



# Use of Augmented Reality in early years of education: A look from literature

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## **Abstract**

Augmented reality (AR) is an information and communications technology (ICT) that blends the real world with virtual interfaces to enhance an individual's interactions with the world around them. In the context of education, AR has been shown to have multiple benefits for students, such as increasing motivation to complete their study tasks and, consequently, fostering a positive attitude toward success. This ICT can be implemented at different stages of education, but its application in early stages of human development can bring significant benefits to the understanding of basic concepts taught in the early years of study. Therefore, the objective of this research is to analyze the existing literature on the use of AR in preschool and early basic education, using the Scopus and Web of Science (WoS) databases, identifying benefits, challenges, and practical applications, in order to establish a basis for the future development of interactive educational solutions that combine physical and digital elements. It will cover how students need this technology, since AR is not only about how it is presented, but also must be intuitive in the way it reaches the user. To do this, the most effective learning

methods this group of students has when receiving instruction will be taken into account.

**Keywords:** Early childhood education; augmented reality; immersive reality; educational technology; ICT in education

### Introduction

The adoption of information and communication technologies (ICT), such as augmented reality (AR), has accelerated since the pandemic due to the need to use them as a result of the context in which the world was immersed during those years, but the impact of these technologies has gone beyond the health crisis and has meant advances in various areas of our society, especially it has been fundamental in the educational field given the possibilities it offers <sup>1</sup>.

When we talk about AR we refer to an information technology (ICT) that arose from the need of humans in the way of communicating, it mixes the real world with virtual interfaces with the aim of enhancing the activities of the individual with the world around him <sup>(2)</sup>. Unlike virtual reality, which is responsible for taking the individual to a synthetic environment in 3D or with content in three hundred and sixty degrees <sup>(3)</sup>, AR keeps the individual in reality with a virtual addition that is distinguished by a series of levels ranging from scanning QR codes for advertising, to lenses that show the routes or restaurants recommended in an app with geolocation <sup>(2)</sup>. This technology, in addition to directly influencing how an individual reacts to their environment, can influence their feelings and emotions <sup>4</sup>. Education being one of the media where AR stands out for its functionalities and benefits as a teaching method.

Therefore, AR becomes a tentative option to implement at different educational levels, this is due to the evolution that exists day by day in society regarding technologies, then it is important to consider a type of teaching more focused on ICT, where these factors are usually key in them, adapting teaching to a much more technological and updated world than it was decades ago, since the teaching method in most schools still maintains the features of traditional education implemented since the 19th century <sup>5</sup>.

However, even though it is a recently emerging technology that is progressively growing and developing, it remains largely unknown in the educational world <sup>6</sup>. Therefore, through a bibliographic analysis of different sources, this research will have AR as a study point in an educational context, focusing on how it can be implemented in a preschool and basic education environment, with the aim of laying the appropriate foundations and a basis for the benefits, difficulties and practical applications for the future development of interactive educational solutions for students in the aforementioned student sector. The Scopus and Web of Science (WoS) databases were used, as they are considered the main databases worldwide, since they bring together publications of scientific impact and relevance <sup>(7)</sup>, especially on educational technology <sup>(8)</sup>, <sup>(9)</sup>, <sup>(10)</sup>, an aspect directly related to the approach sought in this research. Additionally, this analysis will consider documents that present methods, techniques, and theories for teaching the most efficient possible to the aforementioned student groups, thereby gaining a deeper understanding of how preschool and primary education works.

Additionally, AR software for preschool education will be identified, with selection criteria including relevance to preschool, accessibility, and ease of use.

AR has many benefits for early years education. However, to develop interactive educational solutions, it is

It is important to consider how a child's mind works when interacting with teachers, peers, and technology. Because, in the first stage of childhood, several factors must be considered, such as the physical, cognitive, socio-emotional, and linguistic development of children when providing a good education system <sup>11</sup> .

The article is organized into six sections as follows. The section "Important Factors in the Early Years of Education" presents the foundations of the mental organizational process of infants in the early years of school. The section "ICT in the Early Years of Education" addresses how ICTs are incorporated into the early years of the school system. The section "AR and Immersive Learning" describes the concepts of Augmented Reality and its relationship to immersive learning. The section "AR in the Early Years of Education" addresses how AR is applied in the early stages of human development. Finally, the final section presents the main conclusions obtained.

