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STRENGTHENING MATHEMATICAL REPRESENTATION AND COMMUNICATION CAPACITY THROUGH THE USE OF SEMIOTICS REPRESENTATION REGISTERS

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Abstract: The objective of this research was to improve the communication skills and mathematical representation of the students of the Calculus I subject of the Professional School of Mathematics of the Faculty of Sciences of the National University of Piura (UNP) using a didactic proposal based on in Raymond Duval's theory of semiotic registers and composed of a set of problems on derivatives. The focus of the research was quantitative and as a result it was obtained that the use of several semiotic registers improved the capacity of representation and communication of mathematical ideas, contributing to enhance problem solving. During the investigation, it was observed that the students presented difficulties in converting records. In addition, personal and collective attitudes related to the ability to solve problems were strengthened.
Keywords: Record of graphic, symbolic, verbal representation, ability, problem solving.

INTRODUCTION

A frequent didactic phenomenon in the teaching of the first cycles of the UNP in the area of mathematics is the high number of failed students in Calculus I. The reasons may be many, but we consider for this research the difficulties of the students regarding to the mathematical representation and communication capacity based on the management of register treatment and conversion operations that did not allow them to successfully tackle the resolution of problems on derivatives.

For Duval (2017) "A record is a sign in the broadest sense of the word: strokes, icons, symbols, etc." In addition, he states that "Semiosis is the apprehension or production of a semiotic representation and noesis is the cognitive act such as the conceptual apprehension of an object, the discrimination of a difference or the understanding of an inference." Therefore, in the process of learning mathematics, there is no noetics without semiotics. These signs can represent mathematical objects and constitute representation systems according to their properties and characteristics. In addition, they comply with a series of rules and conventions typical of mathematics. A semiotic system must satisfy three cognitive activities, the first is to be a set of marks recognized as a representation of an object, the second is that the representations can be transformed within the system allowing an increase in knowledge and the third is that these representations can be turn others into other systems making it possible to visualize other characteristics or signifiers. (Duval, 2017; Rico and Moreno, 2016).

To represent a record D'amore (2015) provides the following symbolism:

$$r^m = m - th\ representation\ register\ (m = 1,2,3,\dots)$$
$$R_i^m(A) = ith\ semiotic\ representation\ (i = 1,2,3,\dots)$$
$$of\ an\ object\ A\ in\ the\ semiotic\ register: r^m$$

Then, given an object A to represent, the distinctive characteristics of it and the semiotic representation are chosen: $R_i^m(A)$ in the proxy register: r^m. With this representation $R_i^m(A)$ *transformations can be made by generating new representation: (i≠j)* $R_j^m(A)$ of object A. This operation is known as Treatment. Finally, the rendering: $R_j^m(A)$ can be transformed to a representation: $R_h^n(A)$ in a new render record: $r^n (n \neq m)$ *besides* $(m,n,i,j,h=1,2,3,\dots)$. This operation is called conversion.

The problems of the proposal were selected from various bibliographic sources referring to the topic of derivatives, taking into consideration the results of the investigations of Planchart (2005), Gutiérrez and Parada (2007), Rojas (2014) and Ospina (2012) that reflected, by students, difficulties in converting from graphical to algebraic register when working with functions, difficulties in associating different meanings to given expressions, tendency to anchor in specific situations, basically iconic view of algebraic expressions, low use of register verbal by students in tasks associated with the description of procedures associated with the application of mathematical content and the use of registers only when they feel the need to expand the information to respond. The problems were presented in the verbal register but their resolution promoted the mobilization of the verbal, algebraic and graphic registers. In addition, the four-phase proposal of Polya (1965) was applied, considering that during the application of the strategy the phases can be repeated over and over again, making the resolution process somewhat cyclical (Gomez and Puig, 2014).

The research corresponds to the quantitative approach with a quasi-experimental design (Hernández, Fernández & Baptista, 2010). The method used is longitudinal correlational (Valderrama, 2015). The observation technique was used and pre-test and post-test tests duly validated by expert judgment were used as instruments, as well as checklists and rubrics.

DEVELOPMENT

The application of the proposal lasted half an academic semester with spaces of five hours per week. Various strategies were developed, such as lectures, group work dynamics, and presentations in order to promote constant, active participation in students, as well as the development of skills such as analysis, synthesis, and evaluation of problem solving.

