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Model for Augmented Reality Applications with Gestural Interface for Children (MARAGIC)

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Abstract

The technological development achieved by humanity has led to the generation of many learning methods that have changed how human being learns. Today, it is common for "traditional" teaching and learning processes to be strengthened through the use of technological environments and tools. The adoption of ICT and ubiquitous computing has created new methods and methodologies for both formal and informal education. In this context, both Augmented Reality (AR) technology and the new interaction modalities provided by sensor-based devices that detect and interpret the movements of the human body, make it possible to build innovative learning spaces that combine real and virtual elements, are interactive in real-time and are recorded in three dimensions (Azuma, 1997). This type of resource added to the[1] Interaction of Natural User (provided by MS Azure-Kinect) makes it possible to take advantage of the experiences and previous knowledge that human beings acquire when managing ourselves day by day in our environment. Different cognitive and learning processes can potentially be supported by this type of technology at different levels and modalities of training. The present work presents a model that guides the development of learning objects based on Augmented Reality and Natural User Interfaces, to improve and facilitate learning processes. The proposed model has been validated through its use in the design or implementation of two applications KARMLS [2] SAM-RAK [3] tested with children of 3rd year and EGB belonging to 4 Educational Units of the city of Riobamba Ecuador, demonstrating that its use facilitated learning of the participating children who used the resources developed based on MARAGIC.

Keywords: augmented reality, child education, learning game, human-computer interaction.

1. INTRODUCTION

The great evolution achieved by both hardware and software offers great opportunities for the creation of new forms of communication, interaction, and work, important activities in the teaching-learning processes, as well as the ubiquity of computing, made possible by the appearance of mobile devices and the Internet, as well as its use as a support for the development of many activities carried out by the human being in his day to day, make the use of computer tools has become an important resource, regardless of the scope of human work in which they are used. This has enabled the creation of many tools based on ICT as support in teaching-learning processes, these tools have captured the attention of researchers and teachers around the world, who study the effects and benefits that these new technologies bring to education.

However, to carry out an adequate study of the benefits and potentialities of ICT to educate, the analysis of the cognitive abilities of the users for whom they are designed is fundamental when assuming the development of applications in the educational field [4] It is important then to consider the set of cognitive abilities, previous knowledge, and interaction preferences that the user who will use the digital learning objects for their learning possesses, this consideration will allow exploiting these capacities, knowledge, and preferences minimizing the extrinsic cognitive load generated by the use of traditional means of interaction (Keyboard and mouse), in young or new users of computer systems. This fact takes greater notoriety if it is considered that the physical and cognitive abilities of the human being vary according to age. For the case at hand, children have a smaller physical constitution and shorter attention span, and their reading, writing, and cognitive ability skills are limited [5] compared to typical computer users ranging from 20 to 55 years old.

Considering that children currently have greater access to computer technologies, the technological tools developed for this type of use must be designed considering their skills, interests, and developmental needs (Hourcade, 2008). In this sense, the development of digital [6]learning objects for children must be carried out by multidisciplinary teams [4] that is, teachers, pedagogues, psychologists, software developers, etc., must participate, who determine and consider the specific characteristics that educational resources must possess for this type of user. When interacting with a computer system, the user's emotions and intentions must be properly determined and predicted to recognize user trends based on their interests and dispositions [7] The proper determination of these aspects will allow the design of a user interface to adapt to changes in the user's emotional reaction and needs. According to [8] aspects such as cognitive skills, fine motor skills, emotional maturity, and knowledge of a sixty-year-old man, a fourteen-year-old teenager, and a seven-year-old boy differ greatly. Therefore, the consideration of these aspects influences the decisions made in the design process of the user interface (UI) of a computer system. This situation is even more relevant if it is young and/or elderly users since most software developers do not consider the particular design requirements that this type of users need due to the changes that, due to their age, occur in their physical and cognitive abilities [8]; [4].

The study of Human-Computer Interaction (HCI) must relate the user with the interaction and with the interface to ensure that the visualization of the interfaces presented in a computer system is understandable for the user, who in the framework that competes, has the previous knowledge necessary to perform the set of actions that allow him to interact with the software properly and achieve the curricular objectives proposed by this type of activities. Section 2 of this article presents the works related to the existing problem on the interaction of users with computer systems aimed at educating and describes the interaction models that were analyzed to propose the model. Section 3 presents the proposed model and describes each of its parts. Section 4 provides an evaluation of the model, as well as an analysis of it in a context in the task of mathematics education for children in early education. Finally, section 5 presents the discussion and results of the study conducted.

2. LITERATURE REVIEW

2.1. Augmented Reality in Education

A didactic challenge that arises in our days in the field of education is the adaptation of curricular content for a group of children and young people who have somehow grown up in a world where the use of digital technologies is a matter of their day today. In this context, a large number of these students need the teachers in charge of guiding their learning to incorporate in the educational processes both the technological tools and the virtual worlds with which this type of user feels so comfortable. Despite what has been said, this important group of users called "digital natives" are mostly students with digital knowledge that still needs to be developed[9]

The need for primary and baccalaureate students to possess a set of basic digital knowledge demonstrates the importance of developing digital skills that enable quality education. Paradigms such as Virtual Reality (VR) and Augmented Reality (AR), have ceased to be emerging topics, reaching a maturity that allows their effective use in

various areas of human endeavor. Works such as the one presented in [4] show the rapid growth of AR technology in the educational field, the most optimistic visions about the development of this technology already foresaw in previous years the vertiginous development that Augmented Reality would have, as already mentioned in the TEDx talk offered by Tomi Ahonen (Ahonen, 2012), augmented reality technology will be the "eighth means of communication" that follows its predecessors, among which the printing press and the mobile phone stand out, so it was long foreseen that AR technology would be a disruptive means that would mark a before and after in the way in which digital information is presented to human beings (Figure 1).[10]

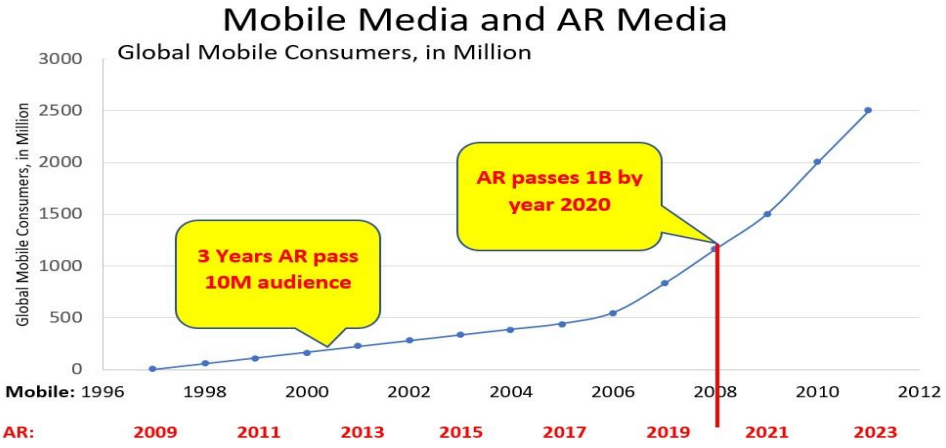

Figure 1: Augmented reality use, year´s prediction (Ahonen, 2012)