### **Important Factors In The Early Years Of Education**

According to <sup>12</sup> , cognitive development in infants is a mental organizational process that infants undergo when receiving information through sensory and perceptual senses, as well as in the way they resolve situations based on past experiences. According to Jean Piaget, cognitive development refers to the process by which children construct an understanding of the world through successive

stages. For the purposes of this study, the first two are of interest since they cover the defined age range, that is, the early years of education.

- Preoperational Stage (2-7 years): Boys and girls develop symbolic thinking, using language and images to represent objects and events, although their thinking remains egocentric and they cannot perform logical operations <sup>13</sup>.
- Stage of Concrete Formal Operations (7-11 years): Children understand the concept of conversation and develop the ability to think logically about specific events <sup>13</sup>.

Hence <sup>14</sup>, indicates that it is important to consider that to achieve efficient cognitive development in infants, emotional development is needed, that is, i) emotionally educate boys and girls, ii) teach about empathy, iii) set limits, iv) encourage self-acceptance, v) respect others and vi) offer strategies for problem solving. In addition to the above, it is correct to affirm that a determining factor in the way infants teach and learn is the development of the ability in which boys and girls are able to regulate their emotions, interact positively with their peers to build healthy bonds and general well-being <sup>15</sup>. These are some of the determining factors when creating a harmony between thought, emotion and action in boys and girls, helping them face problems without compromising their self-esteem.

On the one hand, it is worth highlighting that, alongside emotional education, children react positively or negatively to receiving information based on their own emotions, highlighting motivation. Children with low socio-emotional development are often resistant to change, so early childhood teachers must detect, and therefore understand, these difficulties to help prevent long-term complications

in children <sup>16</sup> . For this reason, it is important to keep them motivated so that they do not face greater difficulties when receiving education <sup>17</sup> .

On the other hand, physical development is closely linked to motor development in infants, which together can be defined as the process of an infant acquiring and improving gross and fine motor skills, which are essential for their physical and emotional growth and well-being <sup>18</sup> . Finally, linguistic development is crucial for communication skills, social interaction, and academic success. During this period, children expand their vocabulary, improve their grammar and pronunciation, and consequently develop skills to form more complex and coherent sentences <sup>19</sup> . Thus, understanding cognitive, socio-emotional, physical, and linguistic development is essential for designing an educational experience that enhances children's learning and well-being. With this foundation, we can begin to define which aspects are essential for the development of interactive technological educational solutions with AR, but we can also explore how these aspects relate to ICTs in general and their impact on teaching.

### **Ict In The First Years Of Education**

The use of ICT in classrooms is not something new, since for decades, the use of video, radios, teaching materials or televisions, among others, have been important means to support the teachings imparted by teachers <sup>20</sup>), ( <sup>21</sup> . The students who are currently in each educational institution, whether universities, schools or preschools, are the generation of students born in the technological era, the Digital Natives, a term coined in <sup>22</sup> . Therefore, it is correct to say that these generations have an ease to interact and live with screens compared to previous generations,

since this relationship is established from the first years of life <sup>23</sup> . For them, today, it is normal to use social networks as a means of obtaining content and knowledge just a couple of *clicks* away <sup>24</sup> .

In research papers <sup>25</sup> and <sup>26</sup> , the authors clarify that the use of ICTs as a teaching resource is essential for children who operate in a technological environment, because in addition to being used as an educational resource, they develop habits, strategies, and skills necessary for today's world. Therefore, in early childhood education, the use of these technologies as a teaching resource is a good alternative, due to the nature of today's children. In paper <sup>27</sup> , it is mentioned that ICTs increase children's understanding of the world around them and generate greater motivation for teaching new knowledge. Therefore, the benefits of these technologies in the educational context would be the following:

- • Promotes creativity.
- • Awakens the spirit of research in the face of new topics raised.
- • Promotes the development of skills.
- • Respect for the students' learning pace.
- • Stimulates collaborative work.
- • Motivates confidence and interest in learning.

By understanding these benefits, we can consider their relationship with the main factors that affect children's education: the aforementioned cognitive, socioemotional, physical, and linguistic development. These benefits help develop each factor, offering students a way of receiving information that is much more tailored to their needs and surrounding context, providing fun and dynamic

learning. Therefore, AR, as an ICT, can be a much more engaging and interesting teaching medium for children in their early years of school. Furthermore, AR has the characteristic of being an immersive technology, increasing its advantages and possibilities.

