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Workshops of Creativity in Mathematics: an experience in primary school

Oficinas de Criatividade em Matemática: uma experiência nos anos iniciais

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Abstract

The research "Activating children's critical and creative thinking in mathematics" carried out in Brasilia - DF, about an intervention with primary school students at a public school, to stimulate the critical and creative thinking, and to analyze the effects of the use of creativity techniques on school performance, motivation, and mathematical creativity. The eight "Workshops of Creativity in Mathematics" that was carried out, the students were encouraged to employ their strategies to solve mathematical problems, according to skills and abilities provided by the National Common Curriculum Base (BNCC). The results showed the viability of the workshops to motivate the students for mathematical tasks and promote significant learning. With the workshops, we can diversify the assessments and methodological teaching strategies, to enable the development of students' critical and creative thinking and helps the teaching practice.

Keywords: Creativity workshops in mathematics; critical and creative thinking; mathematical learning; problem-solving.

Resumo

A pesquisa "Ativando o pensamento crítico e criativo das crianças em matemática" realizada em Brasília – DF, trata de uma intervenção com estudantes dos anos iniciais do ensino fundamental de uma escola pública, para estimular o pensamento crítico e criativo, bem como analisar os efeitos do uso de técnicas de criatividade no rendimento escolar, na motivação e na criatividade em matemática. Foram realizadas oito "Oficinas de Criatividade em Matemática" nas quais os estudantes foram instigados a criar estratégias para solucionar problemas matemáticos, conforme as competências e habilidades previstas na Base Nacional Comum Curricular (BNCC). Os resultados mostraram a viabilidade das oficinas para motivar os estudantes nas tarefas matemáticas e promover aprendizagens significativas. Com as oficinas, podemos diversificar as avaliações e estratégias metodológicas de ensino, de modo a possibilitar o desenvolvimento do potencial crítico e criativo dos estudantes e auxiliar a prática docente.

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Palavras-chave: Oficinas de criatividade em matemática; pensamento crítico e criativo; aprendizagem matemática; resolução de problemas.

Introduction

The National Common Curriculum Base – BNCC, acronym in Portuguese, (Ministério da Educação, 2018) brings in its scope the need to structure students' mathematical knowledge through mathematical literacy. This means organizing the pedagogical work in order to provide students with situations in which they can develop their mathematical skills and abilities, emphasizing reasoning, the exercise of intellectual curiosity, representation, imagination, communication, and the use of argumentation in mathematics. The teacher, by proposing pedagogical actions based on this approach, enables students to establish conjectures, make estimates, formulate and solve mathematical problems in a variety of real-life contexts, using mathematical concepts, strategies, information and tools (Ministério da Educação, 2018, p. 264).

In the face of the need to prepare the student to deal with challenges and demands typical of the knowledge society (Alencar *et al*., 2018), as an alternative to stimulate the development of mathematical thinking, taking into account its critical and creative dimension, the following research presents a brief description of the implementation of the activities named **Workshops of Creativity in Mathematics**, carried out in two 4th grade classes of Primary Education from a public school in Brasilia, in the Federal District – DF, acronym in Portuguese.

The application of these workshops is part of the research "Activating children's critical and creative thinking in mathematics", carried out in the year 2018 by the PI Group: Group of Research and Investigations in Mathematical Education, based in Brasilia - DF. The research in discussion aimed to conduct an intervention in creativity in the field of mathematics, with a focus on stimulating divergent thinking, to analyze the effects of using creativity techniques on school performance, motivation, and critical and creative thinking in mathematics of students in the early years of primary school.

With the research undertaken in this paper, we also propose to investigate whether the application of creativity techniques can contribute to stimulate students in the early years to employ their own strategies to solve mathematical problems, based on the skills and abilities set forth in the BNCC according to the stage/year of schooling of the classes participating in the Workshops of Creativity in Mathematics.

