

Problem Posing: images as a trigger element of the activity

Janaína Poffo Possamai

Universidade Regional de Blumenau
Blumenau — SC, Brasil

✉ janainap@furb.br

 0000-0003-3131-9316


Norma Suely Gomes Allevato


Universidade Cruzeiro do Sul
São Paulo — SP, Brasil

✉ normallev@gmail.com

 0000-0001-6892-606X



2238-0345 

10.37001/ripem.v13i1.3274 

Received • 02/12/2022

Approved • 27/01/2023

Published • 09/03/2023

Editor • Gilberto Januario 

Abstract: This article aims to analyze the possibilities of problem posing activities by students when images are provided as a trigger element. To do so, in the theoretical discussion related to problem posing, we present understandings assumed by us and in the literature related to the theme, and different possibilities of didactic activities, especially in association with Problem Solving. Qualitative research is portrayed, regarding Problem Posing, implemented by teachers who teach Mathematics, participants of a continuing education course, and developed with masters and doctoral students in a postgraduate course. The results indicate the potential of this type of activity for the development of creativity, mathematical learning, and also as a tool to evaluate the understanding of students, especially when associated with problem solving.

Keywords: Problem Posing. Problem Solving. Teacher Training. Mathematical Learning.

Proposición de Problema: las imágenes como elemento desencadenante de la actividad

Resumen: Este artículo pretende analizar las posibilidades de las actividades de proposición de problemas por parte de los alumnos cuando se proporcionan imágenes como elemento desencadenante. Para ello, en la discusión teórica relacionada con la proposición de problemas, presentamos comprensiones asumidas por nosotros y en la literatura relacionada con el tema, y diferentes posibilidades de actividades didácticas, especialmente en asociación con la Resolución de Problemas. Se retrata una investigación de naturaleza cualitativa, en lo que concierne a la Resolución de Problemas, implementada por profesores que enseñan Matemáticas, participantes de un curso de formación continuada, y desarrollada con estudiantes de maestría y doctorado en un curso de posgraduación. Los resultados indican el potencial de este tipo de actividad para el desarrollo de la creatividad, del aprendizaje de las Matemáticas y, también, como herramienta para evaluar la comprensión de los alumnos, especialmente cuando se asocia a la resolución de problemas.

Palabras clave: Proposición de Problema. Solución de Problemas. Formación de Profesores. Aprendizaje Matemático.

Proposição de Problemas: imagens como elemento disparador da atividade

Resumo: Este artigo tem como objetivo analisar as possibilidades de atividades de proposição de problemas pelos estudantes quando são fornecidas imagens como elemento disparador. Para tanto, na discussão teórica, apresentamos entendimentos assumidos por nós e na literatura relacionada ao tema e diferentes possibilidades de atividades didáticas, especialmente na associação com a Resolução de Problemas. Uma pesquisa de natureza qualitativa é retratada no

que tange à Proposição de Problemas, implementadas por professores que ensinam Matemática, participantes de um curso de formação continuada, e desenvolvida com mestrandos e doutorandos em uma disciplina de pós-graduação. Os resultados indicam o potencial desse tipo de atividade para o desenvolvimento da criatividade, de aprendizagens da Matemática e, ainda, como instrumento de avaliação da compreensão dos estudantes, especialmente quando associada à resolução de problemas.

Palavras-chave: Proposição de Problemas. Resolução de Problemas. Formação de Professores. Aprendizagem Matemática.

1 Introduction

This article discusses the importance of moving beyond textbooks or the teacher as the only sources of problems to be solved in the Mathematics classroom, providing opportunities for students to get involved in the creation of their own problems. In this regard, English (2020) emphasizes that

when mathematics is inviting for students, accommodating all levels of achievement in school mathematics, and relating significantly to students' world, we have a greater chance of engaging more students. Problem posing offers substantial potential for achieving such engagement - from both a learning and teaching perspective (p. 5).

Also, the National Common Curricular Base — BNCC (Brazil, 2018) indicates, in a significant number of skills to be developed by throughout Elementary School and deepened in High School, the association of the posing (referred to in the document as *elaboration* or *formulation*) with the problem solving. And, in this respect, it is necessary to advance, so that Problem Posing¹ in Mathematics classrooms is recognized as an important component of Mathematical Education.

It should be noted that Problem Solving, sometimes, has been reduced to the application of mathematical knowledge in situations called *problems*, which involve a context described by words (Cai & Lester, 2012; Allevato, 2014; Possamai, Poffo, Bertotti Junior & Stein, 2021), with little or no contribution to the participation of students as protagonists of their learning. When associated with problem posing by students, the possibilities to go beyond the limitations of words are expanded, bringing the students' interests and experiences into the creation of the problems to be solved (Bonotto, 2013).