As can be seen, the predictions about the use of AR have not been wrong since the volume of its use has grown exponentially since its launch to the present day (Ahonen, 2012), becoming a tool that can improve the motivation of children and novice users in the use of computer systems [10][4], this fact corroborates what is indicated in [11] who point out that AR has the potential to be a disruptive technology in the field of the distribution of educational materials at all levels since it allows a didactic, experiential and kinesthetic learning. Studies such as those presented in [4] show part of a large number of educational research developed to demonstrate the potential that AR technology has to transform the classroom into a highly interactive learning space. In this sense, it is important to mention that the Immersive Education Initiative [12]and the Immersive Learning Research Network [13]have met to discuss the concept of Immersive Education, which seeks to interfere with anyone in a learning system that uses the principles of collaborative learning with the potential of assimilation of VR or AR technologies combined in video games presented in 360°. These scenarios are developed within spaces that are reproduced in Head-Mounted Display (HMD) mode allowing user interaction with programmed virtual elements.

In the educational field, AR technology has several advantages such as the possibility of presenting in a different and motivating way abstract concepts for the understanding of students [4] without forgetting that this technology also allows offering mixed teaching methods in which students have elements of traditional learning (static written materials) along with visualizations of the processes involved (AR-based material) [14] observe facts that if not presented with RA would be very complicated to present, this fact is important both for medical and chemical phenomena and for the case of concepts of physics and mathematics.

2.2. Psychology of Human Development

From the psychological point of view of the development of the human being, when relating the latter to the context, two large relatively opposing currents are distinguished. Because the theoretical models are not uniquely identified with one or the other current but present a noticeable inclination towards one of these two approaches, it is important to mention that the polarization constitutes only an

explanatory resource, since there may be other approaches in this regard.

The first approach considers that development is an individual process that is presented as the development of endogenous potentialities. from this point of view, the context is made up of the physical world and the social world without there being a distinction between the two. Likewise, from this approach, the development of the human being implies the uniform passage through a series of successive stages that can be explained according to one or several factors, being considered in particular, age (Foix & Piaget, 1970), (Gesell & Bates Ames, 1956). A representative of this current is Piaget's Theory of Genetic Psychology.[15][16]

The second conceptual approach, contrasted with the previous one, argues that development is linked to the social and cultural context in which a human being develops. From this point of view, the psychological development of the human being is considered as a process of intersubjective character, linked and influenced by contexts and cultural products (such as language, traditions, values, etc.), which mediate the construction of the individual. Therefore, in contrast to the previous vision, there is a differentiation between the physical world and the social world, the latter being responsible for providing stimulation for psychological transformation (Vygotsky, Cole, & Luriia, 1996). In this sense, development can follow several paths, depending on the socio-relational context in which the human being participates, this context being more influential in the case of children.

These two currents of psychological development are important for the present work since they take advantage of concepts conceived by both theoretical tendencies. Next, the theoretical bases that will support the conceptual model that is presented as a contribution of this work are explained in more depth.

2.2.1 Constructivist theory

In the early 1960s, cognitivism (from which constructivism arises) replaced behaviorism as the dominant learning theory (Clark, 2018), being since then strongly employed and adapted, this theory focuses on the study of the mental activities of the student during the learning process. The main mental activities that cognitivist theory deals with are thinking, memorization, perception, interpretation, reasoning, problem-solving.[18]

In the case of this study, the analysis of cognitivism is interesting, since from these pedagogical current theories are derived quite accepted and adopted to the different learning styles that consider factors such as disposition, preferences, patterns of behavior, skills, and learning strategies as factors that allow the learning process to be meaningful. From its theoretical conception, this pedagogical current considers the needs of students, being humanistic and holistic as well as cognitive without neglecting the physical, motor, social and emotional development of the child, the theory of multiple intelligences is based on this current for their studies since this current is concentrated on the study of cognitive dimensions such as attention, memory, perception, intelligence, thought and language, which is different depending on the age and stage of development of children.

Within the current of cognitivism, one of the most widely accepted and used approaches is the constructivist theory of learning by Jean Piaget (Piaget, 1976), which provides a framework that allows us to understand how children think and execute tasks as they go through each of the levels of their development (stages). From the Piagetian point of view, how children think and execute tasks follows a logic that adapts to their possibilities and needs, which vary according to the stage of psychological and physical development in which the infants find themselves. In that sense, it is important to consider that the opinions that the child has about himself and the world are changing not only with his physical and intellectual growth but also as he interacts with other human beings and with the elements of his environment.[19]

Piaget also indicates that both cognitive ability and intelligence are closely linked to the social and physical environment. This author considers that the two processes that characterize the evolution and adaptation of the human psyche are those of assimilation and accommodation (Piaget, 1976). Assimilation is how an individual faces a stimulus from the environment, mental assimilation involves the incorporation of data from experience into the

innate structures of the subject. Accommodation on the other hand involves the change of current mental structures in response to the demands of the environment, in other words, it refers to the modification of existing schemes to accommodate new information.[19]

In his studies, based largely on the observation of the development of his children, Piaget observed that there are periods (stages) of development and noted that in some of these assimilations prevailed and in others accommodation. From this experience, Piaget concretized his four epistemological stages (generally called cognitive stages), widely accepted by the scientific community and which are very defined in humans (Piaget, 1976), these periods of development are mentioned below:[19]

