CONCEPTIONS OF CREATIVITY MATHEMATICS: THREE CASE STUDIES WITH STUDENTS IN 3RD CYCLE OF BASIC EDUCATION

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Abstract
Mathematics creativity is difficult to define, given the diversity of meanings that appear to today. But it is crucial, whether in society or in mathematics education. Mathematical creativity today is not valued as an integral part of the classroom context and in practices teachers of teaching, possibly due to the constant changes in the Portuguese curricula. In this sense, it is necessary to promote the development of creativity as an integral part of the pedagogical practice of the teacher, and the role is fundamentally to allow students opportunities to be the use of didactic resources, such as the mathematical tasks and using technology. For this purpose, this paper investigates of possible conceptions of students of the 3rd cycle of basic education about the mathematical creativity, an investigation was in 2013/2014 and 2014/2015, with the use three years of distinct (7th, 8th and 9th years) in total of five classroom, from two public schools Portuguese of northern country.

In this investigation was used a methodology qualitative and interpretative nature, with the case study design. The data collection instrument was the questionnaire survey, filled by the participants in math class, because the investigator was the teacher of the discipline. The processing of data was based in the contend analysis of written documents relating to responses of the participants and analysis categories formulation. The results achieved indicated, that conceptions of mathematics creativity, for these participants was divergent. In cases I and II, was associated to "Class Environment" and in case study III the mathematical creativity was view an "Innovation".

Keywords: Mathematics creativity, Conceptions, Basic education (3rd cycle).

1 INTRODUCTION
Mathematical creativity is little valued in the educational context, including in the pedagogical practices of teachers, possibly due to the constant changes in Portuguese curriculum. In this sense it is necessary to develop mathematical creativity, making this an integral part of the teacher's practice, in the context of the classroom. The role of the teacher then becomes that of allowing students opportunities to be mathematically creative by providing scenarios and contexts that develop students' creativity. In order to do this, a prior knowledge of the concepts of the students is necessary, in agreement with the one reported by Moscovici [1], who affirms that it is important to know the concepts about the different themes, since they are crucial for the understanding of human behavior and for influence changes in different behaviors. Of equal ability, listening to what students think of mathematical creativity is fundamental from the perspective of several researchers (Sadeghi and Ofoghi [2], Sathier and Fleith,[3]) and Gibson, Luckman and Willoughby [4] alludes to, it is essential to listen to "the students' voice" (p. 611). For this situation to be achievable, it is important that teachers given their students a voice about conceptions of the term mathematical creativity, so that the teacher can resort to teaching strategies and methodologies that challenge the creativity of students in the teaching process and learning. The motivation that led to the realization of the present study was focused both on the concern for the success of each student in school and on the each difficulties of the teachers, mainly Mathematics, to confront the lack of motivation and enthusiasm of their students in the learning process of this discipline (Machado [5]).

Regarding the concept of the term mathematical creativity, it was not been easy to reach a consensus around its meaning, since there is no concise definition (Mann [6]).

Nevertheless, some examples of investigations in which the mathematical creativity came to have a meaning are presented. In the investigation of Pinheiro and Vale [7], mathematical creativity is seen as: "[...] creativity is closely linked to mathematics [...]", although the "teaching system does not value this field in mathematics [...] "(p.31). On the other hand for Gontijo [8] the mathematical creativity is defined as being:
"The ability to present numerous appropriate solution possibilities for a problem situations so that they focus on distinct aspects of the problem and / or differentiated ways of solving it, especially unusual forms (originality), both in situations requiring resolution and Elaboration of problems as in situations that require the classification or organization of objects and / or mathematical elements in function of their properties and attributes, either verbatim, numerically, graphically or in the form of a sequence of actions" (Gontijo [8], p.37).

In research study by Laycock [9], mathematical creativity is problem-solving ability, through a distinct point of view, the visualization of similarities and differences, the generation of multiple ideas, the selection of resolution strategies of unknown situations. The author Leikin [10] consider mathematical creativity as being a dynamic characteristic of the human being that must be developed, otherwise it will be forgotten. In addition, the same author refers that mathematical creativity is related to innovation (novelty or originality). As mentioned by Valdés [11] it is impossible in mathematics education to improve the quality of teaching without taking advantage of activities that allow the use of creativity. In Feinstein [12] investigation on the development of mathematical creativity in different contexts and with diverse participants concluded that creativity mathematical is linked to the creation of ideas and innovation. In the another investigation by Shiriki [13], teachers become to responsibility for creating opportunities, based on learning contexts that contribute of the development of mathematical creativity. This contexts may involve the use of mathematical tasks, in agreement with the said by Kaufman and Sternberg [14], of course, mathematical creativity must be diffused in the classroom. In the studies of Leikin and Pantazi [15] regarding the importance of a creative classroom environment, we highlight the selection of activities, interaction in class, and work in pairs, among others which are factors that favor the process to create.