In this regard, it is noteworthy that, in line with the current perspectives of student training, teaching takes place through problem solving (Allevato & Onuchic, 2021, Bonotto, 2013; Cai & Hwang, 2020; Figueiredo, 2021), in which “a problem is everything that one does not know how to do, but is interested in solving” (Onuchic, 1999, p. 215) and the focus of mathematical learning is on obtaining the solution to this problem. Meanwhile, “teaching through problem posing, learning takes place during the process of students' posing of mathematical problems and classroom discussion of posed problems” (Zhang & Cai, 2021, p. 962).

Efforts to incorporate student problem posing into school curricula are recent and it appears that, “in contrast to the ubiquity of problem solving in school mathematics, problem posing — the process of formulating and expressing a problem in a given situation — has been

¹ We use Problem Posing with upper-case letters to indicate an educational practice oriented by the problem posing, a topic, a field of study and/or an investigation; with lower-case letters it indicates the act, the action of posing a problem.

far less prominent in school mathematics” (Cai & Hwang, 2021, p. 1403).

The challenge of making problem posing a frequent activity in Mathematics classes lies in teachers accepting that they will plan an activity without knowing exactly what they can expect from students (Chen & Cai, 2020). Thus, the importance of research regarding problem posing by students lies in supporting teachers, presenting possibilities of how to teach Mathematics through problem posing, relating them to pedagogical objectives in the context of real classroom practice (Zhang & Cai, 2021).

It stands out that research on Problem Posing — with students being those that create and present the problems — can take on three aspects when analyzing: the contributions related to the training aspects or the mathematical learning of students; different possibilities of educational practices that guide teaching through problem posing; implications of the different starting points (*prompt* and trigger element).

It is in this last aspect that the study presented in this article has its focus, when considering images as a trigger element in problem posing activities, implemented by teachers who teach Mathematics, participants of a continuing education course, and developed with masters and doctoral students in a postgraduate course. Thus, this article aims to analyze the possibilities of problem posing activities by students when images are provided as a trigger element.

For socialization of this study, the theoretical framework is presented below; the methodological characterization of the research; the description and analysis of data aiming to insert problem posing as an activity developed in school Mathematics and having images as a trigger element; and, finally, the final considerations.

2 Problem Posing

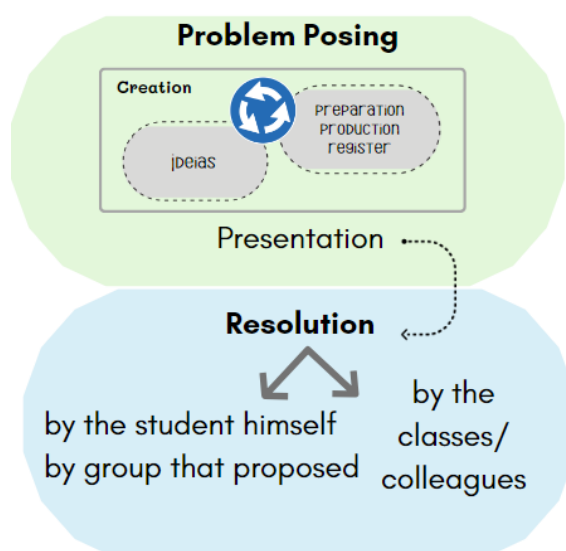
The investigation of problem posing by students is indicated as an emerging demand for research (Zhang & Cai, 2021), especially as a way to expand and deepen learning when associated to Problem Solving.

It should be clarified that, in Brazil, researchers use elaboration, formulation or posing to denote the creation of problems by students, but without a clear position on their meanings, with no consensus or explicitly defined meaning for each of these terms (Possamai & Allevato, 2022).

In our recent studies, we assumed the complexity of analyzing, studying and reflecting on these terms beyond a literal translation, but considering the associated social and school context and the linguistic meanings they present, inherent to the Brazilian language. At this moment, we assume the expression *problem posing* to denote the whole set of ideas that constitute the processes involving the creation of problems, that start with the organization and construction of the first mathematical ideas and the structure of the problem, advancing to the expression, in which the statement is established, associating mother tongue and mathematics; and continues with the presentation of the problem created to a potential solver (Allevato; Possamai, 2022). This structure, which we call problem posing, is shown in Figure 1.

As shown in Figure 1, we are associating Problem Posing with Problem Solving, which can be made possible by different strategies that must be consonant with what is intended by the teacher when developing the activity.

