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Artículos científicos

Estrategias didácticas a través de la realidad mixta para el aprendizaje teórico-práctico en estudiantes de educación media superior

Didactic Strategies Through Mixed Reality, for Theoretical-Practical Learning in High School Students

Estratégias didáticas por meio de realidade mista para aprendizagem teórico-prática em alunos do ensino médio

Laura Encarnación De Jesús
Universidad de Guadalajara, Centro Universitario de los Valles, México
lauencarnacion@gmail.com
https://orcid.org/0000-0003-4902-3361

Suhey Ayala Ramírez
Universidad de Guadalajara, Centro Universitario de los Valles, México
suhey.ayala@academicos.udg.mx
https://orcid.org/0000-0003-1079-9605

Resumen

Por las características que presenta, la realidad mixta es una tecnología prometedora dentro del sector educativo. El objetivo de esta investigación fue evaluar la influencia que tiene esta tecnología en el aprendizaje teórico-práctico de estudiantes de educación media superior. El enfoque fue de carácter mixto. Se apoyó de un pretest y postest para evaluar aprendizajes específicos de arquitectura de *hardware*. Asimismo, se apoyó de las aplicaciones Creator AVR y PC Building. Para evaluar la influencia de la realidad mixta, se utilizó el modelo de aceptación de tecnologías que evalúa los rubros de facilidad, usabilidad y utilidad. Como resultado general, se obtuvo 79.2 % de conocimientos teóricos-prácticos. En el indicador de utilidad, se obtuvo 87 %, en el de usabilidad 69 % y en el de facilidad de uso 65 %. El estudio permitió observar que el uso de la realidad mixta puede apoyar el aprendizaje teórico-práctico de los estudiantes.

Palabras clave: aprendizaje práctico, realidad aumentada, realidad virtual, tecnologías disruptivas.

Abstract

Due to its characteristics, mixed reality (MR) is a promising technology within the education sector. The objective of this research was to evaluate the influence that MR has on the theoretical-practical learning of high school students. The study approach was mixed. It was supported by a pre-test and post-test to evaluate specific learning of hardware architecture. Likewise, it relied on the Creator AVR and PC Building applications. To evaluate the influence of MR, the technology acceptance model (TAM) was used, which assesses ease, usability, and utility. As a general result, 79.2 % of theoretical-practical knowledge was obtained. In utility 87 %, 69 % of usability, and 65 % in ease of use were obtained. The study allowed us to observe that the use of MR can support students' theoretical-practical learning.

Keywords: practical learning, augmented reality, virtual reality, disruptive technologies.

Resumo

Pelas suas características, a realidade mista é uma tecnologia promissora no setor educacional. O objetivo desta pesquisa foi avaliar a influência que essa tecnologia exerce na aprendizagem teórico-prática de alunos do ensino médio. A abordagem foi mista. Ele contou com um pré-teste e um pós-teste para avaliar o aprendizado da arquitetura de hardware específica. Também contou com os aplicativos Creator AVR e PC Building. Para avaliar a influência da realidade mista, foi utilizado o modelo de aceitação de tecnologia, que avalia as áreas de facilidade, usabilidade e utilidade. Como resultado geral, obteve-se 79,2% dos conhecimentos teórico-práticos. No indicador de utilidade, foi obtido 87%, no indicador de usabilidade 69% e na facilidade de uso 65%. O estudo possibilitou observar que o uso de realidade mista pode subsidiar a aprendizagem teórico-prática dos alunos.

Palavras-chave: aprendizagem prática, realidade aumentada, realidade virtual, tecnologias disruptivas.

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Introduction

The evolution that has occurred in information and communication technologies (ICT) implies new needs and processes in different areas. Education stands out among these. ICT in recent years have become a relevant component within the different educational levels, and especially in upper secondary education. These advances have made it possible to experiment with new devices, resources and applications that have opened up a wide range of opportunities in this sector. Within the technological advances, emerging tools, scientific innovations and advances have emerged that have been and are being used in the context of pedagogical training at the service of various purposes related to teaching-learning, in addition to being shown as disruptive tools, since they can generate changes in academic activities. In this context, virtual reality (VR) arises, a tool that allows users to immerse themselves in another space and interact with virtual elements through a viewer.

Focusing on the educational context, the Horizon report notes that VR and immersion applications have added functionality and currently offer greater potential for learning (Ministry of Education, Culture and Sports-National Institute of Educational Technologies and Teacher Training [Intef], 2017). Another tool that recently broke into the education sector is augmented reality (AR). AR is characterized by superimposing a real image obtained through a screen with 3D images or other information generated by a computer (Prendes, 2015, p. 187). And it is from the combination of these tools, VR and AR, that mixed reality (MR) arises. MRI refers to the superposition of virtual objects in a real environment that allows users to interact in the real world and, at the same time, with virtual images (Vásquez, 2017). These tools can contribute to the development of knowledge in students by covering the spectrum of traditional education and, at the same time, favoring competence-based education. Competency-based learning, in addition to contributing to a solid formation, promotes the skills that are necessary for students to be competitive from a personal and professional point of view (Villa and Villa, 2007).

