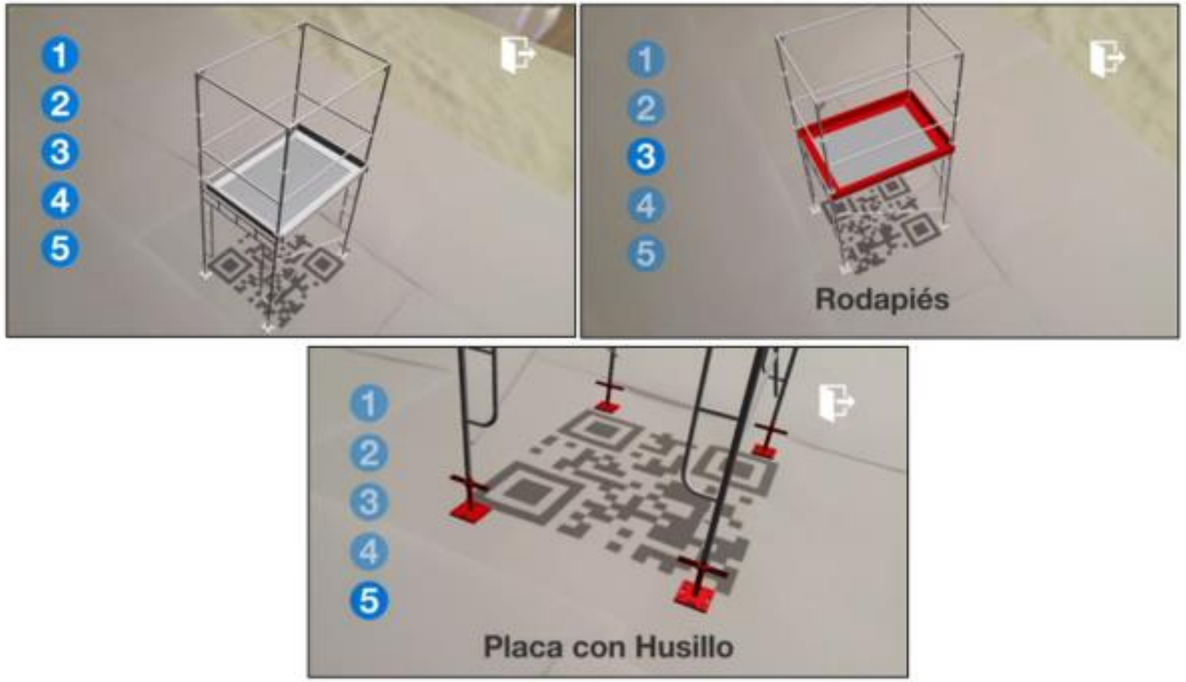
Utilizar deep learning para descubrir procesos complejos que tienen múltiples caminos y variaciones

