STUDY OF EFFICACY OF SERIOUS GAMES WITH AUGMENTED REALITY TO DEVELOP MATHEMATICAL SKILLS IN CHILDREN OF A PERUVIAN PRIMARY SCHOOL, BASED ON NEUTROSOPHIC STATISTICS

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ABSTRACT
This research seeks to unite the playful and technological to overcome the difficulties in the area of mathematics from the beginning of schooling. Its purpose is to take advantage of the natural orientation that children have for using video games to develop mathematical skills and lay the foundation for future success. Its objective is to determine the level of development of basic mathematical skills, through the application of serious games with augmented reality, in students of the first grade of primary school of the Educational Institution "Jesús Nazareno", Huaraz –2020 Its development is addressed from the quantitative perspective, with experimental design applying pre-test and post-test. We worked with the population, made up of 19 students from the first grade of primary school, with which a strategic plan based on serious games with augmented reality technology was developed. Riquelme's adapted basic math skills test was used to collect the data; which was subsequently processed and analyzed using descriptive statistics and the parametric t-Student test. Neutrosophic Statistics was applied to carry out the study, since the measured data can be given in the form of intervals. This way of measuring the data is more imprecise, although more accurate, which is an advantage that the authors of this article propose.

KEYWORDS: Serious games, augmented reality, basic math skills, video games, Neutrosophic Statistic.

MSC: 03B50, 03B52, 03B60, 91D10, 91F99, 97M10.

RESUMEN
Esta investigación busca unir lo lúdico y lo tecnológico para superar las dificultades en el área de matemáticas desde el inicio de la escolaridad. Su propósito es aprovechar la orientación natural que tienen los niños por usar los videojuegos para desarrollar habilidades matemáticas y sentar las bases para el éxito futuro. Tiene como objetivo determinar el nivel de desarrollo de las habilidades matemáticas básicas, mediante la aplicación de juegos serios con realidad aumentada, en estudiantes del primer grado de primaria de la Institución Educativa "Jesús Nazareno", Huaraz – 2020 Su desarrollo se aborda desde la perspectiva cuantitativa, con diseño experimental aplicando pre-test y post-test. Se trabajó con la población, conformada por 19 estudiantes de primer grado de primaria, con los cuales se elaboró un plan estratégico basado en juegos serios con tecnología de realidad aumentada. Para la recolección de datos se utilizó la prueba adaptada de habilidades matemáticas básicas de Riquelme; la cual fue procesada y analizada posteriormente mediante estadística descriptiva y la prueba paramétrica t-Student. Para realizar el estudio se aplicó Estadística Neutrosófica, ya que los datos medidos se pueden dar en forma de intervalos. Esta forma de medir los datos es más imprecisa, aunque más exacta, lo que es una ventaja que proponen los autores de este artículo.

PALABRAS CLAVES: Juegos serios, realidad aumentada, habilidades matemáticas básicas, videojuegos, Estadística Neutrosófica.

1. INTRODUCCIÓN

Mathematics is fundamental for the intellectual development of children, it helps them to be logical, to reason in an orderly manner and to have a mind prepared for thought, criticism and abstraction; at the same time they form attitudes and values. However, in school, the area of mathematics tends to be by far the one that has the greatest difficulties from the beginning of schooling. For this reason, the educational systems of many countries have placed great emphasis on learning mathematics in order to improve results in this area and prevent the appearance of learning difficulties and in the future guarantee the sustained development of their

