Augmented Reality in Physics Teaching

*Jairo Sánchez**

Mario Humberto Ramírez Diaz

Instituto Politécnico Nacional, Mexico

Faculty CICATA Legaria

Mexico City, Mexico

*jsl18_mtl@hotmail.com

(Received 07.12.2021, Accepted 20.01.2022)

ABSTRACT

In this work a review of the research on augmented reality (AR) and its use of the learning of physics in the classroom is carried out. These two concepts of technology and learning are interrelated. Teachers have pre-teaching concepts and methods (conceptual changes), with the aim of having a deeper understanding of physical concepts that occur in everyday life. This is why the idea of using other teaching methods to apply in class was born. AR is considered until now as the process of development of undifferentiated thinking. Current attempts to teach and learn physics concepts are old and repetitive, that is why by using a learning progress method such as augmented reality in physics, the student's learning will be more assertive, thus generating an interest in the same, since the traditional method can become boring for some people, on the other hand, the use of technology, and in this case Augmented Reality, can facilitate the teacher's work when it comes to generating interest in their students. With the use of augmented reality in physics, it is expected to achieve a scientific advance, and thus make the teaching of physics more satisfactory for all types of students.

Keywords: Augmented Reality, physics education, review of literacy.

INTRODUCTION

Physics as a science of nature, is part of the curriculum in the usual teaching in colleges or universities in different countries. The teaching of science has used different resources, such as didactic sequences and technological tools, but technological resources such as Augmented Reality (AR) and learning in physics are scarce.

In the teaching of Physics, pedagogical activities must be proposed accompanied by technological tools with which the interest of students is promoted, for example, through experimental assembly in the classroom. The above is essential since this is a source of motivation and managing to capture interest in Physics by observing phenomena that occurred at a given time. Sometimes described as "a waste of time" (Hodson, 1989). The laboratory is a motivation for the student when he performs practical activities in the classroom and in a laboratory.

AR can be fundamental in teaching, as more and more people surround themselves with technology, making traditional teaching methods boring for some. In science, this new teaching tool further facilitates the learning process, since, in the case of virtual teaching, laboratories could be replaced with the help of this technology.

AR is a technology that is based on observing the real world, augmenting it with additional information generated by a computer, tablet or cell phone. Intelligent, realizing a combination between real and virtual objects in a real environment. From augmented reality you can propose the combination in real time and align the virtual objects in 3D reality.

From a first approximation, and as Cabero and García (2016) point out, it can say that “it is a technology that allows the combination of information digital and physical information in real time through different technological supports such as tablets or smartphones, to create a new reality enriched”. For these authors, their distinctive characteristics are also those of being a mixed reality, offer in real time the combination of different layers informative, being an interactive technology, it is easy to handle, and that through its use we enrich or alter the information of reality by adding Additional Information.

What Is Augmented Reality?

The Augmented Reality according to Milgram and Kishino (1994) refers to real environments that are augmented through virtual objects, that are generated by computer. In this sense the interaction of the user with worlds or objects generated by it. Azuma (1997) defines the term as an incorporation of virtual objects in the real world. In this way the two environments, virtual and real, are merged into one, it can be used as a support tool in teaching because it allows interaction, with the user such as the area of medicine in the anatomy of the human body in a three-dimensional way, where there would be practically no time limit or usability that would allow us to acquire knowledge without cognitive filters. AR is becoming increasingly widespread and has garnered much attention, the term AR has been defined in different meanings by researchers. Early on, as mentioned by Milgram et al. (1994). Although AR is a new technology but the affordances and benefits to support learning were worth to mentioned and discussed. According to Chien, Chen and Jeng (2010), AR has an ability to encourage kinesthetic learning. Furthermore, since AR use 3D registration of virtual and real objects, it could allow user to view the learning content in 3D perspectives.

Augmented reality is a technology that integrates signals captured from the real world (typically video and audio) with computer generated signals (three-dimensional graphic objects and two-dimensional); makes them correspond to build new coherent worlds, complemented and enriched - makes coexist real world objects and virtual world objects. This technology takes advantage of derived technologies of visualization to build applications and content with the qualities, that these areas have matured in recent decades, (Cabero, Llorente and Gutiérrez, 2017).