1. *Sensory-motor stage:* It covers from birth to approximately two years. The child uses his senses and motor skills to know what surrounds him, relying initially on his reflexes and, later, on the combination of his motor and sensory abilities. That way you prepare yourself to then be able to think and process with images and concepts.
2. *Preoperative stage:* This stage is the one that follows the sensory-motor stage and takes place between 2 and 7 years of age. It is characterized by the internalization of the reactions of the previous stage giving rise to mental actions that are not yet categorized as operations due to their vagueness, inadequacy, and/or lack of reversibility. Characteristic processes of this stage are symbolic play, intuition, animism, egocentrism, juxtaposition, and reversibility (inability to preserve properties).
3. *Stage of concrete operations:* It goes from 7 to 11 years. In this cognitive stage, when talking about operations refers to the logical operations used for problem-solving. At this stage, the child no longer only uses the symbol but can logically use the symbols and, through the almost perfected ability to preserve information, comes to make wide generalizations.
4. Between the ages of 6 and 7, the child possesses the intellectual capacity necessary to understand and remember numerical quantities: lengths and liquid volumes. At this stage, 'conservation' means the ability to understand that the quantity remains the same, even if its shape varies. Before, in the preoperative stage, the child has been convinced that the amount of a liter of water contained in a tall and long bottle is greater than that of the same liter of water transferred to a low and wide bottle. On the other hand, a child who has accessed the stage of concrete operations is intellectually able to understand that the amount is the same in containers of many different forms.
5. From 7 to 8 years the child develops the ability to preserve materials, this ability is called reversibility. For example: taking a ball of clay and manipulating it to make several balls, the child is already aware that gathering all the balls the amount of clay will be practically the original ball.
6. Between the ages of 9 and 10, the child has accessed the last step in the notion of conservation: the conservation of surfaces.
7. *Stage of formal operations:* From the age of 12 and for the rest of his life, the human being is in the stage of concrete operations. It is from the age of 12 onwards that the human brain is capable of formulating truly abstract thoughts, or a hypothetical deductive type of thought.

2.2.2 Sociocultural theory

The studies of Lev Vygotsky, Soviet linguist, and psychologist interested in the study of the higher psychological functions of the human being such as memory, voluntary attention, reasoning, problem-solving, formulated his theories in the late 1920s, which were not disseminated until 1936, two years after his death because the purely naturalistic branch of Pavlovian, A current that had become dominant, did not look favorably on Vygotsky's historical-social orientation. It is worth mentioning that since 1956 his works have been widely republished while active disciples continue their work. In his writings, Vygotsky indicates that the ontogenetic development (development and maturity of the genetic potentialities that were acquired since fertilization and develop with social experiences) of the psyche of the human being is determined by the processes of historical-social appropriation of culture, with this approach to psychological development, Vygotsky proposed a methodology for genetic and historical research at the same time (Matos, 1995). According to Vygotsky's vision, the higher functions of thought are the result of cultural interaction and the understanding of the psyche and consciousness merits the analysis of

a person's life, as well as the real condition of his existence since a person's consciousness, is presented as a subjective reflection of objective reality and to analyze it, it is necessary to consider consciousness as a socio-cultural and historical product [20][17]

The epistemological foundation of Vygotsky's theory points out that the problem of knowledge between the object and the subject is solved with the Marxist subject-object dialectic (S-O), in which the subject (person) acts mediated by the practical social activity on the object (reality), transforming it and transforming itself (Matos, 1995). In this process of transformation that produces knowledge, it is important to use sociocultural instruments, mainly tools and symbols, the former produces changes in objects and signs that transform the subject who acts. These symbols are nothing but psychological instruments generated from the evolution of thousands of years and sociocultural interaction, example of these symbols are language, writing, mathematics, and calculation, etc. (Baquero, 1996)[20][21]

One of the central categories of sociocultural theory on which many of the educational practices or the design of teaching-learning strategies have been based has been the Zone of Pro-Development (ZDP), whose wide and often superficial dissemination, has generated the birth of several positions and attempts to decipher the most diverse teaching situations. In its most widespread version, published in Vygotsky's original work, the ZDP is presented as: "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peer" (Vygotsky, 1980).[22]

It is important to mention that this idea is complemented and supported by the clauses: a) what is done today with the assistance or with the help of a person more expert in the domain at stake, in the future will be done with autonomy without the need for such assistance and b) such autonomy in performance is obtained, as a product of assistance or assistance, which forms a dynamic relationship between learning and development (Baquero, 1996).[21]

Under this conception, the child is appropriating the cultural manifestations that have a meaning in the collective activity, making the "higher" psychological processes develop in the infants through the enculturation of social practices, the acquisition of the technology with which the society to which one belongs, of its signs and tools and through education in all its forms [23] According to this point of view, the ontogenetic development of the human being presents the following structure: a) collective activity and communication, b) culture (signs), c) appropriation of culture (teaching and education), d) individual and group activities, components that influence the psychic development of the human being. This structure transmits a historical-contextual specificity to the development of the psyche of individuals according to the time and culture in which they develop (Matos, 1995).

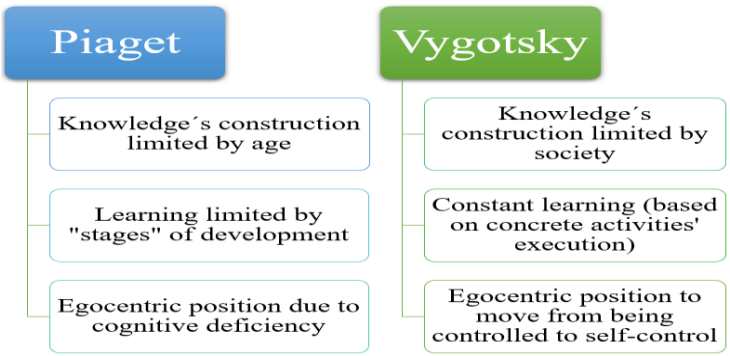

Figure 2: Historical differences between the conceptions of Piaget and Vygotsky [2]

For this study, several factors of both currents of the psychology of human development are important since the approach that is sought to originate is that of a work

environment in which the child, supported by his teacher and his classmates (sociocultural approach) carries out activities aimed at learning basic mathematics in a highly interactive scenario that, Your nature raises your motivation and consider your preferences, abilities, cognitive abilities without neglecting your physical, motor, social and emotional development (constructivist approach).

2.2.3 Social constructivism theory

The theoretical support of Social constructivism has its foundations in the two theories of the psychology of human development mentioned above: the genetic psychology of Jean Piaget and the sociocultural psychology of Lev Vygotsky, whose original elaborations have been renewed by a set of scientific investigations from the currents called neo-Piagetian and neo-Vygotskian, according to the epistemological inclination that each study takes. It should be mentioned that the profound development of the concepts on which Social constructivism is based was carried out under the perception of Lev Vygotsky. Next, an image that aims to show the theoretical-conceptual bases of the social psychology of Cognitive Development from which Social constructivism emerges.

