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Autism spectrum disorder and shared creativity in mathematics: breaking the stigma of limitation in order to bring out potentialities.

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ABSTRACT

It was analyzed how the processes involved in shared creativity in mathematics of an 11-year-old student with Autism Spectrum Disorder take place in interactions with peers at the same age. This study aimed to understand how subjects with this condition can generate mathematical ideas when doing collective work, helping peers and getting their help. Based on a qualitative approach, a math creativity test was used as a data collection instrument, and students were invited to respond to it and come up with open problems. Interviews and interactions were recorded, transcribed and, later, treated by using content analysis. Seventeen initial categories were found in which the creative production process occurred in the reality studied, and they were grouped into 4 intermediate categories: a) Personal traits, b) Favorable traits to shared creativity in mathematics, c) Production of ideas, d) Improvement of peers' ideas. In turn, these were allocated to final categories: a) How an autistic person collaborates in the production of ideas, and b) How an autistic person receives collaboration in the production of ideas. Based on the findings, it was concluded that the performance of the autistic student, with his particular conditions, made the mathematical idea sharing process a phenomenon with many possibilities.

KEYWORDS: Autism. Shared Creativity in Mathematics.

INTRODUCTION

Kaspar Hauser is sitting at the table together with his tutor and a teacher who came from a distant place to assess his logical thinking ability. Two years after he had been found at the Unschlittplatz square in Nuremberg, Germany, at the age of 15 and devoid of any form of language, many intellectuals were interested in studying the curious case of a subject who had been raised in a dungeon since birth, with no contact with anyone else whatsoever, but who showed a rapid development in so little time of interaction with a social environment.

The year was 1827, and the teacher raises an issue:

> Let's suppose this is a village (he shows a coffee pot) where everyone tells the truth. Here (he shows a cup) is another village. The inhabitants of this village always lie. There are two roads, each coming from one of these villages, that run to where you're standing. A traveler comes along, and you want to know if he came from the village of truth-tellers or the village of the liars.

Then, the teacher explains that, in order to solve the issue in a logic manner, there is only one question that should be asked to the traveler. Kaspar remains silent for a few seconds. The teacher then quickly gives the answer he expected, based on the double-negative logic, posing a question to the traveler: "If you came from the other village, would you answer 'no' if I asked: Do you come from the village of the liars?" However, Kaspar surprises everyone with another valid answer: "I would ask the traveler whether he is a frog". Adamantly, the teacher does not accept his answer and feels offended by the boy and, annoyed, tells him that could not be a valid solution according to the laws of logic.

The scene interpreted in the classic movie "The Enigma of Kaspar Hauser" (HERZOG, 1974), which depicts the true story of a German youth, allows us to draw comparisons between the themes proposed in this article. Firstly, the authoritarian and inflexible behavior of the teacher when faced with an unexpected response of his interlocutor ends up becoming iconic and reflects the reality of many classrooms. Beghetto (2010) described how this happens in the school routine:

> Espere o professor fazer uma pergunta, levante a mão rapidamente, aguarde silenciosamente até que o professor lhe chame, compartilhe sua resposta (geralmente tentando combinar sua resposta com o que você acha que o professor espera ouvir), e espere que o professor lhe diga se sua resposta é apropriada, correta ou aceitável. (BEGHETTO, 2010, p. 450).[2]

For those who study the field of creativity in mathematics, this is the central problem that guides research on the theme real school versus ideal school for the needs of the current time. Knowing that students will need to be better prepared in order to successfully navigate through the increasingly complex and poorly

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defined nature of life in the 21st century (BEGHETTO, 2010, p. 447), attitudes such as the one the teacher had towards the solution Kaspar came up with must be fought, in order to develop the awareness that teachers must offer effective teaching methods that stimulate the students' creative thinking (LEE, et al., 2019, p. 198).

Knowing that the Organization for Economic Co-operation and Development (OECD, 2021) recently reported a drop in creativity and intellectual curiosity among young people (among other socio-emotional skills), it is necessary to reflect on the role of school and how it can make pedagogical interventions so that, besides academic learning, all students, including those with disabilities and disorders, find adequate challenges in order to feel creative, produce ideas collectively, cultivate creativity and develop creative thinking. School is where students can learn and feel accepted by their classmates and teachers, preparing them for the world that awaits them outside school walls (OECD, 2021, p. 3).

A second point that should be highlighted from Kaspar's story concerns the place of the social interaction in the process of human development. The interaction with tutors helped the boy develop oral and written language skills, enabling him to develop rapidly and effectively. Considering that every higher function originates as actual relationships between individuals (VIGOTSKY, 1998, p. 75), the role played by the subjects who received the boy and showed him the social world was of the utmost importance for his appropriation of cultural practices.

These are the two main dimensions that motived the reflections presented here: the need to develop creative thinking in students in the school setting and to look carefully to subjects who, due to their singular conditions of being in the world, may encounter difficulties exactly with what essentially makes us humans: social interaction. Thus, the objective of our study is to analyze how the processes involved in shared creativity in mathematics take place for subjects with Autism Spectrum Disorder, that is, how subjects with this condition can produce mathematical ideas when doing collective work. We are interested in analyzing how responses to open mathematical problems emerge when subjects with ASD construct collective solutions, collaborating with and receiving collaboration from peers.

CREATIVITY IN MATHEMATICS AND SHARED CREATIVITY IN MATHEMATICS: MAIN CONSTRUCTS

The first construct to be addressed in this study concerns creativity in mathematics, a subject that has been discussed since the pioneer work of the French Henri Poincaré titled "Mathematical Creation" (dated 1908). Since then, a range of scholars seek to define and propose what would be creativity in mathematics. This has not been easy, as many researchers have argued that so far there is no single well-accepted definition for mathematical creativity and a way in which it can be better assessed..." (PITTA-PANTAZI et al., 2013, p. 2005).

In this range of concepts regarding the theme of creativity in mathematics, a definition is important for this study, as it will help to evidence when and how students can use creative thinking when solving problems with the help of mathematics. Thus, it is based on the definition given by GONTIJO (2007), who considers creativity in mathematics as:

> A capacidade de apresentar inúmeras possibilidades de soluções apropriadas para uma situação-problema, de modo que estas focalizem aspectos distintos do problema e/ou formas diferenciadas de solucioná-lo, especialmente formas incomuns (originalidade), tanto em situações que requeiram a resolução e elaboração de problemas como em situações que solicitem a classificação ou organização de objetos e/ou elementos matemáticos em função de suas propriedades e atributos, seja textualmente, numericamente, graficamente ou na forma de uma sequência de ações. (GONTIJO, 2007, p. 37).[3]

By defining creativity in mathematics in this manner, GONTIJO (2007) indicates ways in which teachers can help students develop the components related to creative thinking (fluence: generation of ideas; flexibility: generation of different ideas; originality: generation of uncommon ideas), indicates the cognitive processes they need to put into action in order to develop creative thinking (resolution of problems, elaboration of problems, and redefinition of mathematical terms according to their characteristics and properties), and suggests a range of resources so that students demonstrate and record the steps that allowed them to arrive at a valid solution (production of texts, calculations, graphical and geometrical constructions, etc.).

In addition to the construct of creativity in mathematics, it is necessary to define what is understood by creativity in its collective setting. Knowing that humans develop through social interactions (VIGOTSKY, 1998) and are different from other animals because they are included in a culture, there is no denying that everything they produce, from objects to processes, is constituted within the fabric established with one another through language. Thus, it is relevant to affirm that creative expression can only occur within a society and culture (CSIKSZENTMIHALYI, 1998; GLĂVEANU, 2014; SAWYER, 2007).

