STRATEGIES AND PROCEDURES IN LITERACY CYCLE CHILDREN IN PROBLEM SITUATIONS INVOLVING INFORMATION PROCESSING[1]

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ABSTRACT

In this article, we report on a study of the axis of "Provinha Brasil de Matemática" content with respect to the math axis of information processing. The aim is to present key strategies and procedures based on the Theory of Conceptual Fields for use by children during the literacy cycle to resolve situation-problems related to this content block. Information processing relates to the reading and organization of data as well as the different presentations of reading in everyday life, especially with respect to graphs and tables. The methodological design is sustained in qualitative studies of research-action in schools.The information processing axis is a block of content with great potential for the development of mathematical thinking, as the children must focus on the proposed situation-problem and use their skills to read and interpret data. We note that the ability to read information presented in tables, charts and other textual carriers is rarely addressed in the context of the classroom; thus, the student's use of procedures and strategies is very rudimentary or is used for other mathematical content.

Keywords: Mathematical literacy; Information processing, Provinha Brasil de Matemática.

RESUMO

Neste artigo, relatamos um estudo realizado sobre o eixo de conteúdos da Provinha Brasil de Matemática referente ao eixo do Tratamento da Informação. O objetivo geral é apresentar, sob o referencial da Teoria dos Campos Conceituais, as principais estratégias e procedimentos utilizados por crianças do Ciclo de Alfabetização na resolução de situações-problema relacionadas a este bloco de conteúdos. O Tratamento da Informação relaciona-se com a leitura e organização de dados e suas diferentes apresentações no cotidiano, principalmente em gráficos e tabelas. O delineamento metodológico sustenta-se nos estudos qualitativos do tipo investigação-ação escolar.

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Observamos que a capacidade de ler informações em tabelas, gráficos e em diferentes portadores textuais é pouco abordada no contexto de sala de aula, de modo que os estudantes se valem de procedimentos e estratégias bastante rudimentares ou que utilizam para outros conteúdos matemáticos.

Palavras-chave: Alfabetização matemática; Tratamento da informação; Provinha Brasil de Matemática.

1. Introduction and qualification of the problem to be addressed

In 2010, the National Education Council established new national curriculum guidelines for basic education through resolution No. 7, and they launched the Literacy Cycle Program, which is implemented the first three years of elementary school. In many cases, it was mistakenly thought that the creation of this cycle was intended to reinforce the teaching of reading and writing in the mother tongue, thus resulting in instruction that is less engaged in mathematics. However, this is a limited perspective, given that literacy should be understood in a broader and more global sense of reading, mobilizing the knowledge and codes of various fields of knowledge (SILVA, 2014; FREIRE, 2002).

In particular, in today's world, literacy must involve more than the initial study of the mother tongue, as mathematical knowledge has also become an indispensable asset for action and social learning in real time. Additionally, new organizational schemes for elementary education have caused a schism in school communities and a demand for further research into the best practices for structuring and developing methodologies related to the teaching of mathematics that are consistent with the new innovative organizational schemes.

Nevertheless, public policies have mobilized multiple resources to discuss the teaching and learning of mathematics for children. The Pro-Literacy protocol, for example, is a set of recommendations for the training of teachers at the beginning of their careers that includes the Brazilian test of Mathematics named "Provinha Brasil de Matemática" (PBM) and the National Literacy Program, which develop themes focused on mathematics literacy. The commonality of these different actions and regulations is that their conception of learning is dedicated not only to content and information but also to the development of skills and competencies.

This gives rise to the pertinent question, "What are the skills and competencies deemed critical for children with respect to math literacy?" The first sources to review when seeking potential answers to this question are the extant curriculum guidelines. Brazil currently has clear curricular definitions. The "Parâmetros Curriculares Nacionais – National Curricular Guidelines" - (PCN) (BRASIL, 1997) guide schools' educational practices in Brazil. As such, this document constitutes the primary manuscript used in this study. These standards were published in 1997, before Brazil established its nine-year primary school concept; thus, they do not establish a cycle or program for literacy. Moreover, changes in the existing resolutions and modifications to the guidelines for the elementary school years have been only in terms of structure and function, while no improvements or revisions have been made with respect to the specific curriculum.

While the Learning Literacy Cycle was published in 2012, it seems that it has not been incorporated into the school curriculum as a referential reality.

The PBM is a census evaluation that seeks to reach all students in all schools in Brazil and to map the development of children's literacy learning. The PBM is based on the PCN format and has become an important assessment tool and guideline for directing effective practices and math instruction in the classroom. Accordingly, we use the skills and competencies listed in the math reference matrix of the PBM as indicators of the literacy cycle, which is the name given to the stage of education for children aged 6 to 8 years.

Depending on the breadth of the field and the complexity of the situation, the investigation was conducted in a consortium (SILVA, MARINHO e FRANÇA, 2013) and encompassed all abilities and competencies as described in the reference matrix.

In this study, we conducted research specifically on competence C6, referring to the axis of information processing. The issue addressed was the development and structuring of strategies and procedures for the teaching of content related to information processing, as defined in the PBM, to literacy cycle children – children between 6 and 8 years of age. The overall objective was to identify key strategies and procedures used by children in the literacy cycle to resolve problems related to this block of content.