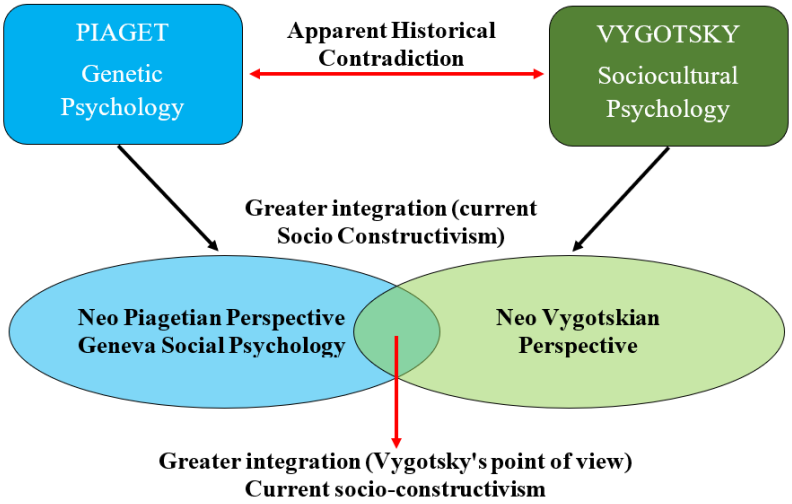

Figure 3: Theoretical-conceptual bases of the Social Psychology of Cognitive Development, (Castellaro, 2017)[24]

Socio-constructivism is presented as an innovative theory of knowledge, approached from sociology and communication theory that analyzes the knowledge and understanding we have of the world as a joint development carried out by the individuals of a society. From this approach, it is assumed that the understanding, importance, and meaning of knowledge are developed in coordination and interaction with other human beings. According to (Leeds-Hurwitz, 2009), this theory has two important elements: a) the assumption that the human being relates his experience by creating a model of the social world and how it works, b) the belief that language is the essential system by which human beings construct their reality. According to this idea, (Roth, 2000), he points out that the bases of knowledge of a human being are found in the interactions of this with his environment o and with other people, a process that happens before said individual internalizes that knowledge. [25][26]

In (Kim, 2001), it is indicated that Social constructivism considers as true several specific assumptions about reality, knowledge, and learning, these assumptions are described in the following paragraphs:[27]

About reality. The first assumption of Social constructivism is that reality does not exist in advance, it is constructed through activity with other human beings and in a specific context. in that sense. Members of a society or group (not individually) invent the properties of the group or world. In this sense, socio-constructivism proposes that, since reality is not done before social interaction and, in a context, it is not something that the human being can discover individually.

About knowledge. From its approach, socio-constructivism assumes that knowledge is a human product that is progressively constructed socially and culturally. This means that people can create meaning when they interact with each other in the context and environment around them.

About learning. The third assumption of Social constructivism indicates that learning occurs as a social process, since it cannot occur on its own within a human being, nor does it develop passively thanks to external forces. This theory states that so-called "meaningful learning" occurs only if individuals are part of social activities such as interaction and collaboration.

Under the conception of socio-constructivism, new roles are born that must be executed by both the teacher and the student. Next, the teacher and student models that are born from this conception are described.

According to this theory, instructors present themselves as facilitators and not as "teachers", according to the functions they play in the learning process. In socio-constructivism, the instructor is a facilitator who helps the student to understand the content from his intuition and point of view, leaving behind the traditional role in which the teacher is the one who gives a master lesson on a topic. Under the traditional conception, the student has a passive role if the teacher only teaches, however, with the Social constructivism approach the student has a leading role in his learning if the instructor facilitates this process and helps the student to learn. This change of roles indicates that an instructor as a facilitator needs a different set of skills than an instructor as a teacher (Brownstein, 2001). From the point of view of socio-constructivism, it is proposed that instead of the teacher saying, a facilitator asks; instead of the teacher of your lecture from the front, the facilitator supporting from behind; instead of the answer teacher according to a predetermined curriculum, the facilitator provides guidelines and guides further creating the appropriate environment for the student to draw their conclusions and arrive at their response based on the contents analyzed; instead of the teacher of a monologue, the facilitator will maintain a continuous and interactive dialogue with the students, in search of the desired meaningful learning.[28]

Concerning the student, he must be considered as an active entity in the process of building his knowledge, leaving behind the passive role proposed from the behaviorist approach, giving importance to the relationships between the student and his peers and the professors and the students, who play roles of trainers and builders of knowledge, employing the Pro-Development Zone to benefit student learning, since, under appropriate conditions, the use of ZDP awakens a variety of evolutionary processes that operate only when the child interacts with people in his environment and cooperation with his peers[28]

2.2.4 Natural User Interfaces (NUI)

The maturity reached by Hardware and Software technologies today, have led to the proliferation of new and varied devices capable of detecting the movements of the human body[29] cited in [30]has allowed the development of a new paradigm in Human-Computer Interaction (HCI), in the case of interest, depth cameras allow users to interact with the software by using gestures made with their hand or other parts of the human body or,without contact and without the physical dependence and limitation involved in the use of traditional input devices such as the mouse and keyboard (Lozada et al., 2015) cited in [32]this feature makes nuI useful tools in educational processes of children since with its application, the student can be introduced to an immersive environment in which their knowledge and previous experiences, acquired during their life, knowledge acquired from the interaction of the subject with the real world, are taken advantage of, fact that facilitates the learning processes.

From this background, the following section proposes a model that takes advantage of the characteristics of Augmented Reality technology and the natural gestural interface, possible through the use of MS Azure-Kinect, with this model, it is expected to verify the results exposed in [33] work in which differences in the mental effort were detected when using Spatial Augmented Reality (SAR) compared to the use of a monitor or a head-mounted system (HMD) in Augmented Reality experiences. The results of this study indicate that the use of a SAR-based system decreases mental effort compared to the alternatives.

3. THE PROPOSED MODEL

This section presents an interaction model for Augmented Reality applications with gestural interfaces (provided by devices such as MS Azure-Kinect) that improves the performance and usability of the target audience considered for the study (school-age children). For the design of the model proposed in the study, the premises and pedagogical orientations that give us both the theory of constructivist learning (Piaget, 1976) and the theory of Socio-constructivism learning and the Zone of Pro-Development[19][17] considered. Following the suggestions of these theories, the proposed model is developed by analyzing several important aspects. Those mentioned below:

Orientations from constructivism. In constructivist learning, the orientations left by the most notable of its exponents, David Ausubel (1918 - 2008), an American psychologist and pedagogue who made important contributions regarding this theory of learning, stand out. Constructivism explains that every new situation we experience will have a meaning that is constructed and based on our past experiences (previous knowledge). As an example of this situation, we can mention that if a child sees an insect jump he may believe that he is flying and is a bird, however, as he grows he will have more information and experience with which he can build new learning. From this point of view, as indicated in (Piaget, 1976) cited in [19][34] the processes involved in the construction of learning are the following:

Assimilation. Internalization of information or event to a pre-existing cognitive structure to decipher it using knowledge obtained from previous but related experiences. Assimilation is then the understanding of the new event by relating it to one's cognitive structure.

Accommodation. Incorporation of new knowledge into the cognitive structure, by creating a new knowledge scheme or modifying a pre-existing scheme.

Constructivism defends that reality is not an external factor, but an internal one. In this way, two people can experience the same event and have different meanings for each of them. For example, for one person earning a lot of money can mean a symptom of success, however, for another person, it can mean a symptom of greed, it all depends on their interpretation.

