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Critical and creative thinking in mathematics and formative assessment: limitations and potentialities

Pensamento crítico e criativo em matemática e avaliação formativa: limitações e potencialidades

Ildenice Lima Costa[1]

Cleyton Hercules Gontijo[2]

Abstract

The present study, which is a segment of the thesis "Formative Assessment and Critical and Creative Thinking in Mathematics: A Perspective from Elementary School Teachers," aims to provide insights into how formative assessment practices used by public school teachers in the Federal District can foster critical and creative thinking in mathematics among elementary school students. Through content analysis, this qualitative, exploratory, and literature-based research identified elements that contributed to characterizing the data collected through individual questionnaires, focus group discussions, and online interviews with eight teachers. Preliminary findings suggest the potential for developing a pedagogical framework that enhances formative assessments and pedagogical resources through ongoing professional development with the aim of promoting critical and creative thinking in mathematics.

Keywords: Critical and creative thinking in mathematics; Early Years; Formative Assessment; Continuing Training.

Resumo

O presente estudo, que consiste em um recorte da tese “A avaliação formativa e o pensamento crítico e criativo em matemática na percepção de professores dos Anos Iniciais do Ensino Fundamental”, objetiva trazer contribuições para uma análise de como a avaliação formativa utilizada por professores da rede de ensino pública do Distrito Federal pode desenvolver o pensamento crítico e criativo em matemática de estudantes dos Anos Iniciais. Por meio da análise de conteúdo, esta pesquisa qualitativa, de caráter exploratório e bibliográfico, reconheceu elementos que contribuíram com a caracterização das informações produzidas na aplicação de: questionários individuais, Grupo Focal e entrevistas *on-line* junto a oito professores. Os resultados preliminares sugerem a possibilidade de constituir uma organização pedagógica que potencialize as avaliações formativas e os recursos pedagógicos por meio da formação continuada que visem o estímulo ao pensamento crítico e criativo em matemática.

Palavras-chave: Pensamento crítico e criativo em matemática; Anos Iniciais; Avaliação Formativa; Formação Continuada.

Introduction

Currently, all over the world and in all contexts of society (media, political, economic,

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[1] Ph.D. in Education from the University of Brasília (UnB) - Professor at the Education Department of the Federal District (SEEDF), Brazil. Email: ildenicelc@gmail.com. ORCID: https://orcid.org/0000-0002-8482-1513

[2] Ph.D. in Psychology from the University of Brasilia. Professor at the University of Brasilia, Brazil. Email: cleyton@unb.br. ORCID: https://orcid.org/0000-0001-6730-8243

technological, cultural, etc.), there is an increase in interest in the so-called "21st century skills". This interest is reflected in the search for its inclusion in school curricula as a way to prepare children and young people for the challenges of contemporary times.

According to the Organization for Economic Cooperation and Development (OECD) project entitled The Future of Education and Skills: Education 2030, some of these skills are: 1) critical thinking; 2) creativity; 3) research and investigation; 4) self-direction, initiative, and persistence; 5) use of information; 6) systems thinking; 7) communication; and 8) reflection.

The educational policies currently in force in several countries are in line with the OECD recommendations, since these aim at the growth of economies and become parameters for the analysis of human development indices. This makes these guidelines an important factor in the search for public policy solutions in a globalized world. This role is fulfilled both through the exchange of information and the alignment of policies between the member countries of this organization (Ministério da Economia, 2022).

Among the competences highlighted by the OECD, creative thinking has been one of the most important and the one that has seen the greatest growth in the field of professional organizations, as can be seen in the ranking of "Fundamental Skills for Professionals in 2023"[3], according to the document Future Jobs of Report 2023 (WEF, 2023, p. 39). The World Economic Forum is a public-private cooperation organization that strives to disseminate actions aimed at the political and economic agenda of global interest.

In 2023, the top ten skills for professionals to be successful at work, according to the WEF classification, were the following (according to Frame 1):

Frame1- 10 skills for work in 2023

1st	Analytical thinking
2nd	**Creative thinking**
3rd	Resilience, flexibility and agility
4th	Motivation and self-awareness
5th	Curiosity and lifelong learning
6th	Technological literacy
7th	Reliability and attention to detail
8th	Empathy and active listening
9th	Leadership and social influence
10th	Quality control

Source: WEF, 2023.

[3]"Core skill for workers in 2023" – this is a series of skills, classified according to the World Economic Forum's Global Taxonomy of Skills, according to the proportion of organizations surveyed that consider them fundamental to their workforce.

According to Bughin et al. (2018, p. 4), “demand for higher cognitive skills will increase moderately overall, but will increase markedly for some of these skills, especially creativity”. In view of this demand, Manyika et al. (2017) recommend that educational policies include this skill, as it is not among those that can be automated. This also applies toother skills, such as understanding human emotions and leadership and teamwork skills.

In the school space, the inclusion of such competences has been debated in all disciplines, and particularly in mathematics, studies on the development of creativity in this context are recent. In Brazil, the Brazilian Common Core Curriculum – BNCC (Ministério da Educação, 2018) suggests that to favor the development of creativity, the curriculum structure of mathematics should be organized for this purpose, in such a way that creativity itself presents itself as an important resource that contributes to personal and scientific growth. The BNCC still proposes that the adoption of new dynamics in school space/time, providing the mathematical experience of creation, since creativity can be fostered along with students who are in a learning environment specially designed for this purpose (Leikin, 2017). In this way, the competence of creativity can be rethought as a methodological resource that contributes to streamline and enrich the educational process.