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societies.
A. González ([11]) and F. Reimers ([24]) indicate that when children enter primary school, their informal knowledge of mathematics is not yet developed to the necessary point required by the formal mathematics curriculum, this is especially attributed to cultural poverty in that the students experience, aggravated by the ignorance of strategies on the part of the teachers to reinforce these knowledge and skills, the lack of didactic material, and the little use and innovation in ICT. In this sense, Cueto et al. ([8]), found that in three studies on learning opportunities and performance in Peru, the cognitive demand in mathematics in primary education had exercises with low levels. Which is consistent with the current curriculum that suggests the importance of having complex learning but without considering the development of basic mathematical skills. This is also evident in the 2012 and 2013 ECE tests in the area of mathematics in which the investigated students obtained low scores.
To reverse this situation, it is necessary to create the most appropriate conditions to facilitate the construction of basic skills within mathematics, in this sense Ricotti ([26]) indicates that the new trends in mathematical education propose strategies that involve attractive situations from the ludic point of view. Where the game is an effective and useful tool for learning. But along the way, technological advancement has changed the tangible environment to the virtual. Chudacoff ([9]) points out that the game played by children and young people today has left parks and sports fields behind, giving way to virtual environments present in video and computer games.
Thus arose the serious games or videogames applied to education whose evolution reaches the cloud gaming and the videogame on demand; and the use of more sophisticated interaction technologies such as augmented reality (AR) that provides interaction and immersion elements superior to conventional ones, combining virtual elements with physical elements to create mixed reality in real time. Then the challenge is created to interact with serious games and adapt them to the local needs of students and educators, taking advantage of their effectiveness in school, especially in mathematics, which is an area of enormous interest for Peruvian education. This integration must be creative and innovative, linking ICT, especially AR to the game with the aim of training or educating, taking advantage of present technologies and children's interests in video games.
The researches reviewed on the study topic do not contain a direct relationship, but they do contain significant elements on the study variables.
At an international level on mathematical skills, Arzate can be cited, who concludes in the master thesis in [2] that to evolve from a mechanical model of learning the mathematics, to a collaborative work student-teacher for the development of mathematical competence, it is essential that the teacher knows the constructivist approach of the current plans and programs of study, which assumes his/her responsibility as a designer of didactic situations that promote meaningful learning in mathematics and act as a guide for students in the construction of their knowledge. He confirms the theory on the evolution of the process of reasoning and solving mathematical problems. It indicates that the principles of meaningful learning embodied in the Bottge Key model [5], contributed substantively to the promotion of mathematical competence due to the relevance it gives to the consideration of the interests of the students and their needs in their daily life. And finally, he affirms that the adaptation of the five aspects model for the resolution of mathematical problems by Pérez [21], turned out to be a useful resource for the systematization of teaching work.
On the other hand, regarding serious games with augmented reality we have Paredes's work, who concludes in the master thesis in [20] that this technology should not be presented in isolation in the educational process, but should be part of the methodology designed by the teacher in such a way that it enhances the capabilities of each student. On the other hand, Herrera in the master thesis in [13] concludes that experiences in virtual reality and augmented reality lend themselves to constructivist models of pedagogical knowledge, as well as constructivism aided by technology, it is ideal for calculation and it is found that augmented reality (AR) removes obstacles to the free building of knowledge by providing better visualizations, which are raw material for the construction of knowledge.
Tenemaza in the master thesis in [34] concludes that from the analyzed projects it is deduced that an adaptive system requires a fluid exchange of data, either from external sources such as sensors, from the user's work context, or demonstrated in their navigation, to detect user interests, which is recorded as feedback in the model.
Celaya, in the final master thesis in [6] concludes that the use of augmented reality is justified because it provides the context with additional key data to understand abstract elements, surpassing that provided by a simple text.
The search for theoretical support motivated an extensive review of the literature, identifying the existence of a set of theoretical perspectives for the study, understanding and development of basic mathematical skills.

Conceiving them as the set of skills in construction that are inherent to certain mathematical activities, which allows the subject to search for or use concepts, properties, relationships, mathematical procedures, use work strategies, make reasoning and judgments that are necessary to solve mathematical problems of greater complexity. According to Piaget, these skills are classification, serialization, conservation, the expression of logical judgment and the symbolic function, [22].

Where the ability of classification is understood by Rencoret ([25]) and Maldonado and Francia ([16]), as organizing different elements through a series of mental relationships based on which objects are brought together by similarities, separated by differences, defines the object membership in a class and is subclassed. Among its properties are the notions of understanding and extension of objects. Understanding is given by the relationships of similarities and differences, and the extension by the elements with common characteristics that belong to the same class of objects.

Computer games are part of the common experience of much of today's childhood. For this reason, when children use the computer and computer programs, they use knowledge and skills acquired outside the school environment; that on numerous occasions, instead of being seen as something positive and usable, they seem to constitute a threat and the school denies the acquired experience, [12]. Precisely for this reason, teachers need training to understand, use serious games in the classroom and provide feedback on their design. Precisely the challenge for teachers and game designers alike is to understand how to shape learning in terms of games, and how to integrate games into learning environments, [30].