It is necessary to consider that, within the space of the classroom, opting for a collaborative approach, in which it is intended that subjects produce ideas collectively, does not mean that subjects will be lost to the detriment of the group, but rather that "a new status and value" will be given to them (GLĂVEANU, 2014, p. 9). Pedagogical interventions are no longer directed only towards a solitary and individual action to also integrate the activity of subjects in mutual collaboration.

In this direction, the simultaneous occurrence of the triad of individual activity, group interrelations, and systematization mediated by teacher are important for building knowledge. Learning is produced by the balance of these three components (MORAN, 2018).

With these considerations, in this work, collective creativity is addressed in the field of mathematics using the nomenclature Shared Creativity in Mathematics, which is defined as

> Um fenômeno que ocorre em coletivos nos quais as pessoas reúnem-se para realizar algum tipo de atividade, trazendo suas marcas individuais e contribuindo com o compartilhamento cognitivo e afetivo de suas experiências de vida. O trabalho coletivo, decorrente de um processo social no qual o conhecimento é construído na ação de seus membros, concretiza-se em situações de interação nas quais a realidade é (re)elaborada. No entanto, tal interação depende do modo como serão geridas as relações de poder entre os integrantes de tal coletivo. De tal modo, no processo de criação compartilhada, identidades não podem ser apagadas em detrimento da superposição de posicionamentos hegemônicos. (CARVALHO, 2019, p. 94).[4]

In this process, some elements become important so that joint efforts allow the appearance of qualitatively superior ideas, that is, more original and efficient ideas in the resolution of problems faced (CARVALHO, 2019). For the present study, seven important elements are addressed: negotiation of directions, positive affection, leadership, provision of feedback, conscientiousness, use of ideas, and divergent thinking.

The first element refers to the **negotiation of directions**. By interacting and trying to reach a consensus on the best solution for a problem, valuable exchanges of information occur, which allows for moments of inspiration, making team members mix ideas and build solutions for problems with higher quality (AUTHOR 1, 2019, p. 217).

Positive affection allows good results when working in teams. By transmitting positive messages, a high-quality interaction is established, allowing people to feel authorized to create, being involved in an environment of loyalty, respect, contribution, and positive affect (GUASTELLO, 2007).

A third element concerns the emergence of **leaderships**. The activity of one or more subjects who, when working in team, organize actions (MUMFORD, et al., 2003), allows for a better creative performance and the observation of many, diverse and original ideas in comparison to groups in which such leadership is not manifested (CARVALHO, 2019). Other elements that derive from leadership collaborate for the collective production of good ideas (MITCHELL; REITER-PALMON, 2017) such as, for example, the **provision of feedback**, which allows for guidance of performance, refinement of ideas, and conflict management. This explains the fact that more creative solutions can come up when people who are involved in creative action provide appropriate feedback or assessment (GUO; DILLEY; GONZALES, 2016). Leaders can also have **conscientiousness**, which attributes judiciousness when choosing adequate solutions for the rules, during creative action, especially when reviewing solutions.

A team that can use ideas suggested by peers, harnessing them to build solutions for the problems, ends up combining elements that, alone or in other contexts, would go unnoticed as they do not provide the expected answers.

Therefore, the element **use of ideas** has shown to be important in the process of creative sharing (CARVALHO, 2019).

Lastly, the team needs to have the ability to think divergently. To Lubart (2007), **divergent thinking** is a process that allows for searching for numerous ideas or answers in a pluridirectional manner from a simple starting point" (p. 26).

For studies that include students with ASD and their peculiar ways of thinking and communicating what they produce, the phenomenon of shared creativity in mathematics assumes an essential and thought-provoking nature to be observed, considering that the ways of sharing their cognition and affection may not correspond to those of students with typical development (TD).

FROM THE STIGMA OF LIMITATION TO THE PERSPECTIVE OF AUTISTS AS SUBJECTS WITH POSSIBILITIES

Considering that the DSM-V Diagnostic and Statistical Manual of Mental Disorders characterizes autism as the presence of, among other characteristics, impaired social interaction, difficulties in language and restricted interests, it is necessary to understand how such characteristics can influence the development of skills oriented towards teamwork and, consequently, to shared creativity in mathematics. The manual states that many individuals with autism spectrum disorder have "intellectual and/or language impairment" (e.g., speech delay, production-comprehension asymmetry). Even those with medium or high intelligence have an irregular capacity profile" (APA, 2014, p. 55).

Based on psychiatry and psychology, such manual moves autism away from "more philosophical grounds, towards organicist perspectives" (SILVA, 2019, p. 24). This definition is based on a deficient perspective, as it indicates what is lacking and forgets to mention subjective aspects that constitute every diagnosed subject. In this respect, we seek to direct this work towards a conception that is contrary to the medicalization of the development of autists, directing discussions towards the social perspective, considering them as children who learn as subjects with possibilities (BATISTA; TACCA, 2011) when interacting with peers and more experienced subjects.

Iatrogenesis in education – a term supported by the Ivan Illich studies (1992) and denotes the medicalization of education, characterized by the increasing dependence on the use of drugs to treat learning problems arising from psychic disorders – is shown to be a dangerous and potentially harmful movement to the development of those who have learning difficulties in school, as seeing the condition of these subjects as a pathology tends to emphasize their limitations to the detriment of the possibilities of overcoming the difficulties encountered. The need of schools to go against the iatrogenic tide of autism diagnosis emerges, problematizing conceptions that guide pedagogical practices based on the absolute faith in medical perspective (ORRÚ; SILVA, 2015, p. 59).

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To Silva (2019), the positivist perspective of "individual" comes from a permanent search for balance, and peculiarities, idiosyncrasies, and contradictions are potential conflict factors for this "peace agreement". In order to reach this positive "humane" ideal, the combination of medication and education would be necessary (SILVA, 2019, p. 27). Thus, autism is not considered as a difference, but rather as a disease that may be cured with medicines. If autism is a difference rather than a disease, the search for cure constitutes an attempt to erase difference and diversity (ORTEGA, 2009, p. 72).

Seeing autists as subjects with possibilities allows one to see them in their integrity, putting what is signaled as evidenced alternative paths for overcoming traditional paths that do not have effect in their development in the wake of learning. It no longer starts from their limitations but guides them in pursuit of knowledge consolidation. It is necessary to consider that the role of diagnosis in the paths of pedagogy has taken from school the possibility of advancing methodologically towards a student-oriented practice, their learning process, and their possibilities (ORRÚ; SILVA, 2015, p. 61).

CREATIVITY IN MATHEMATICS AND AUTISM

Research that aims to understand the creative processes of subjects with autism have sought to quantitatively compare the performance of people with typical development with that presented by autistic individuals in tests of verbal and figurative creativity (KALANDADZE, et al., 2022; KASIRER et al., 2020; BEST et al., 2015). These studies have shown that autistic people can perform on tests equal to or better than people with typical development.

Kasirer et al. (2020) found that children with autism demonstrate a unique creative cognition profile, using cognitive skills when subjected to a verbal creativity test in which they were asked to generate metaphors and another figurative creativity test in which they were required to perform cross-category insertions (create something new by combining elements from different objects). Despite the literature hegemonically finding limited imagination in autistic individuals, deficits in cognitive flexibility and difficulty in understanding figurative language, performing literal interpretations in metaphorical constructions, studies such as Kasirer et al. (2020) bring a counterpoint by understanding that autistic individuals do not necessarily differ from their peers with typical development (TD) in all aspects of figurative language processing (not demonstrating impairments in the ability to identify new semantic connections between seemingly unrelated concepts, that is, in non-lexicalized figurative language) and who are able to present creative thinking.