The Education Sector of the Unesco Office in Montevideo (2009) has stated that education must improve and that educational models must be developed and applied that meet the needs of the current era, as well as promote the development of personal and social competencies. and learning that are elementary so that students can overcome any challenge that may be presented to them in this 21st century. Likewise, efforts should be directed towards students obtaining comprehensive learning and solid knowledge that allow them to enter future academic degrees, or explore the solution of social, environmental and economic problems, among others.

However, in some Latin American institutions there are external factors that prevent students from obtaining comprehensive learning. For example, while slightly more than 80% of the inhabitants of developed countries use the Internet, in developing countries only 41% of connectivity is reached; It is about a deficit in telecommunications infrastructure, lack of human capital, poverty and an inadequate environment (Galperín, 2017). In this sense, practices or experiences are sometimes complex. The educational sector in Mexico faces a series of challenges within the curriculum, educational evaluation, didactics and their application in daily life. Precisely within this last area the practices are located, an essential component for a comprehensive training, which range from the contents to the student's practice. These activities fall mainly on practical exercises, experiences and investigations, whether documentary or experimental (Pérez and Chamizo, 2016).

The purpose of this research was to evaluate how the didactic strategies through the use of RM favor the theoretical-practical learning of the field of hardware architecture in high school students. A determining aspect in this work is that the selected school lacks computer equipment to carry out the practices requested by the curricular plan in the area of computer science. The research is expected to contribute to the improvement of teaching, as well as to encourage the use of VR and AR within the educational sector. Thus, in line with what has been mentioned so far, the question that guided this research was the following: how do the didactic strategies designed through MRI favor the theoretical-practical learning of hardware architecture in upper secondary education students? whose branch of training is computer science?

Methodology

To achieve the proposed objective, the combination multi-method paradigm was chosen. According to Bericat (1998), it is a matter of subsidiarily integrating one method with another. In this case, the qualitative was supported by the quantitative in order to strengthen the validity of the latter and compensate for its own weaknesses by incorporating the data from the application of the qualitative method. In this sense, what was sought was to perfect, through the implementation of the qualitative, only one component of the research.

Regarding the degree of depth, the research is explanatory since it sought to test the cause-effect links between the independent variable, “RM”, and the dependent variable, “Theoretical-practical learning”. Likewise, due to the design and manipulation of these

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variables, it is an experimental investigation, since it was a process that consisted of subjecting a group of high school students to a stimulus (design of didactic strategies through the use of RM) and evaluating the effects and reactions that occurred in the dependent variable. For this, a pre-test and a post-test were designed (Arias, 2006).

For the independent variable "RM", the categories of analysis "RV" and "RA" were established. For these, its indicators were: Ease, Usability and Utility. While, for the dependent variable, "Theoretical-practical learning", the categories of analysis were established: Theoretical knowledge and Practical knowledge.

To carry out the intervention with the group of students, a series of didactic strategies was designed in a learning object based on an instructional design model congruent with the mediation of ICT and the constructivist learning theory that allowed to observe the change in the variable dependent.

Data collection instruments

Quantitative instruments

For the analysis of the categories Theoretical knowledge and Practical knowledge, a pre-test and a post-test on hardware architecture (see table 4) were used, which allowed evidence of the students' previous knowledge and the results after applying the didactic strategies through the use of the RM.

Likewise, the test (see table 5) of the Technology Acceptance Model (TAM) of Davis (1986, cited in Davis, Bagozzi, and Warsaw, 1989) was used, which measured the variables “RV” and “RA” through their indicators: Ease, Usability and Utility. This model has been used to evaluate the acceptability of technologies by users. In order to improve the reliability of the results, the Cronbach alpha statistic was supported. The TAM model was made up of nine items that offered five options according to the following scale of values: Totally disagree = 1, Disagree = 2, Indifferent = 3, Agree = 4 and Totally agree = 5.

Qualitative instruments

The integration of the qualitative method was carried out to incorporate complementary data on the interaction of students with technology. This was done through participant observation. For the emptying of the data and its subsequent analysis, it was supported by a checklist (see table 6), which consisted of keeping track of the practices carried out by the students, according to the issues raised, with the support of the Creator AVR (AR range) and PC Building (RV range) applications. An attempt was made to collect all possible data through direct observation and capture them in the observations section of the checklist, this to generate a better interpretation in the Theoretical knowledge and Practical knowledge categories.