### **Ar And Immersive Learning**

Before beginning to detail the use of AR in students in the first years of education, it is important to explain the benefits of AR at a more general level and how this technology relates to the concept of Immersive Learning. The word "immersion" evokes the practice of diving, an action by which a person enters a place with water, with the purpose of carrying out a specific activity (educational, commercial, recreational, sporting, scientific or military)<sup>24</sup>. In<sup>28</sup>, the concept is specified in its second meaning as the "Action of introducing or fully introducing someone into a given environment." Thus, immersive learning can be understood according to the meaning of both words, learning and immersive, that is, an educational method that involves introducing the student to a new and highly interactive environment, designed to facilitate learning through total immersion in the subject matter<sup>28</sup>. According to<sup>29</sup>, immersive learning is described as an educational methodology that allows students to immerse themselves in a virtual environment, actively interacting with the content and other participants. Furthermore, based on the above,<sup>29</sup> points out the importance of properly developed educational tools, since an attractive and well-designed environment can capture and maintain students' attention, creating a highly engaging and immersive

learning experience. This is why AR emerges as an effective immersive learning method in this regard.

Study<sup>30</sup> indicates that AR can significantly improve student interest and motivation, as it provides a much more dynamic and visually stimulating learning experience. This is reinforced by study<sup>31</sup>, which focuses on the relationship between student motivation and AR. Importantly, according to study<sup>32</sup>, motivation is one of the main elements in ensuring the quality of teaching and studying within a classroom. This study demonstrates the value of AR in education. It consisted of university students interacting with pre-designed AR educational materials. These materials included visual representations and animations that complemented the theoretical content of the subject, such as the visualization of 3D models and animations on specific topics of the subject they were taking. This allowed them to understand complex concepts in a clearer and more interactive way. This confirms that the use of AR in education stimulates student motivation, which in turn increases student engagement with the subjects taught.

Another benefit of AR is information retention. <sup>33</sup> mentions that AR can use both oral and visual media; therefore, it is this combination of media that allows AR to achieve significantly higher retention levels, with up to 85% short-term retention and 65% long-term retention<sup>34</sup>. <sup>35</sup> mentions that AR helps in the understanding and development of spatial ability; the author indicates that spatial intelligence includes skills such as the perception and visualization of space, the ability to perform mental rotations, spatial relations, and spatial orientation. These

competencies are essential in the field of geometry, which is dedicated to their development. In this sense, AR provides a considerable advantage by allowing students to interact with content from various spatial perspectives and at their own learning pace. This flexibility is crucial for success in university courses where adaptation to a space that might not be available ordinarily is required.

### **Ra In Early Years Of Education**

In addition to being able to be used in universities or higher education, as noted above, AR can also be integrated into different educational stages. Study<sup>36</sup>, conducted in Spain, highlights its application in early stages of human development, as it can bring significant benefits to the understanding of basic concepts taught in the early stages of schooling, more specifically in preschool, a crucial stage for the evolution of human development. Table 1 describes some of the most popular programs that enable the development of this technology and could be used in the development of interactive technological educational solutions with AR.

Table 1 Description of programs for AR development.

| Programa          | Descripción                                                                                                                                                                                                                                                                |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Unity con Vuforia | Unity es una plataforma de desarrollo ampliamente utilizada para crear experiencias 2D y 3D, incluidas aplicaciones de RA. Vuforia es un SDK que se integra con Unity y permite crear aplicaciones de RA utilizando marcadores, seguimiento de imágenes y objetos 3D [37]. |
| ARKit de Apple    | Es el framework de Apple para crear aplicaciones de RA en dispositivos iOS. Ofrece herramientas avanzadas para el seguimiento del entorno, la detección de superficies y la integración de objetos virtuales en el mundo real [38].                                        |
| ARCore de Google  | Es el SDK de Google para la creación de aplicaciones de RA en dispositivos Android. Ofrece herramientas para la comprensión del entorno, la estimación de la luz, y la detección de superficies [39].                                                                      |
| ZapWorks          | Es una plataforma de creación de RA que ofrece una herramienta de programación visual y soporte para lenguajes de programación como JavaScript. Permite crear experiencias de RA interactivas y complejas sin necesidad de una profunda experiencia en programación [40].  |
| CoSpaces Edu      | Es una plataforma educativa que permite a los estudiantes y profesores crear experiencias de RA y VR. Utiliza un lenguaje de programación visual para facilitar la creación de interacciones [41].                                                                         |

Source: Prepared by the authors.