Thus, these researchers demonstrated that autistic children have more difficulties in understanding conventional metaphors (for example, feeling angry is a volcano) than their TD peers of the same age, and the same does not occur with unknown metaphors, that is, unusual ones (for example, feeling worthless is evaporated water), a situation in which they demonstrated better performance

(KASIRER et al., 2020). In addition, autistic subjects elaborated more creative metaphors and used more cross-category insertions, that is, they were able to combine elements of different objects or beings in an original way.

With the study by Kasirer et al. (2020), it is evident that autistic children build creative responses because they present a cognitive process guided, above all, by two distinct characteristics in relation to students with typical development. First, they show a good ability to make new semantic connections that do not depend on prior lexical verbal knowledge, since “unlike conventional metaphors that are encoded in the mental lexicon, the interpretation of new metaphors is not encoded and, therefore, does not depend on prior knowledge”. (KASIRER et al., 2020, p. 9). The second characteristic refers to the mental blindness that allows them to ignore the addressee, focusing on their own thoughts, which may favor the emergence of less conventional expressions (KASIRER et al., 2020), since they are not concerned with the audience's judgments, but rather are looking for solutions that satisfy their inner thoughts (internal dialogue).

In line with the perspective that autistic people demonstrate peculiar cognitive processes, Best et al. (2015) suggest that these people have a potential cognitive advantage that allows them to produce unusual responses in problem solving. People with typical development produce more common responses first to, over time, produce less common responses, evolving from semantic associations of what is available in their episodic memory to more elaborate strategies based, for example, on the decomposition of parts of objects and re-composition through the combination of these parts.

Autistic people, on the contrary, approach problems in a different way, not resorting to an associative or memory-based route (a broader semantic process that occurs in the right hemisphere of the brain and which, in autistic people, is impaired), but depart directly of more elaborate strategies (narrow semantic processing that occurs in the left cerebral hemisphere and that is not impaired in autistic individuals). The answers presented are likely to be more original and unusual, since they start from more complex processes to create their solutions (BEST et al., 2015). By acting in this way, the cognitive processes of autistic people make up for what they lack (difficulties in resorting to trivial knowledge conventionally shared in society), insofar as they focus on elaborating solutions based on more elaborate associations (since they do not start from ideas already known socially).

In the area of creativity in mathematics, the study by Hetzroni et al. (2019) also compared the performance of autistic children with that demonstrated by typically developing children in tests of general creativity and test of creativity in mathematics. The authors conclude that creativity is a skill that can also be found in autistics, since they performed similarly in both tests of creativity, with autistics slightly outperforming TD students in terms of originality.

Studies involving creativity in autistic people focus on traditional areas such as creativity in general or artistic creativity, and in other areas, such as mathematics, this theme still needs to be explored (HETZRONI et al., 2019). Combining this finding with the fact that research has not yet managed to reach a minimum level of consensus regarding the relationship between creativity and autism (KASIRER et al., 2020) and, furthermore, that there is a hegemony of quantitative approaches and a shortage of qualitative ones, the present study presents an unprecedented character and proves to be important and necessary.

The inconclusive results (KASIRER et al., 2020), which are divided into demonstrating that autistic people are less, as or more creative than people with TD, have created a paradoxical reality (WING, 1981; BEST et al., 2015; KONKIEWITZ, 2018), as some studies have suggested the non-commitment of creative abilities in autistic individuals, even though other findings point to deficiencies in the domains of social behavior, communication and imagination (WING, 1981; KONKIEWITZ, 2018), which would appear to be limiting for these subjects to outline some form of creativity.

In the present study, it is suggested that other focuses, in addition to the comparison between autistic people and TD people, need to be better explored, seeking to study the autistic person in view of his/her limitations and possibilities. It is not a question of finding out who is more or less creative, but of studying the evidence that allows access to the cognitive processes employed by the autistic person when developing ideas. With this, one can understand the idiosyncrasies that make such people constitute different learning and development routes, allowing those responsible for supporting their school success (parents, teachers, etc.) to develop appropriate pedagogical interventions for their needs. Quantitative methodologies do not favor highlighting this dimension, thus requiring a qualitative look that allows access to cognitive processes that are difficult to detect through psychometric approaches.

METHODOLOGY

The qualitative methodology guided the study, having as a pillar the dialogic mathematical learning approach (DIEZ-PALOMAR, 2017), adopting the dialogic conversation methodology. Thus, opportunities were created for the subjects to work in trios, in order to favor the understanding of how, in this reality, an autistic student communicates with peers, collaborating, receiving collaboration, negotiating meanings and participating in the collective construction of solutions to mathematical problems. We understand that the dialogic conversation methodology allows creating a relational space in which “interactional events when two or more individuals work together to solve a mathematical task” can be analyzed (DIEZ-PALOMAR, 2017, p. 41), taking dialogue as a means to observe cognitive learning.

Three students enrolled in the fifth year of a public school in the Federal District participated in the research, one diagnosed with Autistic Spectrum Disorder, CID 10-F84, and two considered as children with typical development (TD). The students were male and 11 years old. They were selected according to convenience criteria (one of the researchers is a pedagogical supervisor at the school where the children are enrolled). The class teacher and the school board were consulted regarding authorization to carry out the study. Then, the consultation was made with the autistic child and their parents, at which time they signed the Free and Informed Consent Form (TCLE). Finally, the child was asked (we will identify with the AA code) with whom he would like to work during the resolution of mathematical problems. The children he chose (AT1 and AT2) and their parents were consulted about participation, proceeding with the signature of the TCLE.

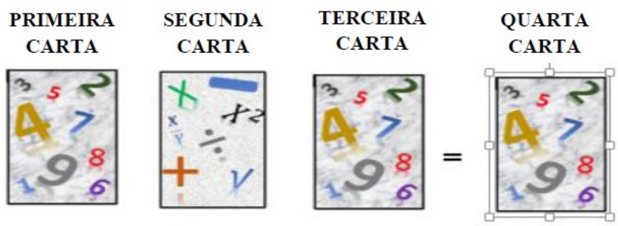
INSTRUMENTS

For data collection, arising from dialogical conversations (DIEZ-PALOMAR, 2017), the Test of Creativity in Mathematics (CARVALHO, 2019) was used. The test consists of problem-solving questions where respondents are required to provide correct, varied, and original answers. Thus, fluency (number of correct answers), flexibility (number of different classes of answers) and originality (statistical rarity) of the set of answers provided by a group of respondents are analyzed.

Since our research has a qualitative nature, we did not focus on raising scores related to the number of correct answers. We are concerned with analyzing the interactions established during the test, therefore, we will direct the discussion to the process of collective production of solutions and not to the result itself. Figures 1, 2 and 3 show the test items.

Figure 1 – Item 1 of the test: Solving open problems

Agora você vai conhecer um jogo matemático disputado em equipes de 4 pessoas. A primeira, a terceira e a quarta pessoa recebem, cada uma, um conjunto de cartas embaralhadas e numeradas de 1 à 9 e a segunda pessoa recebe um conjunto de cartas embaralhadas com todos os sinais de operação matemática que você possa conhecer. As três primeiras pessoas retiram uma carta formando uma operação matemática cuja resposta deve ser a carta retirada pelo quarto participante. Se a quarta carta apresentar um resultado correto para a operação, a equipe ganha ponto.