Participants

The sample was drawn from students of upper secondary education through a non-probabilistic sampling for convenience and intentional. Likewise, students who had taken the Hardware Architecture course were considered, that is, students of computer science training in the 5th semester, who were in an age range of 16 to 17 years. The total sample was 13 students, which consisted of five men and eight women.

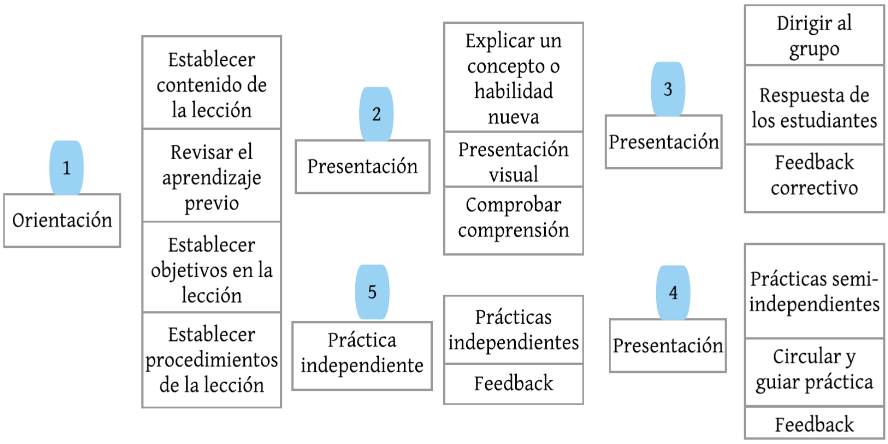
Data analysis method

For the analysis of quantitative data (pretest, posttest and TAM model), it was supported by forms created in Google Forms, which allowed its subsequent analysis with the support of the SPSS statistical package. Thus, descriptive graphics were generated according to the analysis criteria. Regarding the TAM model, it should be mentioned that it relied on Cronbach's alpha to verify the reliability of the applied instruments and, therefore, of the results obtained. In the case of the qualitative instrument, the checklist was used to empty the data derived from the observation and its subsequent analysis according to the criteria established in said instrument.

Description of the implementation process

The implementation of MRI-supported teaching strategies was based on the five-phase model: analysis, design, development, implementation, and evaluation (Addie). This process is interrelated in a transversal way with theoretical contributions of constructivism. The Addie seeks for the student to be the protagonist of their learning (Jonassen, Peck & Wilson, 1999). The instructional design that was used considers learning in virtual environments and directly, which means that this project has been shown in a direct training and virtual environments, as shown in Figure 1.

Figura 1. Diseño instruccional basado en una formación directa según Hirumi



Fuente: Villafañe (2009)

Broderick (2001) defines instructional design as the science of creating work environments; Instructions are detailed there, clear and effective materials are provided that favor the development of abilities and skills on the part of students. In accordance with the aforementioned, the implementation of this project was supported by an instructional design that was adapted to a learning object that consisted of materials and instructions, in addition to relying on MRI. Next, it is detailed on each one of the phases of the Addie.

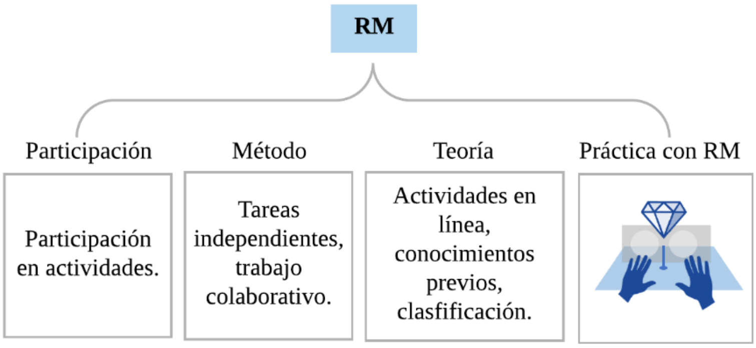
Analysis

The implementation was carried out in high school students of 5th semester belonging to computer training. Although they had already taken the Hardware Architecture course, the core problem was the lack of practices due to the lack of computer equipment and resources to purchase these, as they are presented in different educational institutions and states of Mexico (Galperín, 2017).

Design

For the design process, it was supported by a methodological proposal (see figure 2) that involved immersion, interaction and action to complement a rewarding and effective learning, in such a way that it could be intervened in person and online, this with the support of the learning object.

Figura 2. Propuesta metodológica a través de la práctica con el apoyo de la RM



Fuente: Elaboración propia

Developing

For the development phase, a learning object (LO) was created, which served as a mediator to complement a rewarding and effective learning, in such a way that the participants could find in it play activities, tasks and resources, as well as precise indications. of each of the proposed activities.