In this line, serious games in the field of mathematics, making an analogy to that indicated by Villabrille ([35]) with respect to games, constitute an important contribution in the teaching of mathematics for which it is necessary to choose the appropriate video game in the different moments of the teaching-learning process, and in this way it will be possible to solve innumerable mathematical problems without using a pencil and paper.

In addition, serious games must involve, like any other didactic game, a symbolic model through which it is possible to contribute to the formation of theoretical and practical thinking of the students and the formation of the qualities that they must meet for the performance of their functions: capacities to direct and make individual and collective decisions, skills and habits of management and social relationships serving as mediators of the learning process, see Cruz ([7]) cited in [19]. Several scholars argue that games capture the player's attention, develop complex thinking and problem solving, [3][10][15]. For example, for Gee and Shaffer, games require the kind of thinking that we need in the 21st century, [10].

The objective of this research is to determine the level of development of basic mathematical skills, through the application of serious games with augmented reality, in first grade students of the Educational Institution "Jesús Nazareno", Huaraz – 2014 in Peru.

Statistical methods were applied to carry out the study. The evaluations were collected in the form of an interval, this allows us for more accuracy, although more imprecision, the former one is a characteristic pursued by the authors of this research. Since we work with data in the form of intervals, it was necessary to use the Neutrosophic Statistics, which is an extension of the classical statistics to the domain of the intervals, [32]. Some papers where neutrosophy applied to problems of pedagogy can be found in [1][4][14][23][28][29].

This paper is divided into the following sections: Section 2 contains the fundamental concepts of Neutrosophic Statistics. Section 3 contains the details and results of this study. Conclusions are given in section 4.

2. BASIC NOTIONS ON NEUTROSOPHIC STATISTICS

In this section we explain basic concepts of neutrosophic sets and neutrosophic statistics.

Definition 1: ([31]) Let X be a universe of discourse. A *Neutrosophic Set* (NS) is characterized by three membership functions, $u_A(x), r_A(x), v_A(x) : X \rightarrow \,]^-0, 1^+[$, which satisfy the condition $^-0 \leq \inf u_A(x) + \inf r_A(x) + \inf v_A(x) \leq \sup u_A(x) + \sup r_A(x) + \sup v_A(x) \leq 3^+$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ are the membership functions of truthfulness, indeterminacy and falseness of x in A, respectively, and their images are standard or non-standard subsets of $]^-0, 1^+[$.

Definition 2: ([31]) Let X be a universe of discourse. A *Single-Valued Neutrosophic Set* (SVNS) A on X is a set of the form:

$$A = \{\langle x, u_A(x), r_A(x), v_A \quad (1)$$

Where $u_A, r_A, v_A : X \rightarrow [0,1]$, satisfy the condition $0 \leq u_A(x) + r_A(x) + v_A(x) \leq 3$ for all x∈X. $u_A(x), r_A(x)$ and $v_A(x)$ denote the membership functions of truthfulness, indeterminate and falseness of x in

A, respectively. For convenience a *Single-Valued Neutrosophic Number* (SVNN) will be expressed as $A = (a, b, c)$, where $a, b, c \in [0,1]$ and satisfy $0 \leq a + b + c \leq 3$.

Definition 3: ([33]) A *neutrosophic number* N is defined as a number as follows:

$$N = d + I \quad (2)$$

Where d is called *determinate part* and I is called *indeterminate part*.

Given $N_1 = a_1 + b_1 I$ and $N_2 = a_2 + b_2 I$ two neutrosophic numbers, some operations between them are defined as follows ([18]):

$N_1 + N_2 = a_1 + a_1 + (b_1 + b_2)I$ (Addition);

$N_1 - N_2 = a_1 - a_1 + (b_1 - b_2)I$ (Difference),

$N_1 \times N_2 = a_1 a_2 + (a_1 b_2 + b_1 a_2 + b_1 b_2)I$ (Product),

$\frac{N_1}{N_2} = \frac{a_1 + b_1 I}{a_2 + b_2 I} = \frac{a_1}{a_2} + \frac{a_2 b_1 - a_1 b_2}{a_2(a_2 + b_2)} I$ (Division).