Theme development

The Workshops of Creativity in Mathematics were a set of experiences that allowed, from challenging situations, the formulation of hypotheses, argumentation about the ways to reach the results, evaluation and re-evaluation of the results obtained by children between 9 and 13 years old. This means that the activities involved in all the workshops correspond, in their essence, to the free exercise of scientific thinking, as well as to situations that stimulate

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reflective thinking, to collaborate to the systematization and formalization of mathematical concepts, using various records and languages (Lisboa, 2019, p. 81).

So that the reader may understand the proposed research as well as its methodology, we develop three sections related to the theoretical framework of the research. In the opening section, we explain the concept of Critical and Creative Thinking. In the next section, we present the Workshops of Creativity in Mathematics and, finally, we list all the actions relevant to the implementation of the Workshops, through the application script. Afterwards, we highlight some perceptions we had about the investigative experience, as well as some opinions obtained from the statements of teachers and students in a more comprehensive way, since the research is still in the process of completion.

Critical and Creative Thinking

This study refers to the concept of competence proposed by the BNCC, which defines it as a set of skills, knowledge, attitudes and values that are mobilized by the individual in order to solve their daily problems, related to their action in the performance of citizenship and in the professional world (Ministério da Educação, 2018, p. 8). This document also discusses the General Competencies of Basic Education that, when stimulated and articulated, contribute to the construction of knowledge, the development of skills, and the building of habits and values of students in Early Childhood, Primary, and Secondary Education.

Hence, we highlight critical and creative thinking as competencies that should be encouraged throughout the individuals' schooling pathway, as a means to ensure that they can develop professionally for the 21st century job market, which contributes to individual well-being and social coexistence, thus promoting the proper functioning of democratic societies, according to the Organization for Economic Cooperation and Development (OCDE, 2020).

The stimulus for critical and creative thinking has appeared in the literature more frequently in recent decades, becoming part of the curricula of some countries as one of the goals to be achieved during the period of basic education. In the Programme for International Students Assessment (PISA), a worldwide study on the development of education in many countries, Creative Thinking is defined as

> the competence to engage productively in the creation, evaluation, and improvement of ideas, which can result in original and effective solutions, advances in knowledge, and impactful expressions of the imagination[4]. (OCDE, 2019, p. 7).

Aligned to the OECD position, the BNCC (Ministério da Educação, 2018) highlights that Critical and Creative Thinking can be encouraged since the early years,

> through the building and strengthening of the ability to ask questions and evaluate answers, to argue, to interact with diverse cultural productions, to make use of information and communication technologies, it enables students to expand their

[4] All translations by the authors, unless otherwise noted.

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> understanding of themselves, of the natural and social world, of the relationships of human beings among themselves and with nature. (Ministério da Educação 2018, p. 58).

However, in relation to the BNCC, Fonseca, Gontijo and Souza (2018) found that:

> (a) there is no formal definition about what critical and creative thinking is, which allows for multiple interpretations about how to work on such skills in the classroom and; (b) there are no indications, suggestions and/or guidelines about how to work to stimulate such skills, nor is there any indication of a guiding document or continuing training that offers subsidies to teachers regarding these skills. (p. 7-8).

Franco and Almeida (2017) also caution that there is no unanimous definition of Critical Thinking. However, they mention that it is shaped from the emphasis of a set of aspects that are characteristic to it and, in this way, constitute it. They also consider that critical thinking refers to skills, which are related to cognitive functioning and problem solving, as well as dispositions, in which variables related to personality and motivation of individuals are associated.

In short, Critical Thinking appears as the use of cognitive skills in order to achieve expected results. It is a rational way of thinking, reflexive and interested in what one should believe or do, in an intentional search in order to solve a problem that requires decision making (Clemente, 2016; Santos *et al.*, 2016). This type of thinking can be deliberate and intentional, less structured and more functional, given the analysis of the information or decision-making to be implemented, differing from the procedures that we naturally automate in our daily lives (Franco & Almeida, 2017).