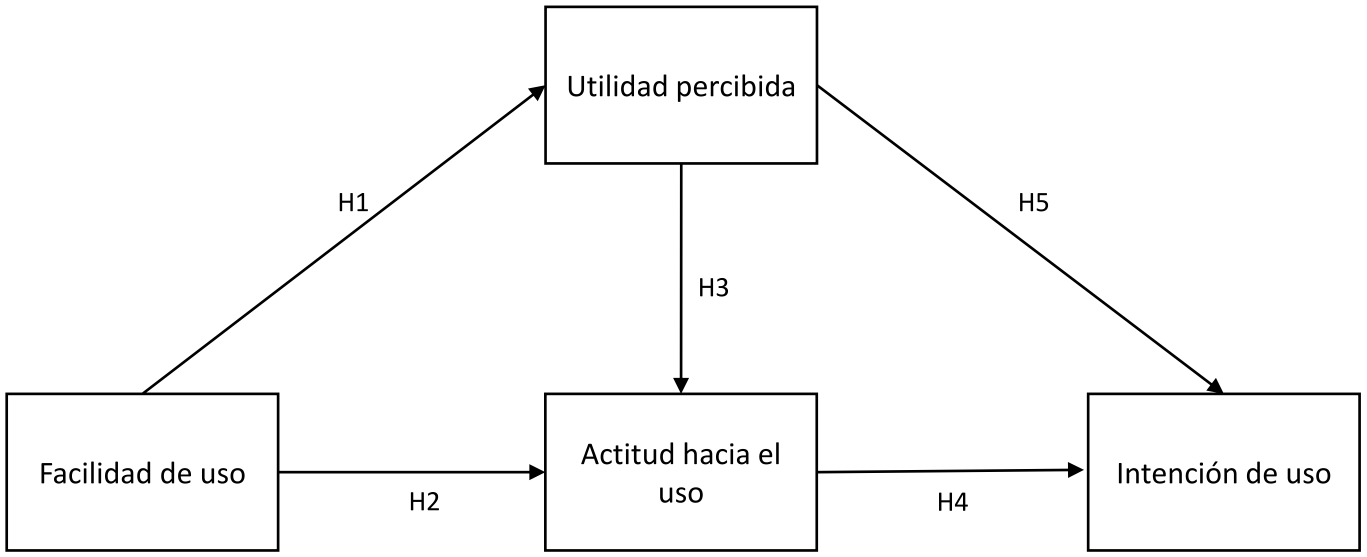
Construcción

4.0

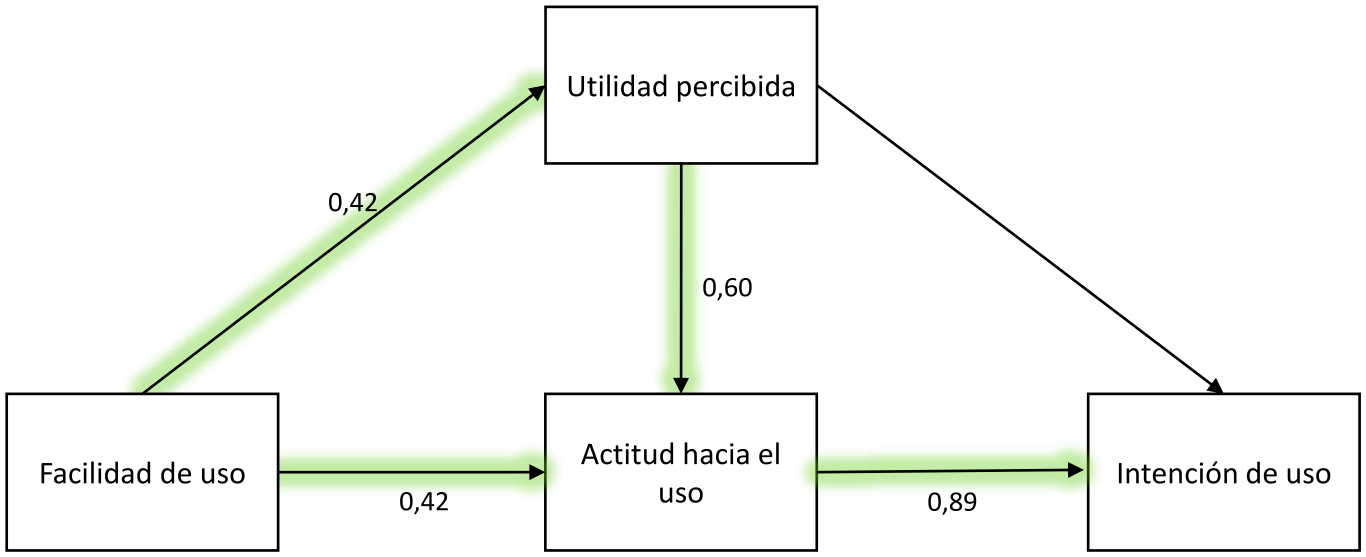
Aceptación tecnológica de la realidad aumentada en la Industria

Aplicación orientada a la prevención de riesgos





N = 29 Empresas del área de la construcción



N = 29 Empresas del área de la construcción

Work 71 (2022) 165–175
DOI:10.3233/WOR-205049
IOS Press

Augmented reality for virtual training in the construction industry

Dario Placencio-Hidalgo[a], Alejandro Álvarez-Marín[a,*],
Mauricio Castillo-Vergara[b] and Renato Sukno[c]
[a]*Departamento de Ingeniería Industrial, Universidad de La Serena, La Serena, Chile*
[b]*Facultad de Economía y Negocios, Universidad Alberto Hurtado, Santiago, Chile*
[c]*Escuela de Ingeniería Civil, Universidad Católica del Norte, Coquimbo, Chile*