Pense em muitas maneiras possíveis em que a equipe possa ganhar pontos e registre abaixo.

Source: CARVALHO (2019).

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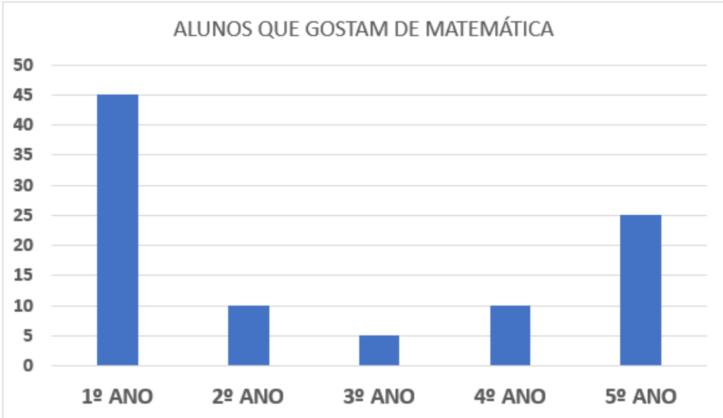
Figure 2 – Item 2 of the test: Elaboration of problems

Em uma pesquisa, Luana deveria descobrir quantos alunos de cada ano escolar gostavam de matemática. Ela registrou os dados no gráfico abaixo.



Crie perguntas que possam ser respondidas com as informações do gráfico.

Fonte: CARVALHO (2019).

Figure 3 – Item 3 of the test: Solving open problems

Utilize retas horizontais, verticais e inclinadas para dividir os retângulos em oito partes de tamanhos iguais. Busque muitas maneiras diferentes quanto possíveis para dividir os retângulos.
Abaixo estão disponíveis alguns desses retângulos para que você possa dar o maior número de respostas possíveis.

Source: CARVALHO (2019).

DATA ANALYSIS

The interactions were recorded and transcribed. By constructing solutions to mathematical problems and expressing their impressions about the collective work, the students provided evidence that allowed them to understand how shared creativity took place when an autistic student participated in the collective work.

For this purpose, content analysis (a set of communication analysis techniques) was used to analyze this evidence and reconstitute, through inferences (BARDIN, 2006), the cognitive processes employed in the production of mathematical ideals. Analyzing the communicative interactions and the solutions presented in the protocols, it was possible to carry out a category analysis (BARDIN, 2006) of the interactions carried out and to understand how the AA student collaborated and received collaboration in the construction of solutions for the problems.

The following steps were followed: pre-analysis (organization of the research material based on a fluctuating reading of the analysis corpus), exploration (text synthesis, reducing the textual information to the keywords that constituted the recording units responsible for allowing 3 levels categorization: initial, intermediate and final) and treatment of results, inference and interpretation (comparison of the treated material, analyzing the categories found, in order to make inferences and interpret the phenomenon, contrasted with the theoretical framework).

PROCEDURES

The research was carried out during three sessions recorded with the authorization of parents and participants. In this article, results of the second version are presented, which lasted about 45 minutes, in which students freely responded to the items of the Test of Creativity in Mathematics - TCM (CARVALHO, 2019) composed of the three items presented in Figures 1, 2 and 3.

RESULTS AND DISCUSSION

After transcribing the interactions that took place, contrasting the dialogues with the records in the protocols and with the theoretical assumptions, the initial categorization was reached, which resulted in 17 categories. Observing the frequency of their appearances in comparison with the contexts in which they occurred, the intermediate categorization, grouping the initial findings into four categories. Finally, we proceeded to the two final categories, showing how the AA student collaborated and received collaboration from their peers, as shown in Table 1.

The analyzes carried out demonstrate that the student with ASD, when interacting with their peers, collaborated and received collaboration in the construction of ideas, contributing to the process of shared creativity in mathematics. The high-quality interactions (GUASTELLO, 2007) established by the participants allowed them to build mathematical ideas collectively. Next, it is demonstrated how, in the dynamics of social interaction in search of collective construction of solutions for mathematical problems, this process was constituted.

Table 1 – Content Analysis

Final categorization	Intermediate categorization	Initial categorization
How an autistic person collaborated in the construction of ideas	Personal characteristics	Access to un-lexicated verbal knowledge
		Internal dialogue
		Denial of the trivial proposal
		Resistance to rigidity of thought
		Analogical thinking
	Characteristics favorable to shared creativity in mathematics	Leadership
		Divergent thinking
		Positive affect
	Construction of ideas	Feedback request for peers
		Problem-solving
		Acceptance of suggestions
		Construction of ideas
		Use of ideas
How an autistic person received collaboration in the construction of ideas	Enhancement of peer ideas	Providing feedback
		Negotiation de senses
		Improvement of ideas
		Review of ideas

Source: Made by the authors (2022).

PERSONAL CHARACTERISTICS

Personal characteristics of the student with ASD constituted important factors that attributed singularities to the collective work, allowing unusual, varied and original answers to surface and qualify the process of elaborating answers to the presented problems. The first concerns the difficulty demonstrated by the AA participant in resorting to lexical verbal knowledge (KASIRER et al., 2020), that is, that knowledge that becomes a consensus to which people usually resort beforehand to solve problems.

For several moments, this was clear in AA's speech, demonstrating that he had difficulty thinking conventionally. For example, when starting the card game activity (Figure 1), the following dialogue occurs:

> Researcher: You will think together.
>
> AA: I don't know how to think, I just know how to do it.

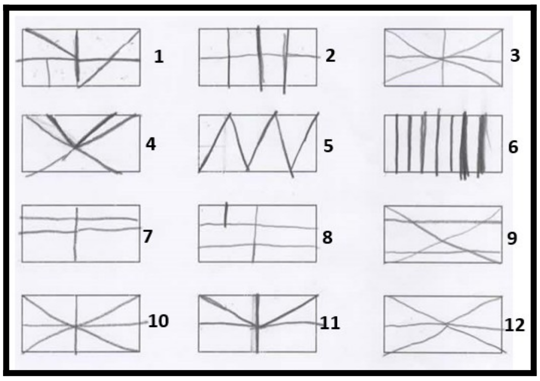
In this passage, and in many other passages, he demonstrates that he has difficulties in resorting to consolidated knowledge (**I don't know how to think**), preferring to create, in practice, non-conventional solutions. Therefore, as he finds it difficult to access prior lexical verbal knowledge, he presents a unique way of acting and creating. A student with typical development and average school performance, for example, would access knowledge built in the classroom consensus to solve a problem, preferring not to risk unconventional paths that could result in error and, with that, escape social judgment (CARVALHO, 2019). To compensate for this difficulty in accessing conventional knowledge, AA ends up resorting to other resources such as, for example, **analogical thinking**.

Gardner (1993) explains that human intelligence is crossed by analogous phenomena from the first months of life (associating, for example, rhythms to visual stimuli). Through analogies and metaphors, people can explain and understand phenomena that otherwise could not be accessed directly.

Analog processes occur through transfers of relational information from a source domain to another to be explained. (VOSNIADOU; ORTONY, 1989). As figurative language, analogy may seem like something an autistic person has difficulty using to compose ideas and explain them. However, in our study, AA repeatedly resorted to this type of process to create solutions to problems and explain this creation process. Since he believed that he could not "think", having difficulty accessing lexical knowledge, he sought inspiration in situations from other domains to obtain valid answers to the questions.