Information processing involves the reading of text, the organizing of data, and the understanding of data in various forms, including graphs and tables, as presented in everyday life. The specific competency axis is coded as C6 code - "*How to read and interpret data in graphs, tables and texts*. Three descriptors - D6.1, D6.2 and D6.3 - indicate the specific skills involved: (D6.1) *Identify information presented in tables*, (D6.2) *Identify information presented in column charts* and (D6.3) *Identify information related to mathematics in different textual carriers*.

1.1. Theory of Conceptual Fields - an aid for understanding strategies for children facing problems involving information processing

Considering that we are interested in uncovering the strategies used by children as they solve problems that involve skills related to information processing, we have adopted the Theory of Conceptual Fields as a referential (VERGNAUD, 1985, 1990) for analyzing the results.

Vergnaud (1985, 1990) defines a conceptual field as a set of concepts that only has meaning within the scope of a set of situations and representations and from which certain cognitive strategies, called invariant operatives, are required to overcome the difficulties imposed by the situation. It is further said that the variety of situations in which the subject has contact throughout his/her history delimits his/her answers and cognitive processes when faced with similar situations. Hence, the importance of considering the possible classes of constituents of a conceptual field.

We consider the situations presented herein as belonging to the conceptual field of information processing, and we intend to identify and understand the theorems-in-action used by the students in the context of the situations as presented. Theorems-in-action are perceived by the subject as true propositions. Unlike mathematical theorems, theorems-in-action cannot always be generalized or proven, as they are always subject to reorganization.

2. Methodology

The present study was conducted in the context of a broader project that aimed to examine the main concomitant strategies and procedures of literacy cycle students for solving problems that involve the competencies and descriptors of the PBM. This proposal is based on the idea of conducting research in a consortium, in which a set of researchers investigate related issues that compose a larger project (SILVA et al., 2013). There are several advantages to this technique, including the possibility to incorporate multiple perspectives on the same case, to examine multiple approaches to different aspects, and to reflect on collective and cooperative methods of data collection and analysis, as well as providing an opportunity to intertwine various similarly investigated themes.

2.1. Outlining

This research is configured as a qualitative study, as it seeks to address a human phenomenon - the learning of mathematics. Garnica identifies qualitative research as having the following characteristics:

> (a) the transience of their results; (b) the impossibility of an *a priori* hypothesis, whose goal of research will be to prove or disprove; (c) the non-neutrality of the researcher who, in the interpretive process, vale yourself from their perspectives and prior experiential filters, which cannot extricate; (d) that the constitution of their understandings is not a result, but in a trajectory in which these same understandings and also the means to obtain them can be (re) configured; (e) the impossibility of establishing regulations, systematic procedures, prior, static and generalities (2004, p. 86).

Considering the characteristics that define qualitative research, we chose a design that would investigate the classroom space. The decision was characterized by the research-action in school, which is a research mode capable of promoting the collection and analysis of data in school situations. It consists of four stages - planning, action, observation and reflection (CARR and KEMMIS, 1988). Research-action relies heavily on the idea of articulation between theory and practice wherein both the researchers and the subject of the research are considered participants in the analyzed action.

The first stage of research-action is planning, which involves organizing the action and making decisions about the implementation of the study. In this step, there is an initial communication among all participants, especially regarding the subject of the research, to determine the environment in which the research takes place. In the initial planning stage, alongside teachers who agreed to participate in the study, we shared our opinions about how we could conduct educational activities in the context of the classroom to collect data that would enable us to achieve the proposed objectives. We elaborated on a particular approach that would allow us to identify and understand how children relate to and demonstrate the competencies required to implement the proposed task.

The second stage of the research-action in school – the **action** – consists of the implementation of the educational activities in the classroom, which entails developing the activities with students, as such involvement highlights the challenges and ideas that reflect the degree of competence and mastery of the skills involved. Thus, planning is performed with the intent to streamline the concepts that were built based on the plan of the imaginary collective of the researchers in reality.

The third stage, **observation**, documents the ramifications of the action, serving as a substrate for the selfreflections, reflections and redesigns of the skills, i.e., "to observe the process of the action, the effects of the action, the circumstances of the action and its limitations, the mode in which the circumstances and limitations cut and channel the planned action, its effects and other things that may arise" (KEMMIS & MACTAGGART, 1988, p. 19). The records are maintained in journals adapted by researchers during and after these meetings and thus serve as important data-collection tools and products of reflection. Given the need for action and simultaneous observation, cooperation and the effective involvement of the teacher of the class are essential for the activity. This cooperation and effective involvement of the teacher cannot be achieved in a differentiated or atypical school context, as such environments cause the estrangement of children and allow for additional, perhaps unrelated activities, rather than promoting careful observation. In this sense, the teacher of the class participates in the entire process of the study - the design, research and analysis.

The fourth stage, **reflection**, is a weighted and evaluative process that incorporates both individual and collective research-action in school. In this procedure, the central focuses of the reflection are the educational practices, the results obtained and the understanding of the participants. Through dialogue, we can share common scenarios, shed light on contradictions and problem situations, including the objective and subjective situations that pertain to the processes of learning, identify indicators and create strategies to qualify actions.