Neutrosophic Statistics extends the classical statistics, such that we deal with set values rather than crisp values, ([32]). Neutrosophic Statistics can be used as a quantitative research method in sociology for testing social hypotheses.

Neutrosophic Descriptive Statistics is comprised of all techniques to summarize and describe the neutrosophic numerical data characteristics.

Neustrosophic Inferential Statistics consists of methods that permit the generalization from a neutrosophic-sampling to a population from which it was selected the sample.

Neutrosophic Data is the data that contains some indeterminacy. Similarly to the classical statistics it can be classified as:

- *Discrete neutrosophic data*, if the values are isolated points.
- *Continuous neutrosophicdata*, if the values form one or more intervals.

Another classification is the following:

- *Quantitative (numerical) neutrosophic data*; for example: a number in the interval [2, 5] (we do not know exactly), 47, 52, 67 or 69 (we do not know exactly);
- *Qualitative (categorical) neutrosophic data*; for example: blue or red (we don't know exactly), white, black or green or yellow (not knowing exactly).

The *univariate neutrosophic data* is a neutrosophic data that consists of observations on a neutrosophic single attribute.

Multivariable neutrosophic data is neutrosophic data that consists of observations on two or more attributes.

A *Neutrosophical Statistical Number* N has the form $N = d + i$, like Equation 2.

A *Neutrosophic Frequency Distribution* is a table displaying the categories, frequencies, and relative frequencies with some indeterminacies. Most often, indeterminacies occur due to imprecise, incomplete or unknown data related to frequency. As a consequence, relative frequency becomes imprecise, incomplete, or unknown too.

Neutrosophic Survey Results are survey results that contain some indeterminacy.

A *Neutrosophic Population* is a population not well determined at the level of membership (i.e. not sure if some individuals belong or do not belong to the population).

A *simple random neutrosophic sample* of size n from a classical or neutrosophic population is a sample of n individuals such that at least one of them has some indeterminacy.

A *stratified random neutrosophic sampling* the pollster groups the (classical or neutrosophic) population by a strata according to a classification; afterwards the pollster takes a random sample (of appropriate size according to a criterion) from each group. If there is some indeterminacy, we deal with neutrosophic sampling.

3. THE STUDY

The experiment consisting in pre and post-test implies three steps to be carried out:

1st A previous measurement of the dependent variable to be studied (pre-test),

2nd Introduction or application of the independent or experimental variable X to subjects Y,

3rd A new measurement of the dependent variable in the subjects (post test).

To execute these steps, a single group is considered, to which the pre-test was applied, then the experimental treatment was applied to this group: application of serious games with augmented reality. Then the post-test

was applied, to make the comparative analysis of the development of basic mathematical skills.
The study included 19 students of both sexes, enrolled in the first grade of the primary level of the I.E. “Jesús Nazareno”, Huaraz, in the 2020 academic year. Among the exclusion criteria, students with withdrawals in the current academic year and students with special educational needs were considered.
Surveys were applied among the data collection techniques and instruments, based first on the Basic Mathematical Skills Test and second on the simplified sheet for cataloging and evaluating educational software.
The Basic Mathematical Skills Test is the proposed instrument that focuses on the basic skills involved in the initiation of mathematics according to Piaget. The test allows them to examine skills earlier to select and create learning conditions more appropriately and according to individual needs. The structure of the test follows as a reference the LAP-D Test and the Basic Skills Test for the initiation of computing ICT, both adapted and validated by Riquelme, which have been adapted to reality of first graders, ([27]). It is made up of 30 items which are organized by each of the skills to be measured following a correlative order. In each item, the behavior to be observed is proposed through the activities that the boys and girls must carry out and the educational materials that they must use.
They include:

- Notions of classification (08),
- Notions of serialization (05),
- Notions of conservation (07),
- Expression of logical judgment (04),
- The symbolic function (06).