Learning according to the constructivist current indicates that over time and as a situation is experienced, again and again, it will provide more and more data, and at the same time, new learning will be built on it. According to these premises, below are presented both the basic principles that support this educational theory and the roles that must be adopted by the teacher and the student, and the characteristics that a learning environment must possess to be considered as constructivist:

Basic principles of Constructivism:

- The individual actively constructs knowledge by interacting with the object of study.
- Learning is facilitated through mediation, interaction, and negotiation with others.
- Learning is an internal constructive process that feeds itself.
- The degree of learning depends on the level of cognitive development in general.
- New knowledge acquires meaning when it relates to previous knowledge.
- Previous knowledge is the starting point of all learning and will be key in the future.
- Learning occurs when what the individual already knows conflicts with what they should know.
- The social and cultural context of the person influences the construction of meaning.

Role of the teacher (as a facilitator in the learning process):

- The teacher must have active participation since he must create, contextualize (and adapt, if necessary) the activities of the learning process.
- It should promote activities that promote the development of cognitive skills.
- He is a moderator, coordinator, facilitator, and mediator.
- He is directly responsible for creating a harmonious, affective, and mutual trusting climate, always being aware of the student's position.

- You must value the student's interests and differences and previous knowledge.
- You must know the evolutionary needs and stimuli you receive in other contexts: family, educational, social, etc.
- Stimulate and accept the autonomy and initiative of the student.

Role of the student (as a builder of their learning):

- The student selects and transforms information, creates hypotheses, and makes decisions based on their experience.
- The individual is responsible for his learning because he is unique in each individual and therefore irreplaceable.
- Participates or should actively participate in activities that contribute to their cognitive development.
- Proposes ideas and defends them constructively
- Accepts, analyzes, and incorporates ideas from others
- Ask a question to clarify and understand

Role of knowledge:

- It depends on the student (interaction with objects in their environment).
- It is not the result of a mere copy of pre-existing reality (prior knowledge).
- It is produced through a dynamic and interactive process through which external information (contents to be learned) is interpreted and reinterpreted (cognitive conflict) by the student's mind.
- It is progressively being built in the mind of the individual as explanatory models, more and more complex, that allow us to explain the reality that we know.
- It depends on the context (environment in which the learning process takes place).
- It covers the dimensions of the human being as a learner (cognitive, psycho-motor, and kinesthetic)
- It allows a personal interpretation of the world.
- It must provide a model (abstraction of reality).

Orientations from socio-constructivism. Vygotsky's theory of social development (Crawford, 1996) cited in (Hodge & Cobb, 2019), holds that knowledge is a cultural product that arises from social interaction through which learning occurs through the social involvement of human beings to share, talk and act on issues and interests that are common to their interests. the analysis of constructivism together with sociocultural ideas generates those known as socio-constructivist. The basic difference between cognitive constructivism (or classical constructivism) and socio-constructivism is that under this approach it is pointed out that language precedes thought, while classical constructivism. holds the reverse. According to those exposed by this current, below are the roles that according to [36][37][37] both the teacher and the student and knowledge must assume.

Basic principles of Socio-constructivism

- Learning is perceived as a community process.
- Priority is given to cultural and social processes over individual psycho-cognitive processes,
- "Expert" students demonstrate or execute the skill or behavior to be learned and less experienced students imitate that skill or behavior.
- Students build their knowledge by participating in collective activities.
- Cognitive conflict occurs when the lack of shared knowledge and the need to overcome this lack becomes evident (relying on the divergence of thoughts, analysis, discussion, or common project).
- Language is the tool used for social interaction.
- According to the concept of The Zone of Proxima Development (ZDP), the human being learns within the social sphere, deliberately through interaction.
- The child is committed and motivated to carry out the proposed activities.

Role of the teacher:

- Guides the student.
- Consider prerequisites (prior knowledge).
- It employs different teaching methods.
- He is a guide who teaches how to learn.
- He presents information in different formats and media to his students.
- It employs various evaluation methods.

Student Role:

- He is the builder of his knowledge.
- You need to get meaning from learning experiences.
- Controls and doses the learning process.
- Connect new knowledge with your previous knowledge.
- He is active in the learning process.

Role of knowledge:

- It depends on the student (cognitive skills) and their social interaction.
- It presents, if possible, the existence of multiple realities of the world.
- The cognitive conflict of the student is presented by the stimulation of the environment and by his interaction with other human beings.
- Knowledge or skill is considered acquired when the student possesses a mental abstraction that allows him to apply that knowledge or skill in real life.
- It depends on the context (environment in which the learning process takes place).
- It covers the dimensions of the human being as a learner (cognitive, psycho-motor, and kinesthetic)
- It allows a personal interpretation of the world.
- It must provide a model (abstraction of reality).

Both the Constructivist Learning environment and the Social constructivism learning environment involve several factors, but both present five well-defined common characteristics, these are:

- It provides contact with multiple representations of reality, which highlight the complexity of the real world.
- It emphasizes the construction of knowledge within the reproduction of it.
- It emphasizes the execution of authentic tasks rather than decontextualized instructions.
- It encourages reflection based on experience, creating a link between the context and the construction of knowledge.
- It promotes the construction of collaborative learning, through social interaction and not the competition that seeks recognition.

The above allows presenting a conceptual instructional approach applicable to teaching through the application of learning objects that combine Augmented Reality (AR) technology and the interaction provided by MS Kinect or MS Azure, thus increasing the motivation in the students. This motivational increase will be caused by the fact that the contents to be treated are presented (according to the constructivist and Social constructivism orientations analyzed) so that the student gives meaning to the contents he is acquiring, being able to be in the form of a problem, a real-life situation, a story, "a novel or playful activity", etc., in addition to the consideration of the other aspects analyzed among which stands out, for example, the connection that must exist between the previous knowledge of the students with the new knowledge presented by the teacher who is in charge of designing learning experiences in which, the correct linking of these contents is considered according to the capacities of the students for whom the class is directed. The use of the technologies involved will also allow to capture the attention of students and increase their interest in the learning experiences proposed by the teacher, a fact that increases their intrinsic motivation (Cordova & Lepper, 1996) cited in (Kaiser, 2020).[39][40]

Based on the principles of constructivism and socio-constructivism and the roles of the student, the teacher, the contents, and the learning environment within these pedagogical currents, the researchers have synthesized in Fig. 4 the roles that are reported as beneficial to improve both the usability of the learning object and the academic performance of students under these educational paradigms. The product of this work will be based on certain specific aspects that both teachers and students must present, knowledge, and the learning environment from the point of view of the constructive and the constructive partner. Aspects will then serve as pedagogical orientations to shape the proposed model. In addition to these approaches, other important pedagogical characteristics were considered, such as a) I try to reach the student with learning experiences based on experimentation and manipulation;b)Employ a characteristic of cognitivism, through which the understanding of how the human mind interprets, processes, and stores is sought. information; c) The

cognitive development of students and their previous knowledge and d) The conditions in which learning occurs (context). The model aims to include all these perspectives and, therefore, its components must be designed taking into consideration these points of view.