The four processes cited are dynamic and comprise the spiraled cycles of school-action research (KEMMIS and MACTAGGART, 1988), which are both retrospective and prospective. In the present research, the stages of the investigation-school action structure are as follows:

Moments	Description
Planning	Initial study of the reality of the proposal within the research group. Study of the skills and abilities of PBM regarding information processing. Construction of the situation-problem. Preparation of the materials to be implemented. Preparation of the screenplay for the activity.
Action	Action in third-grade classes in city schools, partners of the research group for the production of the data. Proposition of the activities. Preparation of questions during the development of the strategies for children.

Observation	Observation of the conduct of children, of the materials produced, and of the explanations adopted for certain strategies. Field journals record the responses of the children as well as the strategies used by children to find solutions to situation-problem.
Reflection	Analysis of the data collected. Reflection on the limits of the situation-problem. Development of an understanding of how literacy cycle children respond and the capabilities feature in the field of information processing.

Table 1 - Breakdown of research-action

2.2. Field of study and research participants

As the initial idea was to understand the strategies and procedures employed by children in the literacy cycle, the subjects of the research were students in the last year of the cycle - the third year. If we were to investigate students from other years, difficulties may have arisen due to the lack of contact with the content being discussed. It is expected that, at the end of the cycle, all students have already been at least minimally exposed to the topics surveyed. The teachers-regents comprised the investigation group and reported during the phase of planning how to configure their groups of students in terms of performance, capacity and knowledge of the content.

The testing of the proposed activities was conducted using three groups of approximately 20 students each, and the final proposal was used in the fourth group. Such a strategy was necessary because the application of each problem noted in the activities elaborated our understanding of both the problem space and the potential difficulties with the collection of the data. Thus, three pilot applications were conducted to ensure that the instrument had reached a satisfactory stage of development. The data presented are drawn from the administration of the problem-situations and activities in the four classes, especially the last, in which the situation-problem peaked in its sophistication and, thus, the strategies and procedures were best observed.

During the implementation of the proposed activities, children were arranged into groups of three to promote discussion and allow them to share their problem solving strategies. This approach facilitated data collection by allowing the observers to capture dialogues and statements from the participants during the course of the study. With respect to analysis, there was no expectation of an individual performance assessment to observe which students ultimately solved the proposed problems. We believe that this function was carried out by our own fact-finding PBM, and contend that the quantitative data were more reliable for our purpose. Therefore, our focus was to observe the qualitative data, with no concern as to whether a child would help another or exchange information while engaged in the task.

2.3. The building of data-collection procedures

Within the perspective of research-action in schools, during the planning stage, there were several structural adjustments and modifications to the situation-problem that had to be developed with the students. At this point, researchers and teachers of basic education were organized to create didactic situations that did not differ much from the typical school context and focused on the skills and abilities as discussed herein.

Within the context of the traditional pedagogies, the contents are understood as sets of information that the teachers are expected to present to their students (BECKER, 2012; SILVA, 2010). In this sense, learning and teaching modes become nothing more than the memorization of information and transmission of knowledge via the sensory pathway. In contrast, contemporary pedagogical practices and various studies in the foundations of education have questioned such approaches and the level of retention of the information after their use. Therefore, the current didactic pedagogy has developed educational models and curricular references that align with the specific skills and competencies, as opposed to a focus on content and information.

While acquiring content and information is an important step in the learning process by itself, it is not sufficient given the importance of knowing what to do, how to interpret data and how to mobilize concepts with respect to the situations and problems confronting children. Thus, Perrenoud (2000) defines competence as the ability to act effectively in situations by mobilizing available resources, e.g., materials and affective and cognitive skills. Similarly, practical knowledge - the knowledge and development of procedures - is also important, as it amplifies the content, which usually emphasizes a more informational background, but does not take time away from acquiring procedural knowledge and supporting attitudinal change (ZABALA, 2000).

As a didactic strategy for the development of skills and competencies, we constructed the concept of the situation-problem. With its underlying aspects as part of a more complex domain, the situation-problem involves knowing how to use cognitive and material resources, make decisions and mobilize troubleshooting strategies (PERRENOUD, 2000). In the same manner, Meirieu (1998) defines problem situations as conditions that require a student to undertake a task he cannot perform without first learning something. In other words, the situation-problem is a strategy that aims to develop an ability; as such, it does far more than simply check for or monitor the accumulation of content. By implementing the situation-problem, we can highlight the skills and competencies that children possess, as well as their ability to learn and react to situations that they have not previously experienced.

Accordingly, the action, which is the second step of the research-action process in schools, is directed to a situation-problem that requires the mobilization of the ability to develop information processing skills, taking into account different actions that involve organizing and reading tables, bar charts and other textual carriers. To monitor their reasoning, the children were given blank sheets and asked to list or record the steps needed to perform the tasks, e.g., calculations, drawings, or phrases.

3. Competence and skills involved in situation-problems

The abilities to read and organize data are paramount due to the abundance of information currently available. Thus, information processing is a block of content that requires the development of these skills to organize and manipulate information. A set of basic capabilities essential for the child to be considered literate are derived from the literacy cycle.

Competence, according to the PBM References Matrix, is defined in C6 as the ability to *read and interpret data in graphs, tables and texts*. Three descriptors - D 6.1, D6.2 and D6.3 - specify the skills involved. (D6.1) *Identify information presented in tables*; (D6.2) *Identify information presented in column charts*; and (D6.3) *Identify information related to mathematics in different textual carriers*.