The educational possibilities of using augmented reality technology have transcended all educational levels. Currently we can find educational experiences based on the use of AR technology both in Early Childhood Education (Agirregoitia, Benito and Artetxe, 2016), Primary (Bongiovani, 2013), Secondary (Carracedo and Méndez, 2012; Palazón-Herrera, 2016) as in various degrees of university education (Zárate et al. 2013; Castañeda, Gutiérrez and Román, 2014; Cabero, García and Barroso, 2016). De la Torre et al. (2013) are in favor of teaching through AR where they establish that in the academic training of students the imagination and manipulation of objects is necessary, this directly related to the educational and fundamental success in both learning and problem solving.

The progressive introduction of new technologies in classrooms, added to the unprecedented increase in mobile devices available to the population as a whole, places AR in a prominent position. In fact, since 2010 Time magazine included it among the ten technological trends of that year (Carracedo and Martínez, 2012). Educators are always looking for a new way to teach students and Johnson et al. (2011).

In any augmented reality system, at least four fundamental tasks are necessary to carry out the augmentation process. These tasks will be explained in greater depth in later sections, but basically, they are scene capture, scene identification, reality mixing and visualization. (Redondo, 2012).

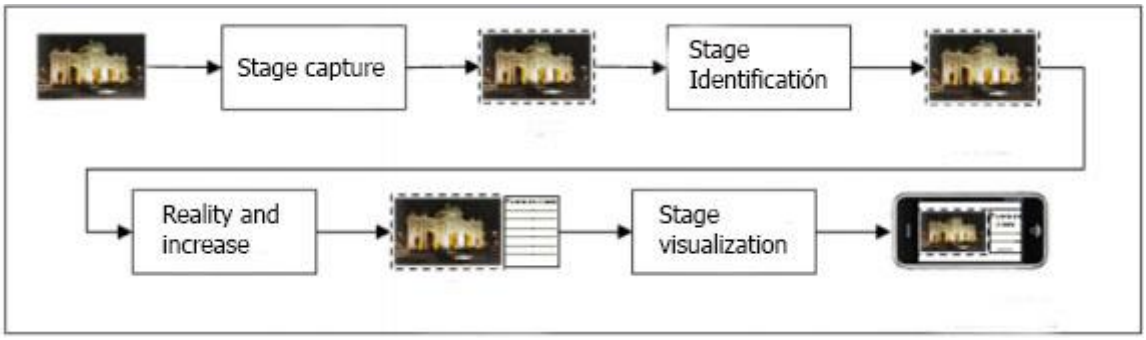

Figure 1. Schematic form of the augmentation process (Redondo, 2012)

AR can be applied in any field, such as education, telecommunications, industrial processes, robotics to name a few. In science, it has been used in the study of electrical storms, geological impacts of an erupting volcano, design of chemical compounds, molecular analysis, as well as in genetic engineering research, among others (Milgram *et al.* 1994).

According to Prendes (2015), there are several of augmented reality. Reinoso (2013), establishes a classification regarding the way of working, parameters of monitoring systems and techniques used.

- **Level 0**

  It is the basic level, here we can find the barcodes and QR codes.

- **Level 1**

  It is the most used and diversified form of Augmented Reality and is based on the use of markers, these are generally square figures with a design (asymmetric drawing) printed in black and white that, once scanned, extract the 3D information contained by showing it through on the device screen. Reinoso, 2013; Estebanell et al. 2012

- **Level 2**

  According to Estebanell *et al.* (2012), is based on image recognition or geolocation, this depends on parameters such as: Position, orientation and inclination of the device.

- **Level 3**

  At this level, the augmented reality viewed through screens becomes augmented vision thanks to technological devices that allow the real environment to become an immersive virtual world, the technological devices used for this purpose are VR glasses, projectors, contact lenses and helmets. (Rice, 2009, cited in Prendes, 2015)

- **Level 4**

  The use of the Global Positioning System sets a reference at this level, as it is in a certain coordinate place recognized by the GPS, content can be displayed in Augmented Reality. (Cabero & Barroso, 2019)

- **Level 5**

  Cabero, Barroso & Llorente (2019) in their work "Augmented reality in university education" classify La Huella Termal at this level. It is intended with this type of technology that every surface becomes tactile, so with the heat that our fingers emanate we can interact with the environment.