Implementation

In the first instance, the intention of the research was broadly given to contextualize the students and participation was voluntary. After having selected the participants, the Hardware Architecture pre-test was applied, to evaluate the theoretical knowledge and practical knowledge acquired in the 4th semester, considering the absence of practices due to the lack of computer and laboratory equipment for these purposes . The implementation process was carried out as shown in table 1, considering and taking advantage of the fact that most of the students had a mobile device.

Tabla 1. Proceso de implementación

Presentación “Estrategias didácticas de Arquitectura de Hardware”	
Sesión 1	Se explicó a grandes rasgos la finalidad de la investigación y la participación que tendrían los discentes. Además, se dio una demostración de RV y RA con el fin de aproximarlos a una experiencia con estas herramientas. Asimismo, se solicitó a los estudiantes contestar el pretest sobre arquitectura de *hardware* y firmar la carta de consentimiento para que conocieran los pormenores de su participación dentro de la intervención.
Sesión 2	En esta sesión, los estudiantes tuvieron un segundo acercamiento con las RV y RA, con el fin de adaptarlos al uso de estas tecnologías. Además, se les proporcionó los recursos necesarios para que pudieran crear sus gafas Google Cardboard en el momento que lo desearan después de la intervención y no se limitaran por las gafas costosas que existen en el mercado.
Sesión 3	Componentes básicos de una computadora En este apartado se apoyó de la aplicación de Creator AVR y de los dispositivos móviles. Los estudiantes interactuaron con la RA e identificaron las partes básicas de una computadora.
Sesión 4	Partes internas y externas de computadora En este apartado los estudiantes contaron con recursos disponibles en el Objeto de Aprendizaje, como Slideshare y Educaplay para interactuar con ejercicios prácticos, además de estar acompañados de la aplicación de Creator AVR, para la familiarización directa con las partes internas y externas que compone una computadora.
Sesión 5	Ensamble de una PC En este apartado los estudiantes conocieron la secuencia correcta de ensamblar una computadora a través del *software* de PC Building Simulator. Esta herramienta educativa tiene la comodidad de simular un laboratorio virtual, donde los discentes tuvieron la facilidad de ingresar para ensamblar una computadora. Asimismo, se pudo llevar la secuencia de ensamble con la RA a través del *software* Creator AVR. Al concluir la

	implementación de RM, se aplicó una evaluación general con la finalidad de medir el aprendizaje que se pudo generar a través de estas herramientas.

Fuente: Elaboración propia

Evaluation

It should be noted that play activities were presented in each unit (AR involvement, crossword puzzles, word searches, guess what it is, and Educaplay activities)[1] to reinforce the learning that was shown in the process. Likewise, at the conclusion of the RM implementation, the hardware architecture post-test was applied to evaluate the categories Theoretical knowledge and Practical knowledge and the TAM model test to evaluate the indicators Utility, Usability and Ease of use. All this with the ultimate aim of measuring the learning generated through MRI, as well as the percentage of acceptability towards these tools.

Results

The analyzed population consisted of the participation of 13 students organized into a single group. In the first instance, it relied on the pretest, which focused on measuring the prior knowledge acquired in the 4th semester, as well as on the analysis of knowledge acquired after implementation. As we have already said, this instance focuses on the categories Theoretical knowledge and Practical knowledge. At the end of the implementation, the TAM model test was also applied, which evaluated the acceptability of technologies considering the indicators Usability, Utility and Ease.

Hardware architecture test results

The data collection process consisted of the analysis of the application of the pretest (see table 4), composed of 13 items, general questions of the Hardware Architecture subject. According to the results obtained, it was observed that the students only reached 53% in solid knowledge in the subject studied in the previous semester. The values with the highest degree of relevance were registered in areas related to information, communication and with a decrease in practical cases (see figure 3).

[1] Educaplay es una plataforma que permite a los usuarios crear actividades educativas multimedia con un resultado atractivo y profesional como mapas, adivinanzas, crucigramas, etcétera.