These factors make us consider the need to include the teacher in this process through training actions that allow him to understand his pedagogical possibilities and potential, to apply them with a view to developing the student's creativity. We consider that, when evaluating mathematical content, the teacher can consider the use of strategies or instruments that may already be present in their pedagogical actions aimed at the application of mathematical content to expand the students' capacity regarding: production of ideas, realization of analyses, stimulus to questioning, generation of multiple hypotheses, argumentation before the possibilities, projections of possible consequences and possibilities of solutions to problems. In other words, assessments can be structured in such a way as to promote evaluative actions that contribute to the expansion of the teacher's repertoire regarding evaluative actions that favor the development of critical and creative thinking in the student in the context of teaching mathematics. Thus, it is worth noting that the scientific literature still lacks research that presents practical proposals with this specific purpose.

In view of this scenario, in which the teacher is a participant and considered essential, since it is through it that educational policies are implemented in the classroom, mediated by pedagogical practices, we propose the following problem to be analyzed through this study: how do the instruments and evaluation procedures that teachers use with your students can serve the development of critical and creative thinking in mathematics?

Through this research question, which represents a segment of one of the developmental phases of the doctoral thesis titled "Formative Assessment and Critical and Creative Thinking in Mathematics: Elementary School Teachers' Perspectives" (Costa, 2023), we investigated with a group of elementary school teachers from the public school system in the Federal District. Data for analysis were gathered using the following instruments/procedures: a questionnaire for collecting sociodemographic data, a semi-structured collective interview for the focus group, and semi-structured individual interviews (all conducted online). In doing so, we examined the possibilities on which the pedagogical

work was grounded concerning the stimulation of students' mathematical thinking, considering the potential for developing learning within the dimensions of critical and creative thinking in mathematics.

Critical and creative thinking in mathematics in the current educational scenario

The edition of Program for International Student Assessment (PISA) 2022 for the first time featured the areas of mathematics, mother tongue and sciences and beyond these, the assessment of creative thinking. At the opportunity, the objective was to promote valid, reliable, and actionable measurement instruments for the countries participating in this evaluation to involve their policymakers, educators, and the public in a debate on ways to promote creativity in schools. This means that in mathematical problem-solving situations, instead of just asking students to do their calculations and put in the correct answers to questions, they will be encouraged to express their imagination with creative solutions, in a variety of open problems (Schleicher, 2019, p. 10).

To be effectively evaluated, Schleicher (2019, p. 12) mentions that PISA understands creative thinking as a competence to be applied in an iterative process involving the generation, evaluation and improvement of ideas that result in new and effective solutions, advances in knowledge and impactful expressions of imagination. This competence is made possible by domain knowledge, cognitive skills, curiosity, confidence, goal orientation and task motivation, as well as by social conditions, and can be exercised individually or as part of a group.

The implementation of creativity techniques in pedagogical planning contributes to the development of creative thinking, as well as the performance in mathematics and the motivation of basic education students (Gontijo, 2015; Fonseca, 2019). In this case, the student will be able to develop the skills necessary to produce new mathematical knowledge, by presenting other approaches to historically constructed knowledge, not just reproducing them. This results in advancing knowledge and understanding and solving problems encountered in everyday life (Gontijo, 2007, p. 43).

With a view to developing creativity as a skill to be encouraged, we highlight the concept of creativity in mathematics proposed in Gontijo's thesis (2007, p. 37). This concept emphasizes that creativity in mathematics represents the

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

This may favor the development of other skills and abilities that instrumentalize and structure the thinking of the student. As a result, the student acquires the ability to understanding and interpreting situations, appropriating specific languages, arguing,

analyzing and evaluating, drawing their own conclusions, making decisions and making generalizations – which would be important attitudes to favor critical thinking in mathematics.

By seeking to reframe their pedagogical work and propose strategies that lead students to reflect more on their own actions and productions, the teacher will be able to help them in the exercise of critical and creative thinking in mathematics (Barros de Araújo e Silva, 2016). This approach can culminate in a deeper learning of this content.

When dealing with critical and creative thinking, we observe that they are different, yet complementary, characteristics that can be assumed together in problem solving, considering the rules of the context, methods, and criteria in specific domains (Bailin, 1993). Siswono (2011, p. 548) considers that "critical thinking is thinking that examines, relates, and evaluates all aspects of a situation or problem. Creative thinking is original and reflective thinking that produces a complex product". This leads us to considering these two elements as components of the same structure, as well as analyzing each one of them in its uniqueness.

Franco and Almeida (2017) note that there is no unanimous consensus on the definition of critical thinking. However, they observe that it is constituted from competences related to the personality and motivation of individuals that relate to cognitive functioning and problem solving. Critical thinking can be deliberate and intentional, more functional and with little structure, differentiating itself from the procedures that we carry out automatically in our daily lives.

Critical thinking skills are essential in all situations in which we need to communicate ideas, make decisions, analyze, and solve problems (Lau, 2011). By analyzing and reflecting on problems to be solved, the student will exercise his own critical thinking, thus being able to implement changes or improve what already exists, creating combinations (Amabile, 1998). In this way, they will have a broader view of their own productions and the conduct of challenging processes, using divergent thinking as a resource that can contribute to expanding the possibilities of problem-solving strategies.

