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THE SUBSTANCIAL RELEVANCE OF THE THEORY OF REGISTERS OF SEMIOTIC REPRESENTATION IN THE MATHEMATICAL LEARNING OF THE RATIONAL NUMBERS IN THE VISION OF RAYMUNDO DUVAL

Jaildo Assis da Silva
Doctoral candidate in Educational Sciences at the Columbia University of Paraguay. Master in Science of Education and Multidisciplinary at Universidade Gama Filho, Rio de Janeiro. Specialization in SPECIALIZATION IN MATHEMATICS TEACHING. Federal Rural University of Pernambuco, UFRPE, Recife, Brazil. Graduation in Full Degree in Mathematics at the Higher Education Foundation of Olinda (FUNESO)

Marcia Cristina Lustosa
Doctoral student in Educational Sciences at the Columbia University of Paraguay. Master in Educational Sciences from the Lusófona University of Porto-Portugal, Professional Education Analyst and Psychopedagogue at IFPE

Abstract: This study aims to analyze how semiotic representations can efficiently contribute to the learning of rational numbers in a clear and accessible way, enabling a gain in the cognitive functioning of students in accessing rational numbers, in terms of coordination and production in interpretation of the quality of knowledge, applying algebraic and geometric problem solving mechanisms, improving understanding. As a methodological procedure, a field research was adopted, where 32 students from two classes of Elementary School, of both sexes, belonging to two State Schools in the State of Pernambuco were interviewed. It was evident in this study that the elements introduced to reduce the difficulties in relation to the rational ones were of great significance in teaching and learning, especially from the point of view of the evolution between the first and second tests proposed to the students. It was possible to evaluate the practice in the comparison of results in relation to the difficulties that we seek to minimize.
Keywords: Rational Numbers. methodologies. Evaluation. Results.

INTRODUCTION

Mathematics is an indispensable science for both the creation and the development of new technologies, because through evidence we can make comparisons and basic findings that can help to contribute to the advancement of knowledge, especially in almost everything that is around us has records. mathematicians.

The understanding and the difficulties that are often insurmountable, have left students unable to think or reason assertively and clearly regarding the understanding of rational numbers, and in other fields of mathematics, which is nothing more than the representation of one or more parts of something that was **divided into equal parts** (fraction),which are worrying issues in teaching, as there is a need to prepare increasingly capable students to face an environment where information technology and technological technical services are increasingly complex nowadays. The goal of mathematics in the initial series is not to form great mathematicians, nor to provide instruments that will only be useful to them in the future, it must contribute to the development in general, encouraging the ability to reason, analysis and visualization, making the cognitive.

From the perspective of DUVAL (1993), an analysis of mathematical knowledge is, essentially, an analysis of the production system of semiotic representations, because any search for the acquisition of knowledge is necessary to resort to the notion of a representation, when representing a number. rational, a valuable artifice is used, both to define the meaning with the help of the drawing, representing the figure, and in the representation of the symbol - numeral, in order to identify how many parts the whole was divided, because when the divided parts are not equal, there is no is considered a fraction. For it has proved to be an important research tool in the study of the complexity of mathematical learning. Where he even deals with which cognitive systems, systems that in 1937, in the work Birth in the child's intelligence, Piaget resorts to the notion of representation as "evocation of absent objects" to characterize the novelty of the last stage of Piaget's sensory-motor intelligence (193, p.305-306 apud DUVAL 2009, p.30). In fact, we can say that the Piagetian theory of the development of artificial intelligence revolves around the opposition between the plan of action and that of representation.

According to Peirce, the precursor of semiotics; semiotics is the study of the relations of signs, the logic of signs. Peirce defines: "a sign is something that represents something to someone". (PEIRCE 2003, p. 46).

For Saussure, objects are real (physical) rather than dynamic (physical) and immediate (non-physical) objects as Peirce defines.

For DUVAL1 (2009) what really matters are the transformations of representations, since the essential function of signs and representations in mathematics is not communication nor the evocation of absent objects, according to PEAGET (1937) but the treatment of information and the transformations from one representation to another, which produce new information, that is, new knowledge and in this perspective of cognition that treats mathematics according to the register theory of semiotic representation.

JUSTIFICATION

The research assumes that to minimize or resolve student learning in activities involving rational numbers, it is necessary to create effective interventions that can overcome difficulties in dealing with learning with rational numbers, since students have difficulties in represent a fraction, sometimes as a drawing or symbol, they cannot even identify the equivalence between fractions, as well as they do not have the ability to perform the basic operations, regarding addition, subtraction, multiplication and division.