The first occurrence occurred when, when trying to divide the rectangles into eight equal parts, after creating some solutions and helping to create others, AA got into the following dialogue, which resulted in the elaboration of answer 4 (see Figure 4):

Figure 4 - Solutions for dividing rectangles



Source: Authors (2022).

AA: I just had a great idea. I'm going to make, more or less, a pyramid. (He draws, in the air, diagonal lines forming triangles).

AT1: Ah! True, they will all have equal sides.

AA keeps drawing and counting how many pieces they form. 1, 2, 3, 4, 5, 6. He snaps his fingers and sees that they made only six pieces. Then he says:

AA: If I make it smaller, I can. And if we cut way. Oh no! (He snaps fingers).

They try other solutions to improve that solution and, despite receiving positive feedback from their colleague AT1, they give up and go to another rectangle. By using analogical thinking to produce a solution different from the previous ones, the student brings innovation that will inspire the colleagues in the construction of the ideas. Note that the next answer, made by colleague AT2, follows the reasoning of using only diagonal lines, which they had not tried in the first 3 solutions.

To build solution 11, AA again resorts to analogical thinking, this time taking inspiration from the movement of clock hands

> AA: Like, here's one and a half hours (draws a vertical line mistakenly referring to the angles formed by the hands of the clock when it says half past 12).
>
> AA: If I think of it like an hour and a half, two and a half, twelve and a half. (Colleagues compare with the other answers and see similarities).
>
> AT2: It won't work.

It is noted that, when analogical thinking was used to produce solutions, the ideas were not implemented, since the barriers encountered made them give up on the initial ideas. However, the action of AA, making analogies (which was not noticed in their peers), allowed the team to produce flexibility of thought and inspired colleagues in their ideas.

Another important characteristic that favored collective creative work concerns the internal dialogue, typical in students with ASD (KASIRER et al., 2020) and which, in the case studied, allowed moments of self-reflection that led AA to contribute with original ideas. At times when colleagues were writing, AA would observe the already divided rectangles and begin to speak, in a loud voice with himself. Moments later, some idea that brought a new aspect emerged, redirecting the solutions to paths not yet thought of. This fact occurred in the example of question 11 mentioned above and can also be observed in the problem elaboration question (see Figure 5).

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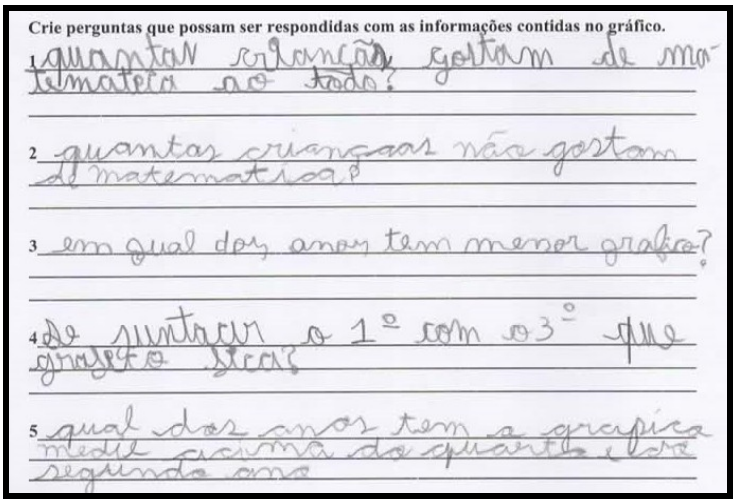
Figure 5 – Elaborated problems



Crie perguntas que possam ser respondidas com as informações contidas no gráfico.

1 quantas crianças gostam de matematica no todo?

2 quantas criançaas não gostam de matematica?

3 em qual dos anos tem menor grafico?

4 Se juntar o 1º com o 3º que grafico fica?

5 qual dos anos tem a grafica medio acima do quarto e do segundo ano

Source: Authors (2022).

From the set of solutions, the first question was created by AA and presupposes the idea of addition (joining quantities). Then, their peers move on to crafting questions that require subtraction ideas. The AA student, talking to himself, states that he had a great idea and changes perspective by elaborating a question that again requires an idea of addition. To that extent, it can be seen that, while colleagues AT1 and AT2 share and remain fixated on the idea of subtraction, the dialogue they establish with themselves stimulates the change of perspective of their peers.

This finding is consistent with two other personal characteristics: **denial of trivial proposals and resistance to rigidity of thought**. Although rigidity of thought is a characteristic commonly found in autistic people, as they tend to show resistance to changes, restrictive or obsessive behaviors (SOUZA NEVEZ, 2019), the AA student showed concern in avoiding responses that repeated characteristics (flexibility) and that they were trivial (originality). This finding may have been due to the nature of the activities, since the student knew that the activity required many different and original responses.

However, in many moments, their peers showed rigidity of thought, not showing the same concern as AA. In the card game activity (see Figure 6), the first one they performed in the study, AA starts by making the first answer and then passes the sheet to the others to answer. Observing the sequence, we see that AA created solutions 1, 4, 7, 10, while AT1 presented answers 2, 5, 8 and AT2 produced 3, 6 and 9.

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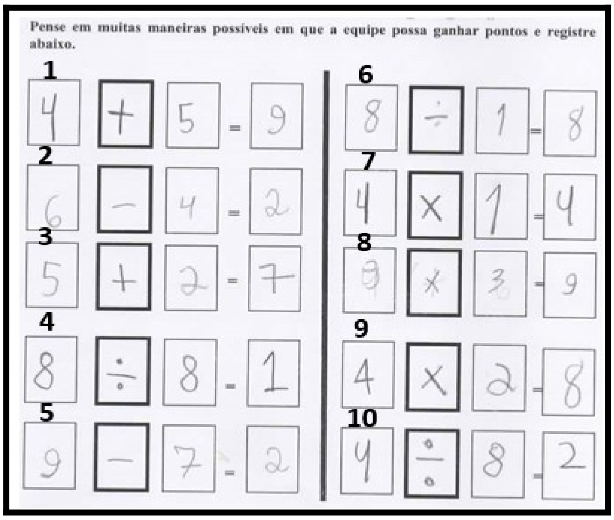
Figure 6 – Card game answers



Source: Authors (2022).

From the sequence of responses, it is noted that AA was responsible for breaking the rigidity of thought, being the first to create an addition, the first to create a division and also a multiplication. The following excerpts make clear the fact that AA seeks to break with the rigidity of thought. After colleague AT1 registers solution 5 (see Figure 6), AA takes the sheet and passes it to AT2. So, his colleague says:

> AT2: I'll do the same as AA.
>
> AA: No, if you do the same, you have to make another operation.
>
> AT2: I know, just the opposite.

So, AT2 is inspired by AA and produces the 8 ÷ 1 = 8. AA's attitude, being resistant to rigidity of thinking and attributing flexibility to group work, represents an essential characteristic for success in activities that require creativity (LUBART, 2007) and creativity also in mathematics (LEIKIN, 2013; GONTIJO, 2007; CARVALHO, 2019).

Below, we have an example of how the student demonstrates that he refuses to accept trivial proposals, favoring the emergence of originality, another key factor for the emergence of creativity in collective work (CARVALHO, 2019; SAWYER, 2010; GLAVEANU, 2014). AA was, in a process of internal dialogue, thinking about how to present an idea that had not yet been demonstrated. So, he put divergent thinking into action, as he sought an answer that no one had yet produced, which enabled the generation of several different ideas and several tracks to follow (LUBART, 2007). Thus, the researcher intervenes:

> Researcher: You can say it out loud, okay AA, what kind of operation are you thinking about?