Prepare the student to question and thus elaborate problems, develop multiple strategies to solve them and seek reflections is not a common practice in our classrooms. Fonseca and Gontijo (2021) conceptualize critical and creative thinking in mathematics as

> the coordinated action of generating multiple and different ideas to solve problems (fluency and flexibility of thought) with the decision-making process in the course of elaborating these ideas, involving data analysis and evaluation of evidence that the proposed paths are plausible and appropriate to arrive at the solution, arguing in favor of the best idea to achieve the objective of the problem (originality or adequacy to the context) (Fonseca & Gontijo, 2020, p. 971-972).

It should be noted that in Brazilian literature there are few conceptual bases to define "critical and creative thinking in mathematics". Research aimed at operationalizing these concepts is recent, and there is still no consensus on what characterizes this type of thinking (Fonseca & Gontijo, 2020, p. 960). Individually, both critical thinking and creative thinking have been recognized as two important skills to be developed by students in 21st century education, as they are necessary skills for the expansion of all sectors of human activity.

As interconnected skills, critical and creative thinking are ways of thinking that are mutually linked, since they

> [...] thinking creatively leads to the production of many ideas, which under the judgment of critical thinking, favors decision-making, that is, the choice among all the ideas, the best or the most appropriate for a given situation (Fonseca & Gontijo, 2020, p. 963).

By stimulating critical and creative thinking, students can expand their learning potential in mathematics (Barros de Araújo e Silva, 2016). Thus, they can demonstrate to be more prepared to deal with issues related to problem solving, showing excellent skills in aspects of flexibility and elaboration (Toheri et al., 2020).

The student will also be able to overcome learning anxiety, as well as overcome learning barriers, as the development of their creative potential can lead you to broaden your field of knowledge and seek new paths and relationships. This resulting ability, in turn, prepares you to solve problems and make decisions when necessary (Mendonça, 2012).

Carvalho (2019) considers that creativity is a collective phenomenon, which manifests itself with qualitative differences when work takes place in groups mediated by the teacher's action, which allows the class a means of expressing its own ideas in a democratic way. On the other hand, Beghetto (2020) highlights the interconnection between creative thinking and critical thinking. He suggests that the development of creative thinking helps students to develop their own skills and enables them to make decisions that can be beneficial both for themselves and for other individuals.

We believe that the development of critical and creative thinking in mathematics provides the manifestation of divergent thinking, reflection on possibilities, the ability to formulate hypotheses and argue in solving problems. This is configured as a means for the exercise of student protagonism in the classroom in the pursuit of pedagogical success and the achievement of learning objectives.

We ponder, then, on the need for teacher training courses, be they initial training or continuing training, to contemplate moments of study that allow for the teacher to understand the three dimensions of creative teaching, proposed by Beghetto (2017). These dimensions include teaching **about** creativity, aiming to increase knowledge related to creativity and its field of study; the education **with** creativity, whose goal proposes the teaching of any content in a creative way; and the teaching **for** creativity, which aims to cultivate critical and creative thinking in students.

We emphasize that the analyzes focused on teaching for creativity will help us to understand what can be the actions that will enable the teacher to contribute effectively in the teaching of mathematics, in order to the development of critical and creative thinking in mathematics of students of the Early Years.

Method

The study setting for this proposal was the public education network of the State Department of Education of the Federal District (SEEDF). The participants were a group

composed of eight teachers (seven teachers and one teacher) from the Early Years of Elementary School, from different administrative regions of Brasília - Federal District. These participants belonged to the staff of permanent professors in regency or in pedagogical coordination in the Initial Years, as well as professors in regency by temporary contract. We chose to carry out an exploratory and bibliographical research, whose approach to data analysis would be qualitative, based on of elements that would contribute to the characterization of the information produced in the discussions held with the study participants.

We chose to carry out an exploratory and bibliographical research. The analysis of the collected data followed a qualitative approach, exploring elements that contributed to the characterization of the information produced in the discussions carried out with the study participants.

As instruments for data collection, we used the individual survey questionnaires as an alternative to identify sociodemographic and other characteristics related to pedagogical issues. In addition, we transcribed the speeches of the participants produced during the Focus Group sessions and in the individual interviews online.

We therefore adopted the following procedures for our data collection:

1. Recognition of the scenarios and participants: at first, we held an adherence meeting with the group of teachers who responded to our invitation. During this meeting, we present the research proposal and explain the importance of voluntary participation. To formalize this adhesion, we asked the professors to sign a Free and Informed Consent Form (TCLE). This approach followed the guidelines of the Resolutions nº 466/12 (Ministério da Saúde, 2012) and nº 510/16 (Ministério da Saúde, 2016), of the National Health Council and authorized by Opinion nº 5.814.638/2022 of the Research Ethics Committee/ Human and Social Sciences, Institute of Human and Social Sciences of the University of Brasília – UnB, available as an annex to the Individual Questionnaire.

2. Focus Group: after joining the survey, we held a Focus Group adapted for online interaction with all participants, via videoconference on the Zoom platform, with a semi-structured interview script, in order to enable the effective participation of all.

3. Individual online interview: before moving on to the next stage foreseen in the research, we conducted an individual online interview to identify the teachers' perceptions regarding creativity.