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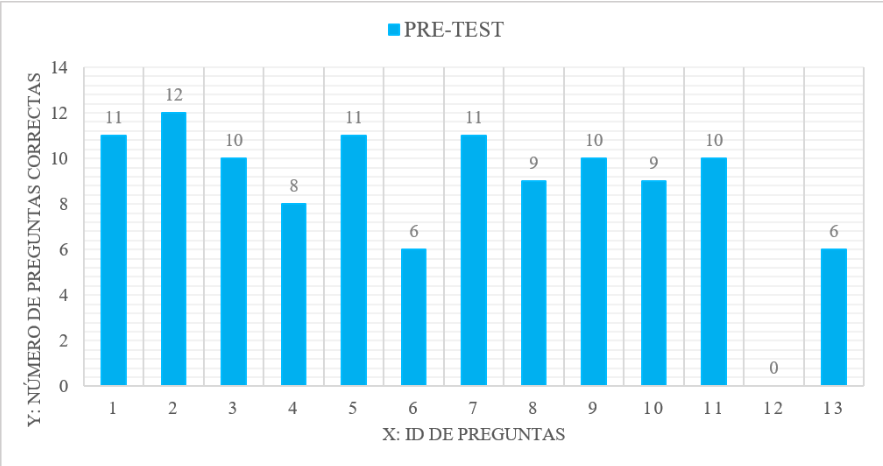
Figura 3. Resultados de conocimientos previos de la materia de Arquitectura de Hardware



Fuente: Elaboración propia

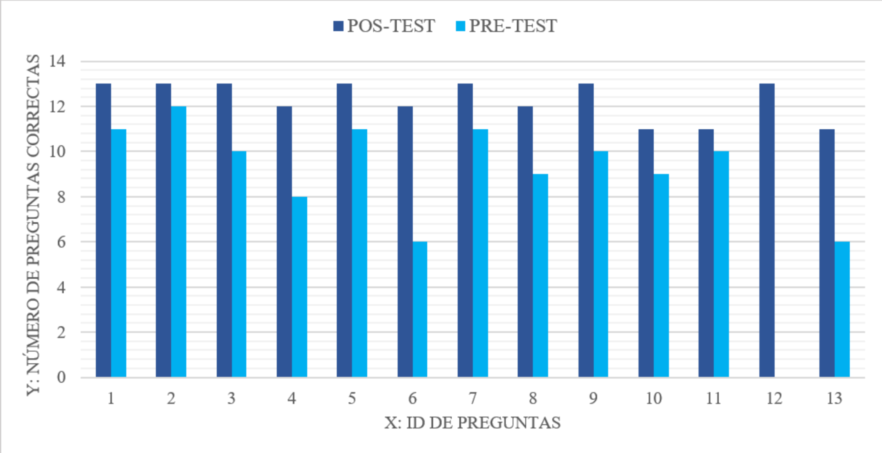
As can be seen, there is a decrease in item six. This represents the identification of the parts of the motherboard. According to the results, only 46.15% (six students) have solid knowledge in identifying it.

Regarding item 12, “Have you ever assembled a computer?”, None of the participants answered affirmatively, that is, they did not carry out certain practices that are proposed in the curriculum.

In item 13, “Do you identify the correct steps and measures to assemble a computer?”, As can be seen, 46.15% (six students) expressed knowledge regarding the assembly process, that is, they consider the appropriate measures for this , in other words, based solely on theoretical knowledge.

To know the influence that was had after the implementation, the hardware architecture post-test was applied. In figure 4 it can be seen that the students obtained an increase in information, communication and, most importantly, in practical cases with 79.2% of result. That is, an increase of 26.03% was achieved with the support of MRI for practical learning.

Figura 4. Resultados del pretest y postest



Fuente: Elaboración propia

Checklist results

Regarding the results of the checklist, it is worth mentioning that it was used to keep track of the practices carried out by the students and supported by the PC Building Simulator and Creator AVR applications. The purpose was to keep track of the recommendations and steps to correctly assemble a PC. This instrument served to reinforce and corroborate the results of the hardware architecture post-test, mainly in items 6, 12 and 13. The data collected is favorable, since the students found it necessary to know all the steps so that the application could Let advance and thus end the activity. It is possible to say that 90% of the students knew the correct steps, as well as the measures to consider before assembling a computer.

Results of the TAM model (Ease, Usability and Utility indicators)

To know the results of the indicators Ease, Usability and Utility, a survey was applied (see table 5), whose support was the TAM model, which is responsible for the study of the acceptance of technology (variables "RA" and "RV") . The survey was made up of nine items in which the scale of values was considered: Totally disagree = 1, Disagree = 2, Indifferent = 3, Agree = 4 and Totally agree = 5. Also, to have reliability in the results , was interpreted with Cronbach's alpha, which was calculated using formula 1.

$$a = \frac{k}{k-1}\left(1 - \frac{\sum V_i}{V_t}\right) \qquad (1)$$

Cronbach's alpha is a coefficient used to measure internal consistency; it is based on the average of the correlations between the items. In other words, Cronbach's alpha is the average of correlations between the items that are part of an instrument. The minimum is 0.70; below this value the scale used is low. While a result above 0.90 indicates that there is redundancy or duplication. Values between 0.80 and 0.90 are regularly preferred (Cronbach, 1951). Table 2 shows the results of the indicators Ease, Usability and Utility of the categories "RV" and "RA". According to the data and the interpretation of Cronbach's alpha, the students obtained 0.81 reliability (see table 3), which means that a good level evaluation was achieved.