METHODOLOGY

Searching for scientific articles on the internet is a tedious job, especially if it is a "new" technology in physics. That is why the use of platforms such as academic Google, Scholarpedia, among others, facilitates the work. Selecting each item used takes time, that is why the items that made the greatest contribution to augmented reality in the teaching and learning of physics were chosen.

AR in Learning Physics

According to Bouciguez, Santos & Abásolo (2013), the teaching of physics is one of the main areas that has used the potential of ICT (Information and Communication Technologies) for the development of new methods teaching, likewise, motivating the field of research.

The use of AR is intended to complement traditional learning methods through interactivity, portability, security for users and equipment, freedom of exploration and analysis of the information. This project proposes a complementary tool for mechanical physics practices related to friction, parabolic draft and energy conservation using AR, where it offers an alternative to the problems of time in the laboratory and availability of schedules, since the tool and experiments can be performed without the need for specialized laboratory equipment that requires a controlled environment and supervised by a laboratory worker. (Nincarean et al. 2013)

Perhaps one of the great limitations of incorporation in classrooms is more linked to the technical aspect of technology than to the didactic-curricular one. It is the case of the large number of failures that, on some occasions, the device (Tablet, in the most cases), or the internet connection, as well as the difficulty that in certain cases ages presents the handling of mobile devices in typical classroom environments. (Almenara, Cejudo, and Castillo, 2017)

On the other hand, it is known that teachers still make little or insufficient use of technology in teaching, and in particular for the teaching of Mathematics, Physics or the environment. It is assumed that this is due to two compelling reasons: on the one hand,

ignorance of new technologies and, on the other, the lack of training for the design of teaching proposals that integrate ICT, (Abásolo et al. 2017).

The theory of variation, initially formulated by Mazur (1997), proposes that the positions from the school that are enriching in learning are those that put the student in a situation where they have to experiment or analyze to change their initial conception, something that from the beginning it should be given at the beginning of the class, and where you can also provide clues and suggestions for its educational use. In this sense, there is a synthesis of learning theories on which their educational use can be supported (Figure 2).

Figure 2. Theoretical models that can give theoretical coverage to the educational use of AR

A direct example of learning physics with the use of augmented reality can be seen as evidenced by (Kato & Billinghurst, 1999; Caudell et al. 1993; Fernández et al. n.d), in a conceptual diagram of a system of augmented reality based on video technology with external monitors. The cameras can be static or mobile. This application was implemented in a practice of Physics II, related to the topic of parabolic shooting, which is taught within the subject of Physics II at the Institute of Engineering and Technology of the Autonomous University of Ciudad Juárez, (Amaya et al. 2016).

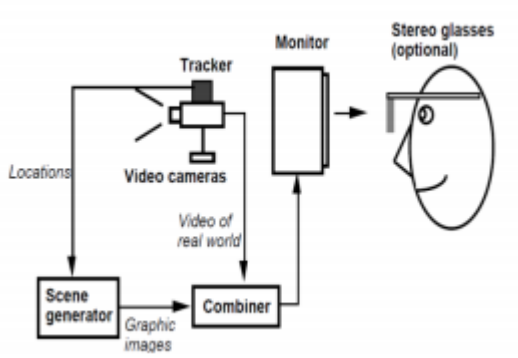

Figure 3. Conceptual diagram Architecture based on external monitors. (Kato and Billinghurst, 1999)

This modality has been analyzed in different investigations carried out in the RAFODIUN project (Figure 2), finding its strong acceptance by students, increased motivation, and the ease of acquisition of the contents presented (Garay, Tejada & Castaño, 2017; Garay, Tejada & Maiz, 2017; Cabero & Barroso, 2018).

Figure 4. Examples of notes enriched with AR objects

In this new scenario of science teaching-learning, Information and Communication Technologies (ICT) offer tools of great interest to promote the development of the various capacities that make up scientific competence. Cañal, García-Carmona & Cruz-Guzmán

(2016) consider ICT as optimal resources to promote science education, which can be integrated into a pedagogical model based on inquiry.