Figure 1: Problem posing associated with problem solving



Source: Allevato & Possamai (2022, p. 156)

When students are informed in advance that they are going to present their problems to a potential solver, they tend to produce better quality problems. In addition, involving them in the discussion and resolution of problems in small groups or in plenary with the class allows them to analyze, synthesize, evaluate, explore controversies and build consensus. English (2020, p. 2) indicates that, in this type of teaching proposal, teachers “delegate intellectual authority to their students and make their life experiences, opinions and points of view legitimate components of the content to be learned”.

There are several potential benefits in the inclusion of student problem posing in mathematics classes. They are related to the development of autonomy, creativity, criticality and the promotion of interest in Mathematics, fostering Comprehensive Education of students (Bonotto, 2013; Silver, 1994).

Cai, Hwang, Jiang and Silber (2015) point out that problem posing is a fundamental activity that allows students to consolidate and think critically about the knowledge they have acquired, in addition to providing opportunities for them to reflect, criticize and question the problems that are presented, thus bringing results about learning. Furthermore, it is recognized that “[...] if a student has created a mathematics problem then that student has had to reflect about mathematical relationships in non-trivial ways.” (Stoyanova, 1998, p. 180).

When students create their problems, they become more significantly involved with the resolution and discussion process, because, as Silver (1994) suggests, students are more likely to connect Mathematics to their own interests in the problems they pose, something that, often, does not happen with traditional textbook problems. Ratifying this position, Andreatta and Allevato (2020), based on a study carried out in a rural community school, found that, in the elaboration of problems, the production of mathematical textual structures gives meaning to students' experiences with problems and promotes protagonism and motivation, as expressing personal preferences and moving through themes that are familiar to them influences the emotional experience of students, promoting the desire to be involved in similar tasks.

Cai *et al.* (2015) point out that the impacts of Problem Posing with a view to students' mathematical learning are due to the fact that they are cognitively more demanding activities and promote more robust skills associated with problem solving.

There are different possibilities for working with the Problem Posing in mathematics classes, aiming for different pedagogical objectives. Stoyanova and Ellerton (1996) identified three categories of situations involving problem posing: free, semi-structured or structured. In free situations, students create problems without restrictions based on a given situation or information, without limiting the type to be proposed. In semi-structured problem posing situations, the students are “given an open situation and are invited to explore the structure and to complete it by applying knowledge, skills, concepts and relationships from their previous mathematical” (Stoyanova & Ellerton, 1996, p. 520). Finally, structured problem posing situations are those in which students create problems by modifying elements of problems that have already been solved or that are given.

For problem posing activities that aim to assess students' mathematical understanding in relation to a certain topic or procedure or from which it is intended to build new learning, more structured starting points are more suitable, providing a mathematical expression, a problem to be continued or modified, for example.

On the other hand, when the teacher has objectives related to the students' formative aspects, activities with a less structured starting point are more appropriate, allowing students to create mathematical problems freely. In this type of problem posing activity, students can more easily bring in real-world situations or connect the problem with their experiences and personal interests. In this sense, when students create problems related to real situations, problem posing becomes an opportunity to critically analyze reality, investigating if the numerical data involved are contextually coherent (Bonotto, 2013).

There are different possibilities for involving students in problem posing activities in which the starting point leaves them freer in relation to the type of problem they can create and, consequently, the ends that are achieved from them: problems created for a friend to solve; those that the student enjoys solving; those involving a specific mathematical concept or method (Stoyanova, 1998); problems created from an image or dataset.

When images are used as a starting point, it is possible to have a free or semi-structured problem posing situation, depending on the aggregated elements. If the image refers to a scenario with no data or additional information to be considered, you may have a free situation. An image with bowling pieces and a score indication for each pin, for example, involves a more structured starting point.

Images without data as a starting point can be used in the students' first experiences with Problem Posing, leaving them freer with regard to the mathematical knowledge and interests that are involved in the problem, having as objective the development of creativity, criticality and relating with formative aspects. When the objective is mathematical learning, the use of images associated with additional data or information is more indicated (Zhang & Cai, 2021).

An important aspect that Problem Posing makes possible is the fact that students are able to incorporate their life experiences into the problems created, so that they observe and perceive the importance of Mathematics beyond the school context. This is possible when using, for example, cultural artifacts as a starting point for problem posing, such as menus, advertising leaflets, weather forecasts, among other material available in people's daily lives (Bonotto, 2013).

Stoyanova (1998) advises that, in less structured activities, the teacher can lead students to reflect on certain content or particular previous experiences, providing additional information. It should also be noted that in free problem posing activities, the mathematical content involved in the problems created by the students can be influenced by — and depend,

in part — on the configuration of the previous tasks performed in class.