Analysis and discussion of results

In the Individual Questionnaire, proposed after signing the TCLE, questions were included that addressed not only the sociodemographic information of the participants (age group, level of training, courses taken in Mathematics Education, time working in teaching and at SEEDF), but also aspects related to their pedagogical and evaluative practice, which were: What are the activities/resources most used in mathematics classes? What could make your math classes more effective in promoting student learning? What do you think would

help students perform better on their math assessments?

The script of questions for the online semi-structured collective interview for the online Focus Group contained the following questions: What do you do to find out if the learning objectives in mathematics were achieved? What instruments and procedures do you use?

The individual semi-structured interview guide on teachers' perceptions of creativity (also carried out online) included the following questions: For you, what does it mean to be creative? Within your performance, when do you notice the student being creative?

We present below a brief analysis of the sociodemographic context of the participants. Next, we will have an analysis of the perceptions we had about the instruments and evaluative procedures in mathematics and about critical and creative thinking in mathematics, elucidated through the reports obtained and related to our motivating question.

Description and analysis of participants

The group of participants consisted of eight teachers from the Early Years of Elementary Education, from educational institutions in different administrative regions of the Federal District. These teachers voluntarily participated in the research, answering the proposed individual questionnaire, as well as participating in the Focus Group activities and the individual interview, both conducted online.

With the intention of characterizing the group based on each individual's statements for the structural analyses of the research and maintaining anonymity, participants were instructed to choose their own code names: Ariel, Bethlili, Elsa, Jasmine, Josué, Milla, Monalisa, and Priscila. This way, we began to establish a sort of researcher-participant connection to facilitate the initiation of the activity in a relaxed manner.

The sociodemographic information collected allowed us to perceive that the age group of the participants in the group was concentrated between 40 and 49 years old, covering four individuals, while the others were aged between 21 and 59 years old, also with four participants. As for academic training, half of the group had an undergraduate degree, while the other half had taken a postgraduate in areas related to education.

Regarding the time of experience in teaching, there were three participants with experience between 21 and 30 years, another three had between one and 10 years of experience, while two reported having between 11 and 20 years of experience. At SEEDF, four participants accumulated between one and 10 years of service, three had between 11 and 20 years and only one had between 21 and 30 years of experience. In other words, it is a group with extensive experience in teaching in the Early Years.

Perceptions about instruments and evaluation procedures in mathematics

The answers to the question on the most frequently used activities/resources in math classes were almost unanimous: seven participants mentioned using, normally, ready-made activities available on the internet, activities from the textbook, games and concrete materials, and even elaborated activities by themselves (six respondents):

> I use the textbook a lot, a lot. Then, I usually give an introduction activity that is not available in the group because I think our book, the Introduction of the content, I think it leaves something to be desired. Then I always give an introduction, often with concrete material, right? (Mona Lisa)
>
> I use the book. However, I leave it to use it as an activity to fix the introduction on the board, I bring a printed activity, but it is because I think the book is much higher, the book that was adopted there at school, it is not very good to be introductory. (Ariel)

The structure of the textbook is constituted with a certain linearity in its presentation – its didactic time, demarcated by the curricular programs, does not contemplate the students' learning times (Pais, 2010, p. 33). And so, during these adaptations, the activities available on the internet emerge as resources that can immediately make up for the lack of the original resource (the textbook).

This supplementary resource, which is relatively easy to access, also turns out to be a material that facilitates the teacher's pedagogical organization, since the teacher does not need to have more time in the elaboration/confection of his own tasks. In this case, it fails to provide contextualized activities in the classroom itself, giving homogeneous meaning to the productions, activities, and personalities, failing to provide students with the necessary protagonism for the development of their own skills. As an alternative to minimize the effects of this lack of connection between the posted content (which is the generic content, presented by this type of activity) and what is necessary for learning, Pais (2010, p. 30) suggests that the mathematical content in question should be recontextualized, relating it to situations that are significant to the student.

When questioned about possible alternatives to improve the effectiveness of mathematics classes in terms of promoting student learning, participants mentioned: training/mastering mathematical knowledge for better pedagogical practice (four answers), pedagogical planning aimed at more dynamics (two answers), the use of games (one answer), and help from professionals to work with students with special needs (one answer).

We agree with the participants' perceptions when highlighting the importance of training in mathematics to enrich pedagogical practices. Investing in the training of professionals also contributes to an emancipatory education for students, allowing them to develop mathematical skills in a more effective and meaningful way, as "the professional development of teachers from the perspective of emancipatory training is centered on ethical-practical and humane principles to assume social roles in the set of pedagogical-didactic actions" (Veiga, 2022, p. 101).

Such activity is supported by the legislation provided for by the BNC-Continuous Training, according to Resolution CNE/CP No. 1, of October 27, 2020. This resolution provides that the teacher must develop General Teaching Skills in three dimensions related to practice within their area of pedagogical activity, which integrate and complement each other in the scope of Basic Education: I - professional knowledge; II - professional practice; and III - professional engagement (Brazil, 2020).

However, what caught our attention was the fact that only one of the participants took a training course in Mathematics Education, offered by SEEDF, and another participant took

a similar course, taught by a private institution. A reflection is in order here, in which we perceive a contradiction: we can see that there was a lack of training for practice, to the detriment of an almost absence of professionals interested in improving their pedagogical practices in mathematics.