Among the mathematical skills that are measured with this program is serialization, which is one of the fundamental pillars when it comes to reaching the concept of number, since number is the union of the concepts of serialization and classification. That is why video games are included where the boy or girl must order figures according to size (big-small), order pencils from shortest to longest, order jars according to weight, fill glasses from smaller to larger volume, order tapes according to length, order following color degradation, for each success they are rewarded with a score and for each error they are assigned a score of 0 as part of the didactic situations.
Another competence is conservation, which is the understanding that once the equivalence or non-equivalence of two sets is established, changes in the configuration of the sets do not modify the equivalence or non-equivalence relationship. That is to say that an object or several objects are considered invariant with respect to the structure of its elements or any physical parameter, despite the change in its size, shape, color or external configuration.
Thus, if a sheet of paper is cut into several pieces, it will still have the same amount of paper. The boy or girl who does not conserve, gets carried away by perception and answers that the amount of mass is different now that it has a different shape. That is why, as a didactic situation, children are shown how to chop a cube into smaller cubes and are asked which one will have greater mass, volume, etc. between the total cube or the set of smaller ones.
The third competence that is measured is the expression of logical judgment, which consists of issuing a value judgment on a daily situation, which is produced verbally to give a certain object a property and establish relationships between objects and situations of daily life. The understanding and use of sentences with different grammars is taken as a reference: negation, conjunction, disjunction and use of quantifiers. In this case, the didactic situation consists of showing different houses with a door or a window and the children are asked if they consider that it is a house with a door and a window, or a house with a door or a window, or is it a house that does not have door, select a sheet where there is more and select the group that has less.
Symbolic competence is understood as an approach to symbols and an approach to the differences between meaning and signifier. In this case, the student is asked, within the serious game, to match a number with its group, name which number comes after, name which number comes before, match a number with its group, say numbers and select numbers that indicate more than another.
Classification is the action or effect of ordering or arranging by classes. In the classification didactic situation, students are asked to group objects, identify characteristics and select objects and shapes. These can be bodies, figures of everyday life such as fruits, animals, etc., for example, group all the vegetables according to their colors.
Within the items, it is measured for each student if they reached the desired objective for each one of them in serialization, conservation, the expression of logical judgment, symbolic competence, and classification in the established time. Each of the competencies have specific ranges of the number of points that boys and girls

must achieve to be considered in the range of achieved, if the proposed objectives were achieved in the expected time, process, if the objectives were partially achieved in the expected time and additional time would be needed to reach them, and finally, start, if it is considered that the objectives were not reached or will not be reached, or he (she) reached them in an erroneous way, among other cases. A detailed explanation of this would be too cumbersome and would not contribute to the mathematical principle of the article, which is why it is left out.

Regarding the validity and reliability, this instrument was validated by the content validity method through the expert judgment procedure in which two specialists participated: a psychologist who works at the “Los Angeles de Chimbote Catholic University” and a methodological adviser teacher of the school postgraduate degree from the University "César Vallejo" - Branch: Chimbote. For the validation, the validation matrix was used, whose evaluation criteria refer to the coherence and relationship of each of the items with the dimension, indicator and response.

To determine the reliability, the test was applied to a pilot study sample, which was determined through a non-probabilistic convenience sampling, made up of 30 students, with an average age of 6 years at the primary level of the I.E. "Ricardo Palma".

For the standardization of this instrument, internal consistency was used through the coefficient of Cronbach's Alpha, resulting in a value of 0.773; which means that the basic math skills test has a high degree of reliability.

On the other hand, the simplified sheet for cataloging and evaluation of educational software is an instrument that focuses on evaluating pedagogical, functional and technical aspects of educational software. It was proposed by Marqués ([17]) and has been adapted to measure and evaluate the serious games with augmented reality that have been built and their potential for application in the strategic plan to be developed. It is made up of 20 items that are organized based on 3 aspects considered relevant to evaluate serious games with augmented reality. In each item the criteria that this must contain according to the aspects to be evaluated are proposed, its distribution is the following:

- Pedagogical aspect (10 items),
- Functional aspect (3 items),
- Technical aspect (7 items).

Its validity was corroborated by two teaching systems engineers from the "Los Angeles de Chimbote Catholic University".

The data have been processed and analyzed using descriptive statistics: frequency distribution tables, measures of central tendency and dispersion.

In the inferential statistics part, to contrast the study hypothesis, the inferential statistician of the parametric t-Student test for related samples was used.