The concept above all is not well assimilated or built by the student, thus bringing disorders to the development of learning, thus blocking the student and preventing the evolution to new knowledge, given that the understanding of rational numbers opens doors to new understandings in mathematics and in the even larger universe.

It is important to justify that when we get frustrated when we cannot understand a certain knowledge, or a simple representation of an object, we fragment our capacity, leaving disorders and sequelae that can last for a long time.

It is through the conversion of the various representations manifested about an object of study that the construction of knowledge is made possible. In fact, the possibility of changing the register is a necessary condition for the teaching-learning process, as there is a cost in the path taken to understand the different representations of the same object.

GOALS

GENERAL GOAL

To analyze how and how semiotic representations can efficiently contribute to the learning of rational numbers in a clear and accessible way, enabling a gain in the cognitive functioning of students in accessing rational numbers, in terms of coordination and production in the interpretation of the quality of knowledge, applying algebraic and geometric problem solving mechanisms improving understanding, thus intending to successfully contribute to the teaching of mathematics in the State of Pernambuco.

SPECIFIC GOALS

- Identify the different representations of rational numbers, developed by elementary school students, around the theory of semiotic representation registers, using mechanisms of algebraic and geometric interpretation that simultaneously mobilize at least two representation registers of the mathematical object.
- Verify through practical actions with the help of diversification of records the change of record, so as not to confuse the student; because a treatment is a transformation that takes place within the same record.
- Find out how the student articulates the different registers of semiotic representation, leaving no conflicts in

the understanding of the mathematical object.

- To detect the extent to which teacher mediation contributes to the understanding of representations of rational numbers, using the language of semiotic representations with elementary school students in Pernambuco.

METHODOLOGICAL FRAMEWORK

Research through the theory of semiotic representations by Raymundo Duval (2009), the contributions of (Piaget,1968b, p.6-7,70,292-293) "which very closely associated the birth of representation to the development of the semiotic function, I was careful to emphasize that natural language was not the only semiotic system corresponding to the phenomenon of the diversification of registers of semiotic representation". Also the contributions of Peirce and Saussure in an approach to signs in the semiotic representation system.

The study will explore the importance and the way of representing the rational number, so that the subject can have access to knowledge, in the different representation registers and can coordinate at least two representation registers within the register itself and the conversion that is the transforming one record into another. This way, it is believed that it minimizes the problems of understanding rational numbers, constituting a condition of access to more significant learning in mathematics.

In order to qualitatively explore the association between the numerical representations of rationals and decimals, two elementary school classes were chosen, in which a questionnaire was applied, at first, with 32 to 35 students, located in Jaboatão dos Guararapes and Paulista, Pernambuco, involved in the research, with the goal of identifying the intervening variables, such as: the level of knowledge about the rational ones, if you like mathematics, class members, form of entry into school, age, gender and if you are repeating.

The identification of these variables had as goal the analysis of their interference in the results of the tests that were applied to the students of the two groups involved in the research, before and after the classes with character of reinforcement in the pre-established days.

The first test applied, before approaching the content to be analyzed in the research, the association between the numerical representations of rationals and decimals, consists of five goal questions, these questions were elaborated considering that this content is part of the program of the 6 year of Elementary School.

After the application of the first test, the classes were developed. The first class, 01, located in the municipality of Jaboatão PE, starts the application of the content in parallel with class 02 located in the Municipality of Paulista PE. Initially, the fraction ruler was introduced, a tool used to break the expectation and anxiety of how we would start the class. The tool helps to understand the parts of a whole. From there, the content on the rational itself is developed. During the classes we try to show symbols, figures and practical exercises. The assessment was aimed at enabling figural and symbolic language, aiming to seek a lower cognitive cost in performing the task, with a view to expanding the field of vision.

According to Duval (2004), the existence, in this activity, of the figural register and the fractional register of the rational number suggests to the student the use of a register change that provides a lower cognitive cost in performing the requested items. Furthermore, the use of the two registers makes it possible to work with two reference systems that have specific internal rules, expanding the field of learning of the mathematical object.