When asked about what they did to find out if the learning objectives in mathematics were achieved, the participants cited elements that characterize the renewal of pedagogical planning (six citations), as exemplified by some of their statements:

> This week we're going to do that, the boys didn't understand, we'll do it again next week. So our planning has been that way within what is charged. (Jasmine)
>
> At our school, planning takes place every two weeks. An interesting thing at our school: that everyone walks together, both morning and afternoon. (Elsa)

When thinking about this issue, the participants reflected on the pedagogical actions that transpose the application of formal assessments for this purpose, such as the use of materials and games, pointing to an informal assessment practice, in which the teacher uses observations to understand the unveiling of learning. This evaluative practice can be carried out through interactions in different spaces and school times, helping the teacher to understand the development of students (Villas Boas, 2001). Thus, we start from the assumption that these denoted, in their responses, understanding the need to maintain focus on student learning, regardless of the type of evaluation to which they may be submitted.

All participants agreed that they use, among the various options presented, written tests as a preferred assessment tool in the formal assessment of mathematical content. This option was selected by all eight participants, as indicated in the responses recorded in the individual questionnaires, as exemplified:

> I won't deny it: it's the written test. (...) Some answer quickly, others don't answer at all because they really don't know. (...) There in the written test, I think it really ends what we are doing there every day. (Jasmine)
>
> I think that at the beginning of the diagnostic evaluation process it is important. Because it is from it that we can already verify some things. (Elsa)

In their speeches about the written test, we had the perception that, by citing it, they would be "displeasing" the researcher, as if they were proceeding in a wrong, "traditional" (in the context of outdated, out-of-fashion) and even incorrect ways. We emphasize that, by vilifying the written test, the teacher fails to consider it as an instrument that can help him in the understanding of learning. Thus, we consider that the written test could be used by the teacher with creativity (Villas Boas, 2013, p. 92), due to the richness of subsidies that are contained in it and that can guide their practice in mathematics.

Although the participants emphasized the importance of an innovative context in pedagogical practices, they did not mention situations in which innovation was incorporated into the application of their assessments. It is important to emphasize that innovating is not limited to promoting changes, but modifying with the purpose of improvement, in a motivated and intentional way (Zabalza &cerdeiriña,2014).

Regarding what they would consider helping students to perform better in mathematical assessments, recurrent alternatives were identified, including carrying out

playful and diversified activities (three responses) and encouraging reading and critical interpretation of mathematical problems (two responses). In addition, other interesting aspects were highlighted in our analyses, which evidence the development of skills, provided for in the curriculum or in the BNCC:

> (...) in addition to the curriculum, I think we must achieve what is foreseen in our curriculum... (Jasmine)
>
> I always look for complementary activities according to the BNCC, what are the skills that are worked on there, these things... So, I always look for very good materials aimed either at the BNCC, or the Curriculum in Movement, in short, we are always working with this set... (Milla)

By highlighting the BNCC as a guiding document for their own pedagogical practice, teachers demonstrate that it may be suffering from an emptying of meaning. This is due to the complexity of issues involving learning in mathematics and the theoretical-methodological limitation of this document, which by itself does not fully cover the mathematical curriculum of Elementary School classes. This limitation is partly due to the fragmented nature of the BNCC, as pointed out by Veiga e Silva (2018).

They mentioned the possibility of carrying out activities aimed at innovation in pedagogical practice, relating it to the use of concrete materials, ludic elements such as games and games, or even in the way of interacting with students, to awaken their curiosity and seek your involvement:

> (...) they set it up in the classroom and it was really cool, the groups that did [the study of geometric solids] with the jujube, I noticed that they got more involved, and they thought it was “great”, right? (Jasmine)
>
> (...) I'm already thinking about the game that we're going to use that can better work on a certain difficulty that I've seen or even to present new content. (Priscilla)

When mentioned again, innovation is seen as the possibility of promoting differentiated pedagogical practices. From the examples presented, we realize that the applied strategies were implemented with genuine purposes, such as: promoting interactions, lightness in activities with playful constructions, involvement, group work, with the primary goal of developing learning. In this case, we perceive the act of innovating as a prerequisite for solving a problem, with the aim of meeting a need, fulfilling the desire to obtain something better, not being reduced to just introducing changes in the elements that configure teaching (Zabalza & Cerdeiriña, 2014).

We noticed in some speeches that the assessment is still configured as a practice that is carried out at the end of learning moments, without delimitation of periods, considering the exercise of assessment for learning and not, at the end of processes:

> (...) Because in the end they will take the final [test], right, which is scheduled for November. Until then, we must make them achieve these skills. (Bethlili)

Or even to train the students:

> (...) we are planning our classes based on this diagnostic evaluation, because the results and the skills that the boys were not able to keep up with came,

> we are focusing on these skills. (Bethlili)

Both situations place the teacher in a context in which they must "obey" the school's own logic, based on an institutional project that is concerned with producing student results in large-scale assessments to the detriment of their learning. Thus, "the grade is celebrated, not necessarily the context in which the result was produced" (Sordi, 2002).