Likewise, for the statistical treatment of the data, the SPSS software and the Excel spreadsheet is used, which allows the information to be systematized in statistical tables, tables and graphs.

The developed study was pre-experimental, which implied intervention at the experimental group level (students) to which a set of sessions was applied, in the same way the data collected in the pre-test and post-test are private, respecting the confidentiality of the participants, is classified like "without risk" for being analytical.

Informed and written consent was obtained from the parents of the participating institution, who were informed about the results of the investigation after presenting the final investigation report.

On the other hand, the benefits for those investigated, lay in the interaction that took place in the development of the sessions that had the purpose of developing certain skills in the area of mathematics.

For the evaluations, specialists were asked if they had doubts about giving a score to a student in a test then they can use an interval where the evaluation that they consider the most appropriate is provided. This way of evaluating ensures that although they do not have a specific evaluation number, they can know with certainty that the true evaluation is contained within this interval.

The final results of the pre-test and post-test appear in Table 1.

N	**Classification**				**Serialization**				**Conservation**				**Expression of logical judgment**				**Symbolical function**			
	Pre-test		**Post-test**		**Pre-test**		**Post-test**		**Pre-test**		**Post-test**		**Pre-test**		**Post-test**		**Pre-test**		**Post-test**	
	P	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**	**P**	**N**
1	4-5	B	6	B	4	B	5	A	2	C	5	B	2	B	4	A	2	C	6	A
2	3	C	7	A	3	B	3-4	B	1	C	5	B	2	B	4	A	1	C	6	A

3	4	B	7	A	5	A	5	A	1	C	7	A	2-3	B	4	A	0-1	C	5	A
4	7	A	8	A	3	B	5	A	2	C	7	A	3	B	4	A	5-6	A	6	A
5	8	A	8	A	2	C	5	A	1-2	C	6	A	4	A	4	A	4	B	6	A
6	2-3	C	8	A	1	C	5	A	5	B	6	A	2-3	B	4	A	0	C	6	A
7	6	B	8	A	5	A	5	A	1	C	7	A	4	A	4	A	6	A	6	A
8	7	A	8	A	2	C	5	A	4	B	7	A	4	A	4	A	1	C	6	A
9	7	A	8	A	5	A	5	A	5	B	6-7	A	4	A	4	A	4	B	6	A
10	5	B	8	A	5	A	5	A	3	B	7	A	4	A	4	A	4	B	6	A
11	5	B	8	A	1	C	5	A	2	C	7	A	3	B	4	A	1	C	5	A
12	4	B	7	A	3	B	5	A	2	C	7	A	4	A	4	A	2	C	6	A
13	6	B	8	A	2	C	5	A	2	C	7	A	4	A	4	A	4	B	6	A
14	2	C	8	A	4	B	5	A	1	C	7	A	4	A	4	A	0	C	6	A
15	8	A	8	A	5	A	5	A	4	B	7	A	4	A	4	A	5	A	6	A
16	5	B	8	A	5	A	5	A	2	C	7	A	4	A	4	A	5	A	6	A
17	4	B	8	A	5	A	5	A	4	B	7	A	3	B	4	A	5	A	6	A
18	7	A	8	A	5	A	5	A	3	B	7	A	1	C	3	B	6	A	6	A
19	6	B	8	A	5	A	5	A	2	C	6	A	3	B	4	A	2	C	6	A

Table 1: Matrix of scores and levels in the development of basic mathematical skills in students of the first grade of primary school.

Table 2 contains the legend of the meanings of the letters used.

Levels of improvement of maths kills		Scores/intervals					
		Classification	**Serialization**	**Conservation**	**Expression of logical judgment**	**Symbolic function**	**Of the total**
Achieved	A	7 - 8	5	6 - 7	4	5 - 6	23 - 30
Process	B	4 - 6	3 - 4	3 - 5	2 - 3	3 - 4	11 - 22
Start	C	0 - 3	0 - 2	0 - 2	0 - 1	0 - 2	0 - 10

Table 2: Legend of the results obtained in Table 1.

Tables 3-8 below summarize the test results (before and after) for each of the measured dimensions.