DISCUSSION

There are several attempts to find alternatives to detect the learning problem of rationals. In the search for an alternative work, but with the use of instruments, which are already common in our environment, and in most students; such as the fractional ruler, the fractional disc, the abacus, the tangram, the golden Chinese game, in short, there is a wide range of materials that must be transformed into necessary tools and are developed through creativity and that enable good work. Most students have great difficulties in learning fractions; they often fail to recognize whether 1/3 is greater or less than 1/4. Fractions involve several ideas and all must be worked on well in the classroom.

Some students acquire incomplete notions, being able to even learn how to add or divide fractions, but mechanically, without a true understanding of what they are doing. So you end up making mistakes, for example: 5/3 + 1/4 = 6/7. Faced with situations like these, the master must reinforce the first basic ideas that gave rise to fractions.

The following figures demonstrate that when pieces of cardboard of equal sizes are inserted in the class, the student is asked to fold the pieces in order to divide them into 2 or 4 or 8 equal parts.

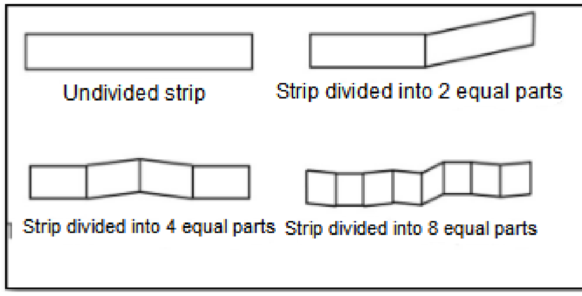

Figure 1 - Fractional ruler

Source – the author.

After finishing with the pieces, that is, the discovery of the half, then the half of the half; the student is encouraged to try to discover the others and so on. Then the fractional ruler is presented, the same composed of whole parts and countless pieces that gradually form the whole.

This way, the memorization of definitions and rules is avoided, without understanding, then it is possible to visualize the representation of the object. Let's check an example of the insertion of the fractional ruler and its importance during the execution of the classes, let's see:

1															
½								1/2							
¼				¼				1/4				1/4			
1/8		1/8		1/8		1/8		1/8		1/8		1/8		1/8	
1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16

Table 3 - Example of a fractional ruler.

Source – The author.

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After presenting the fractional ruler, the student is instructed to paint each part. With a different color, cut out the parts of one of the leaves. The use is quite simple, you are asked to check how many means are needed to have an integer; how many rooms do we need to have a medium; how many sixteenths does it take to get an eighth. Secondly, they are asked to add ½ plus 2/4, for example, and present the result. For this, use the sheet with the entire fractional ruler and the cut parts. As such, students are likely to conclude that ½ plus 2/4 is an integer and that it takes 2/4 to get ½.

This way, the student begins an understanding between the fractional numerical form and the symbolic register; a distinction is made between the role of conversion from a mathematical point of view and from a cognitive point of view. From a mathematical point of view, the conversion consists only of the change to the more economical register, it does not play an intrinsic role in the mathematical justification or proof processes.

Being treated as a side activity; however, from a cognitive point of view, it is conversion, as it has a fundamental role. It is what leads to underlying operations of understanding, which they want so much that it advances every day, aiming at a student who has the power to produce concepts, create possibilities to solve problem situations, in short, be able to produce in a general way.

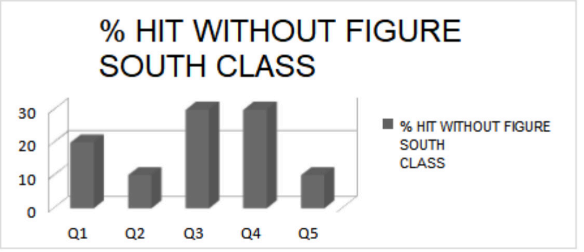
It is through the transmitted meaning that reflections on the actions developed by the teacher are given, which will possibly enable advances in the construction of knowledge and in the elaboration of concepts. It can be seen that from the contributions offered through the fractional ruler there was an evident degree of satisfaction, which can be seen by the interaction between the other colleagues. Then, the room is stimulated in general and the progress achieved is discussed.

After this explanation of the fractional strips and the ruler, some practical problems of the daily reality of these subjects were proposed, aiming to perceive the transformations through the representation records; now investigating whether a greater understanding is really established, when the student is offered another type of object to be worked on in different classes.

This way, the first challenge was initially proposed without the use of figures and with few symbols, initially evaluating how many can develop without the aid of a representation. These tests were designed and presented to elementary school students, in two ways, the first one does not contain much information, but it has the necessary to develop a calculation and reach a certain result. The second problem presents itself with the same context, but contains data from figures, thus facilitating the transit between the representation records, seeking a better understanding of the object of study.