> AA: Divide. (He is trying to create the first division, recorded in answer 4 in Figure 6).
>
> AT2: Why don't you put number 2 there? (Suggesting an easier solution).
>
> AA: I only have 15 minutes, there's only 15 minutes!!! (Denying the trivial proposal)
>
> AT2: 2 + 2. So, 2 + 2 equals 4. (Resumes the trivial proposal).

AA keeps thinking and, refusing to accept his colleague's proposal to create a rather trivial addition operation, arrives at a solution not yet presented by any of his peers (8 ÷ 8 = 1) and which will inspire other solutions of this nature.

FAVORABLE CHARACTERISTICS FOR SHARED CREATIVITY

In addition to the divergent thinking previously mentioned, student AA displayed other characteristics favorable for creativity in mathematics, such as leadership and positive affect. Mitchell and Reiter-Palmon (2017) showed in their research that leadership action enhances the creativity of teams. In the case of AA, this was clear since the leadership role came to the fore from the child's first contact with the activities. Thus, the child soon took the activity sheet, provided the first solution, and started to organize the relay of the process of creating mathematical ideas.

Leadership activity proves to be paramount in the collective creative process (TIERNEY et al., 1999; GUASTELLO, 2007; MITCHELL AND REITER-PALMON, 2017), with leaders playing an organizational role in this dynamic (MUMFORD, et al., 2003) by boosting the creativity of others. In the first interactions, AA projects himself as a leader by organizing the alternation of the answer sheet, passing it in all hands, and ensuring everyone's participation.

Over time, this leadership develops into more complex dialogic processes, such as providing feedback, negotiation of meaning, problem-solving, and reviewing the ideas of his peers. In playing this role, AA contributes to the development of a complex interaction process characterized by the variety and quantity of conversational behaviors, in which moments of questioning, offering creative ideas, expanding on the ideas of others, and facilitating the expression of his peers can be noted (GUASTELLO, 2007).

During the recorded interactions, the child demonstrates coordination of activities. In nine episodes, he directs the processes of the creation of ideas. Below, we reproduce an excerpt to illustrate his leadership posture. After they finish the elaboration of problems (see Figure 5), the researcher questions them:

> Researcher: You still have a little bit of time left. Do you want to change anything, add anything, or anyone to read to see if everything is written right?

> AA: Me. How many kids like mathematics... (Takes the initiative and begins to read the prepared questions, leading colleagues to review the produced ideas.)

This leadership posture is consistent with another characteristic favorable for the collective production of ideas: the demonstration of **positive affect** toward his peers. In many moments, AA acted by installing a positive atmosphere, bringing psychological security when colleagues seemed distressed by the problems to be solved. For example, when they tried to divide the first rectangle of the question (see Figure 4), after taking turns among the three colleagues trying to get to eight pieces, they encountered difficulties:

> AT2: Five with this one.
>
> AA: Then I'll make one just like it. Six, seven (counts seven, mistakenly). THERE's the last one... (passes to AT2 to conclude the idea).
>
> AT1: Now it's a problem.
>
> AA: No problem. Keep dividing (he supports his colleague, who feels safe to continue the idea).

With the moral support transmitted by AA, they proceed with the idea by completing the figure with a vertical line (AT2) and another diagonal line (AT1) and arrive at the eight pieces needed. In the end, AA checks the solution and realizes that the first diagonal line resulted in different-sized pieces. Then, AA pulls the sheet close and encourages his classmates to move to another rectangle.

It shows that AA provides "psychological safety [and] encourages their employees to share new and creative ideas and be more creative" (MITCHELL; REITER-PALMON, 2017, p. 372) by conveying positive affect. This support came in the form of words, of excitement communicated by snapping fingers and clapping hands, and by encouraging peers to continue ideas even in the face of difficulties.

CONSTRUCTION OF IDEAS

The autistic student demonstrated five different ways of receiving help and helping to construct ideas: **by requesting feedback from peers, solving problems, accepting suggestions, creating ideas, and taking advantage of ideas** that seemed fruitless at first. The request for feedback occurred when he faced some barrier or had doubts if he was following the necessary rules to present a valuable idea, a moment when he encouraged peers to participate by giving their opinions.

When faced with barriers to completing an idea, AA was persistent, checking for misunderstandings and solving the problems encountered. One can exemplify his ability to find ways out of the barriers in the episode in which they

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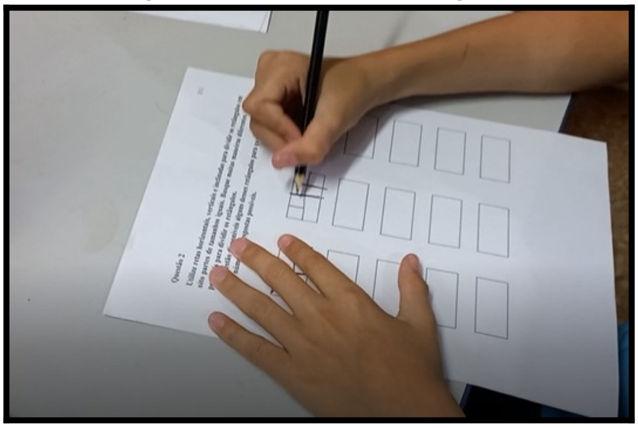
constructed the division of rectangle 2 (see Figure 7). After deciding to use only lines with no inclination (receiving and accepting the ideas of peers) and collectively creating the idea, AT2 realizes that they did not reach eight equal parts.

> AT2: It's wrong. One is bigger than the other.

AA counts again. He realizes that there are seven pieces and complements the shorter line lengthening it. He checks and realizes that he has solved the problem, arriving at eight pieces.

Figure 6 - Answers to the card game



Source: the authors (2022)

When reviewing solution 5 (see Figure 4), the children realize that the idea resulted in only six parts. Then, AT1 asks the researcher:

> AT1: Can I pull a square over here? (Drawing straight lines in the air, asks if he could extend the rectangle by drawing another piece on its side).
>
> AT2: No. You can't (providing feedback to the colleague).

AA observes what AT1 proposed and eventually has an inspiration, taking advantage of the peer's idea. Therefore, he goes to the next rectangle and solves the problem of the previous solution, taking advantage of his peer's suggestion and creating rectangle 6, a new, original, and flexible idea.

In this situation, we can witness an interactive process in which AA receives feedback from peers, makes use of opinions, and can help his team to elaborate and share mathematical solutions while collaborating in the construction of ideas. Fischer and Mandl (2005) conceived this as co-construction, that is, complex discursive patterns established by people in the learning process who respond transiently to the contribution of their peers, building on what the others collaborated on before.

IMPROVEMENT OF IDEAS

Once a group can establish moments of intense exchanges, guided by the evaluation and negotiation of meanings, it finds conditions to improve ideas, resulting in flexible and original solutions, therefore, more qualitative (CARVALHO, 2019). In our study, the improvement of ideas occurred to the extent that AA could provide help (giving and receiving feedback, negotiating meanings, improving and revising ideas), which was reciprocal since he also received contributions from his peers. The following excerpt allows us to apprehend one of these moments when ideas were improved. The moment happened in the context of problem elaboration (see Figure 5).

> AT2: Ask a question like this, oh. Hmm, how many more like math?
>
> Researcher: How many more, what? Discuss you three.
>
> AT2: How many kids...
>
> AA: I got it, I got it, I got it. So, oh: How many kids like math altogether?