Received 23 October 2020
Accepted 30 March 2021

Abstract.
BACKGROUND: Technology has evolved in surprising ways, and augmented reality (AR) has positioned itself as one of the technologies with outstanding value. Its importance in education is still being debated, but its incorporation in business training has been left out.
OBJECTIVE: This study aims to determine variables that explain the intention to use this technology in construction training, focused on preventing injuries and disabilities.
METHODS: This study was carried out using the Technology Acceptance Model (TAM) through the structural equation method. The variables: *perceived ease of use*, *perceived usefulness*, *attitude toward using*, and *behavioral intention to use* were incorporated. An AR app was developed that addresses the teaching of safety elements on scaffolding, and we collected data from Chilean construction companies.
RESULTS: The results show that *perceived usefulness* and *perceived ease of use* explain the *attitude towards using* augmented reality, while *perceived usefulness* and *attitude towards using* explain *behavioral intention to use*.
CONCLUSIONS: These findings enrich AR's literature in the construction industry and have high business managers' implications. It may allow them to implement this technology more likely to succeed in their virtual business training to prevent injury-related disability.

Keywords: Business training, augmented reality, TAM, technology acceptance

1. Introduction

Today, many companies must address the challenges posed by non-planned difficulties, such as the COVID-19 pandemic. The various containment,

to maintain some activities, primarily meetings via streaming platforms. Nevertheless, there are other resources that companies can use to keep running crucial activities like employee training, such as aug-

Placencio-Hidalgo, D. Álvarez-Marín, A., Castillo-Vergara, M., and Sukno, R. The Augmented reality for virtual training in the construction industry. WORK: A Journal of Prevention, Assessment & Rehabilitation, 71(1), 165-175 (2022). Doi: 10.3233/WOR-205049 [Public, Environmental & Occupational Health; Q4]

WoS Q3

CONS-TRUIR INNO-VANDO

Reto CONSTRUYE ACADEMIA

MÉTODOS MODERNOS DE CONSTRUCCIÓN **(MMC)**

MMC 1

MÓDULOS ESTRUCTURALES 3D

Elementos volumétricos Espaciales (3D) que forman parte del sistema estructural, fabricados en condiciones controladas previo a su instalación.

MMC 2

COMPONENTES ESTRUCTURALES 2D

Elementos planos (2D) estructurales como losas, muros y/o techumbre de diversos materiales, que son fabricados en ambiente controlado y que se ensamblan entre ellas o montan junto a elementos en obra para aportar al sistema estructural.

MMC 3

COMPONENTES ESTRUCTURALES 1D

Partes o componentes estructurales prefabricados que se montan y conectan en obra para formar parte del esqueleto estructural soportante de un proyecto.

MMC 4

COMPONENTES ADITIVOS

Componentes aislados que pueden ser o no estructurales, que forman parte de los sistemas constructivos de un proyecto y son fabricados mediante procesos de impresión tridimensional y/o manufactura aditiva.

MMC 5

PREFABRICADOS NO ESTRUCTURALES

Componentes prefabricados (unidades volumétricas, panelizados o elementos aislados) que no aportan resistencia estructural al proyecto.

MMC 6

PARTES Y PIEZAS SUSTITUTIVAS

Elementos, partes y piezas que adelantan faenas en obra y que disminuyen los recursos utilizados en los procesos constructivos, ya sea por su fácil ensamblaje y montaje o por su eficiencia ante los requerimientos de un proyecto.

MMC 7

TECNOLOGÍAS SUSTITUTIVAS

Tecnologías para mejorar los procesos contributivos y constructivos en sitio. El trabajo fuera de sitio es prácticamente nulo, ya que se aplican en obra herramientas digitales y tecnologías que brindan mejoras productivas, facilitan y/o sustituyen procesos tradicionales.