Allowing the subjects to understand and interpret the information displayed in the figures and this way the students will possibly transit at least in at least two registers of semiotic representation according to Duval (2003), that is, this would occur when the student is able to identify a representation record of the studied mathematical object.

Thus, the first test has 05 (five) questions, as already mentioned and investigates what percentage of subjects in the universe of 10 students in a class composed of 32; how many have the ability to develop and present results moving through at least two registers of semiotic representation.



Graph 1 - % of correct answers without figure South class.

Source – The author.

After the application of these tests, there was a lot of discussion and endless questions, most asked as it usually happens; teacher! Will I harm myself if I don't do well? The results were not very expressive, but will be indicated later in the data analysis. It was evident that the approach, where only writing appears with greater rigor, naturally shows a low level of understanding, in view of the difficulty in reading interpretation.

First, understanding becomes difficult if we do not distinguish the represented object, this Duval makes clear in his contributions to mathematics, because when represented, they tend to undo any misunderstanding, not leaving the subject confused.

The new proposal this time aims to represent the objects described above in rich detail, seeking to establish a more real approximation to the understanding of the investigated subjects. Problems are now illustrated providing a greater level of understanding, in order to present more representation records.

Comments and analysis of the test results of the second class in the North Zone.

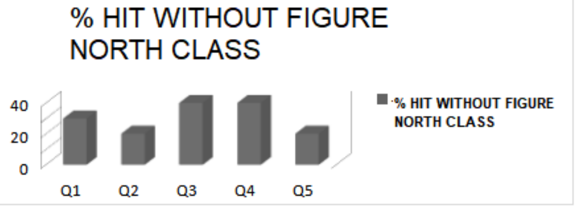
1- 30% of students were able to successfully solve the first problem without assistance, including doodling some figures to get the result.

2- In this second exercise, 20% developed correctly reaching the result.

3 – 40% of the students reached the results that were reasonable, much more significant than the previous ones, noting that in the request of the problem, the understanding was better accepted.

4- In this problem, 40% of the students were kept with positive results, because even the exercise maintained a certain similarity with the previous one, perhaps not requiring much interpretation effort.

5- Only 20% of the students were able to solve this exercise successfully, although the exercise requires similar attention to the first one, but it can be justified or not due to lack of attention.



Graph 2 - % of correct answers without figure North class.

Source – The car.

This second test has well-illustrated figures with a wealth of details, seeking to facilitate the understanding of the same subjects who participated in the first, thus investigating whether in this second condition the results are more expressive, in addition to clarifying the idea of the object studied; because fractions always appear as a stigma, when in the moment of breaking, dividing, adding smaller parts, difficulties always appear.

<u>Second test:</u>

1 - The length of a board is 20 m. How big is 3/5 of this board?

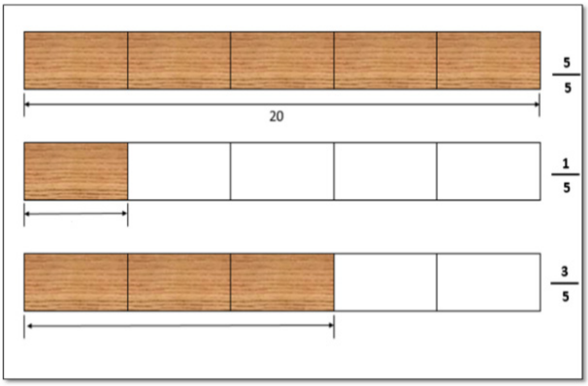


Figure 3 – length of a board.

Source – The author.

In this other problem presentation model, the level of acceptance and understanding caused a very positive impact from the beginning, as the figure naturally brings greater security at the level of transformation in the representation of the object. And so the other four problems followed the same pattern.

Comments on the application of the second South class test:

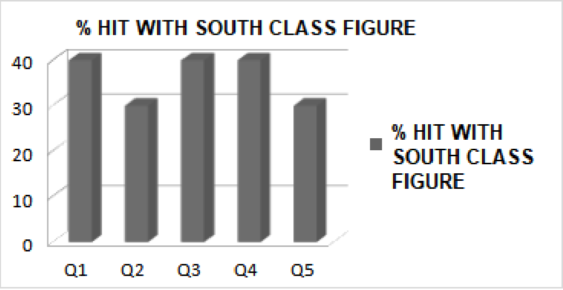
1- In this new format of elaborating the same test, but with more information and richness of details, because another language than figural, the student does not need to mentally request the figure, because it already presents itself facilitating the reasoning, this way way 40% of the students solved the problem.