These different starting points for student problem posing activities — be it information, images, mathematical expressions, among others — are called by Teixeira and Moreira (2020) trigger elements, a term that we will use hereinafter.

Just as there are different trigger elements for problem posing, the associated pedagogical objectives imply different results on the processes of teaching and learning and impact student performance in creating problems.

In this article, we discuss, in particular, the possibilities of problem posing activities that use images as a trigger element, highlighting some proposals presented by teachers. Next, we present the methodological characterization of the research carried out.

3 Methodological characterization

This research, of a qualitative nature, is based on the attribution of meanings and interpretation of phenomena (Kauark, Manhães & Medeiros, 2010), with the objective of analyzing the possibilities of problem posing activities by students when images are provided as a trigger element.

Using the observational method, data are analyzed based on the adopted theoretical framework, depicting explanatory research, which “aims to identify the factors that determine or contribute to the occurrence of phenomena” (Kauark, Manhães & Medeiros, 2010, p. 28).

To this end, the activities presented by teachers who participated in a continuing education course, in the second half of 2021, and by teachers in a postgraduate course are discussed. General aspects related to the familiarity of these teachers with Problem Posing are also discussed.

The continuing education course, which took place remotely, was offered to teachers working in Basic Education at two regional directorates in the city of São Paulo (called DR1 and DR2), but carried out separately for each region.

The training sessions were organized into five meetings, of two hours each, and the teachers also carried out asynchronous activities proposed by the trainers. In one of the meetings, the theme was Problem Posing and, in the others, various aspects related to Problem Solving. Before the meeting on Problem Posing, the participating teachers were asked to implement, in class, an activity in which students were asked to pose problems. The teachers should write an essay describing how the activity was carried out.

This activity constituted a preparatory step for the meeting, before Problem Posing was discussed. The purpose was to discuss the proposals presented by the teachers and analyze the potential for the Problem Posing.

Problems created by teachers (who are masters and doctoral students) are also presented, in a postgraduate course, to discuss the context of the problem posing by students based on images as a proposal in the context of Mathematics classes. For each activity presented by the teachers, the educational possibilities are discussed and what would be the possible associated educational objectives. Posteriorly, the data are presented and discussed.

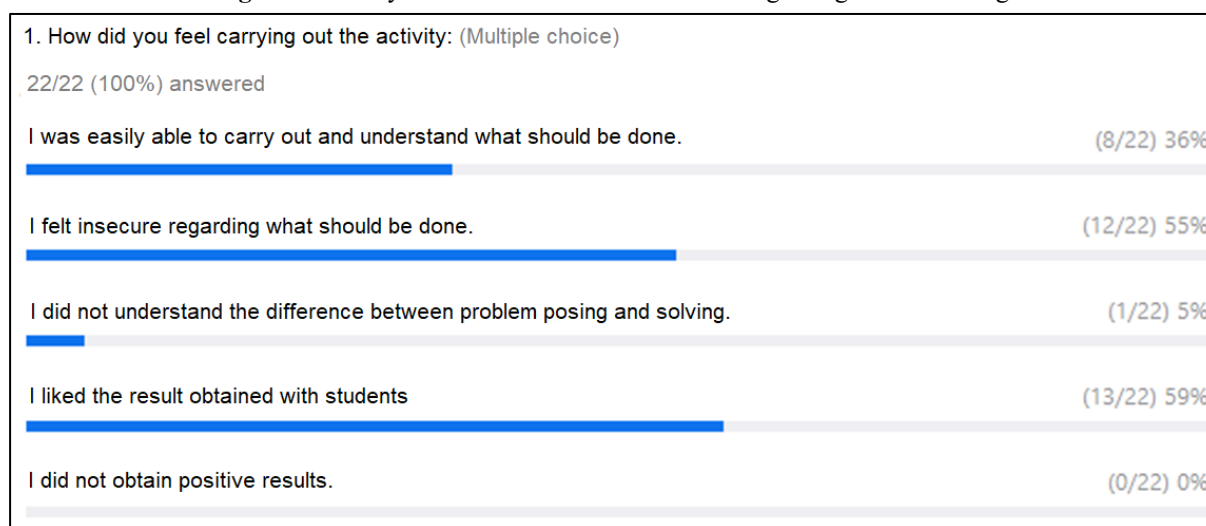
4 Data description and analysis

In the continuing education courses held, 45 activities were sent by teachers, 18 of which involved proposals in which the teachers created the problems for students to solve. Thus, the students were involved in solving activities instead of problem posing. This data reveals, in line

with the teachers' reports, that the pedagogical proposal of students being those who create problems is not yet a widespread activity considered natural by teachers in school Mathematics.