Perceptions about critical and creative thinking in mathematics

The concept of the term "creative" emerged strongly associated with the term "different", with high recurrence in the instruments (11 citations), as we can see in some lines:

> Creative for me is when I can do different things... (Priscila)
>
> The moment I'm in, the direction I'm taking is taking me nowhere, it forces me to think differently, to try to find new paths there. If I don't think outside the box, I'll continue the same trajectory. (Josue)
>
> Oh, yesterday something different happened, which I hadn't noticed, I think this is creativity. (Mona Lisa)

In fact, as the terms "creation" and "creativity" derive from the verb "to create", to produce something and this refers to a process, which is continuous and gradual and involves the accumulation of culturally shared knowledge and skills (Celik & Lubart, 2016). Creativity also marks a characteristic that is its own: the inexistence of only one concept that can define it; however, there are several common elements that characterize it. Through the speeches presented, the concept of creativity was systematically associated with innovation (seven recurrences), as we can read in the following quotes:

> Innovate. (...) Seeking a solution through new methods... (Ariel)
>
> (...) you look at something that is already ready, but do it your way by innovating, renewing, doing it differently. So, I think that's what being creative is, in addition to creating some things, but I don't think it comes from nothing, you know... I think there's a starting point and then you create through something... (Jasmine)
>
> Maybe innovate, right? You take something that already exists, you make a change there, right? Innovate that. (Mona Lisa)

Alencar and Fleith (2003, p. 161) point out that creativity and innovation are very close concepts, but the individual's creativity is a fundamental factor for the generation of innovation, while innovation encompasses the implementation and application of new ideas. Nogaro and Battestin (2016) emphasize that innovation contributes to enabling creative education, changing practical mindsets, theoretical-methodological foundations, ways of thinking and conducting pedagogical processes. For Csikszentmihalyi (1996), the production of innovation is a result of creativity.

We pay attention to the fact that we observe the presence of statements that cite insight as an essential element for the existence of creativity or as a characteristic of the creative individual (in all, six recurrences), as we can see in the following quotes:

> (...) some already catch a quick bid and others still take a while, you know... Like, you keep thinking... So, I think that this creativity is something like that that must be sharpened every day, it's not an easy thing, we think it's an easy thing to come to

> creativity: “Oh, it's easy, it's easy to be creative”, but it's not. (Jasmine)
>
> Creative, people! I think it's you are giving that insight... (Monalisa)
>
> When I innovate some things, then it comes to mind... (...) Then an idea comes up... (Milla)
>
> So, when you start me like that, when I'm teaching and some ideas come to me out of nowhere, then I add... (Milla)

Insight (or enlightenment) is cited in the literature as an intuitive process that starts from the perceptions that the individual has, in which he presents an “intuitive vision” about a problem that he needs to solve, and the solution appears suddenly or unexpectedly (Alencar & Fleith, 2003; Ostrower, 2001). Introduced at the beginning of the 20th century by Gestalt psychologists, the concept in question is based on an analogy elaborated by these professionals. They theorized about creative thinking by considering that, faced with a problem that presents an impasse in its resolution, this problem can be restructured through insight. This means that the occurrence of an impasse can trigger a sudden restructuring of the problem, resulting in a new perspective coming to mind (Weisberg, 2020).

In the question that deals with the student's perception of creativity in their pedagogical performance, the participants brought in their speeches some aspects that allowed us to connect them to the elements that characterize creative thinking in mathematics: fluency, flexibility, and originality, as we can observe in the following speeches:

> (...) when inside a game, he extrapolates what I had determined to find solutions, this I think he is being creative. [Fluency] (Priscilla)
>
> Creativity is having a new vision within a new perspective, something that is unexpected and being able to find ways to reach a more viable solution, within what you have now. [Flexibility] (Joshua)
>
> (...) he created a new strategy to show me the results of subtraction operations with ungrouping in a way that I had never thought was possible and he gave me all the support and I understood. [Originality] (Priscilla)

In Beghetto's studies (2017, 2020), the author emphasizes that by becoming familiar with the components and processes of creative thinking, we can comprehend and assist students in developing their own creative thinking. Accordingly, creativity should be employed to provide suitable responses to emerging challenges, manifested through these characteristics.

We then observe the presence of the term “creativity” associated with the possibility of solving problems, as we can see in these quotes:

> It's about using the resources you have at the moment to find a solution to a particular problem. (Josue)
>
> Because that way, I have my way of doing the operations, I even do it on the board, right, I put it and I'm doing it, calculating and I put it below, you know, the answer, he didn't: (...) he did it on the lines below; so, I had never witnessed this and I do on the board what we usually do. (Mona Lisa)
>
> (...) then I looked at it like this: it was not that traditional way of doing it. He created other means to do the math, I don't remember exactly how (...) (Josué)

The Early Years teacher deals daily with the challenge of proposing mathematical

problems so that students can solve them. Bearing in mind the different personalities of students who are involved in the educational process, we suggest that the teacher considers that when solving problems, all possibilities presented must be appreciated, so that students can exercise divergent thinking and thus try to generate a diverse set of possible alternative solutions to a problem (Sternberg, 2008).

Conclusion

We emphasize that the considerations included here are part of a spectrum that still carries the weight of the initial analysis, based on a set of preliminary results that make up a much broader and diverse range of situations that emerged and evolved in the development of a doctoral research project.

We can see in the speeches the constant mention of the term “innovation”. However, the participants resorted to the use of these pedagogical resources without us noticing the much-vaunted innovation behind their utilization (textbook, written test, games, etc.). In the same way, we observed the constancy in the speeches about the “different”, the “original”, “innovative” to characterize creativity. Thus, they demonstrated little theoretical knowledge on the subject, highlighting some beliefs about creativity (such as, for example, resulting from insights, or from the pedagogical work that must be carried out with games to demonstrate creativity, in a reference to the ludic, or the appeal to artistic elements). Despite that, they mentioned aspects related to the characterization of creative thinking in mathematics; and this theoretical approach – even with little knowledge of the subject – points to a possible conceptual construction, based on teaching practice.

