MANIPULATIVE MATERIALS AND AUGMENTED REALITY: A CHALLENGE FOR THE TEACHING-LEARNING OF MATHEMATICS IN EARLY CHILDHOOD EDUCATION

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Abstract

Mathematical education in early childhood education has the challenge of incorporating ICT (Information and communication technologies) as a vehicle that helps the teaching-learning process, adapting in this way to digital natives. It is also important not to lose the essence of the manipulative and experiential materials that help to build and develop mathematical thinking. Learnings such as the genesis of number, counting, order or magnitude relationships, classifications, associations, identifications or topological and projective coordinates are fundamental concepts for this stage, that will be the basis and a prelude to learning the operations of the additive field and multiplicative or 2D and 3D geometry in the following stages of primary education. On the other hand, motivation when carrying out these activities is essential for lasting and meaningful learning to take place. This proposal aims to make explicit an experience carried out in the second cycle of early childhood education within the field of logic-mathematics with an active and participatory methodology of a playful nature, that respects the different learning rhythms. To do this, augmented reality tools have been used combined with manipulative materials that are part of a themed common thread that unites the entire proposal. Autonomous learning achieved by discovery of the experiential and observational method will be analyzed through a grid of items. All this, to achieve a lasting and meaningful learning in mathematics in early childhood education.

Keywords: early childhood education, augmented reality, logical-mathematical, ICT.

1 INTRODUCTION

Mathematics in early childhood education has been oriented towards a renewed approach with the purpose of focusing on competence development, allowing students to acquire the necessary skills to function effectively in and with the environment that surrounds them, acquiring the autonomy so necessary in these early educational stages [1]. It is already a fact that the implementation in the classroom through the development of innovative experiences is complemented by the use of active methodologies that integrate Information and Communication Technologies ICT [2].

Today, teachers continue to adapt to the new modes of communication today through ICT, progressing towards the construction of participatory and shared knowledge [3]. According to [4], ICT favor methodologies to be more flexible, active and dynamic, giving preference to constructivist learning. ICT can be found in various contexts of daily life, in this way new opportunities arise learning for students in the digital age. It is necessary to propose a search for new strategies to enhance mathematical learning through what they call active technologies [5]. In this same sense, [6] is committed to new technologies in education to provide new possibilities and didactic resources to the teaching-learning process.

Among these new technologies, recently applied in the educational field, and with many possibilities in mathematics, is Augmented Reality (AR), which consists of directly or indirectly viewing components of real environments combined or augmented with virtual components produced by a technological device [7].

According to [8], working with AR promotes learning by discovery, enriching the information and providing the opportunity to study objects that are difficult to obtain in real life, all this through projections with the smartphone. With AR, it causes a faster assimilation in the learning processes and increases the intrinsic motivation of children, developing in them the ability to find varied and creative solutions to the problems posed [9].

For [10], AR has a great relationship with education since it allows virtual information to be presented in the real world. The image that is reflected may appear to be a two-dimensional (2D) object, when taking into account the alignment or composition of the elements, we would be facing three-dimensional (3D) objects. Inquiries have been carried out that denote in AR a great motivational and reinforcement value for learning by students and therefore, different projects have been carried out to develop platforms and

applications to be able to take the classroom through different technological devices such as mobile phones. These resources are increasingly playing a leading role in education [11].

Without losing the objective of contextualizing mathematics for correct learning, [12] understands that the game and the use of manipulative material, in addition to complementing ICT and being motivating, is a reference for the understanding of abstract concepts by the student.

The objective of this article is to present a series of innovative activities to deal with the logical-mathematical block in early childhood education. Learnings such as the genesis of number, counting, order or magnitude relationships, classifications, associations, identifications or topological and projective coordinates are fundamental concepts for this stage. Designed in such a way that the manipulative material can be combined with the AR. For this, it is intended that educational dynamics with different digital tools are capable of improving skills and abilities in the participating students.

After an analysis in the introduction of the theoretical framework of the proposal and the establishment of the study objectives, the experience and the results achieved will be exposed in a final evaluative activity to see if the learning objectives and their visual comprehension of the images in 2D and 3D in AR have been met.

2 METHODOLOGY AND EXPERIENCE

In this section, the context of the didactic experience carried out will be exposed and each one of the dynamics designed with manipulative material and AR will be detailed, including the final dynamic as an evaluation of skills and knowledge.