Morais and Fleith (2017) emphasize the difficulty in establishing a single concept to define what Creativity is, due to its own characteristics, since it is a dynamic, continuous, procedural process and is defined by individual aspects related to the context. Because it is not a static, predetermined phenomenon, established at some point in the individual's life or that depends on personal factors, "creativity occurs in the interaction between processes, environment, and aptitudes, resulting in something new and useful in a given social context" (Morais & Fleith, 2017, p. 22). Tschimmel (2010) and Clemente *et al*. (2016) mention Torrance (1979) as the first researcher to propose analyses within this perspective in a pedagogical context.

The absence of curricular guidelines about how to stimulate critical and creative thinking motivated the development of the Workshops of Creativity in Mathematics. We highlight that, when discussing creativity in mathematics, we are referring to the

> ability to provide numerous possibilities of appropriate solutions for a challenging situation, so that they focus on different aspects of the problem and/or different ways to solve it, especially unusual ways, both in situations that require problem solving and making and in situations that require the classification or organization of objects and/or mathematical elements according to their properties and attributes, either textually, numerically, graphically or in the form of a sequence of actions (Gontijo, 2007, p. 37).

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The concept put forward by Gontijo (2007) for creativity in mathematics proves to be useful both for empirical research, aimed at investigating students' creativity, and for the development of practical activities to be developed in everyday school life, as it reveals three dimensions that enable its operationalization: it investigates the characteristics of creative thinking (fluency, flexibility and originality), suggests strategies for stimulating creativity (problem solving, problem making and redefinition), and highlights different ways of expressing creative thinking (textual, numerical, graphic production or sequence of actions).

When referring to the characteristics of creative thinking, Gontijo (2007) emphasizes that fluency is related to the ability to produce many ideas to solve a given problem; flexibility is related to the ability to produce ideas that are different from each other, which could be categorized by bringing together different paths to solve the same problem; and originality is related to the ability to produce unusual ideas in the elaboration, development, and improvement of the produced solutions.

The creative process, according to Beghetto (2020), implies a series of phases, steps or procedures, in which thoughts are generated (ideas, interpretations and insights) and evaluated, as being original or significant in the context of a particular task, situation or domain, that is, in its possibilities. The author points out that by familiarizing ourselves with the components and processes of creative thinking, we can understand and assist students in developing their own creative thinking.

We consider it important to point out that creative thinking can manifest itself at different levels, according to the experiences, knowledge, and possibilities of individuals. One way to indicate these levels was proposed by Kaufman and Beghetto (2009), known as the Four-C Model of Creativity. This model allows us to go beyond the stereotypes that consider as creative only those individuals who have produced works or ideas with great impact on society. The authors postulate the existence of a level of creativity called "mini-c", defined as a new and personal interpretation that the individual gives to an experience, action, or event that was significant to him/her, therefore being self-referential to the individual him/herself. The "little-c" level refers to creativity focused on everyday activities, such as those creative actions in which any person who is not an expert in a given subject can perform every day. According to the authors, this type of creativity is inherent in the learning process. The "Pro-c" level represents a progression of development and effort beyond "little-c", such as professional experience in any creative field. The highest level, the "Big-C", is found in people with great projection in a certain area of knowledge due to the impact of their works on society. Thus, creativity could be observed from a more elementary level all the way to a level that represents great creations (mini-c, little-c, Pro-c and Big-C). This model shows that it is possible and feasible to discuss creativity in the school environment, since students are potentially able to create new ways of presenting their ideas and knowledge, even if at an elementary level, nevertheless relevant to their developmental stages.

Regarding the combination of creative thinking with critical thinking, some authors point out that, despite being different constructs, they are related. Lipman (2003), for

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example, considers that thinking is intrinsically critical and creative, since there are phases in which creativity is required to generate new and different ideas for problem solving, and these phases are followed by stages that require evaluation and decision-making in the course of actions, thus requiring critical thinking. Hence, creative processes interact with critical thinking processes at different stages of the problem-solving process. Beghetto (2020) stresses that creative thinking differs from critical thinking, but also benefits it, inasmuch as it helps students develop their own skills and guides them in decisions that benefit both themselves and other individuals.