2- The second problem, even with the help of figurative language, only 30% of the subjects were able to successfully solve the problem and reach the correct solution, as this problem still presents itself initially with the fractional part requiring greater attention from the student.

3 - In this third challenge, only 40% of the students were able to successfully solve the problem, as the presentation of the exercise helps in solving it with more practicality, requiring reasoning, but with more simplicity.

4 – The fourth challenge 40% of the students successfully solved, considering the degree of difficulty is similar to the previous exercise.

5 – Only 30% of the subjects successfully solved this exercise, as it requires a little more attention, since it starts the question with the fractional part, thus requiring a greater mental effort to reason.



Graph 3 - percentage of correct answers with the figure of the southern class.

Source – The author.

Comments and analysis of the second test in relation to the North Zone class.

1- In this first problem, 90% of the students were able to solve it successfully, reaching a satisfactory result, including using the figure very properly, showing how the form of representation can facilitate the understanding of an object, leading the subject to a higher level of understanding. degree of relevance;

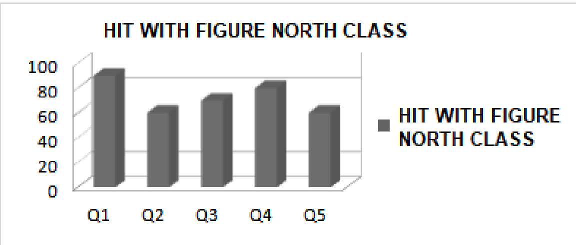
2- The second exercise 60% of the students reached the goal, reaching a satisfactory result; however it is clear that the form of presentation in the exercise request required a greater degree of difficulty;

3 - In this third test, the students got 70% of the questions correct, always signaling in the figures, something that demonstrates the use of the second representation record, as a facilitating factor in understanding the question;

4 - 80% of the students got the problems right, a very significant amount of correct

answers, demonstrating a good level of attention;

5 - 60% of the students managed to get the exercises right, even resembling the first exercise requested, as the exercise requires a degree of difficulty very similar to the first one.



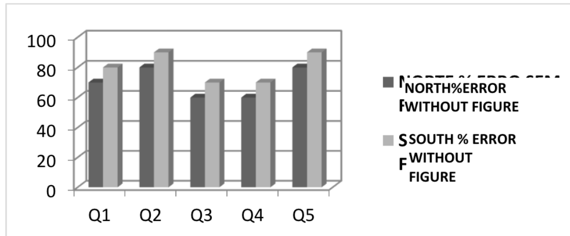
Graph 4 - % of correct answers with the figure of the northern class.

Source – The Author.

After the results obtained in the second test with a greater representation in the formation of the problems, including with the help of the figures, offering details that certainly allowed a greater understanding. These tests raised the students' self-esteem, as the results had previously made the boys very worried, including using questions like, hey! I don't think I can learn this subject. It was clear that the northern group received more information, demonstrating in the results even a greater concentration, where the results are much more significant than the first group.

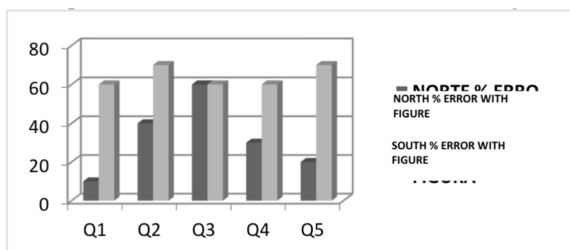
In the indications of the graph analyzing the two north and south classes respectively, it is observed that the north class presents more expressive results than the south class; these analyzes in more detailed conversation with the form of conduct in relation to rational numbers during classes, have some particularities.

The north class is more assiduous than the south class, in addition to having a greater power of concentration during the development of the contents, as well as in the resolution there are traces dividing figures in the search for a better interpretation of the proposed problem. It is worth noting that the North group clearly demonstrated the search for the figure in solving the issue, thus showing that there was a conversion of records, so there was transit in more than one representation record. Not saying that the southern group did not show, as the change also occurred, but in a more modest way.



Graph 5 - % error north class x south class.

Source – The author.