2.1 Context and Experience

This study has been carried out in the Early Childhood Education stage with 25 students from a four-year-old classroom. Each group will be a team in such a way that we will have a total of 4 teams with approximately 6 students. The experience has four activities, the last one as evaluation activity.

The experimental method will be taken as the starting point of discovery learning in which the appropriate tools that act as a facilitator for the autonomous learning of students [13].

As a common thread of the proposal, it has been chosen to turn students into explorers and interact with animals, for [14], one of the main objects of study in early childhood education should be living beings and specifically animals since children at these ages have a great sense of curiosity and interaction with the environment and nature, seeking answers about what is happening around them.

To make learning more enriching, the activities that have been proposed have been experiential, and playful, where through play and experimentation with manipulative material, students have had the opportunity to learn by themselves by interacting with them, that they have prepared for the development of these, respecting their learning rhythms. In addition, the activities have not only been oriented towards individual learning, they have also worked collaboratively, taking advantage of the heterogeneity of the class group. A total of 4 activities are presented where it can work on logic-mathematics, arithmetic, and space and geometry. The AR application used has been Arloopa

2.1.1 Activity with RA and polycubes to measure height and establish the order scale

The specific objectives of this activity have been:

Establishment of order and comparison from highest to lowest and lowest to highest, calculation of the height with the manipulative material of the polycubes (it helps to understand what animal is taller than another), place value of the ordinal number when establishing the scales.

Each team will have a leader who will be the one to organize their team in the animal´s search. Each team will go out in order to look for animals. The same student may not take more than one animal so that the others students also have the opportunity. When all the teams have found the animals, they will proceed to calculate the length individually with the help of the polycubes. The height can be calculated with plastic animals or with the use of Augmented Reality through the mobile phone, so that they continue to check the difference between one dimension and another. Next, the students will put the animal on the table and stack cubes in the same position until they reach the animal's head and will point out the number of cubes that belong to each animal (Fig. 1), in order to start to the second part of the activity.

In this second part, taking advantage of the fact that they know the height of the animals, in a large group, they will make an order scale (Fig. 2) among all of them, placing the animals from highest to lowest height, and viceversa, in function of its length by counting the number of cubes that each one has, until obtaining the order scale indicating the position of each of the animals with ordinal numbers.

Figure 1. Height calculation of an AR animal with polycubes.

Figure 2. Order scale and size.

2.1.2 Activity to work on the genesis of the number

The specific objectives of this activity have been:

Work on the genesis of number, that is, association of the number of animals with the concept of cardinal, assignment of spellings

To carry out individualized learning where everyone has the opportunity to count the number of animals of each type, they must individually associate the number with the number of animals that are represented on the different cards provided. In addition, behind each set they will write their cardinal to reinforce their spelling (Fig. 3).

These cards, both the number and the Animal cards, will be placed on the tables in front of each child. So that there are no major errors in counting because they do not have a good one-to-one correspondence, they can be helped by marking each animal that they count with a marker so as not to repeat it (Fig. 4).

Figure 3. At working on the genesis of the number.

Figure 4. At working the spellings of the numbers from 2 to 16.

2.1.3 Activity to work 2D & 3D

The specific objectives of this activity have been:

Work the geometry in three dimensions through flat developments, work the special visualization of the students.

In this activity, they will go from plane to space through the development of plans and will obtain a spatial vision of it with AR.

Each child will be given a 3D cut-out figure of a lion printed on a sheet of paper that they will have to color, remember and assemble by gluing the indicated tabs (with the teacher's help) (Fig. 5). This will allow students to form a whole by relating these angles in their mind set.

On the other hand, we will also do magic thanks to Augmented Reality, using the Arloopa application as a means on a mobile phone to give ourselves a spatial vision of the animal. In this sense, it will be possible to verify the usefulness of the AR and, specifically, this application for the mobile phone (Arloopa). They will be able to see the animals in a much more realistic way from any perspective, as well as see their physical characteristics closer and know their onomatopoeia or even their movement, being able to interact with them as they appear, through the camera, anywhere in which you aim with the objective (Fig. 6). In this way, they become even more involved in this teaching-learning process.

Figure 5. 3D figures from planar developments.