Considering the objective assimilated in this study, it was assumed of concept of conception attributed by Thompson [16], which defines conceptions as mental structures of an individual, washing part of beliefs or any other type of knowledge of the experience, meanings, concepts, propositions, rules, mental images and preferences.

2 METHODOLOGY

The objective of this investigation was to analyze conceptions the students of the 3rd cycle of basic education on the concept of mathematical creativity. For this we used a methodology of a qualitative, interpretive and oriented for study case. A methodology of a qualitative nature it was preferred, given some of this characteristics as: the direct source of data is the natural environment, in which the investigator is the main instrument of data collection; descriptive, formed by words or images; the analysis is done in an inductive manner, not to wanting the confirmation of previously formulated hypotheses, but the search for specific characteristics in the collection data, relating them and grouping them, in order to contribute to the interpretation of the phenomenon under study (Cohen, Manion and Morrison [17]). The analysis of the data by Bogdan and Biklen [18] is done in a way that:

(...). It involves work with data, its organization, division into manipulable units, synthesis, search for patterns, discovery of important aspects and what is to be learned, and the decision about what is to be passed on to others ([18], p. 205).

The interpretive nature of the methodology was based on the perspective of Erickson [19] where the main fields of interest are nature: from the classroom as an organized means for learning; of teaching as an aspect of the learning environment, and the perspectives and meanings of the students. Similarly the case study was due to the one indicated by Stake [20], in which one intends the understanding of this particular case.

The case of this study is a multiple case composed of three case studies, Case I, Case II and Case III, of each of the three years of school, of the 3rd cycle of basic education, in which each year constitutes by itself a case. Case I was composed of a 7th year class (defined by A), Case II by two 8th year classes (defined by B and C) and Case III by two 9th year classes (defined by D and E) from two Portuguese public schools (designate by AG1 and AG2) from northern of Portugal. So the three cases are in line with the characteristics of a case study: explore, describe, explain and evaluate.

The data collection was based only on the questionnaire survey instrument, completed by the participants, in a Mathematics class, in each of the classes, during the first period, of the 2013/2014 and 2014/2015 school years. This questionnaire survey was consisted of eleven questions in which one of the questions (number eight) was open nature and oriented to this study.
The method of analysis focused on the content analysis of participants' responses (Bardin [21]) and the formulation of recursively defined categories of analysis, in view of the objective of the proposal (Sampieiri, Colado and Lucio [22]). Although the categories of analysis were not pre-defined, they were based on a framework of contextualization that signed them.

The categories of analysis are for Esteves [23] considered as: "[...] the operation through which data are classified and reduced after they have been identified as pertinent in order to reconfigure responses to the objectives of the study, becoming categories" (p.109). Then, the categories of analysis were made after having classified and reduced the number of responses and the identification of relevant words or phrases in order to reconfigure answers that could integrate the intended objective (Cohen, Manion and Morrison [17]). It should be noted that these categories of analysis were in agreement with the principles of Bardin [21]: homogeneity, completeness, exclusivity, objectivity and pertinence. The participants were 74 students, 17 from Case I, 25 from Case II (of school AG1 and school year 2013/2014) and 32 from Case III (of AG2 school and 2014/2015 school year. Case I was composed of a group of eight in female and nine male gender, whose ages ranged from 12 to 14 years (mean of 12.4 and a standard deviation of 0.57). Case II was composed of two classes, one of them with 12 participants (9 female gender and 3 male) and the other with 13 (10 female gender and 3 male), respectively, aged between 12 and 17 years (mean of 13.36 and standard deviation of 0.87). In Case III consisted of two groups, one with 17 participants (seven female and 10 male gender) and the other with 15 (six female and nine male gender), respectively, whose ages ranged from 12 to 15 years (mean 14 years and Standard deviation of 0.38).

3 RESULTS

3.1 Conceptions of Mathematical creativity

The analysis of participants' responses to question number eight (8) of the questionnaire survey: What is mathematical creativity to you? Was carried out through content analysis and then four categories of analysis (three main categories) were created: Classroom Environment, Innovation, Imagination and Others, in which the gender, age, school environment and school achievement were made. Table 2 shows the number of responses and the percentage relative frequency (in %) of each of the categories for each case.