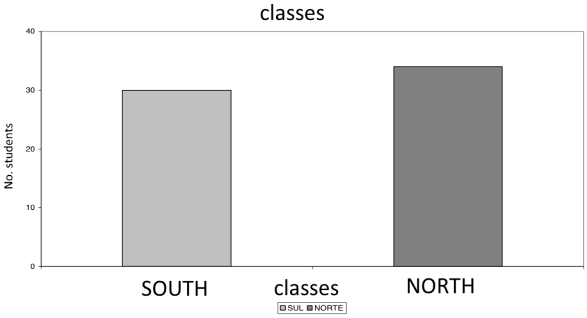
Graph 6 - % error north class x south class with figure.

Source – The author.

The object of study of mathematics is only accessible through its representation, so the more varied the ways of representing it, the greater the possibilities of understanding it. Duval also complements this idea by stating that the diversification of representations of the same object expands the subjects' cognitive capacities as well as their mental representations. The development of the latter "takes place as an internalization of semiotic representations in the same way that mental images are an internalization of perceptions". (DUVAL, 2009, p.17).

DATA FINDINGS

In this work, the data collected during the research are examined, so that at a later date, a comparison of the data can be elaborated, where possibly there will be a new application of the tests. It is important to point out that almost always the student is only offered or presented a single treatment, and those who actually manage to learn are rare.



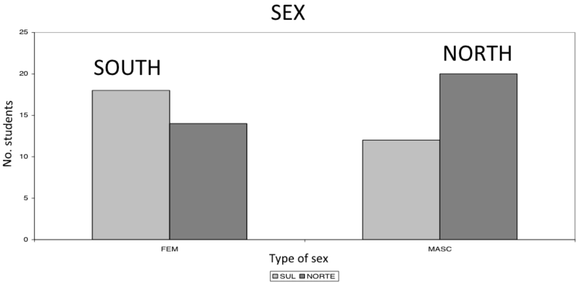
Graph 7 - comparisons of students and class.

Source – The author.

Graph 7 initially refers to the classes that were divided by regions, one located in the northern region and another in the southern region. The locations are very different, with approximately a distance of 32 km between each other. From then on, it was divided into two classes, totaling a universe of 67 students, but the south class has a total of 32 students while the north class has 35 students.

From now on, graphically according to the legend, the north class will be identified as black and the south class as gray. The North and South classes have approximately 30 to 32 students each, but they were previously selected, as there was a need to develop classes on Saturdays, which made it impossible for some to attend, as they help the family with their work; even on weekends.

Where the issue in relation to sex is addressed, it is observed that there is a greater number of females in the southern class, the girls are 18 in their entirety and the boys are 12; while the North group, the boys add up to 20, but the girls have a total of 14.

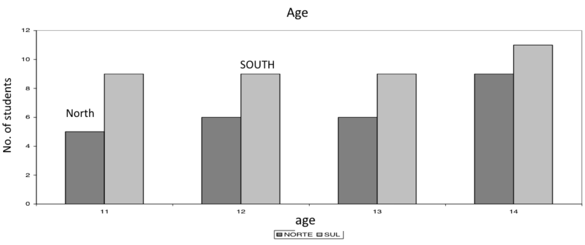


Graph 8 - comparison graph of students and sex.

Source – The author.

In the age modality, there is no doubt that it is a highly relevant and fundamental variable in knowledge analysis, considering that the mental age for certain content can undoubtedly interfere with learning.

A greater number of more mature students were observed in the south class, but younger in the north class. At the end of the evaluations, we will record the degree of interference caused by this factor in relation to age, in order to have a relevant character in the result of the teaching-learning process.

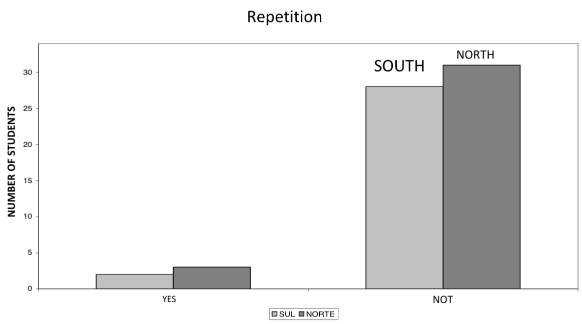


Graph 9 - Comparison of student numbers and age.

Source - The author.

In graph 9, data are collected regarding the taste for mathematics, where normally, when the topic deals with this science, there is a great expectation in the way students react. During the study, it is noticed that the students use stigmas, heard almost always by the teacher, such as "I hate mathematics", "I don't know mathematics", etc.