The performance of students in physics classes is not the best when it comes to understanding or understanding a problem that arises in class, that is why, Flores et al. (2015) suggests the interaction of the subject and object through the real and graphic representation of physical situations through animation. Thus, we can establish alternatives to improve the teaching of Physics, one of these alternatives is AR.

When the student in physics classes is faced with computer simulations, a situation of distributed cognition is formed. This concept supposes that human cognition can be conceived as distributed beyond the scope of the own organism, and in different senses; embracing other people, relying on symbolic means and taking advantage of the environment and artifacts. (Bouciguez, 2010)

It could also be thought that simulations in physics classes would allow building bridges between students' previous knowledge and the acquisition of new knowledge, through the development of strategic knowledge to solve physical problems. (Bouciguez, 2010)

According to Basogain et al. (2007), in several prestigious institutions, such as Massachusetts, MIT and Harvard in progress of game development; These games seek to involve high school students in situations that combine real world experiences with extra information on their mobile devices. In addition, they have developed other games to teach math and science subjects.

According to Cabero & Barroso (2016), AR is becoming more important, since technology offers many advantages for learning, some of them are:

- Easy understanding of concepts and phenomena difficult to abstract.
- Useful as a constructivist methodology in teaching and learning processes.
- In the educational process, students play an active and participatory role.
- Increase motivation
- The level of learning is increased
- It can be applied in different educational contexts (levels and subjects) with different

technologies.

An example of physical phenomena where AR can be used, according to (Milgram et al. 1994), are in the study of electrical storms, geological impacts of an erupting volcano, design of chemical compounds, molecular analysis, as well as in research in genetic engineering, among others.

In physics, motivation in students is essential, because, if initially, the approach to an exercise frustrates them, AR can make it motivate them. As mentioned, (Cabero & Barroso, 2016), AR increases the level of learning, and this, in physics class, complements the aforementioned, the motivation of the students.

According to Robert Gagné, the learning process goes through a series of phases (figure 3) that must be fulfilled so that the knowledge remains entrenched in the student's mind.

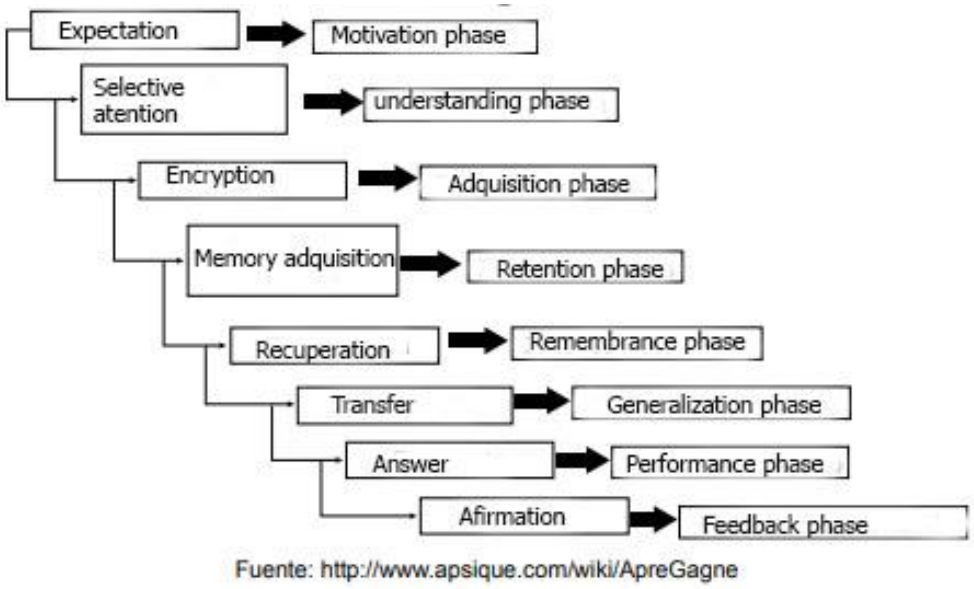

Figure 5. Learning Process According to Robert Gagné

Based on this, the retention phase is where the technology can be used, in this case, AR. According to Bouciguez (2013); Santos (2016), they describe some educational video games to teach physics. Using a video game, you can enhance the level of learning in the classroom, for the teaching of physics.