In order to address the initial question, **"how can the assessment tools and procedures that teachers use with their students contribute to the development of critical and creative thinking in mathematics?"**, we can indicate that there is a strong potential to utilize the mentioned resources in a way that fosters critical and creative thinking in mathematics. However, it is important to note that the teacher needs to recognize the potential of assessments, their essence, functions, their purpose, and the intended application. Thus, we understand that ongoing teacher training on this topic could assist in this regard.

By proposing strategies that encouraged the process of critical and creative thinking in mathematics of the students, they also noticed the emergence of new learning and the consolidation of previously explored knowledge. Consequently, they recognized the need to innovate effectively in their evaluative activity proposals in mathematics, suggesting tasks involving problem elaboration and resolution containing elements that would enable the exercise of fluency, flexibility, and originality. Thus, we can ascertain that assessments aimed at promoting the development of critical and creative thinking in mathematics stimulate students' learning, influencing the strategies they use to formulate and solve mathematical problems.

Therefore, we consider ongoing professional development activities for Elementary School teachers, specifically focused on assessment for learning, to be necessary. These activities aim to expand the repertoire of knowledge about assessment tools and procedures

that can be employed by teachers in mathematics classes. The objective is to highlight the development process of critical and creative thinking in mathematics of students and nurture this competence, as a means of strengthening, above all, the own learning objectives set out in the curriculum for this content.

References

Alencar, E. M. L. S., & Fleith, D. S. (2003). *Criatividade: múltiplas perspectivas* (3ª. ed.). Brasília: Editora da Universidade de Brasília.

Amabile, T. M. (1998). *How to kill creativity. Harvard Business Review*. 76 (5), 76–87. Disponível em: https://hbr.org/1998/09/how-to-kill-creativity.

Bailin, S. (1993). Epilogue: problems in conceptualizing good thinking. *American Behavioral Scientist, 37*(1), 156-164. https://journals.sagepub.com/doi/10.1177/0002764293037001016.

Barros de Araújo e Silva, F. (2016*). Trabalho pedagógico e criatividade em matemática: um olhar a partir da prática docente nos Anos Iniciais do Ensino Fundamental*. (Dissertação de mestrado em Educação). Brasília: Universidade de Brasília.

Beghetto, R. A. (2017). *Creativity in Teaching.* In J. C. Kaufman, V. P. Glăveanu, & J. Baer (Eds.), *The Cambridge Handbook of Creativity Across Domains* (pp. 549-564). Cambridge: Cambridge University Press.

Beghetto, R. A. (2020). On creative thinking in education: eight questions, eight answers. *Future EDge Future Edge: NSW Department of Education, 1*, 48-71. Retirado em 1º de novembro, 2022, de: https://education.nsw.gov.au/teaching-and-learning/education-for-a-changing-world/future-edge/future-edge-issue-1

Bughin, J., Hazan, E., Lund, S., Dahlström, P., Wiesinger, A., & Subramaniam, A. (2018). *Skill shift: automation and the future of the workforce*. New York: McKinzey Global Institute.

Carvalho, A. T. de. (2019). *Criatividade compartilhada em matemática: do ato isolado ao ato solidário.* (Tese de doutorado em Educação). Brasília: Universidade de Brasília.

Celik, P., & Lubart, T. (2016). *When east meets west.* In V. P. Glăveanu (Org.), *The Palgrave handbook of creativity and culture research (pp. 37-55)*. London: Palgrave Macmillan.

Costa, I. L. (2023). A avaliação formativa e o pensamento crítico e criativo em matemática na percepção de professores dos Anos Iniciais do Ensino Fundamental. (Tese de doutorado em educação). Brasília: Universidade de Brasília.

Csikszentmihalyi, M. (1996). *Creativity: flow and the psychology of discovery and invention.* New York: Harper; Collins.

Fonseca, M. G. (2019). *Aulas baseadas em técnicas de criatividade: efeitos na criatividade, motivação e desempenho em matemática com estudantes do Ensino Médio*. (Tese de doutorado em Educação). Brasília: Universidade de Brasília.

Fonseca, M. G., & Gontijo, C. H. (2020). Pensamento crítico e criativo em Matemática em diretrizes curriculares nacionais. *Ensino Em Re-Vista, 27*(3), 956-978. https://doi.org/10.14393/ER-v27n3a2020-8.

Fonseca, M. G., & Gontijo, C. H. (2021). Pensamento crítico e criativo em matemática: uma abordagem a partir de problemas fechados e problemas abertos. In: Perspectivas da Educação Matemática, 14(34), pp: 1-18. https://doi.org/10.46312/pem.v14i34.12515

Franco, A. H. R., & Almeida, L. S. (2017). Definição e medida do pensamento crítico. In L. S. Almeida (Org.), *Criatividade e pensamento crítico: conceito, avaliação e desenvolvimento* (pp. 107-132). Porto: CERPSI.

Gontijo, C. H. (2007). Relações entre Criatividade, Criatividade em Matemática e Motivação em Matemática de Alunos do Ensino Médio. (Tese de doutorado em Educação). Brasília: Universidade de Brasília.