The Workshops of Creativity in Mathematics

The school participating in the Workshops of Creativity in Mathematics is characterized by being part of the project "*Escola Integral em Tempo Integral* [Full Time School in Full Time]", of the Secretariat of Education of the Federal District. It is a public school that has its own action plan, different from the other institutions in the region.

In total, there were two 4th grade classes, with 56 students involved in the research. Eight (8) workshops were held by some members of the PI Group, who developed the activities according to a collaborative pre-defined plan. Each of them contained a particular characteristic that could trigger in the students the desire to employ their own strategies to solve the mathematical problems presented here. All of them addressed mathematical content related to the grade of the participating classes, contextualized with real situations experienced by students, taking as reference the skills and abilities set forth in the BNCC. They were fully encouraged to think critically, having their answers problematized, with questions that would lead them to reflect on the elements that determined each possible answer.

The workshops took place with the participation of the mathematics teachers of the classes, who were engaged with the group of researchers in order to help carry out the activities and learn from them, along with the students. The teachers' integrated participation was essential for the implementation of the processes, since they needed to observe how each activity would take place so that they could develop their own capacity to formulate mathematical questions as a way to encourage the students to constitute their learning through an investigative approach, using questioning, thinking, and discussion. Such attitudes are important as they allow the teacher to expand their own repertoire of typical questions, formulated by the students themselves and with the others that follow throughout the course of the activities (Lutz-Westphal, 2019).

To check the potential of the workshops to stimulate students' creativity, some measuring instruments were applied at the beginning of the activities, as well as after all the workshops had been carried out. Before the beginning of the workshops, three instruments were applied: a) Climate Scale in the Classroom for Creativity (Carvalho, 2015); b) Attitudes Towards Mathematics Inventory (Gómez Chacón, 2003 - with adaptations) and; c) Creativity Test in Mathematics - Version A (Carvalho, 2019). After the end of the workshops, the following instruments were applied: a) Creativity Test in Mathematics - Version B (Carvalho,

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2019); b) Letter to a friend (text production reporting the experiences encountered during the workshops) and, c) Scale of Perception about the Workshops of Creativity in Mathematics.

Below, we briefly present the Workshops of Creativity in Mathematics:

Workshop 1 - Mathematical (magical) guesses: workshop in which the students had to conjecture, establish hypotheses and identify patterns, based on guesses. In this occasion, the contents of addition, multiplication and numerical expressions were explored. The work with mathematical guesses, at the beginning of the intervention process with the workshops, had as its main objective to create an attitude of enchantment with mathematics, motivating students to get involved with all the work that would be developed throughout the research.

Workshop 2 - Estimation – the number of pencils and school cases: Two activities comprised this workshop: the first activity consisted in investigating how many pencils there were in the school, producing reasonable arguments that could justify the answers given. The second activity was related to estimating the mass of school cases. These activities, besides exploring the ability to make estimates and work with measures, also sought to develop skills to solve and elaborate problems with natural numbers involving the different meanings of the operations. This activity mobilized the students for an investigative process related to the objects present in their school routine (pencils and other materials), however treated as mere accessories to perform their tasks. In order to motivate the investigation process, students were shown a video about the industrial production of pencils and how the sustainable management of tree planting for this production occurs. Thus, a work with mathematical contents was associated with a consciousness-raising activity about sustainable development, taking as a main object a material from the students' everyday use.

Workshop 3 - Investigating movements – balloon-powered cars: In this workshop, the students made balloon-powered cars in order to investigate the factors that could contribute to the cars reaching the greatest distance in the shortest time. Thus, the students could test ways to increase the distance traveled by the cars from an investigative process, in a collaborative and playful experience, as a way to foster creativity in the school context. The workshop sought to explore the theme based on a survey, alongside the students, about the types of transportation used to get to school, analyzing urban and road problems that make it difficult for the population to move around in their daily lives.