A concrete example of the application of AR in early childhood education is the study conducted in <sup>42</sup> by Peruvian and Spanish researchers, which presents the results of experiences with the "Wordtastic Kids" application for learning English. In this study, preschool children used the application to interact with objects and English words, which significantly improved their comprehension and vocabulary retention compared to traditional methods. Another study highlighting the advantages of AR in early childhood and primary education is the one conducted in <sup>43</sup> in Chile, where, through AR and a digital whiteboard, 18 children were able to interact with 3D objects, achieving better command of semantic, syntactical, and phonological aspects of language, compared to a test administered prior to the study. Furthermore, it is highlighted that the animations and movements facilitate

the development of the ability to reflect and understand cognitive experiences, which allows for awareness of situations while exploring language.

Meanwhile, a study focused on astronomy using AR was conducted in

- Children are the protagonists of forming their knowledge, thanks to the skills they have in using the ICTs available to them.
- The use of AR sparked children's interest, increasing their motivation and understanding of the knowledge acquired. This confirms that the study conducted by <sup>31</sup> in Spain can also be applied to other educational stages.
- AR can be a great asset for subjects where, in the case of astronomy, nighttime observation and sighting are vital. This allows us to understand the potential AR has to engage students in a much more immersive and enriching experience.

On the one hand, study <sup>45</sup>, conducted by Ecuadorian researchers, emphasizes that AR, by combining virtual elements with a real environment, creates a visual and practical experience when interacting with mathematical concepts, since the sensorial immersion this technology represents allows for the stimulation of critical thinking, problem-solving, and logical reasoning. This is beneficial since early mathematics is a factor that significantly determines cognitive development and academic performance in children. This study also confirms the positive reception of this technology among the majority of students evaluated. The students determined that AR was both beneficial and entertaining, once again confirming the positive reception and motivation to study that this ICT has in children.

On the other hand, <sup>46</sup> American researchers developed an AR application focused on the plant life cycle, where students could plant a virtual seed and observe its

growth in real time, from germination to flowering. This application allowed children to manipulate three-dimensional models of plants, explore their parts and functions, and watch animations explaining biological processes. The result of this interaction with AR helped students understand abstract concepts in a visual and intuitive way, promoting greater information retention and increased motivation. The latter being a constant in AR.

These studies confirm that AR represents a significant advance in the way we deliver and receive information. According to study <sup>47</sup>, conducted on preschool children in Mexico and Ecuador during the pandemic, conventional teaching methods currently tend to fragment learning into disconnected content, leading to superficial learning and disinterest among students, who do not see the relevance of what they are learning to their real lives. In other words, the traditional educational approach does not promote active and effective student participation; instead, it focuses primarily on passively acquiring knowledge, which undermines the objective of a dynamic educational process that should promote high academic performance <sup>(5)</sup>.

Similarly, Chilean researchers in <sup>48</sup>, indicate that traditional education does not work efficiently with non-conventional student populations such as users with Autism Spectrum Disorder (ASD), this unlike a learning methodology with the use of AR, since the impact of this tool could be even much more beneficial in the child population with ASD characteristics than in the population without these characteristics, since it is a tool that allows multisensory stimulation and controllable environments, which is crucial for users with this disorder, because

they are mainly visual learners and often have difficulties communicating and socializing, unlike users without ASD who assimilate their context through observation and imitation of their environment. According to the study presented in <sup>49</sup>, carried out in an Argentine education center for children with special abilities, it was indicated that 78% of the experts considered that AR would be beneficial in promoting new learning knowledge in ASD individuals. This increases the value of this technology as a study tool, since in addition to being revolutionary in the way it delivers information, it is inclusive for the ASD population.