In fact, in the first meeting about Problem Posing with the teachers in DR1, it was noticed, through the reports and discussions, a lack of familiarity of the teachers with this type of activity. Thus, in the meeting held with DR2 teachers, held later on, it was decided to conduct a survey with the professionals right at the beginning of the meeting, the results of which are shown in Figure 2.

Figure 2: Survey carried out with teachers at the beginning of the meeting



Source: Research Archive

Figure 2 reveals that the fact that a significant part of the teachers feel insecure with the proposed activity, suggesting that Problem Posing – or problem elaboration, a term frequently used in the BNCC – is not known by these teachers. Still, further relevant information refers to the fact that that the teachers liked the results obtained and that no negative results were pointed out in the execution with the students.

These insecurities were also reported at the meeting about Problem Posing, which took place in a postgraduate course on Trends in Mathematics Education, with 18 masters and doctoral students. The discussion between them also showed that they did not know and did not use this type of activity in their classes.

Doctoral student DI reported that “in the *Aprender Sempre* material there is problem posing at the end of the chapter, but I would skip it because I didn't know how it would be, how to conduct it, and I didn't know what contributions it could make to my classes”.

It should be clarified that “*Aprender Sempre*” (Always Learn) is complementary material to the São Paulo Curriculum, provided by the Government of the State of São Paulo to teachers and students. Analyzing this material, we can verify the type of activity reported by the teacher, as illustrated in Figure 3.

Figure 3: Problem posing activity in “Aprender Sempre”

2. Time to create! Imagine a typical life situation and propose a problem with numbers in fraction or decimal form to be solved by another classmate. Attention! The problem must contain one of the fundamental operations: addition, subtraction, multiplication, division or exponentiation.

Source: São Paulo (2022, p. 128)

Analyzing the material mentioned by the teacher, it is verified that problem posing

activities are always presented at the end of a block of activities of a topic, making it possible to summarize and evaluate the objects of knowledge discussed.

These reports presented by the teachers do not only happen in Brazil, being similar in other countries, as discussed by Zhang and Cai (2021, p. 964) when describing that Chinese teachers participating in a professional development program “had never used problem posing to teach mathematics. A survey of these participating teachers at the beginning of the first workshop showed that they had little or no knowledge about mathematical problem posing”.

These scenarios confirm that “there is a need from both a theoretical and a practical standpoint to build up the field’s base of knowledge about what teachers can actually do when they use problem posing in the classroom to teach mathematics” (Zhang & Cai, 2021, p. 963).

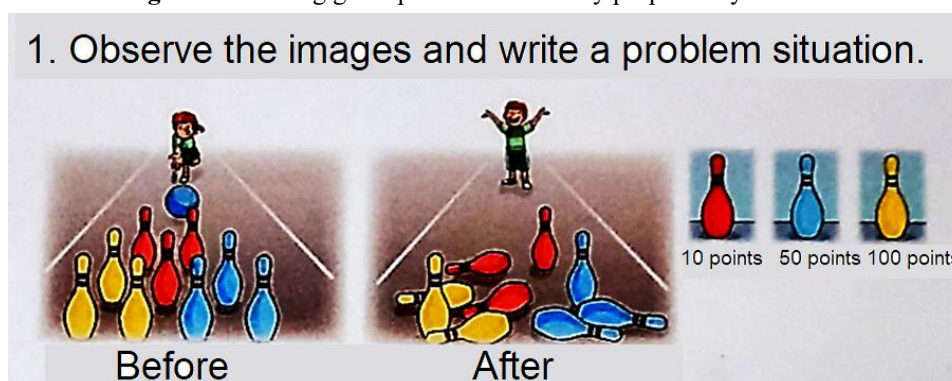
As a contribution to advance in this perspective, next, we discuss the possibilities of working with images as a trigger element for the problem posing by students.

4.1 Images as a trigger element

Among the proposals sent by the teachers in the continuing education course, of the 27 that dealt with the problem posing by students, 4 involved an image as a trigger element.

The activity used by teacher A, from DR1, with students from the 5th grade of Elementary School, is shown in Figure 4.

Figure 4: Bowling game problem — activity proposed by teacher A



Source: Research Archive

Teacher A describes that, initially, he asked the students to report orally what the image showed and what was happening in the scenes, and some already raised questions regarding the number of pins and the score. This initial discussion took place with the whole class and, afterwards, the students were invited to work individually creating their problems. The presentation of the problems happened to the whole class, who solved them collectively.

This teacher reported that “it was the first time that the students produced a problem situation. They engaged in production and exchanged ideas. It was good to see them working” (Teacher A, 2021).