Gontijo, C. H. (2015). Técnicas de criatividade para estimular o pensamento matemático. *Educação e matemática, 135,* 16-20.

Lau, J. Y. F. (2011). *An introduction to critical thinking and creativity: think more, think better*. New Jersey: John Wiley & Sons, Inc..

Leikin, R. (2017). Developing mathematical creativity and expertise in students and teachers: focusing on multiple solution and investigation tasks. *The 10th Mathematical Creativity and Giftedness International Conference* (pp. 7-16). Nicosia, Cyprus: Department of Education, University of Cyprus.

Manyika, J., Chui, M., Miremadi, M., Bughin, J., George, K., Willmott, P., & Dewhurst, M. (2017). *A future that works: automation, employment, and productivity*. New York: McKinsey Global Institute.

Mendonça, P. V. C. F. (2012). *Treinamento de criatividade com professores: efeitos da criatividade e no rendimento escolar de alunos com e sem Transtorno de Déficit de Atenção e Hiperatividade*. (Tese de doutorado em Psicologia). Universidade de Brasília, Brasília.

Ministério da Economia. (2022). *O Ministério da Economia e a OCDE*. Retirado em 19 de dezembro, 2022, de: https://www.gov.br/economia/pt-br/assuntos/ocde

Ministério da Educação. (2018). *Base Nacional Comum Curricular*. Brasília: Ministério da Educação. Retirado em 05 de janeiro, 2023, de: http://basenacionalcomum.mec.gov.br/wp-content/uploads/2018/02/bncc-20dez-site.pdf.

Ministério da Educação. (2020). *Base Nacional Comum para a Formação Continuada de Professores da Educação Básica (BNC-Formação Continuada)*. Resolução CNE/CP Nº 1, de 27 de outubro de 2020. Retirado em 09 de dezembro, 2022, de: http://portal.mec.gov.br/docman/outubro-2020-pdf/164841-rcp001-20/file

Ministério da Saúde. (2012). *Resolução CNS nº 466, de 12 de dezembro de 2012*. Brasília: Conselho Nacional de Saúde. Retirado em 28 de fevereiro, 2022, de: https://www.gov.br/defesa/pt-br/assuntos/hfa/ensino-e-pesquisa/comite-de-etica-em-pesquisa-cep-hfa-1/arquivos/resolucao_cns_n__466.pdf

Ministério da Saúde. (2016). Resolução CNS nº 510, de 07 de abril de 2016. Brasília: Conselho Nacional de Saúde. *59ª Reunião Extraordinária*. Retirado em 30 de janeiro, 2023, de: https://doi.org/10.14393/ER-v27n3a2020-8

Nogaro, A., & Battestin, C. (2016). Sentidos e contornos da inovação na educação. *Holos, 32*(2), 357-372.

Ostrower, F. (2001). *Criatividade e processos de criação*. Petrópolis: Vozes.

Pais, L. C. (2010). Transposição didática. In S. D. A Machado (Org.), *Educação matemática*: uma (nova) introdução (Série Trilhas) (pp. 11-48). São Paulo: EDUC.

Schleicher, A. (2019). Assessing creative thinking to empower learners. Creating Creators: How can we enhance creativity in education systems? *Creativity Matters,* 1, 10-12. Billund: The LEGO Foundation.

Siswono, T. Y. E. (2011). Level of student's creative thinking in classroom mathematics. *Educational Research and Review, 6*(7): 548-553.

Sordi, M. R. L. (2002). Entendendo as lógicas da avaliação institucional para dar sentido ao contexto interpretativo. In B. M. F. Villas Boas (Org.), *Avaliação*: políticas e práticas (pp. 65-81). Campinas: Papirus.

Sternberg, R. J. (2008). *Psicologia Cognitiva* (4a. ed.). Porto Alegre: Artmed.

Toheri, T., Winarso, W., & Haqq, A. A. (2020). Where Exactly for Enhance Critical and Creative Thinking: The Use of Problem Posing or Contextual Learning. *European Journal of Educational Research, 9*(2), 877-887. https://doi.org/10.12973/eu-jer.9.2.877

Veiga, I. P. A. (2022). Formação de professores: uma análise por dentro da Resolução nº 2/2019. In Veiga, I. P. A, & Santos, J. S. (orgs.), *Formação de Professores para a Educação Básica* (pp. 94-116). Petrópolis: Vozes.

Veiga, I. P. A., & Silva, E. F. (2018). Ensino fundamental: gestão democrática, projeto político-pedagógico e currículo em busca de qualidade. In I. P. A. Veiga, & E. F. Silva (Orgs.), *Ensino fundamental: da LDB a BNCC* (pp. 43-67). Campinas: Papirus.

Villas Boas, B. M. F. (2001). Avaliação formativa e formação de professores: ainda um desafio. *Linhas Críticas,* 12(22), 75-90.

Villas Boas, B. M. F. (2013). *Virando a escola do avesso por meio da avaliação*. Campinas: Papirus.

Weisberg, R. (2020). Insight. In S. Pritzker, & M. Runco (Orgs.), *Encyclopedia of creativity*. Amsterdam: Academic Press; Elsevier.

World Economic Forum (2018). *The future jobs report*. Davos: Centre for the New Economy and Society.

Zabalza, A. M., & Cerdeiriña, A. Z. (2014). *Innovación y cambio en las instituciones educativas.* Rosário: Homo Sapiens Ediciones.