HABILITADORES ‹ **DfMA - BIM - LEAN MANAGEMENT** ›

Mapeo del Proceso Industrial MMC1 – MMC2

MMC 1

Hallazgos Clave:

- 30% de los tiempos muertos se debieron a problemas logísticos
- Transporte: Tiempos de carga y descarga, rutas de transporte, incidentes en el trayecto.

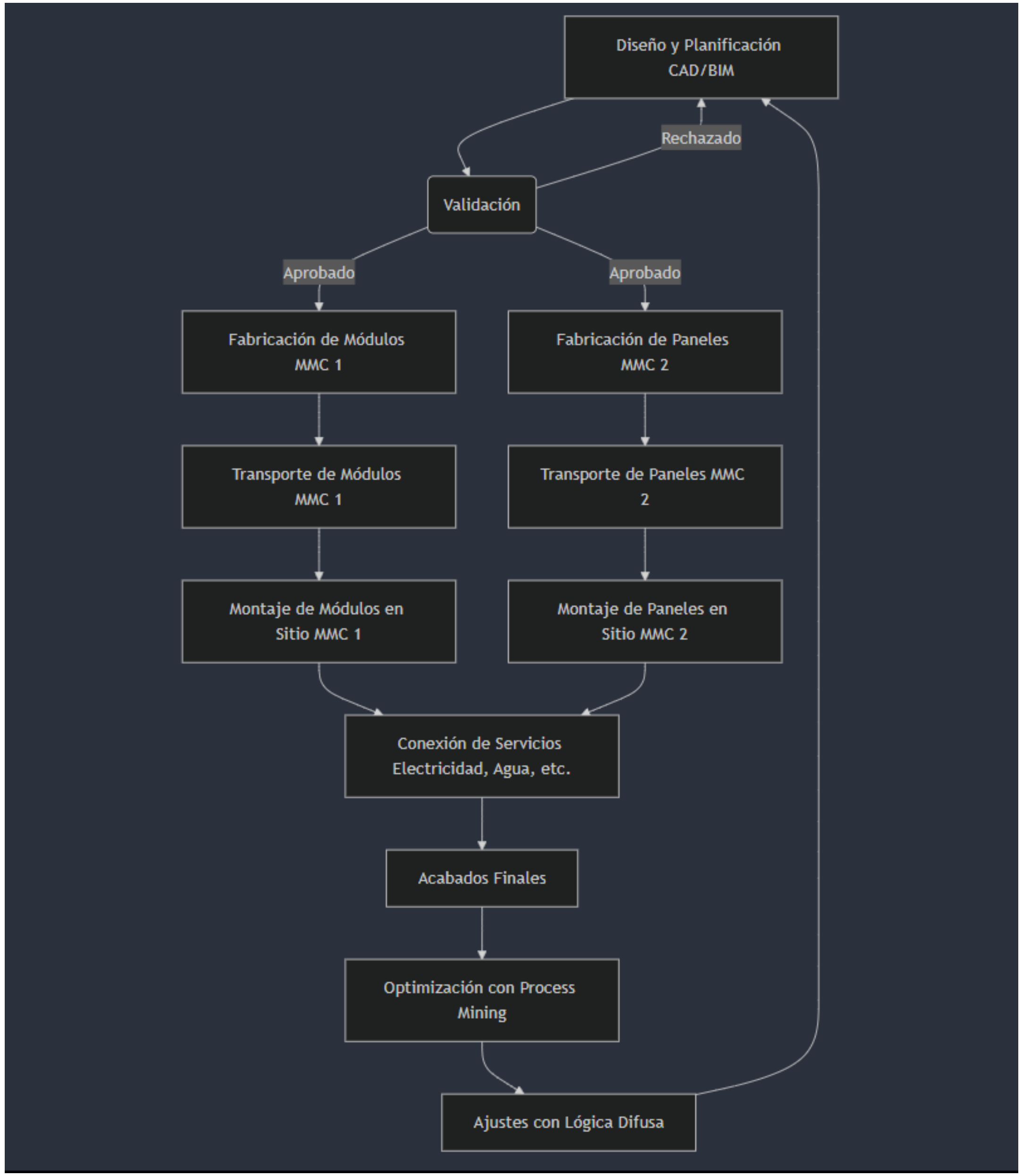
Mapeo del Proceso Industrial MMC1 – MMC2