All of the skills require the ability to identify, that is, the expectation is that the child can read the item and recognize specific information. While there is an expectation of additional interpretations and more sophisticated recognition, the child must first identify the information that is treated in a textual carrier differentially.

With respect to tables, the cycle of literacy involves rather simple models, such as the single-entry table. Such a table has one column for the item that is to be quantified and a second column in which the item is quantified. Thus, in principle, this is the first formal contact the child has with information presented in a table. Tables with more columns indicating quantities, i.e., tables with two, three or more entries, tend to be studied by children in the second cycle of the early years of education.

With respect to graphics, children typically use a bar chart. The bar chart requires the child to identify a specific concept, such as greater than/less than or more/fewer, by associating the bar height in the chart with the greater than or more vs less than or fewer quality. Another simple bar chart model requires the child to count the squares formed between the bar and the guidelines. Thus, it becomes exclusively necessary to identify the quantitative value present in the indicators of the axes to which the data relate.

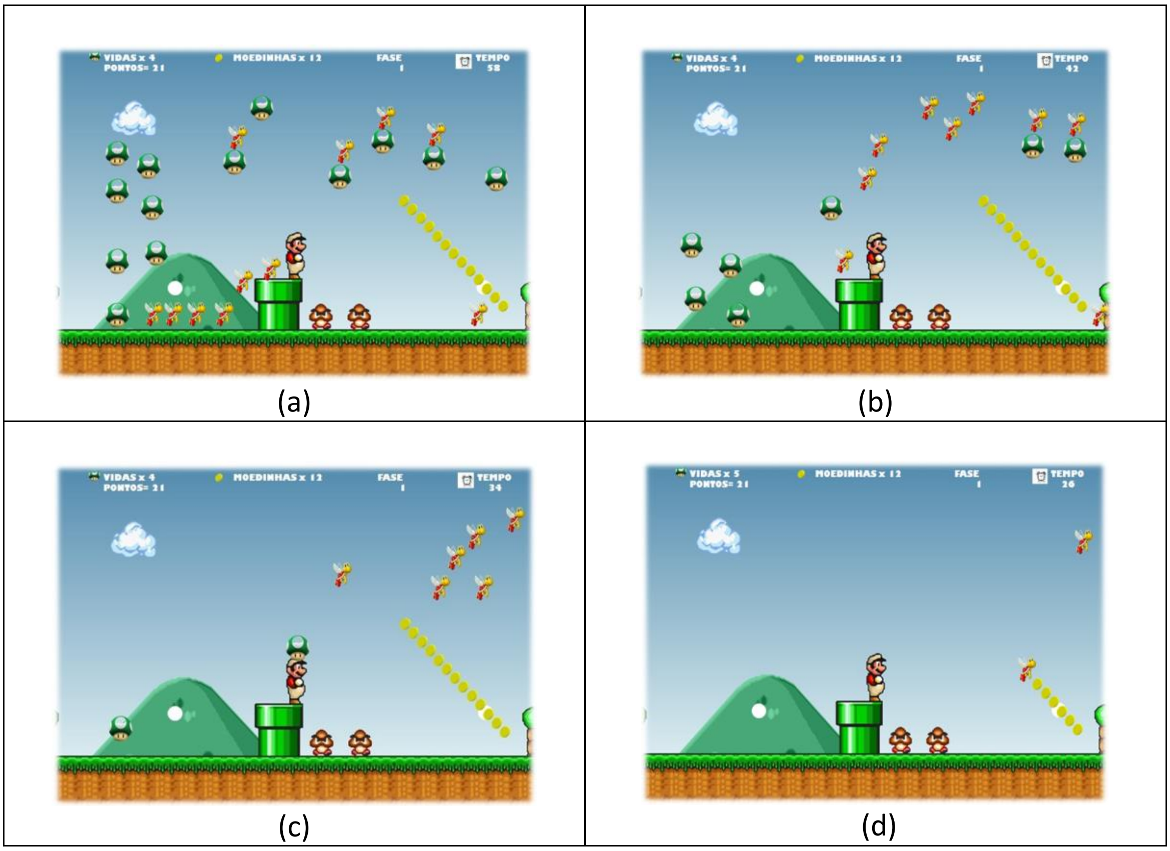
The third descriptor, which refers to different textual carriers, relates to the ability to read information linked to mathematics in different presentation forms. In general, children are familiar with mathematical data in specific situations but are unable to understand that same data in different contexts. Thus, it is expected that the ability to identify values and indicators in different brackets than those in which the data are conventionally presented will be developed.

Across the six different samples of the PBM available until the current year for this block of content, there were eight items for skill D6.1 (tables), seven questions for D6.2 (graphics) and only one for D 6.3 (other textual carriers). The latter descriptor is the least explored in the six editions of the Brazil Stemmed, appearing in just one example - case number 14 on the first test of 2012 - and even then, it referred to a table in which there were drawings of food and corresponding prices. In the application guide, in which access is available only for the test administrator of the PBM, there is an alert stating "…even if the data are in a table, the item shows the need to identify objects and values." We understand that the need for such justification was precisely due to the difficulty the creator of the item had in classifying it as being aligned with the D6.3 descriptor. Additionally, we understand that this absence of items relating to the ability to identify information in other carriers relates to the textual difficulty in presenting items that meet the demands of assessments that can adequately measure this ability.