Levels	**Pre-test**		**Post-test**	
	n	**%**	**n**	**%**
Achieved	2	11%	19	100%
Process	16	84%	0	0%
Start	1	5%	0	0%
Total	19	100%	19	100%

Table 3: Percentage levels of improvement in the development of basic mathematical skills in students of the first grade of primary school

Levels	**Pre-test**		**Post-test**	
	n	**%**	**n**	**%**
Achieved	6	31%	18	95%
Process	10	53%	1	5%
Start	3	16%	0	0%
Total	19	100%	19	100%

Table 4: Percentage levels of improvement in the development of the mathematical ability of classification in students of the first grade of primary school.

Levels	**Pre-test**		**Post-test**	
	n	**%**	**n**	**%**
Achieved	9	48%	18	95%

Process	5	26%	1	5%
Start	5	26%	0	0%
Total	19	100%	19	100%

Table 5: Percentage levels of development of the mathematical ability of serialization in students of the first grade of primary school.

Levels	**Pre-test**		**Post-test**	
	n	**%**	**n**	**%**
Achieved	0	0%	17	89%
Process	7	37%	2	11%
Start	12	63%	0	0%
Total	19	100%	19	100%

Table 6: Percentage levels of the development of the mathematical ability of conservation in students of the first grade of elementary school.

Levels	**Pre-test**		**Post-test**	
	n	**%**	**n**	**%**
Achieved	10	53%	18	95%
Process	8	42%	1	5%
Start	1	5%	0	0%
Total	19	100%	19	100%

Table 7: Percentage levels of the development of the mathematical ability of expression of logical judgment in students of the first grade of primary school.

Levels	**Pre-test**		**Post-test**	
	n	**%**	**n**	**%**
Achieved	6	32%	18	95%
Process	4	21%	1	5%
Start	9	47%	0	0%
Total	19	100%	19	100%

Table 8: Percentage levels of the development of the mathematical ability of symbolic function in students of the first grade of primary school.

Table 9 contains the comparisons of results between the pre-test and the post-test for each dimension measured.

Dimension	**Indicators**	**Post-test**	**Pre-test**	**Difference**
Classification	$\overline{X}$	7.74	5.32	2.42
	Index of success	96.70%	66.40%	30.30%
	Level	Achieved	Process	
Serialization	$\overline{X}$	4.95	3.68	1.26
	Index of success	98.90%	73.70%	25.30%
	Level	Achieved	Process	
Conservation	$\overline{X}$	6.58	2.53	4.05
	Index of success	94.00%	36.10%	57.90%

	Level	Achieved	Process	
Expression of logical judgment	$\overline{X}$	3.95	3.21	0.74
	Index of success	98.70%	80.30%	18.40%
	Level	Achieved	Achieved	
Symbolic function	$\overline{X}$	5.79	3.05	2.74
	Index of success	96.50%	50.90%	
	Level	Achieved	Process	
Levels of development of basic mathematical skills	$\overline{X}$	29	17.79	11.21
	Index of success	96.70%	59.30%	37.40%
	Level	Achieved	Process	

Table 9: Percentage averages of improvement in the development of basic mathematical skills in students of the first grade of elementary school.

Finally, Table 10 contains the results of applying the t-Student test, to compare the results of the pre-test and the post-test for determining if the improvement is significant.

Difference of means	Standard Deviation.	Typical deviation of means	Tc	df	p-value
11.21	4.09	0.93	11.947	18	0.0000

Table 10: Result of applying the t-Student test between the pre-test and the post-test.

As can be seen from Table 10, the improvement is significant, due to $p<0.05$.

4. CONCLUSION

This paper was dedicated to exposing the results of studying the application of serious games with augmented reality in a group of 19 primary school children from the "Jesús Nazareno" school in Peru in the 2020 school year. For this, 6 dimensions were studied that were measured with their corresponding tests, before and after including the serious game method with augmented reality. The specialists who conducted the evaluation were asked that in case of doubts about a student's grade they could include grades in the form of intervals, so that there would be more accuracy at the cost of having more imprecision. This led us to process the data with the neutrosophic statistics. After using a t-Student test, it could be seen that there was improvement and this is significant. That is why this result suggests extending the method to other groups of primary school children in the country.

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