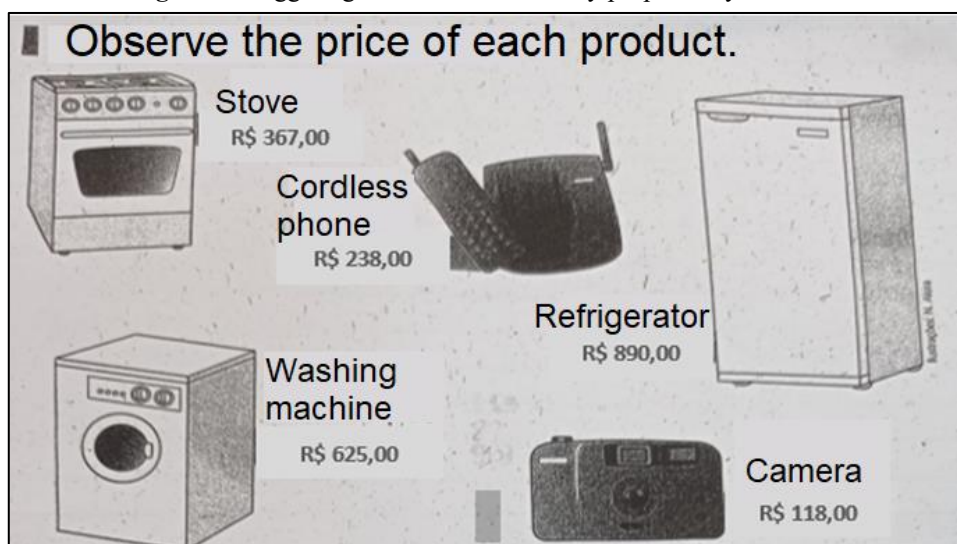
The image in Figure 4 is characterized as a trigger element that refers to the four fundamental operations, given that the score of the pins is provided, but does not limit them, in the sense that students can advance beyond the information presented in the image.

This is a relevant characteristic to be considered in problem posing activities, since even students with less conditions in relation to mathematical knowledge manage to create problems, even simple ones, but it also allows everyone to advance, because “they can make use of their full potential to understand the problem posing situation and then propose complex problems”

(Zhang & Cai, 2021, p. 962).

The image used as a trigger element by teacher B, from DR2, is shown in Figure 5:

Figure 5: Triggering element of the activity proposed by teacher B



Source: Research Archive

Teacher B asked the 4th year students to create a problem to be solved by a colleague, that is, the problems created would be exchanged between them. In this regard, Silver (1994) points out that, when students are asked to create problems for their colleagues to solve, they are more likely to develop creative problems.

During the resolution of the problems, teacher B had the opportunity to assess difficulties that the students presented related to some mathematical topics. These questions were taken up again afterwards, in plenary with the whole class, as he describes in his report.

A similar activity was developed by Teacher C, from DR2, also with 4th year students, using supermarket brochures from different establishments as a trigger element. The teacher describes that, at the beginning of the activity, the leaflets were presented to the students, raising the following questions with the class: “What are the leaflets for? What is the intention? What information is contained?” (Teacher C, 2021).

The students in this class created the problems, solved them and also exchanged them. This process was described by the teacher:

It was observed, at the beginning of the activity, a lack of 'creativity' for the elaboration of the problems. They asked for a lot of help; I gave some examples and then they started to create. However, I noticed that many still, in the elaboration, created a context, but forgot to put the “objective”, the question [of the problem]. Then they exchanged activities so that their friends could respond and the exchange of information on how to arrive at the result was very useful, because the one who had prepared it already knew how to solve it and when the student who was answering used other methods, the students realized that there are several possibilities to reach the result (Teacher C, 2021).

The association of problem posing with problem solving was carried out in the activities portrayed by the four teachers and, in this regard, Bonotto (2013, p. 51, our translation) points out that “By solving the problems created by their peers, the students become able to analyze them in a more detached and critical way”, reflecting on what information is really important and discovering that numerical information is not always the most important information

contained in the text of a problem.

Teacher D, also from DR1, did not present a detailed description of the activity, but indicated using a scene that contained numbers, so that students could study them and create and solve their problems.

It is important to highlight that these described activities, in which there are numbers that attribute meaning to the image, have a more open structure, with different possible ways for the students to pose problems; but they also allowed some predictability for teachers in relation to the mathematical content that would be addressed in the problems created.