When AA realized that information was missing in his colleague's proposition, he **improved the idea**, supplying what was needed and leading the team to compose the first solution. This improvement process usually precedes moments of **reviewing ideas, providing feedback, and negotiating meaning**. AA demonstrated skill in reviewing ideas and checking the validity of the solutions to see if they conformed to the established rules. When he found a mistake, he would expose it to the group, providing feedback, and then they would reflect together and negotiate until they reached a consensus.

In the following excerpt, we can see how these actions complemented each other until an initially wrong solution came to be evaluated, managing to repair the misconceptions and improve the solutions. AT1 was thinking of a solution to the letter problem (see idea 8 in Figure 6). Then, AA reviewed the idea by counting on his fingers and realized that the result was 10. Afterward, he gave the following feedback to his colleague:

> AA: Oh, no! It's from 1 to 9, bro! You'll have to think of another solution.

AT1 checked the previous solutions, realized that there were already two additions, and suggested creating a 3x3 multiplication. The group embraced the solution and came up with a more flexible answer. Van Den Bosch et al. (2011) warn that for a team to build patterns of learning behaviors with high-quality interactions, processes of construction (of meanings and understandings) and constructive conflict (agreement on the proposed solution) are relevant. Being aware of this fact allows the teacher to install significant dialogical processes in the classroom since, when interacting, students share their cognitions, express and defend personal constructions, and listen to those of others, constituting the negotiation of mathematical meanings (RODRIGUES et al., 2018).

CONCLUSIONS

During this study, one realizes how relevant interactions were for ideas development enabled by sharing solutions to problems. Just as Kaspar Hauser appropriated human culture by living with other humans, the interaction with teachers and peers in the classroom allows a set of interactive processes favorable to the appropriation of cognitive and affective knowledge necessary for the construction of solutions to the problems faced. Therefore, providing opportunities for rich interactions is a significant factor for students with typical development and students with ASD to individually and collectively build mathematical knowledge, a rich collaborative process in which everyone benefits.

To label students with autism as "socially limited individuals" is a very cruel facet imposed on these individuals by those who consider themselves to be people with typical development. Looking at the students as unique and different beings, as everyone is, allows us to attribute a character that favors their development since the focus goes from what they cannot accomplish to highlighting their possibilities (BATISTA; TACCA, 2011), skills and unique conditions that allow them to enrich social interactions.

The findings of this investigation, which still need to be extended with studies involving autistic individuals with various levels of impairment, allow us to understand how their unique conditions make the sharing of mathematical ideas a phenomenon with rich possibilities. The result of the conjunction of their unique characteristics and ways of helping and being helped with the characteristics of their peers proved to be a relevant counterpoint during studies that account for limitations in imagination, creativity, and social interaction of autistic people as something that hinders or prevents their development.

The autistic child allowed for the qualification of both the discursive exchanges and the solutions presented to problems by showing unique abilities such as thinking analogically, drawing on non-lexical knowledge, dialoguing with himself before debating with peers, deviating from trivial solutions, and with fixed thinking. Adding to this, the way he led the idea production process allowed for the sanding and polishing of initial solutions (SAWYER, 2007).

It is still necessary to unveil many singularities that autistic individuals present. It may favor the development of pedagogical interventions that allow their development in the school environment. However, ongoing investigations already signal that, just like any other human being, autistic individuals have weaknesses and potentialities, being fully capable of building mathematical ideas individually and collectively.

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Transtorno do espectro autista e criatividade compartilhada em matemática: rompendo o estigma da limitação para dar lugar às potencialidades

RESUMO

Analisou-se como se dão os processos envolvidos na criatividade compartilhada em matemática de um estudante de 11 anos de idade com Transtorno de Espectro Autista em interação com pares da mesma idade. Buscou-se compreender como sujeitos com essa condição conseguem produzir ideias matemáticas submetidos ao trabalho coletivo, ajudando os pares e sendo por eles ajudado. Partindo de uma abordagem qualitativa, utilizou-se como instrumento de coleta de dados um teste de criatividade em matemática em que os alunos são convidados a responder e elaborar problemas abertos. Entrevistas e interações foram gravadas, transcritas e, posteriormente, tratadas por meio da análise de conteúdo. Encontraram-se 17 categorias iniciais nas quais o processo de produção criativa ocorreu na realidade estudada, sendo agrupadas em 4 categorias intermediárias: a) Características pessoais, b) Características favoráveis à criatividade compartilhada em matemática, c) Construção de ideias, d) Aprimoramento de ideias dos pares. Por sua vez, essas foram alocadas nas categorias finais: a) Como um autista colabora na construção de ideias e b) Como um autista recebe colaboração na construção de ideias. Com os achados, conclui-se que a atuação do estudante autista, com suas condições singulares, tornou o processo de compartilhamento de ideias matemáticas um fenômeno com ricas possibilidades.

KEYWORDS: Autismo. Criatividade Compartilhada em Matemática.

NOTES

1. Wait until the teacher asks a question, quickly raise your hand, wait in silence until the teacher calls you, share your answer (usually trying to combine your answer with what you think the teacher expects to hear), and wait until the teacher tells you whether your answer is appropriate, correct or acceptable. (BEGHETTO, 2010, p. 450, translation ours).

2. The capacity to present numerous possibilities of appropriate solutions for a problem situation, in a way that these solutions focus on distinct aspects of the problem and/or different ways of solving it, especially uncommon manners (originality), both in situations requiring the resolution and elaborations of problems and in situations requiring 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 sequence of actions (GONTIJO, 2007, p. 37, translation ours).

3. A phenomenon that occurs in groups in which people gather to do some type of activity, bringing along their individual traits and contributing with the cognitive and affective sharing of their life experiences. Collective work, resulting from a social process in which knowledge is built in the action of its members, materialize in situations of interaction in which reality is (re)made. However, such interaction depends on how power relations will be managed among members of such group. In this way, in the process of shared creation, identities cannot be erased to the detriment of overlapping of hegemonic positions (CARVALHO, 2019, p. 94, translation ours).

4. Translate: Lukelly Fernanda Amaral Gonçalves. E-mail: certifique-se@hotmail.com

REFERENCES

AMERICAN PSYCHIATRIC ASSOCIATION-APA (2014). **Manual diagnóstico e estatístico de transtornos mentais**: DSM-5. Porto Alegre: Artmed., 2014.

BARDIN, L. (2006). **Análise de conteúdo**. [Analysis Content] Lisboa: Edições 70., 2006.

BATISTA, A. S.; TACCA, M. C.V. R. (2011). Errata: onde se lê deficiente mental, leia-se criança que aprende como sujeito de possibilidades. In MARTÍNEZ A. M.; TACCA, M. C. V. R. (Orgs.). **Possibilidades de aprendizagem**: ações pedagógicas para alunos com dificuldade e deficiência. Campinas: Alínea, 2011. p. 139-152.

BEGHETTO, R. A. (2010). Creativity in the Classroom. In: KAUFMAN, J. C.; STERNBERG, R. J. **The Cambridge Handbook of Creativity**. New York: Cambridge University Press, 2010. CapChapter. 23, p. 441-463.

BEST, C.; ARORA, S.; FIONA PORTER, F.; DOHERTY, M. (2015) The Relationship Between Subthreshold Autistic Traits, Ambiguous Figure Perception and Divergent Thinking. **Journal of Autism and Developmental Disorders**, p. 1-11., 2015.

CARVALHO, A. T. (2019). **Criatividade compartilhada em matemática**: do ato isolado à ação coletiva. [Shared creativity in Mathematics: from the isolated act to the collective action] 2019. Ph.D. dissertation Tese (Ph.D. in EducationDoutorado em Educação) – College of Education, University of Faculdade de Educação, Universidade de Brasília, Brasília, 2019.