<table>
<thead>
<tr>
<th>Analysis categories</th>
<th>Case I (7th year)</th>
<th>Case II (8th year)</th>
<th>Case III (9th year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class Environment</strong></td>
<td>9 (53%)</td>
<td>14 (56%)</td>
<td>10 (31.2%)</td>
</tr>
<tr>
<td><strong>Innovation</strong></td>
<td>6 (35%)</td>
<td>8 (32%)</td>
<td>16 (50%)</td>
</tr>
<tr>
<td><strong>Imagination</strong></td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>3 (9.4%)</td>
</tr>
<tr>
<td><strong>Others</strong></td>
<td>2 (12%)</td>
<td>3 (2%)</td>
<td>3 (9.4%)</td>
</tr>
</tbody>
</table>

Given the results obtained, it is possible to verify that the conceptions of the term mathematical creativity by the participants of this study were different. In Case I and II, the conceptions were the same, but in Case III the conception obtained was different. The participants in Case I (cycle start year) accounted 53% of Classroom Environment category, thus adding mathematical creativity to the Classroom Environment. This same conception was verified in Case II, in which 56% responded in the same way. The results obtained were quite consistent with those obtained in other research studies (Kaufman and Sternberg [14]; Shiriki [13]). In these studies it was concluded that mathematical creativity was related learning contexts including the classroom environment, which according to Laycock [9] and Gontijo [8] the proposed tasks are part of these learning contexts.

In Case III (final year of the cycle), the participants have a different conception of the concept of mathematical creativity. The Innovation category obtained 50% of the total responses compared to the other two cases, which had 35% and 32% respectively of responses. These results are supported by the research carried out by Feisntein [12], Gontijo [8] and Leikin [10], who explored the conception of the term mathematical creativity, concluding that it was related to innovation (novelty or originality). Likewise, taking into account the results achieved in the description of this category, participants in this case responded according to the creativity conception of the research of Acevedo [24], in which
(12%) of the respondents declared that creativity is Innovation. However in this investigation, 24% of the respondents answered that creativity is Imagination. As was shown, with some responses from participants, Case III, although insignificant, since 9.4% associated the creativity with the Imagination, and a percentage of zero in the other two cases. Then, for each of the three categories of analysis formulated, three representative transcripts of answers obtained by the participants are presented for each case. These responses configure in the figures, Figure 1, Figure 2, and Figure 3, and designated the participants of these responses by P 7, P 6 and P 10, respectively. In addition, the answers were selected from each of the three cases, one for each case, and seeming to be the most adequate for the proposed objective and in which, in the simple understanding, they represented implicitly and enlightening the category, in relation in their words and Relevant information.

![Image](image1.png)

Figure 1. Response given by the participant (P 7) of Case I.

In the previous figure it is mentioned that one intends a mathematics assumed to be something new and has a playful part (amusing mathematics) through the discovery.

![Image](image2.png)

Figure 2. Response given by the participant (P 6) of Case II.

In the previous figure it is mentioned the existence of a mathematics class in which it is assumed that the teacher explains way to be able to perceive Mathematics and that at the same time it is a fun class. Therefore, in both figures, it is implicit to create a classroom context with scenarios that could pass through the inclusion of tasks that provide this environment (Haylock [25]; Kaufman and Sternberg [14]; Laycock [9]), including resolution of problems (Gontijo [8]). Analogous studies by Leikin and Pantazi [15] insinuate the classroom environment as a proportioned of the development of mathematical creativity, being necessary to select appropriate tasks and a dynamic classroom environment.

![Image](image3.png)

Figure 3. Response given by the participant (P 10) of Case III

In the latter it is observed that innovation is essential in learning, as well as originality, which are different ways for the student to learn. This conception of mathematical creativity is firm with the results obtained in the investigations of (Feinstein [12] and Leikin [10]).

4 CONCLUSIONS

The results obtained in this study were generally divergent since the participants in Cases I and II (7th and 8th years of school) associated the term mathematical creativity with the Classroom environment, consistent with what verified in the investigations of (Kaufman and Sternberg [14]). In Case III (9th year of school) the participants presented another conception of the term of mathematical creativity, being view as Innovation, confirming the results of the investigations of (Acevedo [24]).

As main contributions of the present study, it is worth highlighting the development of studies related to the conceptions of the term mathematical creativity of students of the 3rd cycle of basic education.
and he sharing of investigation experiences in this thematic area, important for the contribution the number of studies reported on student conceptions the meaning of mathematical creativity.

As a future recommendation, it is worth enhance the need to carry out further investigation studies in this area, in order to understand if other participants of the same school years of the participants of the present study have the same conceptions or not and if there are differences significant. As in two of the three cases, participants considered mathematical creativity dependent on the Classroom environment, it is pertinent to reflect on the teaching practices of teachers (Lin [26]). Thus, it is intended, as future recommendation, a reflection around of environment (classroom environment) conducive to the development of students' mathematical creativity, motivate in these the creation of their own solutions in the presentation for different challenges (Nadjafikhah, Yaftian, and Bakhshalizadeh [27]).

REFERENCES


[19] F. Erickson, “Qualitative methods in research on teaching,” in M. C. Wittrock (Eds.), Handbook of research on teaching, pp. 119-161, New York: Macmillan, 1986.