As can be seen, the number of benefits of AR is considerable, contributing to several areas of education, making it versatile and dynamic, in addition to being attractive to students and offering an inclusive study methodology. This does not mean that AR does not have drawbacks, since one of the disadvantages of AR lies in the level of knowledge that teachers have about it, this being a fundamental factor in how students receive this technology <sup>45</sup>. This obstacle is highlighted by <sup>50</sup>, where through a systematic review of scientific documents related to AR and primary education, between 2015 and 2019, it is mentioned that at least 28% of the experiences analyzed allude to the fact that teachers must have prior training with this technology. Additionally, other obstacles that affect AR in education are highlighted, such as the level of classroom infrastructure, the availability of the necessary equipment to use this technology, and the need for methodological adaptation of content. This is why implementation and knowledge of AR are very

important in determining the success of AR as a learning methodology, especially for children.

On the one hand, according to different studies analyzed by <sup>6</sup>, the medium in which this technology is usually widely used is mobile phones. The methodology that relates cell phones with education is known as Mobile Learning (ML), and is characterized by facilitating ubiquitous and flexible learning, since it can be used anywhere and at any time, which offers us the possibility of teaching in variable contexts <sup>50</sup>. On the other hand, Spanish researchers in <sup>51</sup> propose video games with AR as a good method of incorporating this ICT in the educational field, taking into account the familiarity of this medium with Digital Natives. This is according to <sup>52</sup>, also carried out in Spain, because video games have been characterized by having an influence on cognitive development, in addition to being a mechanism where the student can learn from their own mistakes in a controlled environment, adapting to their tastes with the use of characteristic strategies and mechanics. From all of the above, it can be inferred that the combination of these three concepts—AR, video games, and ML—serves as an educational methodology friendly to the current generation of students, as it integrates technological tools they are familiar with, promoting more interactive and personalized learning. This synergy not only better captures students' attention but also fosters a more dynamic educational environment tailored to individual needs and preferences, potentially improving learning outcomes and student motivation.

As seen, AR also contributes to the development of cognitive and socio-emotional skills. The immersive nature and close interaction with virtual models or scenarios

encourages collaboration and communication among children, improving social and emotional skills. These virtual environments help children develop critical thinking, problem-solving, and logical reasoning skills, which are important factors in children's holistic development in their early years of education. In short, AR is presented as a dynamic and versatile learning methodology, with immense possibilities in different areas of study, from language and mathematics to natural sciences and astronomy. This technology not only improves the comprehension and retention of information but also fosters a positive attitude toward learning and develops essential skills in students.

It is worth noting that these types of AR applications would be enriched with the use of artificial intelligence algorithms, through which the use of traditional AR markers could be replaced by automated image detection by using, for example, *Segment Anything Model 2* (SAM 2). This is because SAM is designed and trained with the premise of being fast and versatile, added to its ability to deal with ambiguous images that correspond to the presence of more than one object in an image<sup>53</sup>.

## Conclusions

The use of AR in preschool and early elementary education offers numerous benefits that can significantly transform the teaching-learning process. One of these is the understanding of abstract concepts, as this technology helps children make these concepts much more tangible and visual.

Applications like 42's "Wordtastic Kids" and the study conducted by<sup>43</sup> demonstrate how this technology helps children understand abstract concepts like language and

speech, important aspects of linguistic development, which are one of the determining factors in teaching. We agree with<sup>45</sup> in highlighting that this understanding of concepts is not limited to language but is also applied to other important subjects for human development, such as mathematics.

Furthermore, AR increases student motivation. Each study analyzed highlights how students are motivated to learn with the use of this technology, feeling a commitment to learning, along with a positive attitude toward education. This increase in motivation is an important factor in academic success.

Another benefit of AR is the flexibility and personalization of learning, as it allows children to learn at their own pace and explore content in a personalized way. The ability to interact with models and perform repetitive activities as needed allows children to adapt learning to their individual needs. This flexibility is especially beneficial in preschool and primary education, where learning rates can vary significantly among students.

Finally, it is possible to conclude that the successful implementation of AR in education requires adequate infrastructure, ongoing teacher training, and the development of high-quality content to maximize its benefits and better prepare future generations. Therefore, future interactive technological educational solutions with AR should have the following characteristics:

- Interactivity and personalization: The
- Applications to be developed should allow students to interact with three-dimensional models and carry out personalized activities according to their needs and learning pace.

- Development of quality content: Consideration should be given to developing pedagogically sound and engaging content that encourages active learning and information retention.
- Teacher training: It is necessary to implement training programs for teachers, ensuring that they are trained to use AR effectively in the classroom.
- Use of mobile phones: Development will tentatively focus primarily on mobile phones rather than other devices such as PCs.

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