Alem & Cano (2011) presented mobile AR game, ARGreenet that aim to increase

people awareness of how important of recycling is and how to do it. In their study, they compared the ARGreenet with the basic mobile phone game for recycling topic. The participants involved in this study involved a total of 38 children where all of them experienced both games but in a different order. The evaluation aspects consist of the knowledge of recycling that the children perceived, the level of engagement, fun and easy to use, perceived willingness to change behaviour and comparison toward AR and non-AR games. Based on the results of the study, there is no significant difference between the two games; however, 69.4% of the children preferred the ARGreenet game, which they perceived it as easy to use and more engaging and fun than basic mobile phone game. In addition, the findings also show that the games had a positive influence on their intentions to change behaviours (Alem, *et al.*, 2011)

According to De la Torre et al. (2013), some applications developed for educational purposes stand out:

1. Construct3D (Kaufmann, 2004) is an AR system for the construction of 3D geometries. It was designed for learning mathematics and geometry. It has been tested with students to compare traditional learning with the AR system.
2. The Mixed Reality Lab in Singapore2 has developed various AR systems for educational purposes, such as: an AR system for learning the solar system, an AR system for learning how plants germinate, etc.
3. The Magic Story Cube (Zhou et al. 2004) uses a cube as a tangible interface that is folded or unfolded.

CONCLUSION

The use of AR in the learning of physics, can change the future of this teaching. The point of view of students about the traditional method of teaching physics, thus causing motivation and an optimal performance in the subject. Nowadays, the use of AR in the learning of physics is used more and more. That is why, in the future, the teaching of physics will change to how it is known to date, using AR as one of the main teaching strategies.

If it is considered a rudimentary learning style, this advance in the learning style opens many doors. In the fundamental models already pre-established for a student to learn

in the best way if it is approached from the point of view of cognitive theory. A technological approach is added with the help of ICT, this process requires special training, not in theoretical knowledge, but in practice and the exemplification of these concepts, that a priori could be more difficult to understand.

In the aforementioned perspective, it is possible that in the short-term multiple or varied methods will be included to grant a contribution to the field of praxis. Physics undergoes a new evolution, in which it brings man closer to the third dimension to strengthen the link between virtual and non-virtual reality. On the other hand, the efforts of scientists in the broad technological field intensify the construction of an ideal world. There is very little time left for real physics to proliferate, and for this the efforts of those who recognize the benefit of its incorporation into teaching, are the main architects of the knowledge of future generations.

REFERENCES

Abásolo, MJ, Sanz, C., Naiouf, M., De Giusti, AE, Santos, G., Castro, ML, & Bouciguez, MJ (2017). *Augmented Reality, Virtual Reality And Tangible Interaction For Education*.

Agirregoitia, A., Benito, Jr And Artetxe, E. (2016). Augmented Reality For Emotional And Social Development At Early Childhood. *Proceedings Of The I. International Congress Of New Technologies And Trends In Education*. CINTE16, Leioa: UPV / EHU. [In Press]

Amaya, PP, Sánchez, JR, Demoss, VG, & Carreón, AM (2016). Augmented Reality Application In The Teaching Of Physics. *Scientific And Technological Culture*, (51).

Azuma, R. (1997). A Survey Of Augmented Reality. Presence: Teleoperators And Virtual Environments, 6 (4), 355-385

Basogain, X., Olabe, M., Espinosa, K., Rouèche, C., & Olabe, JC (2007). *Augmented Reality In Education: An Emerging Technology*. Bilbao School Of Engineering, EHU.

Bongiovani, P. (2013). *Augmented Reality In School: Technology, Experiences And Ideas*. Educ @ Contic.

Bouciguez, MJ, & Santos, G. (2010). *Applets In The Teaching Of Physics: An Analysis Of*

The Technological And Disciplinary Characteristics.

Cabero Almenara, J., & Barroso Osuna, JM (2018). *Technological Scenarios In Augmented Reality (AR): Educational Possibilities In University Studies*.

Cabero, J., García, F., And Barroso, J. (2016). The Production Of Learning Objects In "Augmented Reality": The Experience Of The SAV Of The University Of Seville. *IJERI. International Journal Of Educational Research And Innovation, (6)*, 110-123

Cabero-Almenara, J., & García, F. (2016). *Augmented Reality. Technology For Training*. Synthesis. Madrid.