4. Delineation of the situation-problem

The skills and abilities addressed and assessed in the survey were the same as those within the axis of information processing. Each of the reference array descriptors was investigated by means of a task that was to be resolved by the children.

With respect to descriptor D6.3, *Identify math-related information in different textual carriers*, we created an activity involving images of characters from a well-known children's video game. Lack of knowledge, experience or awareness of the game, however, did not preclude participation in the activity. Children were shown pictures with images of different moments in time that could be displayed in the upper right of each illustration. We asked students to organize the figures in any way they deemed appropriate. The expectation was that they would read the mathematical data on the images, especially the time, and organize them based on that data. The five pictures shown to the children are presented in Figure 1.



(a) (b) (c) (d)

(e)

Figure 1 - Images used to study the strategies of descriptor D 6.3

With respect to the descriptor D6.1, *Identify information presented in tables*, we took information from the images as initially presented and organized. However, to ensure that students did not use the information directly from the images, the moment we presented the table, the images in Figure 1 were no longer available to the children for reference. Figure 2 displays the tables that were presented to the students. The tables were carefully planned and designed and underwent some changes throughout the investigation, such as changes in the ordering of the items or the values of the quantities, to highlight the children's procedures and test certain hypotheses regarding strategy. The initial instruction given to the children was that they should order the tables any way they deemed appropriate. In another session, we asked specific questions about the quantities of specific items.

Tempo	42
Cogumelos na tela	7
Tartarugas na tela	9
Monstrinhos na tela	2
Moedinhas na tela	13

(a)

Tempo	34
Cogumelos na tela	2
Tartarugas na tela	6
Monstrinhos na tela	2
Moedinhas na tela	13

(b)

Tempo	58
Cogumelos na tela	13
Tartarugas na tela	11
Monstrinhos na tela	2
Moedinhas na tela	13

(c)

Figure 2 - Tables used to study the strategies of descriptor D6.1

With respect to descriptor D6.2, *Identify information presented in column charts*, the children produced vertical bar charts from the table and images. These graphs are presented in Figure 3.