In addition, in Figure 4 a color code is presented that represents which of the technologies used for the development of the learning objects used helps in the fulfillment of the roles contemplated for each of the aforementioned actors, in that sense, it should be noted that the light green color indicates that augmented reality technology contributes in the fulfillment of a role and for its part, the light orange color is an indicator that the use of a natural user interface favors the fulfillment of the role in which said color appears. In the case of presenting a role with the two colors, this would indicate that both technologies contribute in the same way in the fulfillment of the corresponding role.

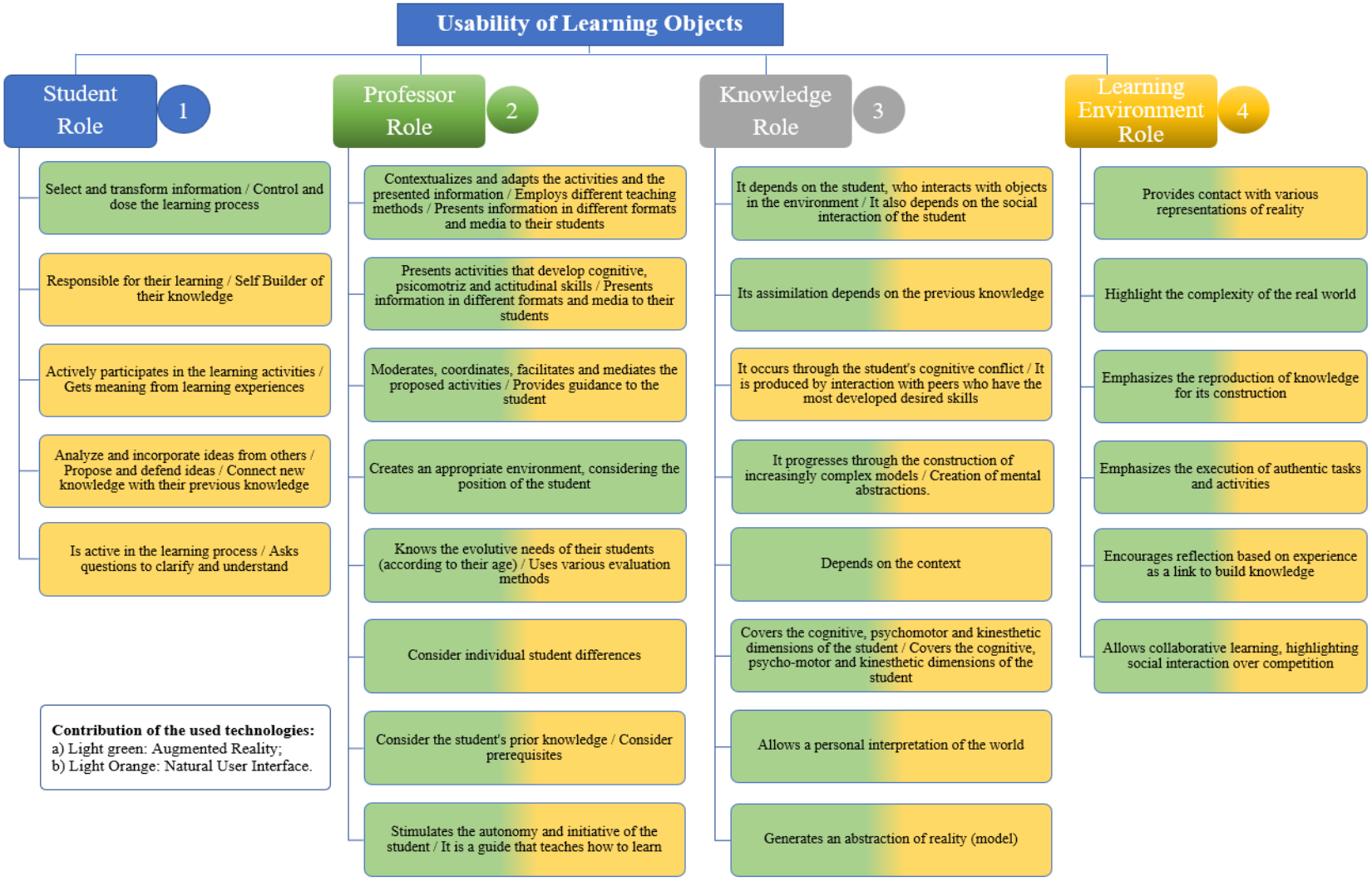

Figure 4: Actors of the learning process, their Roles, and the contribution of the used technologies

The model proposed by the study considers the roles that the 4 main actors have in the learning process, as well as the characteristics detected in both the constructivist and sociocultural approaches that contribute to the benefit of each of these roles. These considerations must be considered by the multidisciplinary team that develops a learning object based on augmented reality and natural interaction so that the materials developed under this approach meet the educational objectives that are pursued with their application, these aspects are those mentioned next:

1. Role of the student: It is well known that the student must be considered as the axis of the learning process, therefore, the consideration of their roles in this process is of vital importance when undertaking the design, development, and implementation of a digital learning object, since the consideration of the needs, roles, and characteristics of the users of the system is important. This consideration should address issues such as the age of the students, their cognitive abilities, their previous knowledge, the context in which they are educated, their socio-cultural situation, etc. In this sense, the analysis of the sociocultural and constructivist educational paradigms analyzed indicates that the student must be responsible for his learning process, so the activities and resources used must consider a high component of autonomous work in the classroom, in which he studies with the guidance of the teacher (or without it), it can selector properly select the information it will review to abstract the new knowledge, being also a regulatory entity that doses and controls its learning processes, a fact that will lead it to understand how it learns better(metacognition).
   It is also important to raise awareness that the student must make about the importance of their active and committed participation in the processes and activities proposed by the teacher, without forgetting the teaching counterpart who must always ensure that these activities are correctly located in the context in which the student develops, so that these activities are not perceived by him as isolated and useless activities but find a sense of for what or why you acquire new knowledge (meaningful learning), both in your classroom experiences and outside of them. In short, it is important to motivate and encourage the participation of the student who must perceive himself as an active entity that has left behind its traditionally passive role and has new roles to fulfill to facilitate their learning process.
2. Role of the Teacher: as in the case of the student, the teaching role undergoes a transformation through which it ceases to be a transmitter of knowledge to be a facilitator that connects the student with appropriate sources that allow him to acquire his knowledge, being also a moderator, coordinator, and mediator between the proposed activities and the students. Within these new activities it must be considered that the teacher oversees selecting, contextualizing, and presenting the information, using the different formats, means, techniques, and instruments that for that task he has at his disposal, he is also in charge of generating an adequate environment in which activities aimed at developing cognitive skills are proposed, psychomotor and attitudinal in their students.
   It is also important that the teacher considers the evolutionary needs of his students, that is, that he can create learning objects and present activities according to the cognitive, physical, and/or effective abilities of the student without forgetting to consider the previous knowledge and prerequisites that his students must possess. These aspects will make the teacher become a guide who teaches to learn while stimulating the autonomy and initiative of his students.
3. Role of Knowledge: being the human being a social entity whose learning process has been based on the transmission of knowledge from generation to generation, it is important to emphasize that it is learned based on the interaction that one has both with other people and/or with the objects that we find in our environment (proof of this is how young children learn based on games) and the relationship and significance that can be given to these interactions from what we have learned before, generating the well-known cognitive conflict that results from relating information we know about an object with new information that must be replaced or updated in our brains when confronted. This fact also denotes the importance that the information that is presented to the student is adequately located and contextualized to their reality and that they must try to cover the cognitive, psychomotor, and kinesthetic dimensions of the student to achieve the desired significant learning and integral formation.