Figure 6. Tiger projected with AR with the Arloopa application.

2.1.4 Final evaluation activity

The specific objectives of this final evaluation activity have been:

Evaluation of the height calculation, logical order from highest to lowest and viceversa, ordinal assignment, cardinal assignment, genesis of the number and establishing the difference between two and three-dimensional objects.

This activity collects everything that the students have learned throughout the other 3 sessions and is presented as an evaluation. It involves completing an interactive mural (Fig. 7 and 8) based on the proposed objectives. The mural consists of 4 parts. In the first part they will have to calculate the height of the animals with polycubes made of cardboard and write the corresponding number of cubes; In the second part they will have to organize these wild animals according to their height, placing their corresponding ordinal below them; In the third part they will have to make flat figures surrounding each animal with a different mark (giraffes with a triangle, elephants with circles, zebras with squares and the gorilla with a heart); In the fourth part they will have to count the number of animals of each type and associate it with their quantity.

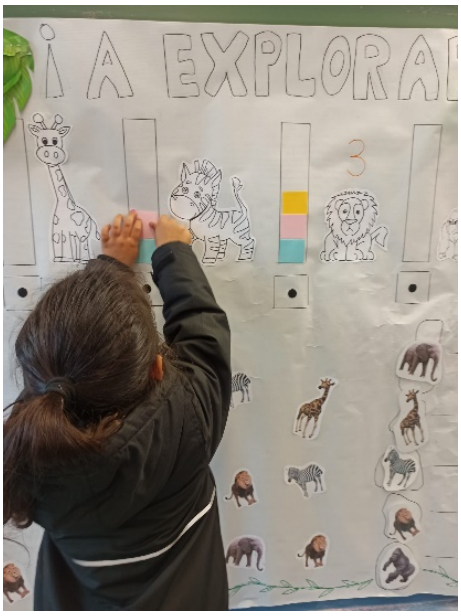

Figure 7. Student with the interactive mural.

Figure 8. Students interacting with the figures in AR.

3 RESULTS

The results observed in the study throughout this experience are explained below.

3.1 Results of the first, second and third activities

In the first activity, all the students have correctly used the polycubes to know the height of the animals and understood the value they have to calculate it. Only 90% of the students were able to correctly identify the extremes of the scale, that is, the highest and the lowest. On the other hand, only 80% of the students knew how to identify the rest of the animals correctly at first until they understood that the number of cubes was a function of the height and therefore the position that each animal had on the scale, considerably improving to from then on. The cube assignment was correct both physically and through Arloopa. On the other hand, they all knew how to assign ordinal numbers to the animals up to the 4^{th} number.

In the second activity, 90% of the students have made use of counting to associate the number with the number of the cards correctly, however, 10% of the students do not have a good one-to-one correspondence, so that failed in the cardinal and its association.

In the third activity, 85% of the students understood that the 2D plan is like drawing on paper and 3D is like giving life to the drawing, being able to see it from different perspectives. However, for the students, the only difference they saw was that sometimes it was seen on paper and other times on mobile without understanding the terms.

The augmented reality application was quite successful, they were surprised to see how an animal could be in their class, next to them, walking and roaring.

3.2 Results of the evaluation activity

The final evaluation data is provided below. Some topics are evaluated under observation and analysis in a Likert scale for 4 points, 1 corresponds to the lowest level and 4 to the highest. In Fig. 9 it can be seen how 98% of the students have been able to calculate the height of the animals with polycubes correctly both physically and virtually through AR. On the other hand, the remaining 2% were doubtful as to the number of cubes they had selected, but when they requested help, they saw that they had the correct number of cubes, but could not identify that they were the same height. Therefore, they were asked to put one more cube and say if it was taller and, by checking, they realized the correct result themselves.