Tabla 2. Interpretación del modelo de TAM con el alfa de Cronbach

	Ítem1	Ítem2	Ítem3	Ítem4	Ítem5	Ítem6	Ítem7	Ítem8	Ítem9	Suma
E1	1	4	1	4	2	2	1	2	1	18
E2	1	1	1	1	4	1	1	1	1	12
E3	1	1	1	1	2	2	1	1	1	11
E4	2	4	1	4	5	2	1	1	3	23
E5	1	4	2	4	4	2	2	1	2	22
E6	2	2	2	2	4	2	1	2	2	19
E7	2	2	2	2	3	2	3	2	3	21
E8	1	1	1	1	5	1	1	1	1	13
E9	1	4	1	4	2	1	2	1	2	18
E10	1	1	2	1	1	1	1	1	1	10
E11	3	4	2	4	4	2	3	3	2	27
E12	1	3	2	3	4	2	1	2	2	20
E13	3	3	2	3	4	2	1	3	3	24
Varianza	0.5562	1.6213	0.2485	1.6213	1.4675	0.213	0.5562	0.5444	0.5917	

Fuente: Elaboración propia

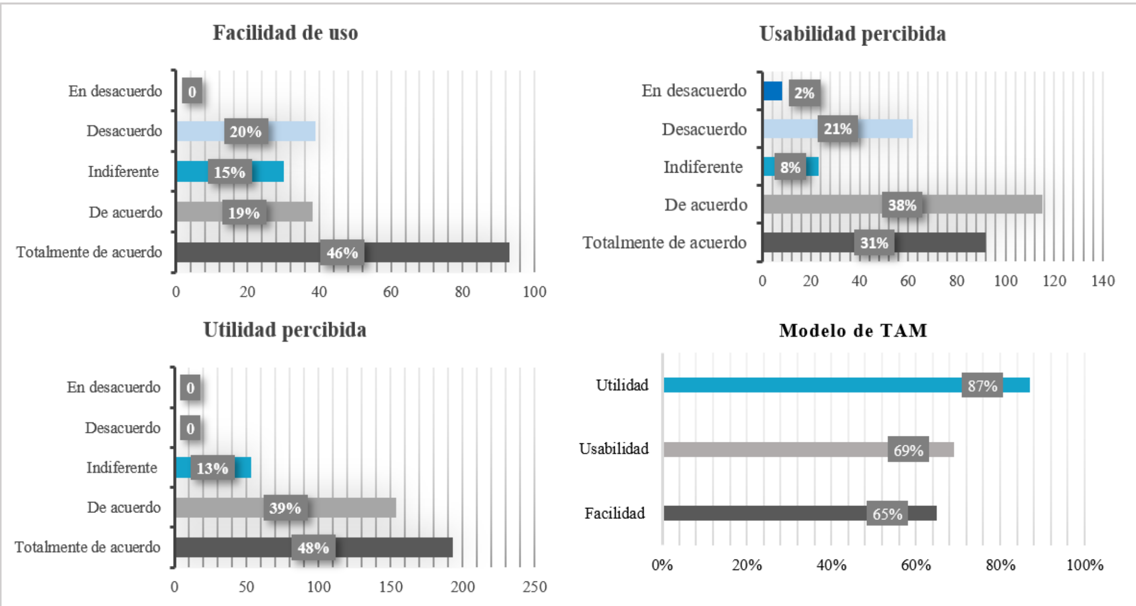
Tabla 3. Interpretación de los resultados del modelo de TAM basada en la ecuación del alfa de Cronbach

A (alfa) =	0.810241
K (número de ítems) =	9
Vi (varianza de cada ítem) =	7.420118
Vt (varianza total) =	26.52071

Fuente: Elaboración propia

Following the analyzed results of the indicators of Ease, Usability and Utility, the integration response of the categories "RV" and "RA" was shown positively by the students. For a better interpretation, figure 5 shows the results for each of the mentioned indicators. Regarding the Ease indicator (totally agree and agree), there is a positive perception with 65%, that is, the number of these participants did not find difficulty in using MRI. However, 35% expressed difficulty in the process of activities that involved MRI because they were not familiar with this type of resources.

Figura 5. Interpretación del modelo de TAM



Fuente: Elaboración propia

Regarding the Usability indicator (see figure 5), 69% was obtained in the interactivity and understanding of content, however, 31% indicated indifference towards the content of VR and AR. This is due to ignorance of the RM, despite this, they stated that they would like the content supported through the RM to be part of their academic training in various subjects.