MMC 1

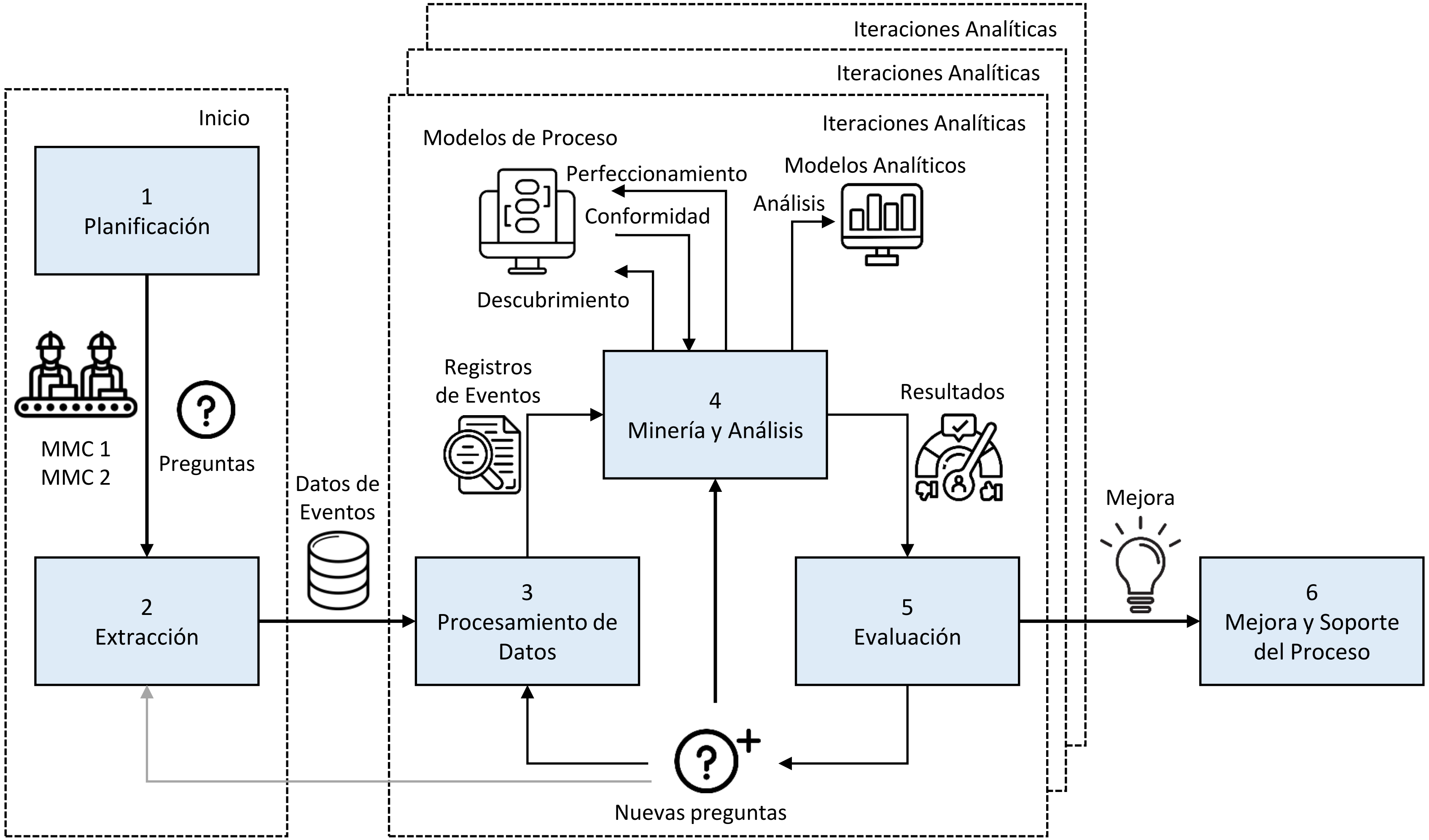
Hallazgos Clave:

- Diseño y Planificación: Tiempos de aprobación de planos, número de revisiones, errores detectados.
- Fabricación de Módulos/Paneles: Tiempos de producción, uso de maquinaria, interrupciones en la línea de producción.