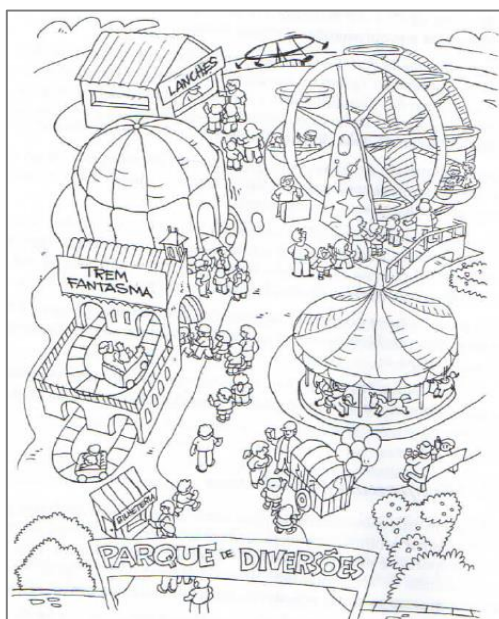
However, English (2020) emphasizes that this predictability also depends on the type of activity that teachers often use in class, which allow them to know the students' mathematical thinking. The author states that “impoverished quality of the mathematical tasks teachers often present in the mathematics classroom prevents them from gaining the desired insights into students' learning” (English, 2020, p. 3), making it difficult for their expectations about the problems created by the students to be confirmed.

The teacher's planning for the problem posing activity is based on these predictions but should not be limited to them. In this sense, the importance of organizing different possibilities with Problem Solving is emphasized, to be associated with the problems posed by the students.

Another possibility of activities with problem posing from images is the use of illustrations which do not provide numeric data and do not refer to specific contexts. For example, the image of a child buying bread at a bakery refers to a circumstance in which students, in general, will create problems with little variation of possibilities.

A more open image, in terms of the possibilities of different problems that can be created, shown in Figure 6, was used in the discussion on Problem Posing carried out with masters and doctoral students in a course held in graduate school.

Figure 6: Park Problem



Source: Carvalho (2007, p. 32)

From Figure 6, students can create different types of problems in relation to objects of mathematical knowledge, providing little predictability to the teacher. In Chart 1, the problems that were created by masters and doctoral students who worked in trios in proposing a problem

for the image are presented.

Chart 1: Problems created for the amusement park image

Problem Posed
1 — When visiting an amusement park, a visitor opted to purchase a single ticket that allows use of four different attractions. Considering that the park has 10 types of attraction and that the visitor will use the four attractions proposed in the ticket, investigate how many different ways this person can use the ticket during this visit.
2 — Felipe will go with his family to an amusement park at the weekend. He has R\$ 83.00 to use during the day. Each ride costs R\$ 27.00 to use. How many attractions can he visit at most? How many possible ways are there to use the rides with that amount of money?
3 — Leonardo's family will go to the amusement park during the weekend. The ticket costs R\$ 45.00 for adults and R\$ 20.00 for children. Since the family consists of two adults and three children, how much will be spent on buying tickets? Leonardo took R\$ 250.00 to spend in the park, so how much will be left for buying snacks?
4 — The ghost train has 2 carts that carry 4 people at a time. Each cart takes 5 minutes to complete the course of the attraction. Assuming there are 7 children in line, how long should the last child wait to get their turn?
5 — Let the length of the radius of the Ferris-wheel be R . What is the length traveled by someone who goes around once on the Ferris-wheel?
6 — Imagine that each seat on the Ferris-wheel has a letter of the alphabet, starting with A. What is the probability that, on your turn to ride, there is a vowel on your booth?
7 — Let's assume that the park is full and that it takes about: 45 minutes on the Ferris-wheel; on the carousel, 30 minutes; and on the ghost train, 20 minutes. The opening hours of the park (from 10:00 am to 5:00 pm, knowing that there would be 40 minutes for lunch, so: <ul style="list-style-type: none"> a) How many hours would it take to ride the 3 attractions in the park? b) How many times will the person be able to ride the 3 attractions, knowing that there will be 40 minutes for the lunch? c) What is the total operating time in the park?

Source: Research Archive

Analyzing the problems posed by masters and doctoral students, who presented problems with Basic Education students as potential solvers, it appears that they reflect problems that could be created by their students. Cai and Hwang (2020) point out that involving teachers in this type of activity is important to develop pedagogical knowledge with regard to teaching through problem posing. We add that it is desirable, even, to encourage discussion about what is a valid problem in order to accept the problems created by students.

The problems created involve several objects of mathematical knowledge: arithmetic operations with natural numbers; time measurements and conversion of measurement units; combinatorial analysis; probability and circumference length. It should be noted that students also reflect experiences and preferences in the context used, given that the open nature of this image presents this possibility. Given this, teachers need to keep in mind which learning strategies can be used.