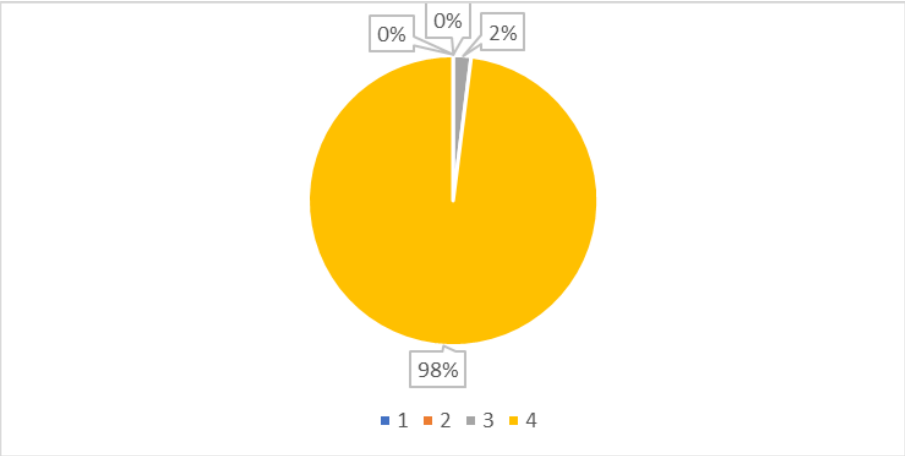

Figure 9. Results of c*alculation of the height of the animals.*

In Fig. 10 it can be seen how 95% of the students established the height of the animals as a function of the number of cubes, assigning the ordinal corresponding to each of them. On the other hand, some students did not associate the last ordinal with their position but did so by discarding it being the last one.

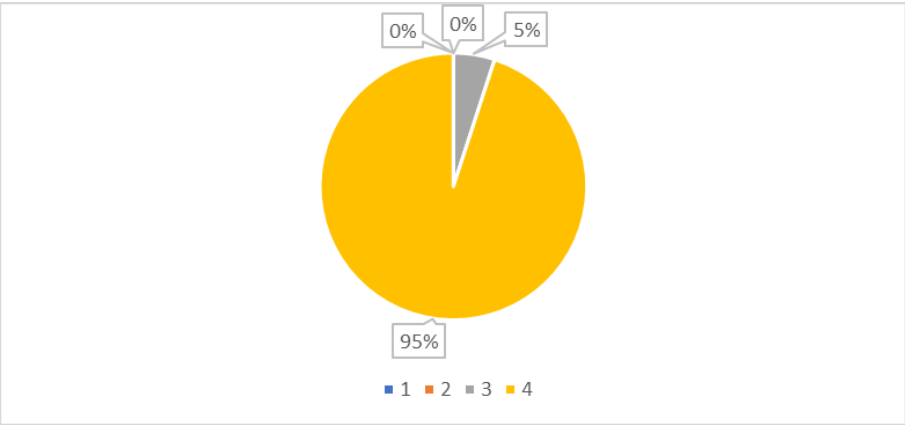

Figure 10. *Results to set the logical order from greatest to least.*

In Fig. 11 we can see that 90% of the students were able to group the animals according to the geometric shape that was requested without confusing the shape or the animal they had to look for. On the other hand, the remaining 10% is distributed among those students who did not know how to relate the figure that was asked to their drawing and in those who left an animal uncircled.

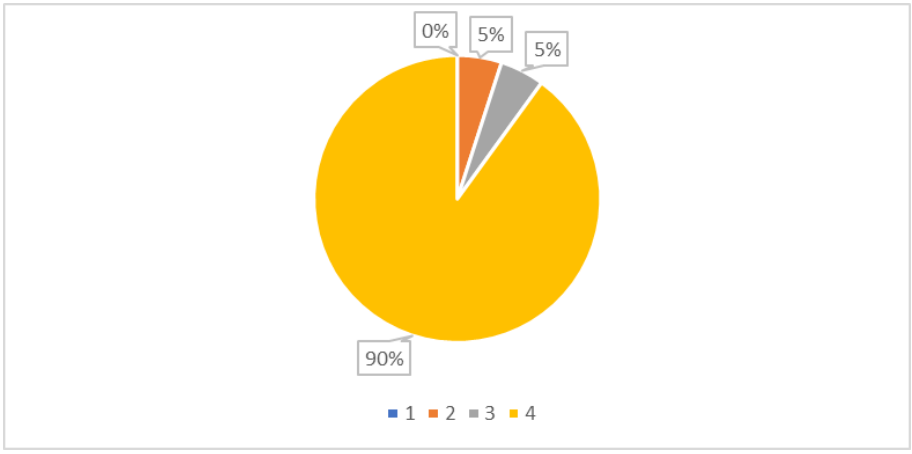

Figure 11. *Results pf grouping animals by geometric shapes creating sets.*

In Fig. 12 it is reflected that 85% of the students carry out the counting of the animals of the set and their association with their cardinal correctly. On the other hand, 15% of the students do not establish a good relationship between spelling quantity and therefore are not able to select the correct cardinal.