DIEZ-PALOMAR, J. (2017). Mathematics dialogic gatherings: A way to create new possibilities to learn mathematics. **Adults Learning Mathematics: An International Journal**, v. 12, n. 1, p. 39-48, 2017.

FISCHER, F.; MANDL, H. Knowledge Convergence in Computer-Supported Collaborative Learning: The Role of External Representation Tools. **The Journal of the Learning Sciences**, v. 14, n. 3, p. 405-441, 2005.

GARDNER, H**.** (1993). **Frames of mind**: the theory of multiple intelligences. Boston: Basic Books, 1993.

GLĂVEANU, V. P. (2014). **Distributed Creativity**: thinking outside the box of the creative individual. Londres: Springer, 2014.

GONTIJO, C. H. (2007). **Relações entre criatividade, criatividade em matemática e motivação em matemática de alunos do ensino médio**. [Relationship between creativity, mathematical creativity and motivation in mathematics of high school students] 2007. Ph.D. dissertation (Ph.D. in Psychology)Tese (Doutorado em Psicologia) – Institute of Psychology, University of Instituto de Psicologia, Universidade de Brasília, Brasília, 2007.

GUASTELLO, S. J. (2017). Non-linear Dynamics and Leadership Emergence. **The Leadership Quarterly**, Milwaukee, WI, v. 18, n. 4, p. 357-369, 2017.

GUO, J.; DILLEY, E.; GONZALES, R. (2016). Creativity and Leadership in Organizations: A Literature Review. **Creativity. Theories – Research – Applications**, Bialystok-Polôniaand, v. 3, n. 1, p. 127-151, 2016.

HERZOG, W. **O enigma de kKaspear hHauser**. Direção deDirected by Werner Herzog. AlemanhaGermany. Distribuição Versátil Home Vídeo. ZDF Productions, 1974, 1 DVD (109 min).

HETZRONI, O.; AGADA, H.; LEIKIN, M. (2019). Creativity in autism: naan examination of general and mathematical creative thinking among children with autism spectrum disorder and children with typical development. **Journal of Autism and Developmental Disorders**, v. 49, p. 3833–3844, 2019.

ILLICH, I. (1992). **In the mirror of the past, lectures and addresses**, 1978-1990. Nova IorqueNew York: Marion Boyars, 1992.

KALANDADZE, T.; BRAEKEN, J.; BRYNSKOV, C.; NÆSS, K. B. Metaphor Comprehension in Individuals with Autism Spectrum Disorder: Core Language Skills Matter. **Journal of Autism and Developmental Disorders,** v. 52, p. 316–326, 2022.

KASIRER, A.; ADI-JAPHA, E.; MASHAL N. Verbal and Figural Creativity in Children with Autism Spectrum Disorder and Typical Development. **Front Psychology**, v. 11, 2020.

KONKIEWITZ, E. C. Inteligência e criatividade dentro do espectro autista. [Intelligence and creativity in the autistic spectrum]. In VIRGOLIM, A. R. (Org.). **Superdotação-processos criativos, afetivos e desenvolvimento de potenciais.** Curitiba: Ed. Juruá, 2018. p. 211- 237

LEE, Y.; CAPRARO, R. M.; CAPRARO, M. M.; VELA, K.; BEVAN, D.; CALDWELL, C. Students' conceptions of mathematical creative thinking and critical thinking in stem pbl activities. *In*: I**nternational MCG Conference**, 11., 2019, Hamburgo. **Anais** [...]. Hamburgo: Universidade de HamburgoUniversity of Hamburg, p. 197-201, 2019.

LEIKIN, R. et al. Teachers' views on creativity in mathematics education: an international survey. **ZDM Mathematics Education**, v. 45, p. 309–324, 2013.

LUBART, T. **Psicologia da criatividade.** [Psychology of Creativity]. Tradução de Márcia Conceição Machado Moraes. Porto Alegre: Artmed, 2007.

MITCHELL, K.; REITER-PALMON, R. Creative Leadership: How Problem Solving, Decision Making, and Organizational Context Influence Leadership Creativity. In: KALFMAN, J. C.; GLAVEANU, V. P.; BAER, J. T**he Cambrigde Handbook of Creativity across Domains**. CambrigdeCambridge: Cambridge University Press, 2017. Cap. 20, p. 363-380.

MORAN, J. Metodologias ativas para uma aprendizagem mais profunda. [Active methodologies for a deeper learning]. In BACICH, L.; MORAN, J. **Metodologias ativas para uma educação inovadora**: uma abordagem teórico prática. Porto Alegre: Penso, 2018.

MUMFORD, M. D.; GUSTAFSON, S. B. Creativity syndrome: Integration, application, and innovation. **Psychological Bulletin**, v. 103, p. 27-43, 1988.

OECD. **Beyond Academic Learning:** First Results from the Survey of Social and Emotional Skills, OECD Publishing, Paris, 2021.

ORRÚ, S. R.; SILVA, V. A escola e a maré iatrogênica do diagnóstico no trabalho junto a estudantes com autismo. [The school and the iatrogenic tide of the diagnosis on the work along with students with autism]. **Ensino em Re-Vista**, v. 22, n. 1, p. 59-66, 2015.

ORTEGA, F. Deficiência, autismo e neurodiversidade. [Deficiency, autism and neurodiversity]. **Revista Ciência e Saúde Coletiva**, p. 67-77, 2009.

PITTA-PANTAZI, Demetra; SOPHOCLEOUS, Paraskevi; CHRISTOU, Constantinos. Spatial visualizers, object visualizers and verbalizers: their mathematical creative abilities. **ZDM Mathematics Education**, v. 45, p. 199–213, 2013.

SAWYER, K. **Group Genious:** The creative power of collaboration. New York: Basic Books, 2007.

SILVA, H.M.M. **Autismo, formação de conceitos e constituição da personalidade**: uma perspectiva histórico-cultural. [Autism, concept formation and the constitution of the personality: a historical-cultural perspective]. 2019. Dissertação (Mestrado em EducaçãoMaster's thesis) – Faculdade de Educação da Universidade de São PauloCollege of Education from the University of São Paulo, São Paulo, 2019.

SOUZA NEVES, R. **Transtorno do Espectro Autista**: Conhecer, Diagnosticar, Intervir e Orientar. [Autism Spectrum Disorder: to know, to diagnose, to intervier and to orientate]. Souza & Neves Edições. Clube de Autores. 1st ª ediçãoedition. São Paulo, 2019.

TIERNEY, P.; FARMER, S. M.; GRAEN, G. B. An examination of leadership and employee creativity: the relevance of traits and relationships. **PERSONNEL PSYCHOLOGY**, v. 52, p. 591-620, 1999.

VAN DEN BOSSCHE, P.; GIJSELAERS W.; SEGERS M.; WOLTJER G.; KIRSCHNER P. Team learning: building shared mental models. **Instructional Sciences**, v. 39, n.3, p. 283-301, 2011.

VIGOTSKY, L. S.; COLE, M. **A formação social da mente**: o desenvolvimento dos processos psicológicos superiores. [The social formation of the mind: the development of the superior psychological processes]. 6. ed. São Paulo: Martins Fontes, 1998.

VOSNIADOU, S.; ORTONY, A. **Similarity and analogical reasoning**. Cambridge University Press, 1989.

WING, L. Language, social, and cognitive impairments in autism and severe mental retardation. **Journal of Autism and Developmental Disorders**, v. 11, n. 1, p. 31–44, 1981.

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