Next, a problem of the proposal is presented and the way in which it was analyzed in the investigation is explained:

Mr. Pérez's house is surrounded by a fence 1.5 meters high, and he wishes to place a ladder from the street that leans against the wall of his house and that barely "frees" the fence, as shown in the figure. If the fence is placed at a distance of 4 meters from the wall of the house, what must be the minimum length of the ladder to achieve its purpose, and at what distance from the fence must a base be built so that the ladder does not slip? ? (Ramirez et al., 2007, p.13)

The problem is presented using a verbal register: r^1, students are asked to make a geometric representation to visualize mathematical properties, clarify ideas and discuss them. The length of the ladder is recognized as the mathematical object to be studied. Thus the first representation of the object is in the verbal register. $R_1^{\ 1}$: ladder length. Here is a conversion from verbal to algebraic register: r^2 obtaining: $R_2^{\ 1}$: $L=AC+CF$.

Applying treatment operations, other forms of representation are obtained, such as: $R_2^1\colon L(x) = \frac{1.5}{sen(x)} + \frac{4}{Cos(x)}$ o $R_3^1\colon L(x) = 1.5Cosec(x)$ $+4Sec(x)$. Conversion to chart logging is conveniente: r^3, to determine characteristics of this function that at first glance could not be determined how to know if it has a maximum or minimum, or what values the variable x can take. For this purpose, the free software Geogebra is used. After having explored the graphic aspects of the function, we return to work with the algebraic register to apply the criterion of the first derivative and determine the minimum value of x.

All the problems of the proposal were worked in a similar way to the one exposed, mobilizing the largest amount of representation register in order to promote a better mathematical communication.

Three specific hypotheses were raised in the investigation. The first indicated that before the application of the proposal, the students had grades lower than 13. When processing the results of the pre-test, a mean of $\mu\_1=8.86$, a median $M\_e=10$ and a mode $M\_o=11$ were obtained. In addition, a variance of $S\^2=8.6$ and a standard deviation of $S=2.933$, which indicates that the ratings are quite dispersed from the mean. Also, there is a minimum evaluation of 2 and a maximum evaluation of 12. To make the decision to reject the null hypothesis, a level of significance ∞=0.05 was considered and a value of p=0.00 was obtained with this result of p being reject the null hypothesis in favor of the alternative hypothesis. The second hypothesis stated that after the application of the proposal, the students had grades greater than 13. When processing the results of the post-test, a mean of $\mu_2=15.21$, a median of $M_e=15.82$ and a mode of $M_o= 15.8$. A variance of $S^2=2.04$ standard deviation of S=1.43 which indicates that the ratings are quite close to the mean. In addition, a minimum evaluation of 12 and a maximum evaluation is 16. To make the decision to reject the null hypothesis, a level of significance ∞=0.05 was considered and a value of p=0.00 was obtained with this result of p being reject the null hypothesis in favor of the alternative hypothesis. The third hypothesis indicated that after the application of the didactic proposal, most of the students improved their ability to solve problems, that is, the means of the pre-test and post-test are different. For this validation, the T-Student test is applied for both tests and a p value of 0.000 was obtained, being less than the level of significance of $\alpha=0.05$, rejecting the null hypothesis.

As a result, after the application of the didactic proposal, the students presented better grades and stated that they felt happier and more motivated with the activities worked on in class, minimizing the fears of the evaluation of the learning in this content of the subject. Likewise, the use of different registers allowed them to improve the level of understanding and reasoning of mathematics. The development of cognitive processes was fundamental and each student learned to recognize them when faced with a mathematical problem.

At the end of the investigation, the following conclusions were reached:

The use of the verbal register allows you to enhance your ability to present mathematical reasoning and your conclusions with clarity and precision in an appropriate way, both orally and in writing. Before and during the application of the proposal, it was evidenced that the students used this register little despite being the most common due to the constant application of the algebraic register to which they are accustomed from school.

The use of the graphic record allows organizing information, making simple estimates and generating resolution strategies. Before applying the proposal, students had difficulty recognizing the right moment in a problematic situation when they could use it. During the proposal, students learn to use this record as a tool to understand information about the problem and to interpret its results.

The use of the algebraic register allows them to handle mathematical language and being able to represent real situations through mathematical notations allowed students to gain security and confidence due to their ability to perform algebraic calculations.

REFLECTIONS

- The Proposal implemented, is being replicated at this time of Pandemic where students are receiving virtual classes. Using other strategies that can be discussed in a long second.

- This research was carried out at a time when the quantitative approach predominated, but currently this research is being developed from a quantitative approach because it allows us to apply the analysis of other instruments that are providing us with information that is closer to the reality of our students this way. We do not base the research on the analysis of a pre and post test.

• In this pandemic context we are taking advantage of many resources such as Geogebra, Mathematica, Derive and applications such as padlet, meet and jamboard, educational platforms such as Classroom, equation editors and tablets to facilitate student understanding. And the most important thing is that we continue to work with tasks that allow the mobilization of records, presenting various context problems.

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