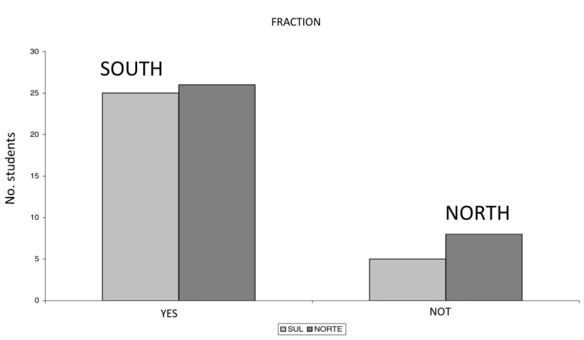
Therefore, the need to improve tools to change this behavior, where, later on, we will have the opportunity to observe the positive or negative inference and the efficiency of the mechanisms applied during the study.



Graph 10 - Comparison: Number of students and taste for the subject.

Source - The author.

It is observed that almost all the girls and boys involved in the research have difficulties in mathematics. This is a relevant reason for us to try to minimize the difficulties in understanding, thus reducing this fear, taboo or even lack of adequate and more consistent information to modify the current configuration and thus provide a teaching-learning process with a high degree of satisfaction.

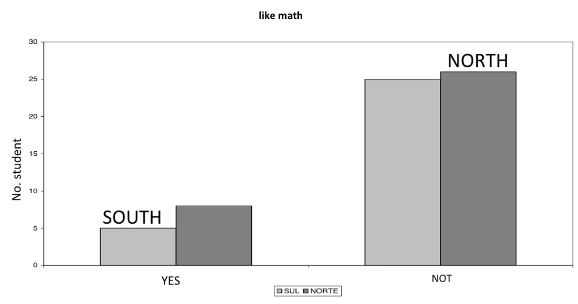


Graph 11 - Comparison between student numbers and fractions.

Source - The author.

Graph 11 refers to the development of activities involving the content of fractions. Where it is clearly perceived that most students experienced the content, however, it is necessary to assess what level of knowledge was acquired and in what way there was a positive contribution. Therefore, at the conclusion of the study, we will possibly arrive at the data gradually, thus assessing whether or not interference is appropriate.

Graph 12 deals with data verification in relation to the level of repetition. Where evidently it is easy to verify that there were almost none, and the number of repetitions comparing one class and another is practically the same.



Graph 12 - Comparison of the number of students and repetition rate.

Source - The author.

After the collection and analysis of the results, it became possible to draw a profile of the two groups involved in the process, it is noted that there were no factors of great relevance that could possibly interfere in the development of activities. Then, it will present a data meeting establishing the total of hits and errors.

DATA CHARACTERISTICS

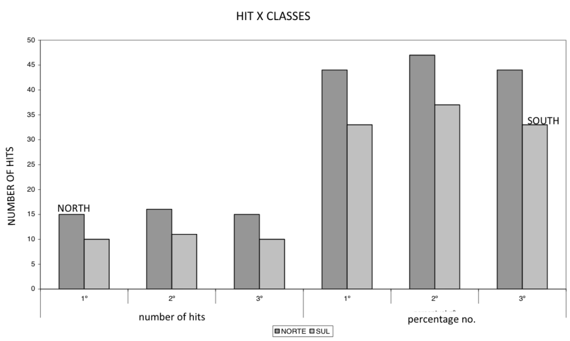
Firstly, a questionnaire was applied, where it consists of an approach referring to the characteristics of the students, as well as: age, class, sex, if you like mathematics, finally, the degree of repetition in the universe of the two classes is verified.

Next, a Fraction Representation Test is presented, (where it is composed of 03 (three) questions. In question number 01 (one), a figure is presented, which refers to a rectangle; students, what information can be transferred to the notebook with the help of the figure.

At this moment, we try to observe the understanding between the language between the figure and the symbol; then there are 03 (three) questions referenced by the letters a b and c. Where in letter a, we seek to investigate through the exploration of the figure how many equal parts the rectangle was divided, aiming at the visualization through the figure.

In alternative b, in relation to the previous question, we ask: What fraction of the rectangle does each part represent? And finally, in the last question referring to letter c, the question is asked about the painted part, which represents what fraction of the rectangle. After this moment, a critical analysis is carried out in order to verify the level of previous knowledge about the rationals.

Graph 13 shows the correct answers by north and south classes, with a higher rate being observed in relation to the north class; a favorable percentage of around 11% stands out, a very considerable factor.