These considerations will allow the student through his psychological, psychomotor, and kinesthetic processes to generate an abstraction of reality, which is transformed into a model that allows him to understand his environment and possess a personal interpretation of the world.

4. Role of the Learning Environment: It has already been mentioned that educational processes must be adequately contextualized to facilitate student learning. In this sense, we must also think about changing the learning environment in which training activities are carried out, it is important then to provide this environment contact with several representations of reality by using all the means, formats, instruments, and available techniques, a fact that also allows us to present the complexity of the world in which we live. This environment to ignite must propose authentic activities and tasks with a clear educational objective to ensure that the incorporation of technological tools in educational processes is useful and does not distract the student from what is important, their training.

Supported by the work of the teacher in the classroom, the learning environment should be a place of reflection in which, from experience, links are created that allow the construction of new knowledge from socialization, the reproduction of relevant content, and the realization of collaborative activities that highlight social interaction over the competition, important skills in the context of the globalized world in which we live.

These considerations, added to the benefits provided by the use of augmented reality and the natural interaction provided by MS Kinect and/or MS Azure, improve the usability of the learning objects developed with the model presented, which used properly also report an improvement in the academic performance of the children involved in the application of the learning objects developed with this approach, the fact that shows that the correct use of these elements (MARAGIC model, Augmented Reality and Natural Interaction), due to their innate characteristics can lead to an improvement in the learning processes of children and young people.

Based on the above, the model called "Model for Augmented Reality Applications with Gestural Interface for Children (MARAGIC)" has been developed, as a response to the lack of models and methodologies that allow the adequate development of digital educational resources (learning objects) based on AR technology and natural user interfaces, for this, from a technical point of view, four layers are considered: interface layer, configuration layer, runtime layer, and storage layer, and from the point of view of the student and his motivation the commitment, absorption, and immersion that he perceives thanks to the technologies used will be considered.

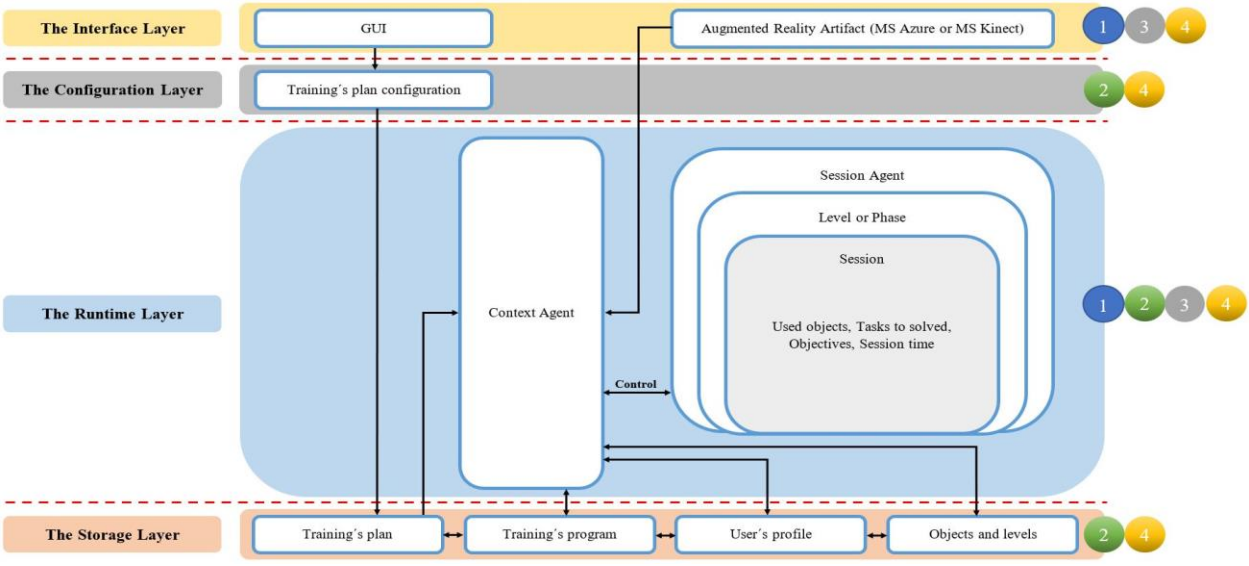

Figure 5: The Model for Augmented Reality Applications with Gestural Interface for Children (MARAGIC)

Description of MARAGIC layers:

1. The interface layer, as the name suggests, is composed of interfaces that make it possible to access other layers. For example, the teacher can use an easy-to-use interface to set up the training plan, while the player interacts with the game via MS Azure Kinect and/or a pair of augmented reality glasses.
2. The Configuration Layer contains the module that allows the training plan to appear, it is with this that the teacher can add a new training plan (thus adapting it to their context or the group of students), and with the pre-existing plans.
3. The runtime layer contains the components that allow interaction with the user while the application is running. These components are a) The context agent and, b) the session agent.
4. The context agent is responsible for saving and retrieving the training plan of each user, as well as its performance, this will allow you to have control over the current session in addition to guiding each user according to their training plan. This agent monitors both the user's interactions and their behavior with the environment while calculating the performance of the users. This agent allows obtaining a better understanding of the users in front of the model, a fact that will allow to improve it. The findings also allow that, in the future, a better training plan for new users can be proposed, considering that the analysis of the information collected is valuable to improve and reinforce the training processes of children. In addition, there is a need to use an intelligent agent that enables the execution of the tasks explained, it is worth mentioning that the learning objects elaborated based on the proposed model, are used by the participating children under the supervision of their teachers.
5. The session agent involves the inclusion and use of levels or phases; where each phase presents an appropriate level of difficulty characterized by the objects used, tasks to be solved, objectives, maximum session time, among others.
6. The storage layer is composed of the components necessary to store data regarding training plans, training programs, users (profiles), game objects, and levels. Each of these components follows a suitable common structure and specification that makes it possible to employ a relational database.