In association with Problem Solving, a possibility can be developed from the discussion carried out by Zhang and Cai (2021), who present a strategy used by some teachers, who mentally classified the problems created by the students, in different levels of difficulty.

For easy posed problems, teachers would quickly guide students to solve them through whole-class discussion by asking students to sort out the answers. For very challenging problems, teachers would often assign them as homework or as instructional tasks to be discussed in the next class. The teachers tended to focus the discussion during the lesson on the moderately challenging problems (Zhang & Cai, 2021, p. 968).

This is a possibility to address the students' solution and value all the problems created, enabling the development of different learning objectives. Through the easy and moderate problems, the teacher can aim, for example, to evaluate the students' learning, to reinforce or deepen the understanding of some mathematical concepts/procedures.

The most challenging problems can be constituted as a generator problem, aiming at “the construction of a new content, concept, principle or procedure; that is, the mathematical content necessary or more suitable for solving the problem has not yet been worked on in the classroom” (Allevato & Onuchic, 2021, p. 52).

In this respect, it should be noted that the work with generative problems can be guided by the Methodology of Teaching-Learning-Assessment of Mathematics through Problem Solving, described in Allevato and Onuchic (2021). Furthermore, Allevato and Possamai (2022) discuss different possibilities of approaching Problem Posing associated with this methodology.

Particularly, in this practice reported here, the masters and doctoral students created the problems in groups and presented them to the class, afterwards. Problem 1 and the second part of Problem 2 are characterized as open, as there is more than one possible solution, and this was well accepted by the class.

While Problem 3, despite also being partly open, generated discussion due to the fact that the different solutions are due to possible interpretations for the problem, being considered by some as inadequate. The question “Leonardo took R\$ 250.00 to spend at the park, so what amount will be left for the purchase of snacks?” was the target of the discussion, as it is not clear whether Leonardo will pay for all of the family's tickets or just his own, and whether he is a child or an adult, generating several possible solutions. The group reached a consensus that the problem is adequate and that the fact that it has more solutions would be an important reason for discussion for students' mathematical learning.

Thus, this activity of posing problems that are less structured in terms of creation, as well as the problems presented that consisted of different possible solutions, are important, both for comprehensive training and for mathematical learning. In this regard, Bonotto (2013, p. 53, our translation) indicates that “less structured, more open-ended tasks could foster flexible thinking, enhance students' problem solving skills and prepare students to cope with natural situations they will have to face out of school”.

There are different possibilities for developing activities with problem posing by students (Andreatta & Allevato, 2020; Allevato & Possamai, 2022) and, before defining the trigger element, it is necessary that the teacher has established his objective in terms of mathematical learning.

Finally, it should be noted that care must be taken so that problem posing is not just used for a different and interesting activity — just as, sometimes, didactic games are used inappropriately — but always aiming at the development of mathematical knowledge or the comprehensive formation of students.

5 Final considerations

This article analyzed the possibilities of problem posing activities by students when images are provided as a trigger element, especially highlighting proposals presented by teachers in a continuing education course and an activity developed with masters and doctoral students in a postgraduate discipline.

The reports of the teachers involved in this research — both those who participated in a continuing education course and those who participated in the course at the masters and doctorate level — reveal an important fact: there is an evident lack of familiarity with the activity of problem posing by students and, although the available materials bring some kind of approach, this lack of training distances them from this type of activity.

In the continuing education course, teachers presented problem posing activities that were developed with students, associating numerical information to images, providing some predictability in relation to the mathematical content that would be addressed. They also involved the students in solving the posed problems, making it possible to broaden the discussion of and about the problems, validating them and advancing with regard to creativity and mathematical learning.

In the course on Trends in Mathematics Education, involving masters and doctoral students of a postgraduate program, in the meeting on Problem Posing, the activity was discussed based on images without numerical elements and with a range of contexts that could be related to the creation of a mathematical problem. This activity made it possible to discuss the potential of open problems as a contribution to the development of a variety of objects of mathematical knowledge and to the comprehensive formation of students, allowing them to involve preferences and experiences in the creation of their problems.

These results indicate that the use of images as a trigger element for problem posing enables the structuring of more or less structured activities, depending on the type of information and context that is addressed. This diversity of problems that can be created by students emphasizes the importance of establishing pedagogical objectives, associating Problem Solving with the possibility of consolidating planning.

The results also confirm the importance of developing reflections and promoting continued training on Problem posing to teachers in order to advance from the prescribed curriculum (in particular we refer to the BNCC and the regional and local curricula elaborated from it) for the practiced curriculum, making problem creation by students a reality in Mathematics classes.

As a continuation of this research, it is suggested that other triggers for problem posing be investigated, analyzing their contributions to mathematical learning.

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