Workshop 4 - Calendar Secrets: In the activities proposed for this workshop, the students had to identify regularities and patterns in calendars, which is a great tool to do investigations in everyday contexts, as well as stimulate logical thinking. The students were oriented to look for patterns of numbers and operations, based on problems presented by the workshop organizers. In this workshop, the goal was to highlight another instrument present in everyday school life to guide the work with mathematics. At school, it is a daily practice to record dates on the board and in the notebooks, to allow students to build notions of time and to perceive the transition of facts that occur in their lives, in the community, and in the national reality.

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Workshop 5 - Healthy and conscious consumption: The students performed activities in which they had to solve and elaborate problems involving buying and selling situations, forms of payment. They used terms such as change and discount, performed mental calculations, estimates, read graphs and elaborated tables, built and interpretated bar graphs. All these actions were developed in a context of discussion about sustainability, ethical, conscious and responsible consumption, based on a contextualized approach.

Workshop 6 - Geometric Constructions: from the proposed considerations through the "History of Tangram" and the handling of the game, students were able to establish links between the geometric shapes that compose it and the real world, in order to build geometric concepts (area, perimeter, side, angles, etc.) from the identification of plane figures, their characteristics, description and classification. The investigation of the classroom and school settings was the initial element to explore the space and the various ways to represent it and, based on this, explore other geometric shapes throughout the workshop.

Workshop 7 - Numerical Problems: This workshop aimed to explore some mathematical "guesses" and to participate in the "rest game". In relation to the rest game, among other objectives, the goal was to exercise the calculation of simple divisions and multiplication tables; to explore the concept of divisors of a number, and to analyze the possible values for the rest of the divisions of numbers on the board by the numbers on the dice. During the game, a set of investigative questions related to the students' daily lives were presented to stimulate the use of critical and creative thinking in the activity.

Workshop 8 - Playing with numbers: This workshop aimed to explore problems involving the operations of addition, subtraction, multiplication and division, in a playful context mediated by games, in which students were asked about the strategies used to "win" in the games and to structure their observations about the strategies built to do so.

Script for the Workshops of Creativity in Mathematics

In his model for creativity development, Alencar (1993) suggests that in order to promote the development of creative potential in the classroom, the teacher must help the student to get rid of emotional blockages, such as fear of making mistakes, fear of being criticized, feelings of inferiority and insecurity. An adequate environment allied to intense motivation reduces barriers that inhibit creative expression (Alencar, 1996). Considering the aspects addressed by the author, a script was used for the execution of each workshop, with its own didactic sequence, to generate a predisposition for the realization of the activities. This would give the students the opportunity to explore several activities, so that they could interact without fear of making mistakes and exposing themselves, and, thus, participate intensely in all the planned didactic moments.

The "Script for Workshops of Creativity in Mathematics" (Gontijo, 2020) to be followed was described in such a way that the workshop organizers could apply in a simple, yet systematic, way in most of the strategies elaborated for the planned moment. Such strategies were designed to allow students to have a playful and creative experience, with

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elements of everyday school life, but were designed to contemplate the didactic sequence presented, aiming at stimulating learning in Mathematics, in the dimension of the development of critical and creative thinking. Each script previously elaborated sought to list:

1. **Objectives:** what the workshops aimed at, i.e., what lessons would be the focus of the work, based on the skills and abilities proposed for the 4th grade of primary school, in the area of mathematics, in line with the precepts of the BNCC.
2. **Problem to be solved:** the main question of the didactic sequence to be answered with the development of the workshop activities.
3. **Activity Contents:** the contents were chosen according to the curricular reference matrices of mathematics for 4th grade classes in primary school.
4. **Target audience:** the participants were two 4th grade classes (A and B), with children between 9 and 13 years old, totaling 56 students. The teachers stayed in class, helping the teams to develop the proposals.
5. **Prerequisite:** depending on the content to be covered, the criteria for each workshop were established, always considering the content that would be covered at this stage of the early years, as provided by the BNCC-2018.
6. **Materials:** each workshop had a previously prepared list of material resources to be used by the workshop organizers and by all students individually and collectively.
7. **Duration of the activity:** all activities were scheduled to last approximately two and a half hours. Depending on the activity, the workshop time could be extended beyond the scheduled time, not compromising the routine activities of teachers and students at the school.
8. **Expected results:** the planning foresaw some results in terms of learning and in terms of creative production expected from the students based on the activities undertaken. Thus, each workshop had a moment of systematization that allowed us to verify whether the results were achieved or not.
9. **Teaching and Learning Strategies:** according to the competencies and skills that were worked on, the contents were administered according to the following schedule:

   a) Warm-up: at this moment, the activities were not directly related to the central question of the workshop, however all the workshops would start with this exploratory activity, of motivational nature, in order to encourage the students to feel stimulated to remain predisposed for the next tasks.

   b) Approaching the task: this is an activity that brings the students closer to the central question to be answered throughout the workshop. This activity also has a motivational character; however, it is already connected with the mathematical questions involved in the workshop, preparing them using low complexity activities.

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c) Task development: the main activity developed with the students, having as central object the problem-solving action. Based on some questions, the students produce their solutions and argue about the results found, or return to the beginning of the activities to reconstruct the paths taken, test hypotheses and build new solutions.

d) Systematization - Formalization of concepts and definitions: After the development of the tasks, the workshop team would collect the students' productions and conduct the work for the formalization of the concepts and definitions involved in the tasks.

10. Feedback: a moment to review the activities of the workshop, leading the students to reflect on all their actions, emphasizing the lessons learned.

11. Future scenarios: at this point, the students are presented with possibilities of exploring the themes worked on in the workshops in other contexts where they are inserted, so that they could take their learning to be applied in other domains.

Analyzing the experience

We must note that since we are dealing with eight workshops with diversified experiences, we will only present a summary of some situations observed that caught our attention and we will report them in a very general and brief way, since they are representative. To explain the whole experience, we would need a larger textual space, in order to promote a greater level of detail about the whole set of activities performed, including: materials used, types of problems raised, results presented by the students, and details that characterized each Workshop.

At the beginning of the workshops, the group of workshop organizers was very well received by teachers and students, all eager to know who these people were who came "from the university" and what the Workshops of Creativity were about. The group was introduced to the students and the activities began, with an introductory moment to "break the ice" through warm-up activities, as programmed in the Script for the application of the Workshops. As they were encouraged to participate in the guessing activities, trying to guess cards from the deck of cards, or to estimate quantities, or to discover secrets and number patterns, the students already felt motivated for the next planned tasks.

In the moments that preceded the activities, we observed the children's anxiety to know what novelty was to come. When they saw the workshop team arriving in the classroom, the students already showed reactions of excitement and contentment. They were excited, but above all, they remained attentive to the commands. This happened throughout all the workshops. In this regard, we identify here dimensions of playfulness, referring to the characterization adopted by the activity as a game, exciting, pleasurable, different, and challenging.

However, we still noticed a certain discomfort and insecurity on the part of some students in producing answers to the questions presented without the intervention of the workshop team and the regular teachers. The fear of making a mistake or of appearing to

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others that they themselves did not have the skills to solve simple mathematical problems, made some students, who normally present a livelier behavior, become more silent, introspective, and even suspicious (Figure 1).