On the other hand, the Utility indicator (see figure 5) registered an effect of 87% (totally agree and agree) in the understanding of the topics covered in the Hardware Architecture subject with the support of the RM.

Discussion

The present research focused on evaluating how the use of MR supported didactic strategies influences the theoretical-practical learning of upper secondary education students, particularly in those who have computer training and, being even more precise, in the hardware architecture topic. In addition to the use of a learning object that served as a mediator for the provision of resources and activities that served to strengthen the knowledge supported by RM.

After having proceeded to the implementation, and based on the data collection, it can be expressed that the use of didactic strategies supported by RM, mediated by platforms that contain resources and activities to reaffirm what has been learned, fosters the meaningful learning of the students. learners. Likewise, it motivates and encourages the learning process through these tools due to the characteristics it presents. In this sense, it could be said that investigations like this become a key piece to understand how MRI could be used for theoretical and practical learning in spaces that lack specialized laboratory equipment.

The results obtained lead us to think that the use of MRI does improve theoretical-practical learning, which is evidenced in items 6, 12 and 13 (see table 4). These results coincide with the findings of Villarejo (2019) and Hamada, Mohamed, Mohamed and Youssef (2018).

Regarding the evaluation of the acceptability of RA and RV, it can be affirmed that, regarding the Ease indicator, composed of two items (see table 5), it allowed to demonstrate the comfort of interacting with the components and the process of activities supported by the AR and VR, as well as the handling of mobile devices during the visualization of 3D images. The results show a positive reception with 65%.

For the Usability indicator, three items were considered that referred to interactivity, content understanding and content design. Here it can be expressed that the students showed comfort for their learning through these tools. This can obviously be corroborated in the results obtained: 69% expressed acceptability in terms of usability.

For the Utility indicator, four items were considered (see table 5), which evaluated whether the MRI supported the academic training of the students, in addition to awakening learning motivation due to the characteristics of these tools. According to the results obtained, it can be stated that they were favorably accepted; 87% profit was recorded here. These results coincide with the research of Mojerón (2018) and Lasheras (2018).

Finally, this document can be expressed as it provides relevant data that could be used to consider didactic strategies supported by MRI, in order to promote theoretical and practical learning that allows them to develop skills and abilities that they require for job placement or future academic degrees. , as well as to motivate and encourage students to acquire comprehensive training.

Conclusions

The objective of this study was, in addition to evaluating the effectiveness of didactic strategies through the use of MRI, to corroborate the acceptability of the use of technological tools (in this case MRI) as didactic resources for learning. For this, the TAM model was considered, which was in charge of evaluating the variables "RA" and "RV" through the indicators already mentioned.

Thus, it is possible to answer that the evaluation effect was positive, since theoretical-practical knowledge was acquired with the support of MRI, an example of this are the results obtained from the hardware architecture test and a checklist where it was possible to visualize a significant increase in theoretical-practical learning. This improvement could be detected by the pretest and the posttest. As a first result, 53% were obtained in theoretical knowledge, without considering practical knowledge. After implementation, there was an increase of 79.2% referred to information, communication and, most importantly, in practical cases: an increase of 26.03% with the support of MRI for practical learning.

It is concluded that the involvement of MRI in the educational sector could support the practices of assembling a computer, in addition to supporting the learning conditions and the inclusion of emerging technologies. On the other hand, this tool could be replicated in subjects that require the practical use of specialized equipment. In this sense, the aCanelma Team (July 11, 2016) expresses that VR can be used in an educational approach based on learning experiences focused on immersing students in places of local, cultural, landscape heritage, etc. In addition, it can be used in various subjects such as: language arts, mathematics, social studies, science, etc. Likewise, it is highlighted that expensive viewers are not necessarily required to view 3D objects, since you can use Google Cardboard viewers, viewers that allow you to experience VR in a simple and fun way.

On the other hand, it is relevant to mention that MRI allows a significant, attractive and motivational learning in students, proof of this was reflected in the applied survey of the TAM model, which evaluated the acceptability of MRI, as well as the object of learning that contained resources and activities that helped to reinforce the learning of the students. This was reflected in the indicators Ease, Usability and Utility; there were significant data in each of these: 87%, 69% and 65% respectively.

Regarding the question outlined for this research, how do the didactic strategies designed through MRI favor theoretical-practical learning about hardware architecture in high school students of computer science training? Following the results obtained, It is possible to answer that MRI produces positive effects on theoretical-practical learning in students, mainly in practical knowledge, which was the core theme of this research.

The analysis of the aforementioned variables highlights the contribution that MRI has for the acquisition of theoretical knowledge and practical knowledge in institutions where specialized equipment is lacking, time or security problems are encountered. MR influences motivation and contributes to the development of skills and abilities required by students in this digital age, according to the results achieved. In general, the perception of students from the use of these tools to support their learning has been favorable, as well as it has aroused interest and motivation for the playful way in which these tools are presented.