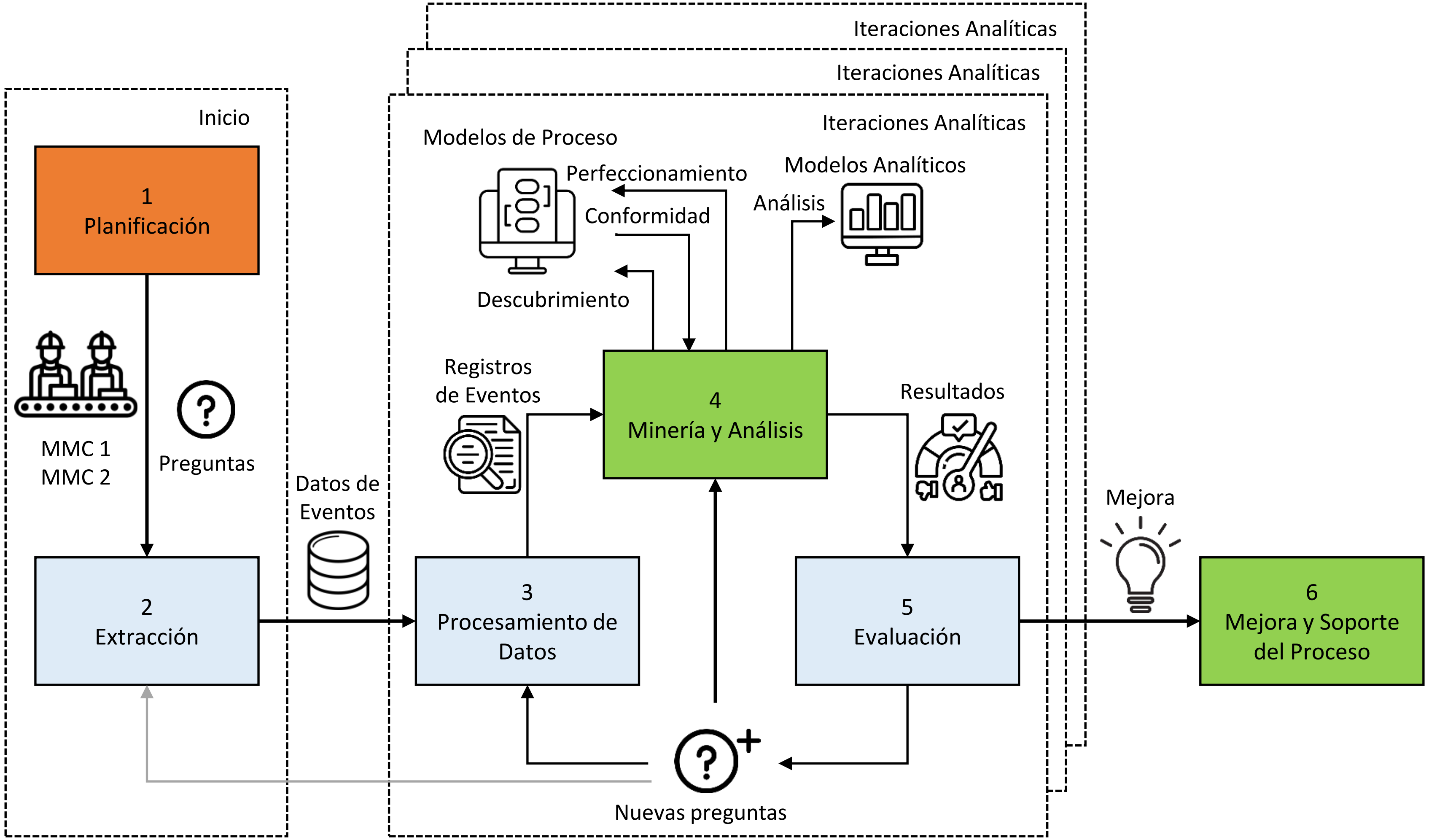
Mapeo del Proceso Industrial MMC1 – MMC2