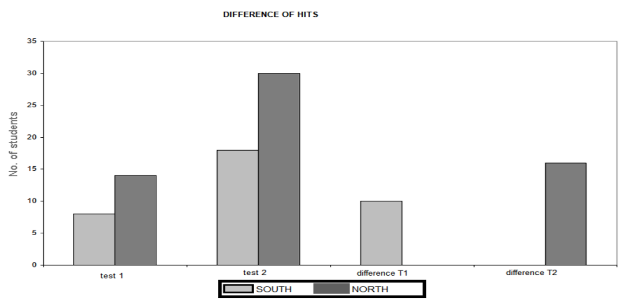


Graph 13 - Comparison of correct answers by class.

Source – The author.

ANALYSIS OF THE CORRECT ANSWERS OF THE QUESTIONS BY CLASSES

At this point, the results of the evaluations and their characteristics of the data after the 2nd application are presented. The test was replicated, and some additional information provided information that deals with the content of fractions that are offered with the goal of dynamizing the stimulus of the students, in view of the approach of the end of the works. The graphs where they will effectively demonstrate the differences in relation to the finding of data, will from then on be called T1, T2 and DT1 and DT2. The first sample after the second application is now shown in relation to the first.

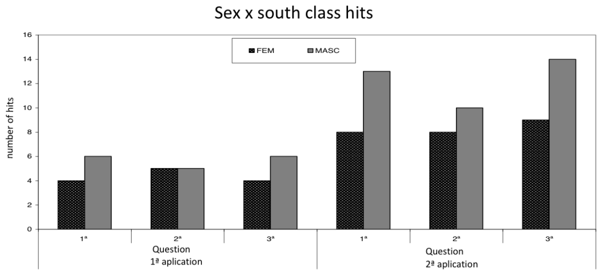


Graph 14 - Difference in hits.

Source - The author.

When analyzing this variable in relation to the first test and the second, it becomes clear, through this sample, that after the reinforcement of information and the effort in relation to the reinforcement classes. There was a very relevant performance, particularly in this sample, where it can be seen that the northern group developed more than the southern group. The development of skills and, consequently, greater responsibility of the participant for learning, requires practice, reflection, study and continuous improvement. It is not possible to achieve it all at once, the degree of learning is variable in relation to each individual, but it was clear in this sample that the effort gradually made a difference.

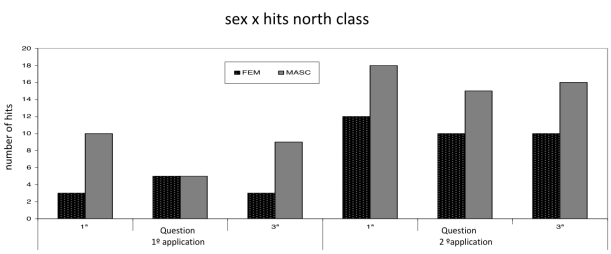
The following graph refers to the difference between the number of correct answers in relation to age between the first application of the test in relation to the second in the group identified as southern.



Graph 15 - South class x sex hits.

Source - The author.

In this variable, it can be clearly seen that there was a significant advance in relation to age, as the most adult students between 13 and 14 years old in the second evaluation undoubtedly had a better performance. When analyzing the following graph, a higher performance of the North class is visible in relation to the more mature students, obtaining a higher rate of correct answers.



Graph 16 - Analysis of correct answers x gender.

Source - The author.

After the analysis of these data referring to the applications of the tests, it was evident that the north class showed a slightly better performance compared to the south class. However, both classes evolved considerably in the second application. It is believed that it was possible to perceive in the analyses, according to the mediation of the teachers and the results presented, that the treatment rules and conventions of different semiotic representations of rational numbers contributed to minimize the students' difficulties in understanding the mathematical concepts of rational numbers.

FINAL CONSIDERATIONS

From this study, it was possible to perceive that new questions emerged for future investigations, since it is not enough just to know the different forms of semiotic representations of rational numbers, above all it is important to evidence equivalence relations between them, so that there is a coordination between the representation records of the numbers. rational. Thus, subjects can develop several transformations within a register or between different registers, so as not to confuse the mathematical object, thus arriving at the actual understanding.

It is hoped that this study will not end now. But that countless people can propagate knowledge and realize that the records of semiotic representations are important for knowledge, not only in mathematics, but in several areas of knowledge.

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