It should be noted that each of the layers of the proposed model is related to the roles suggested by the currents and socio-constructivists for the actors of the learning process shown in Fig. 4. In this way:

a) The interface layer is correlated with the roles to be fulfilled by the student since, under this approach, the person responsible for their learning is the student who actively participates in the activities that are proposed for this purpose, being an active entity In the training process, this fact is achieved mainly through the use of the Natural User Interface (NUI). This layer is related to the role of knowledge since this, in any situation must adapt to the environment and particular situation in which the learning processes occur, appropriately covering the cognitive, psychomotor, and kinesthetic conditions of the learners, enabling the creation of a personal interpretation of reality. Likewise, the interface layer is congruent with the role to be fulfilled by the learning environment since, through augmented reality and NUI, a new representation of the complexity of reality is achieved that in many cases without this type of technology will not It is possible to show, emphasizing the execution of authentic training activities that allow reflection from previous knowledge and experiences to generate new knowledge.
b) The configuration layer is related to the role of the teacher since with this the activities are adapted, which will use different teaching methods enabling the presentation of information in different formats. Mediante this layer. the tutor can moderate, facilitate and coordinate the training activities considering the needs (educational and evolutionary) of the student, their previous knowledge, and, in an ideal scenario, the individual differences of their apprentices achieving an adequate learning environment centered on the student. This layer is also related to the role of the learning environment since, depending on the activities presented, contact with different

representations of reality is possible, these activities must be conceived from the guidelines established inadequate training plans that allow putting It understandably reveals the complexity of the real world, a reality that in many cases, due to the abstract nature of the subjects, is difficult to represent.

c) The execution time layer corresponds to all the roles of the actors of the learning process, since in the case of the student's role it is in this layer, through the adequate dosage of the sessions presented, it will be possible for the student to analyze and incorporate the ideas of others, allowing analysis, contrast, and discussion (cognitive conflict), that make it possible to connect their previous knowledge with the new knowledge acquired. In addition, the correct design of the activities will allow their active participation in the proposed training processes. This layer is related to the role of the teacher since he must prepare and present training sessions in which the autonomy of the initiative and autonomy of the students are developed and stimulated, without forgetting that the student (and the teacher) is an integral being who needs the development of his cognitive, psychomotor and attitudinal skills. The relationship of the runtime layer with the role of knowledge occurs because in each session authentic activities must be proposed that use objects from the student's environment, this allows and relate the previous knowledge of the student with the new knowledge presented, a fact that together with the interaction between peers facilitates the acquisition of new knowledge and skills. It should not be forgotten that the development of the sessions must respond to the context and a progression (presents levels) that allows the abstraction of knowledge and the acquisition of increasingly complex skills. This layer is also related to the role of learning since the sessions presented must emphasize the execution of authentic tasks that allow collaborative learning using, but not abusing the reproduction of knowledge for its construction and promoting social interaction over the competition.

d) The storage layer is related to the role of the teacher since he will be in charge of generating the plans and contents to be applied based on the evolutionary needs of his students and their differences, using various teaching methods that therefore involve presenting, storing, and retrieving information in different formats, the adequate selection of this information will allow to contextualize and dose properly the proposed training activities, important it is also important to mention that this layer allows storing both the profiles of the students and their progress, a fact that will allow obtaining a better understanding of the users and their progress in each work session. This layer is related to the role of the learning environment since depending on the information stored and presented to students, different representations of reality will be achieved, a fact that will allow showing certain contents that due to their abstract nature are not easily observable.

4. MODEL EVALUATION

The advantages observed when using an application that uses the proposed model, which emphasizes the inclusion of context information, can be evaluated by comparing with the model of traditional educational systems. This motivated the execution of a practical evaluation, which was carried out by designing, developing, and applying prototypes based on the model product of this work, as detailed below:

The MARAGIC model and the design methodology of Learning Objects (OA) DICREOVA 2.0 [40] in [41] were used as a framework for the creation of two learning objects called"KARMLS" and "SAM-RAK", which were tested in two quantitative studies published in [2] and (Lozada-Yánez et al., 2020) respectively. In these works, learning objects were developed and applied as support for the teaching of mathematics to children from four Educational Units (2 for each study) attending the third grade of Basic General Education of the City of Riobamba in Ecuador. The results of these studies indicated that computer systems designed and developed based on the proposed model had a positive effect on the academic performance of the participating children when they were used as a support tool in the classroom, these studies allowed. Also, show that the participating children were motivated and in general, showed positive attitudes about the use of computer

systems based on Augmented Reality and Natural User Interfaces.

5. CONCLUSION

The MARAGIC model developed based on Augmented Reality technology and the Natural User Interaction Paradigm, is characterized by its clarity and simplicity, which is why it has enjoyed good acceptance by teachers and students who have used the learning objects developed using the model. Although the proposal is not the definitive answer to the problems detected concerning the incorporation of this type of technology in the classroom, it is presented as an important indication in the understanding of how they facilitate the processes of academic training, through the transformation of educational practices and activities.

MARAGIC focuses on the great need to improve the competencies of the teacher as a mechanism to strengthen the educational act, where it is the teacher who develops skills that enable the inclusion of technological strategies that follow an appropriate order and structure, from the point of view of researchers, this fact is a challenge in most of the educational institutions of the world, regardless of the academic level or. In this sense, it is considered that one way to improve the above is the promotion of academic interaction and collaborative work, through the formation of multidisciplinary groups that, based on new research, focus on the in-depth study of proposals such as the MARAGIC model that will allow the design of contextualized and quality training programs.

It is important to mention that the usefulness and benefits that can be obtained with the use of the MARAGIC model do not depend on the simple application of it but on the consideration of different factors that are known to influence the development of an educational process such as the context, needs and characteristics of the group of students, their previous knowledge, their differences, the infrastructure and technological access of both the educational center and the home, teacher training and development, use of appropriate educational methodologies, among others. In consideration of these factors, it is vital to mention that it is most likely that there is not or is not possible to develop a model that completely covers the vast educational complexity, despite this limitation, the proposed model is presented as a conceptual framework in the study of how technologies such as Augmented Reality and Natural User Interaction can contribute to facilitating the learning of new content and the adoption of the skills that students need to function in the globalized world of our days.

The results obtained with the application of the learning objects developed from MARAGIC, yielded evidence on the positive effects that the application of Augmented Reality and Natural User Interfaces has on the motivation and performance of students. The work presented constitutes a conceptual framework for future research involving the inclusion of the technologies in the educational field, an inclusion that presents important challenges due to the lack of recognition of their benefits and characteristics.

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