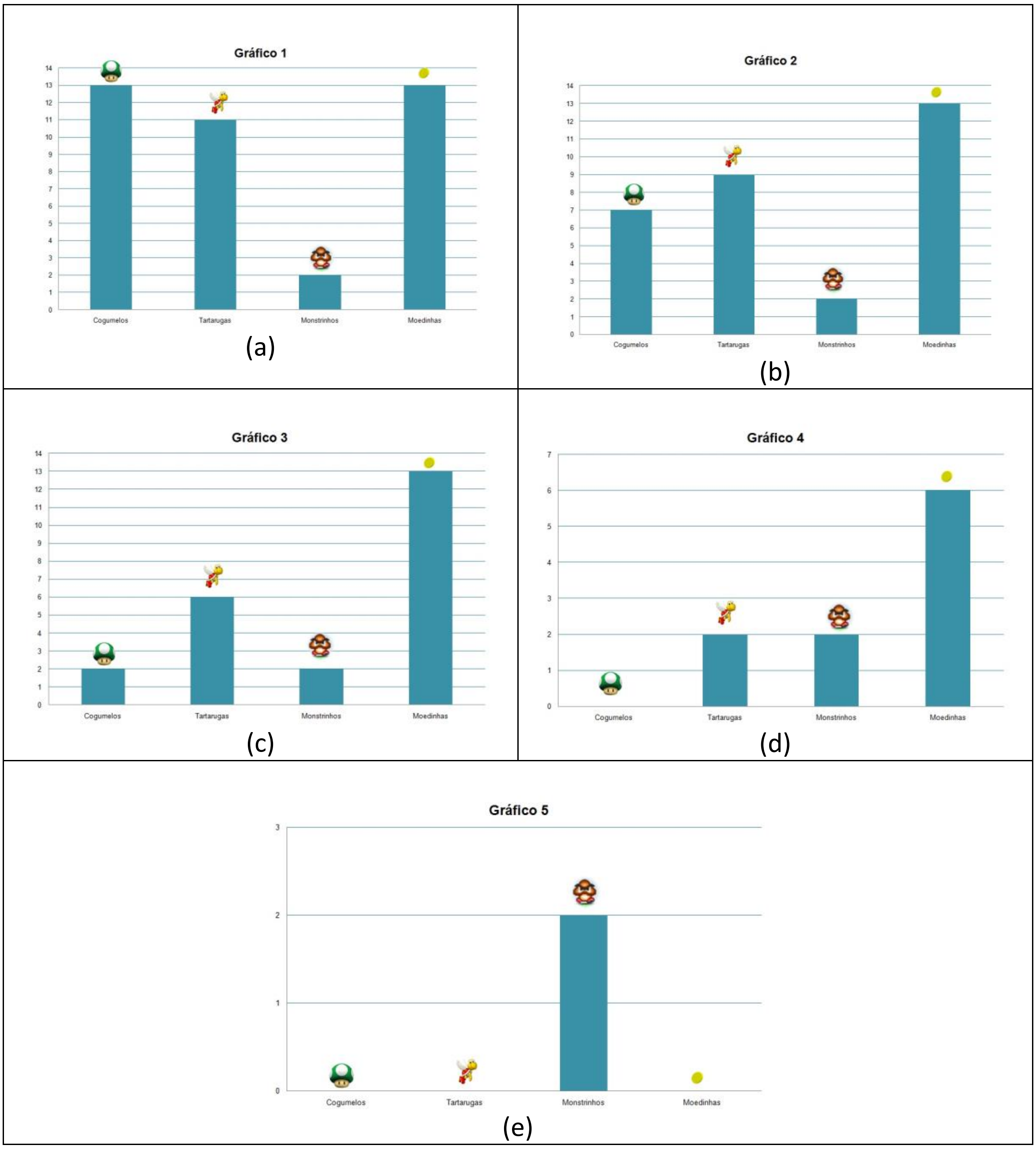


Figure 3 - Graphics used to study the strategies of descriptor D6.2

To create the graphics, we asked the children to indicate certain information from reading the material by answering such questions as which is greater, who has less, how do they compare, etc. In particular, an additional challenge was represented in Figure

3(c) where there were two mushrooms, six turtles, two little monsters and 13 coins. The chart was produced with these quantities associated with the respective images.

To produce a graph for another activity in which the quantities of some of these characters had decreased, we accessed the graph presented in Figure 3(e). It is interesting to note that the bar of little monsters in Figure 3 is greater than the bar of little monsters in Figure 3(c), even though the number is the same in the two figures. This is because there is a significant difference between the minimum and maximum values of the vertical axes counting scales on the graph in Figure 3(c). As this difference is much smaller in the graph in Figure 3(e), the result is an increase in bar height. We exploited this difference between the scales in the activity, although it was not directly addressed in the descriptors. In fact, the comparison was just a pretext to motivate the identification of quantities in both graphs. We chose this strategy because we noted that, in the vast majority of cases, the children did not read the contents of the chart axes as they were guided only by more visual aspects. Thus, this comparison allowed us to highlight those who developed more sophisticated procedures for reading charts.

From the images, tables and charts presented above, and in view of the descriptors studied, we developed a roadmap to guide the activity.

Script for processing activity 1) Submit images for children to view. State, "This is the game of Super Mario". "Time will decrease until reaching zero, while the turtles are passing and Super Mario is just watching". Question the children as to what they can say about the images that they are presented. 2) The students are asked to put the tables in order. 3) The students are asked to put the graphics in order. 4) Ask how many lives Super Mario has at time 50 (for some groups show the tables; for others show the graphics). 5) Ask how many lives Super Mario has at time 26 (for some groups show the tables; for others show the graphics). 6) Show one of the graphs and ask which is more (or less). 7) Choose any of the images and ask how many coins Mario has and how many coins are on the screen. (Ask and write down which strategy the student used, including whether he conflated the two, those of Super Mario and the image, and also ask if the result was achieved using images or tables). 8) Show two charts and ask if the number of monsters changes. Ask and record the students' responses and justifications. Note: This is interesting because the number actually does not change, but the bar increases and decreases in size from time to time because of the values of the other characters.

Table 2 - Script of the activity

We identified that this is a situation-problem insofar as the action reaches the parameters proposed by Zabala (2000), Perrenoud (2000) and Meirieu (1998). The table below illustrates how the activities fit with the principles of problem situations.

Descriptors Indicators	TABLES	GRAPHICS	CARRIERS
SITUATION	Activities with tables.	Activity with graphics.	Activity with images.
OBSTACLE	Compare unordered values and between different tables.	Compare unordered values and between different graphics.	Compare unordered values and between different images.
CHALLENGE	Identify the values and the corresponding values.	Identify the indicators of the axes and quantify the bars	Locate and identify the time counter to order it.
KNOWLEDGE	Knowledge of the numerals. Read and identify information in tables.	Knowledge of the numerals. Read and identify information in graphics.	Knowledge of the numerals. Read and identify mathematical information in different textual carriers.
LEARNING	Comparison of values, identification of information.	Comparison of values, identification of information.	Comparison of values, identification of information.
RESISTANCE	Differentiated comparative values in different tables.	Comparison of graphs with different scales.	Reading of a situation in which it is not normal to observe mathematical issues.
VALIDATION	Return to tables and comparisons with graphics or images.	Return to graphics and comparisons with tables or images.	Return to images and comparisons with tables or graphs.

Table 3 - Framing of the situation-problem

5. Analysis and discussion of the data collected

The data were analyzed and discussed according to the skills that were investigated. The order of presentation is that by which the information was collected.

5.1. Different textual carriers

We have previously discussed the frames used to investigate the skills pertaining to different textual carriers. When presenting the images in Figure 1 at the beginning of the activity, the children wondered what they could freely say about what they were seeing. One group spontaneously cited information from the upper part of the screen. The descriptions were always related to the characters and drawings that were part of the image. After the description given by the child, we wondered what information sources they had used and what they could say about the numerals and symbols that were presented.

One of the groups simply did not identify any of the information from the top, but rather spoke only of the drawings and the characters. Another trio already knew the game and the characters. Still, none of them commented initially on the image’s mathematical information. However, after being questioned, they detailed without difficulty the values represented.

Other children described the drawings and the characters only after being asked to talk about the information at the top of the image. Children were able to identify many of their strategies, knowing they had already had previous contact with the game. The following is an extract that highlights this ease of identification.