Finally, it should be mentioned that one of the strengths of this research was the planned and supported intervention of an instructional design. In this case, the Addie model was used. Specifically, the Addie was adapted according to the needs of students and teachers.

Future lines of research

For future research, it is suggested to explore other institutions with the same conditions to compare results. Likewise, the study could be applied with control groups that allow in-depth analysis. Another interesting line could be the incidence in the use of these tools by teachers, that is, how they can adapt this type of technology to mediate the teaching-learning process. Finally, it would be interesting to use didactic strategies supported by VR or AR in other disciplines, such as, for example, stimulating mathematical thinking in students.

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Anexo

Tabla 4. Cuestionario sobre arquitectura de *hardware*

Instrucciones. Estimado estudiante, la intención del cuestionario es conocer los conocimientos previos sobre la materia de Arquitectura de Hardware, el cual no tiene ningún valor en la evaluación del semestre correspondiente.
1. ¿Qué es la informática? a) Es la ciencia que estudia los componentes físicos de una computadora. b) Es la ciencia aplicada que abarca el estudio y aplicación del tratamiento automático de la información. c) Es la ciencia que estudia el uso de Word, Excel, Power Point, etc.
2. Las TIC involucran teléfonos, consolas de videojuegos, cámaras, laptops, tabletas, etcétera. a) Verdadero b) Falso
3. ¿Dispositivo que permite la salida de información? a) Mouse b) Teclado c) Impresora
4. El procesador es: a) El cerebro de una computadora b) El chip central de la computadora c) La capacidad de almacenamiento d) El sistema operativo
5. Los periféricos se clasifican en: a) De entrada, salida, de almacenamiento y mixtos b) De entrada y de subida c) Mixtos, de subida y almacenamiento d) De subida y de bajada
6. Mencione cada una de las partes de la *motherboard*:
7. Existen dos tipos de memorias principales: a) RAM y ROM b) RAM y PROM c) ROM y PROM

d) BROM y Rambus
8. Los dispositivos de salida son todos aquellos mediante los cuales el computador: a) Funciona correctamente b) Maneja efectivamente los dispositivos de entrada c) Permite ver toda la información en bruto d) Entrega al exterior la información procesada
9. Es el componente más importante de la computadora, ya que es el cerebro que controla y administra información, y ejerce el control de la computadora. a) CPU b) Monitor c) Teclado
10. Menciona qué son los elementos de entrada a una computadora. a) Son programas en espera al ser ejecutados b) Son los que te permiten abrir Internet c) Son los que permiten dar entrada al CPU
11. Las características de gran importancia de un microprocesador son: a) Tecnología de fabricación. b) Aceleración de gráficos. c) Velocidad de procesamiento de datos.
12. ¿Alguna vez ha ensamblado una computadora? a) Sí b) No c) Algunas veces
13. ¿Identifica los pasos y las medidas correctas para ensamblar una computadora? a) Sí b) No c) Los recuerdo ligeramente

Tabla 5. Modelo de TAM

Objetivo: Comprobar el grado de aceptación tecnológica de la realidad mixta (RM) como uso didáctico, para el aprendizaje práctico de los estudiantes.								
En desacuerdo	Desacuerdo	Indiferente	De acuerdo	Totalmente de acuerdo				
1	2	3	4	5				
Facilidad de uso percibida con RM								
Escala					1	2	3	4	5
1. Fue fácil interactuar con componentes de RM.									
2. He encontrado dificultad en realizar tareas en el mundo virtual.									
Usabilidad de realidades RM									
Escala					1	2	3	4	5
1. Fue fácil entender el contenido con el uso de RM.									
2. Los componentes visuales de RM son interactivos.									
3. Los componentes visuales de RM son complejos.									
Utilidad de aprendizaje y motivación con las RM									
Escala					1	2	3	4	5
1. Me resultó fácil comprender el contenido de Arquitectura de hardware con las RM.									
2. Me gustaría realizar actividades con el uso de RM en clases.									
3. Me resultó fácil conocer las partes de una computadora con RM.									
4. Me resultó interesante usar las RM para mi aprendizaje.									

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Tabla 6. Lista de cotejo

Procedimiento de ensamblaje			Observaciones
	Sí	No	
Identifica el proceso de seguridad para el ensamblaje correcto.			
Identifica cada uno de los componentes: Disco duro, tarjeta RAM, tarjeta gráfica, etcétera.			
Inicia procedimiento.			
Coloca cada una de las partes en el lugar correspondiente:			
Realiza pruebas de funcionalidad.			
Ensambla de manera satisfactoria.			