Figure 1 - Student with doubts about solving the problem.
Source: PI Group collection (2018)

During the completion of the proposed tasks, they already felt more confident and showed willingness to collaborate with their participation and answers (Figure 2). We understand that, by giving the student the opportunity to be willing and to take the risk of making mistakes and exploring several alternative answers, we can stimulate creativity and contribute to expand the interaction with/in the group, as well as help the formation of autonomy and favor the student's protagonism. As one of the regular teachers told us, "children feel more motivated when they are challenged to build knowledge in conjunction with the teacher, and that 'playing' is a way to achieve this goal".

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Figure 2 - Student presenting hypotheses for solving the problem.
Source: PI Group collection (2018)

The boldness in presenting creative and diverse answers was still little noticed in the actions of the group of students. By proposing open questions, we observed a good diversity of possible answers to the same proposed challenging situation, among all those that were presented. Flexibility, one of the components of creativity that relates to the amount of ideas produced about the same term, is ratified by Lutz-Westphal (2019) as "operative flexibility" in the context of mathematical problem solving, implying that the student operationalizes several solutions for the same mathematical question.

We then found in some students a preference for providing known and possible answers, which offered them the security of what they already knew and tested, rather than seeking new alternative answers and "thinking outside the box," i.e., little operative flexibility. Some showed a certain concern about how their ideas would be received, as well as a certain insecurity and fear in presenting answers different from those presented by their colleagues.

In the workshop "Investigating the movement of objects", a playful and creative mathematical experience was proposed to the students of the early years, focused on the construction of balloon-powered cars, with the purpose of understanding the scientific thinking related to rocket propulsion. In this workshop, the students, arranged in small collaborative groups, were motivated to employ their own strategies to solve mathematical problems (Figure 3).

Figure 3 - Workshop Investigating the movement of objects – building balloon-powered cars
Source: PI Group collection (2018)

With the initial guidance of the workshop organizers, they designed and built a balloon-powered car to understand the scientific ideas related to rocket propulsion. They also utilized the ideas of mass and force to figure out ways to improve the distance traveled by the car (Figure 4).

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Figure 4 - Workshop Investigating the movement of objects – testing the cars
Source: PI Group collection (2018)

Here we identified some dimensions of creativity, favoring mathematical learning: flexibility, by creating different models of cars, and originality, by presenting unusual models of cars, shaped like flowers, butterflies, and many other unconventional patterns to the car standards we know. In this workshop the excitement of the students was visible, especially in the final activity of competition between the cars produced (Figure 5).

Figure 5 - Workshop Investigating the movement of objects – competition of cars between the classes
Source: PI Group collection (2018)

In the "Healthy and Conscious Consumption Workshop" (Figure 6), it was intended for the students to work with statistical calculations. To do so, they had to use supermarket flyers with prices in order to make sandwiches for their families. They observed that there are other factors that affect the final price of products and that many foods that we buy can be produced at home, economically – and one of the challenges was to find out how this would be possible. During the activity, however, they worked with graphs and tables, realizing in practice more complex concepts such as "average" and "mode" in a brief and visual way.

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Figure 6 - Healthy Consumption Workshop
Source: PI Group collection (2018)

The teachers reported that they noticed a greater motivation and understanding of the students about what was being worked on, because as they participated in the construction and in the graphs and used them frequently, the activity came closer to their experiences and they were prompted to think about what was happening at each step, thus trying to solve the proposed challenging problem.

In the "Calendar Patterns Workshop" (Figure 7), it was notorious the students' surprise when they identified patterns in objects that are not necessarily used to perform mathematical calculations, as well as in calendars. They even began to observe other types of mathematical patterns in non-mathematical objects, such as the number of objects in pairs, in triads, sums of birthdays, patterns in multiplication tables, in rulers, and a diversity of other findings.