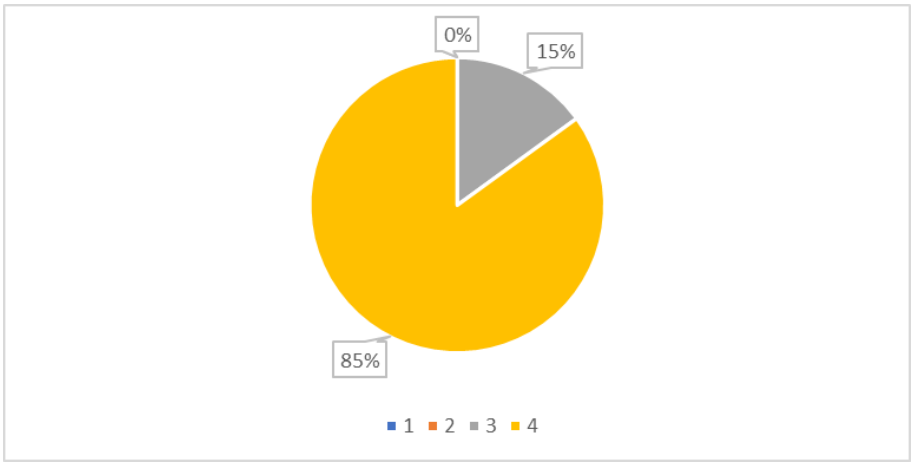

*Figure 12. Results of a*ssociation of the cardinal to the animals of a set.

Figure 13 shows that 90% of the students know that what they were doing on paper was a 2D drawing and what they saw on their mobile was reality in 3D. On the other hand, the rest of the students did not identify the difference of the concepts, that is, they are not capable of differentiating one dimension from the other, if not when verifying that things are seen differently on paper and on mobile.

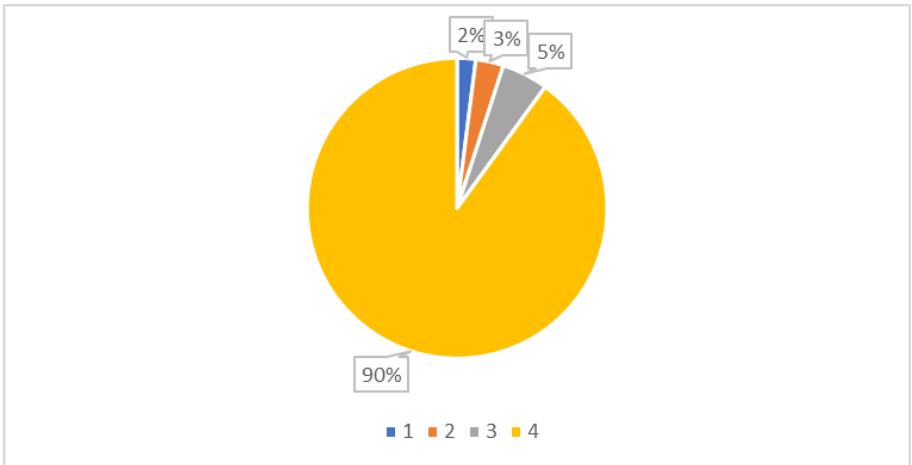

Figure 12. Results of understanding the difference between two and three dimensions.

4 CONCLUSIONS

Augmented Reality is a tool that provides a new way of learning content, stimulating student learning and complements the learning process [15]. Introducing Augmented Reality (AR) in the classroom has been a positive point for students and their learning since with it they have been able to see beyond reality and compare both perspectives both in the field of arithmetic and in the field of space and geometry. All this was even more attractive for the students since the application that was used for it (Arloopa) had the same theme with which they were working until then and for which they have great interest, and also this not only showed the animal if not that it was also endowed with its onomatopoeia so it gave it even more realism. Based on the results obtained throughout the experience, it has been demonstrated that in combination with manipulative materials, digital tools are capable of improving skills and abilities, in addition to increasing the student's motivation in the teaching-learning process in Early Childhood Education.

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