> —What can you tell us about this figure?
> —It's the game of Mario. You have to kill the monsters − *pointing to the character Mario and the little monsters, not identifying other elements of the image*.
> [...]
> —And these things on top, what can you say about them?
> —Has life, points, coins−pointing to mentioned amounts.

In particular, in one group of three, we noticed that there was great difficulty in identifying information regarding the "phase" of the game. However, this group had no difficulty identifying the number of lives, points or coins on the screen.

> —And these things here on top of the screen? What do you know about them?
> —Has life, point, currency, time−pointed without identifying quantities−and this I do not know. [...] Oh, I think it's a phase. The phase that he is − After reflecting for a long time, seeming to have difficulty in reading the word "phase".

Another group initially recognized the characters and affirmed that they already had experience with the game, but they only commented on the information on the top after being asked. However, upon being asked, they described this information accurately, indicating each of the elements and announcing the corresponding values.

We observed that the children did not identify participants spontaneously from textual carriers from the upper part of the figure; we always needed to draw attention to that part of the image. However, the activity did not initially specify a demand that required the use of these carriers, so our original question was essentially exploratory.

We found that the only group that failed to identify any information in the image, including the data that were written, contained no members who recognized the game. The groups that showed ease in identifying information in textual carriers, which is the goal of descriptor D6.3 of PBM, all had some experience with the game. Therefore, we posit that, of the proposed skills, this was the one most influenced by experience, and we therefore must bear this limitation in mind. For now, taking as a control the group that had never had contact with the game, we conclude that this was the skill with which children had the most difficulty.

Moreover, the point of the study seems linked to identifying skills and reading information in textual carriers, as children did not precisely define quantities or point to them without direct stimulation during the questioning to reflect upon the quantification of this information. This result leads us to conclude that the procedure of "pointing" is a rudimentary information reading trait because the children did not find the information, even though they had a clear idea of quantity.

Clearly, prior contact with the game favored heavily on the identification and reading of information. Memory and perception exerted a significant role in this situation. From the perspective of the Theory of Conceptual Fields (VERGNAUD, 1985, 1990), we can conclude that the action of pointing, coupled with reflection performed to retrieve some information from the memory of having experienced the game in an earlier time, constitutes a theorem-in-action, which we refer to as pilot followed by memory.

5.2. Tables

The information used to investigate the skills related to reading includes the tables that follow. The tables were based on the images presented initially, which made reference to the *Super Mario* game. In the game, time is decreasing, and when it reaches zero, the character loses a life and has to start over from the beginning. Purposely, we did not explain this to the participants in the survey because we deemed it important to observe their reactions when they did not know the game and to organically determine the relationship between what they knew and the proposed situation-problem.

One group, who claimed to have previous experience with the Super Mario game, considered the decrease of time and organized the images in an appropriate manner in the tables. Three groups organized the images according to increasing time, and one group could not establish any criteria to sort the tables.

One of the groups ordered the images according to the time sequence (34, 42, 50). When asked why they established this order, students responded that they looked only at the first digits (3, 4 and 5). This is important because it shows that children do not always read the given entity in its entirety, relying instead on solitary features or more immediate information.

We asked the other children, who ordered the images by increasing time, if there were more turtles at the beginning or at the end. They identified correctly the larger amount, even if they did not use a consistent argument, as in the case of the end of the tables.

> — Where are there more turtles, at the beginning or at the end?
> — The end.
> — How do you know that in the end there are more turtles?
> — Because yes.

Although many groups did not establish more elaborate criteria to sort the tables, this does not mean that the participants are not developing the skills as described in D6.1 of the PBM because this standard concerns only identification. Comparison and order are additions to the proposed skill and, in this activity, were also used as a pretext to explore the modes of organization and the existing procedures for the formulation of responses. Thus, in terms of identification, we note that children do not have difficulties with this concept, as they responded easily and quickly.

We find that identifying data in tables is also linked to perception and relies heavily on the skill of the student with respect to quantification, i.e., the association between the symbol and the value that the symbol represents. Those who ran the quantification had no trouble after locating the quantities required because they needed only associate the required amount to the symbol. Thus, we posit that the measurement was used as a theorem-in-action in this case, although this strategy is not necessarily associated with information processing.

5.3. Graphics

The illustrations used to investigate the skills related to reading include the graphics that follow. In general, the vast majority of students paid more attention to the sizes of the bars than to the numerical quantities or the lines that linked the quantities with the bars. In one of the graphics presented (Figure 3c), the same number of coins and mushrooms were presented, and so we asked which had "more".

The following is an extract from one of the collected data dialogue.

> On the graph in Figure 3, we asked:
> —Which has more?
> —Mushrooms. No, tie.
> —Tie?
> —Mushrooms and currency.
> —As in, you know I gave it a tie?
> —You can see it.
> —How can you see it?
> —By the lines.

First, the children responded that there were more mushrooms, and then changed their response to a tie. The note tells us that they opted for the number of mushrooms because it was a very large bar and because it was more to the left of the chart, suggesting that data are read from the vertical axis to the right, similar to reading a several-digit numeral. Thus, in the immediate reading, the mushroom bar was the biggest, but it was soon correctly compared with the coins.