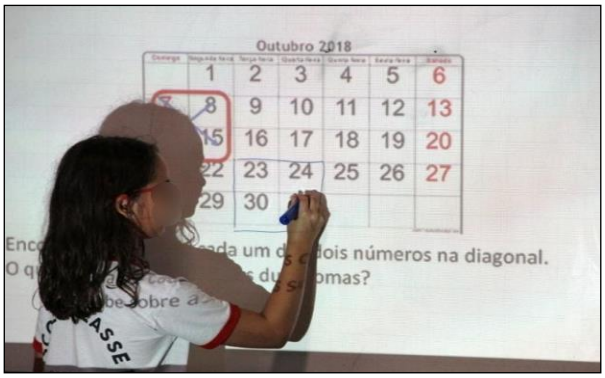

Figure 7 - Calendar Patterns workshop
Source: PI Group collection (2018)

The teachers evaluated the workshops as dynamic, playful and different from the conventional approach of mathematics classes. According to them, the students knew they

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were entitled to recreation time, but remained so involved with the activities that they did not want to leave the classroom. They emphasized that even when doing the activities proposed in the workshops, they were so interesting that they did not want to miss the opportunity to do them. They reported a greater impact on content learning after the Pencil Estimation Workshop and the Calendar Patterns Workshop, because they verified a greater appropriation and functionality by the students in their daily school life.

Moreover, in the context of the mathematics classroom, it also happens when the teacher intends to carry out activities that promote functional enjoyment: it enables students to face and overcome challenges and stimulates them to develop critical and creative thinking in solving challenging situations (Lisboa, 2019, p. 68). These activities can become a valid teaching resource for mathematical learning, which favors the development of creativity in this area (Gontijo, 2007).

The teacher plays an important role in this type of activity, by applying the tasks jointly, asking questions, guiding the execution, which makes them dynamic by allowing students to work not only individually, as they form small working groups (Martins, Vieira, Reis & Ribeiro, 2013).

The teachers reported that the greatest benefit of the workshops was the possibility of presenting and exploring complex content with simplicity. They considered the proposals interesting, different, well-produced, and with an interdisciplinary approach that drew attention to other significant themes to the students. They emphasized that they were rich learning moments in which the students learned through playing. Since expensive materials were not used in each workshop and the same resources that the students already had were used to carry out the activities, simplicity was a great ally, which would not be a constraint for a future project from the regular teachers.

Concluding Remarks

The development of the "Workshops of Creativity in Mathematics" showed the viability of using creativity techniques to motivate students and engage them in tasks, resulting in meaningful learning. Furthermore, we emphasize the need to invest in strategies that can contribute to the training of educators to understand the need to establish differentiated pedagogical actions that contribute to the learning of their students based on the perception of the context in which they are inserted and on a practice that enables the use of interdisciplinary knowledge.

Yet, we understand that the development of the creative potential in the classroom happens when the teacher helps the student to overcome emotional blockages, such as the fear of making mistakes, the fear of being criticized, feelings of inferiority and insecurity. As a result, during the workshops, when the students felt autonomous and confident, we identified characteristics of creative thinking, such as flexibility and originality in the resolution of challenging problems.

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In this sense, we reaffirm the need for the teacher to be aware of his/her own pedagogical praxis, so that he/she can reflect on it and become fully acquainted with it, as the theoretical training will enable him/her to act with more confidence. Similar to the experience of the workshops that are the object of this investigation, the relevance of knowing and giving students the opportunity to adopt diversified pedagogical strategies, such as the Workshops of Creativity in Mathematics, would certainly provide subsidies to expand the process of learning of the students, in order to give new meaning to their own teaching practice.

We emphasize that, despite the completion of the workshops, the project has not yet been concluded, because the research team is working on the analysis of the protocols produced by the students and on the analysis of the results of the instruments applied at the beginning and at the end of the work. This will result in a mixed approach research, according to the nature of the data presented. However, the researchers' view throughout the work, through the systematic recording of the activities developed, allows us to announce that, so far, the objectives were satisfactorily met and, soon, other conclusions will be presented.

Finally, we believe that conducting didactic workshops in mathematics creates considerable room for the diversification of assessments and methodological teaching strategies that can enable the development of the students' critical and creative potential and assist teachers in their pedagogical practice.

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