Process Mining

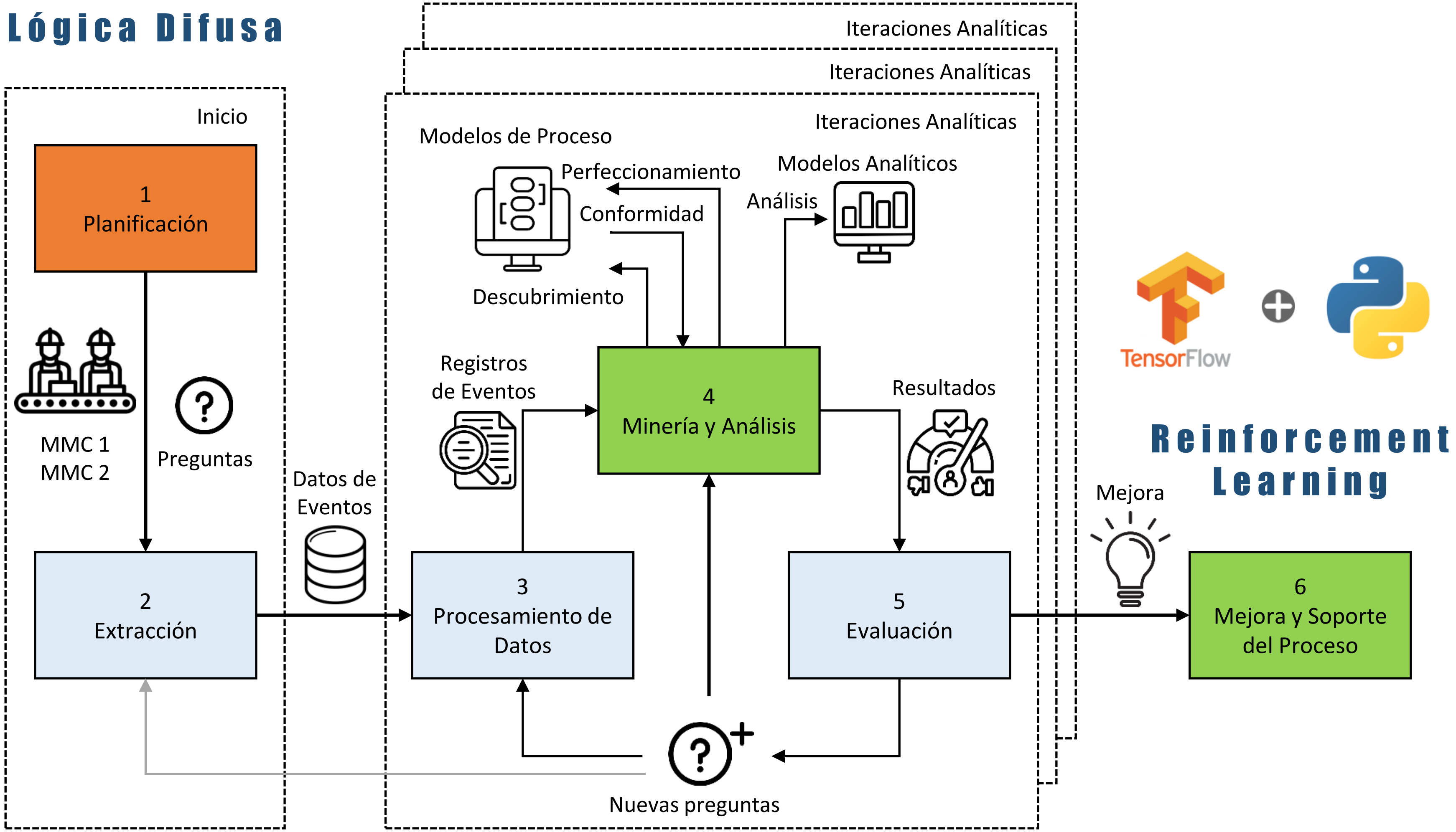


Process Mining



AI en tiempo real sobre el Process Mining

Process Mining



AI en tiempo real sobre el Process Mining

Capacitación en

Realidad Aumentada & Inmersiva 3D

Estado del Arte

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