In another group, we presented the chart in 3(a), in which there were more coins, and we asked which had "more". Without difficulty, the group answered correctly. We then presented the graphs from Figures 3(c) and 3(e) − which had the same number of monsters but with different dimensions in the representation of the bars − and asked which figure had more characters. In general, the children pointed to the chart in Figure 3(e), although the quantities of the two figures were the same.

The following is an extract from the recorded journal data, which highlighted this situation:

> —Which has more?
> —Coins.
> —Why coins?
> —This image has more coins because it is bigger − referring to the size of the bar graph in columns, without observing the explicit number in the vertical axis and considering only the size of the bar as the only criterion for comparison.

In another group, we presented a chart in which there was a greater quantity of mushrooms and asked which had more. The children pointed to the correct answer. We then presented the graphs in Figures 3(c) and 3(e), and we asked which of the graphs had more monsters. The children responded that there were more in the graph of Figure 3(e). It was clear that the main strategy used by this group was to monitor the lines that related the quantities between the bars without consulting the axes indicators. When they reasoned that we had the same number of mushrooms and coins (Figure 3c), the children said it was a tie because the lines were at the same height.

—What's more?
—It’s a tie, mushrooms and coins.
—How do you know?
—Because the lines are at the same height.

We had previously asked similar questions to another group to determine if they took into account the quantities or the lines. They exclusively used the size of bars as the criteria for comparison.

—Which has more monsters? − showing the graphs of Figures 3c and 3d.
—This − pointing to the chart in Figure 3d.
—How do you know?
—There's more because it's bigger.

Only one of the groups directly observed the quantities, although this group also used the lines to identify while giving little emphasis to the size of the bars.

—What is less? − the chart in Figure 3c.
—Monsters − answered correctly.
—And what's more?
—Currency and "life"! − in the game, the mushroom means a new chance and that children usually call of life. The Group answered correctly.
—How do you know?
—Ah, looking straight at numbers and at the line − pointing to the lines.

We realize that the main strategies used by children to identify information in column charts, as in the descriptor D6.2 of PBM, were observing the sizes of the bars and following the lines to compare the sizes of the bars, that is, children directly or indirectly use the size of the bar as a criterion for estimating the order of magnitude of the quantity. Few children used the numbers from the vertical axis of the graph as a criterion.

Considering the Theory of Conceptual Fields referential (VERGNAUD, 1985, 1990), we determine that the students solved this problem using two different theorems-in-action: identification by the size of the bar and identification by row heights.

We emphasize again that the comparison between the graphs in Figures 3(c) and 3(e) only served as a pretext to assess the influence exerted by the size of the bar in the comparative thought of the child, which seemed to be much greater than the amounts expressed in the vertical axes of the graphs. We conclude that because children sketched out comparative thinking even though they considered only the size as a criterion and did not pursue other information, they still fulfilled the requirement. Thus, we can conclude that children can compare quantities by comparing bars with quantities, though they still do not recognize other procedures as criteria.

6. Final Considerations

In general terms, we could identify how the teaching of mathematics in schools is strongly characterized by the presence of numbers and operations. Often, the form of the presentation hinders children’s perception of mathematical information. In response to images from the game, none of the participants spontaneously referred to existing values, but rather described the landscape. When we questioned them in a more direct manner, they were able to identify where the amounts were located in the textual carrier, but they were unable to identify the values themselves. The primary procedure was to point to the location of the information without having to read the entire text of the information.

In the case of tables, we noticed that students are relatively organized and have good mastery of the skill. However, they formulate their conclusions from information that is more apparent, such as observing only the data from the rows above or from the first digits of information.

Additionally, in the case of graphics, we noticed that the more immediate information is prioritized. The procedure for reading was observed to be from left to right, using as a criterion the length of the bars. Thus, support lines are an important aid instrument as they facilitate these comparisons more directly. The children still do not consult the values indicated on the axes, and few of them quantify the size of the bar. Thus, we believe that the visual information is more apparent and is the determining factor in reading information.

Generally speaking, we realize that reading strategies are more focused on peripheral information - direct and more obvious - and that the strategies used fail to provide more sophisticated interpretations of relationships. Nonetheless, we can still establish relationships using the different elements of the images, tables and graphics. While children have the relative abilities to think about tasks, they are not very familiar with the situations; even for those who are more accustomed to such situations, e.g., electronic games, the children are not accustomed to consulting and reading the mathematical information.

The study featured four theorems-in-action - pilot followed by memory, quantification, identification by the size of the bar and identification by the height of the rows. The characteristics of these theorems-in-action identified in the survey suggest that the strategies used by the students to address problems involving the treatment of information make more use of memory and perception than they do the more complex cognitive elements. Thus, one can say that the situation addressed in this study is less dependent upon other mathematical subjects; thus, caution must be taken when selecting figures and themes involved in the activity, as the previous experiences of the students may facilitate or hinder their way of thinking.

This indicates that these problems are appropriate for students in the early years of elementary school and that the skills involved contribute to the student’s ability to interpret information correctly in the future.

Finally, the Information Processing axis is a block of content with great potential for the development of mathematical thinking, as the children become engaged in the proposed issues and use the relevant skills to solve the problems involving those skills. It is noted that because the ability to read information in tables, charts and other such textual carriers is minimally addressed in the school context, students tend to use procedures and strategies that they use for other mathematical and reading contents, such as reading from left to right or observing the first digit of information.

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