Castañeda, L., Gutiérrez, I., And Román, M. (2014). Enriching Reality: Augmented Reality With Social Education Students. @Tic Revista D'innovació Educativa, 12, 15-25. Doi: 10.7203 / Attic.12.3544

De La Torre Cantero, J., Martín-Dorta, N., Sorín, J., Carbonel, C., And CONTERO, M. (2013). Ubiquitous Learning Environments With Augmented Reality And Tablets To Stimulate Understanding Of Three-Dimensional Space. *RED, Journal Of Distance Education (37)*, 2-17.

De Pedro Carracedo, J., And Méndez, Clm (2012). Augmented Reality: A Methodological Alternative In Nicaraguan Primary Education. *IEE-RITA, 7*, 102-108.

García-Carmona, A., & Cruz-Guzmán, M. (2016). With What Experiences, Potentialities And Predispositions Do Future Primary Education Teachers Begin Their Training In Science Teaching? *Eureka Magazine On Science Teaching And Dissemination, 13* (2), 440-458.

María José Bouciguez, Graciela Santos, María José Abásolo (2013) Potentiality Of Video Games In The Learning Of Physics. Proceedings Of WEFA 2013 I Workshop On Physics Teaching In Argentina. *Universidad Nacional Del Centro De La Pcia*. De Bs. As., ISBN 978-950-658-342-2

Martínez Pérez, S., & Fernández Robles, B. (2018). Augmented Reality Objects: Pedagogy Students' Perceptions. *Pixel-Bit: Media And Education Magazine, 53*, 207-220.

Mazur, E. (1997). Peer Instruction: A User's Manual. Prentice Hall: New Jersey. Https://Doi.Org/10.1063/1.881735

Milgram, P., & Kishino, F. (1994). A Taxonomy Of Mixed Reality Visual Displays. *IEICE*

TRANSACTIONS On Information And Systems, *77* (12), 1321-1329.

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995, December). Augmented Reality: A Class Of Displays On The Reality-Virtuality Continuum. In Photonics For Industrial Applications. 282-292. *International Society For Optics And Photonics*

Palazón-Herrera, J. (2016). Musical Cubes: A Didactic Proposal For The Music Classroom In Secondary Using Augmented Reality. In R. Roig (Ed.), *Technology, Innovation And Research In Teaching-Learning Processes*. Barcelona: Octahedron. [In Press]

Prendes Espinosa, C. (2015). Augmented Reality And Education: Analysis Of Practical Experiences. *Pixel-Bit. Media And Education Magazine, 46*, 187-203.

Redondo, DA (2012). Augmented Reality.

Reinoso, R. (2013). Introduction To Augmented Reality. Simo Network.

Ruiz, UG, Garitano, ET, & Garrido, CMC (2017). Students' Perceptions Towards Learning Through Educational Objects Enriched With Augmented Reality. Edmetic, 6 (1), 145-164.

Telefónica, F. (2011). Augmented Reality: A New Lens To See The World. Telefónica Foundation.

Villalustre Martínez, L., Del Moral Pérez, ME, & Neira Piñeiro, MR (2019). Teacher Perception On Augmented Reality In Primary Science Teaching. SWOT Analysis.

Zárate, Mr, Mendoza, Cf, Aguilar, H., And Padilla, Jm (2013). Bookmarks For Augmented Reality For Educational Purposes. RECEIVES, 3. *Http://Recibe.Cucei.Udg.Mx/Revista/Es/Vol2-No3/Pdf/Computacion04.Pdfc*

Prada, E. L. And Quevedo, A. U. (2013). Educational Multimedia With Augmented Reality Applied To Mechanical Physics. *International Meeting Of Engineering Education.*

García, S. F., Quezada, M. D. G., Sandoval, O. R., Quiñones, M. D. L. Á. C., Pierce, J. C., Saldaña, N. N., & Chávez, O. R. (2018). Proposal For The Conceptual Understanding Of The Parabolic Shot Based On Augmented Reality Part II. *Latin-American Journal Of Physics Education*, *12* (4), 15.