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Analysis of Textbooks of Mathematics in Relation to the Disposition of Tasks in the Light of Attention as a Neurocognitive Mechanism

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ABSTRACT

The present work has the objective of analyzing the tasks on trigonometric functions presented in three books approved in the last three PNLDs, from 2009 to 2017 regarding Levels of Attention Transfer according to Sternberg (2010). The research has a documentary nature, within its intended purpose and is divided into two sessions. The first concerns the theoretical part, concatenating three pillars: the screening of tasks according to Dante (2005); the official documents, especially the Guide of the Didactic Book and the Attention, with neurocognitive lenses like Lent (2002), Lima (2005) and psychological with Sternberg (2010) and Willingham (2011) among others. The second part brings to the fore the empirical part of the work, with the analysis of the three books, namely: "Mathematics" by Dante (2005a), "Mathematics" by Ribeiro (2010) and "New Mathematical Souza (2013). The tasks were screened at three levels of attention, where it was noticed that most of the tasks found in the analyzed books are within the second level, none appearing at the third level of attention.

Keywords: Textbook. Attention. Trigonometry. Cognitive Neuroscience. Cognitive Psychology.

Análise de Livros Didáticos de Matemática em Relação à Disposição de Tarefas à Luz da Atenção como um Mecanismo Neurocognitivo

RESUMO

O presente trabalho tem como objetivo analisar as tarefas sobre funções trigonométricas apresentadas em três livros aprovados nos últimos três PNLD, de 2009 a 2017 quanto aos Níveis de Transferência de Atenção segundo Sternberg (2010). A pesquisa tem caráter documental, dentro de seu objetivo traçado e está divida em duas sessões. A primeira concerne com a parte teórica, concatenando três pilares: o crivo das tarefas segundo Dante (2005); os documentos oficiais, em

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especial o Guia do Livro Didático e a Atenção, com lentes neurocognitivas como Lent (2002), Lima (2005) e psicológicas com Sternberg (2010) e Willingham (2011) dentre outros. A segunda parte traz em seu bojo a parte empírica do trabalho, com a análise dos três livros, a saber: "Matemática", de Dante (2005a), "Matemática", de Ribeiro (2010) e "Novo Olhar Matemática", de Souza (2013). As tarefas foram crivadas em três níveis de atenção, onde se percebeu que as maiorias das tarefas encontradas nos livros analisados estão dentro do segundo nível, não aparecendo nenhuma no terceiro nível de atenção.

Palavras-chave: Livro Didático. Atenção. Trigonometria. Neurociência Cognitiva. Psicologia Cognitiva.

INTRODUTION

The importance of the Didactic Book for the teaching and learning process in any discipline is indisputable. Many times it is the first contact with reading, advocating the habit of reading. Over time, the concept of Didactic Book has been transformed, naturally accompanying the dynamics of the classroom and the spirit of its time.

For Freitas (2009, p.2) "Didactic Book (in an operational sense) materializes the discipline". In other words: it brings the content that will be taught in the different didactic situations, that is, totally linked to the disciplinarization of school knowledge (Freitas, 2009). Besides these assumptions, it brings with it all institutional intentionality (what could be thought of as the curriculum) that answer the reason for the existence and permanence of certain content.

In relation to mathematics, sequential language shows this materialization even more. Thinking from a perspective of Chevallard (1992 quoted in Almouloud, 2007, p.116) "the entire institutional praxis, in this case school, can be seen on different looks in a well-delineated system of tasks." These are most often presented in textbooks, where the relations between the object (knowledge) and the person are fortified or distanced. Regarding the resolution of these, a level (or levels) of attention is necessary, directing the neurocognitive processes for this task. Attention is a phenomenon that makes us focus certain aspects of the environment to the detriment of others (Cosenza & Guerra, 2011).

Based on these assumptions, the objective of the present work is to present an analysis of the three textbooks of the collections approved in the PNLD from 2009 to 2017, starting from the list of tasks proposed by Dante (2005) and relating them to the processes that involve attention by such as Lent (2002), Lima (2005), Gazzaniga (2006), Sternberg (2010), Willingham (2011) and others.

It was divided into two parts: the first part, concerning the theoretical moment of the research, shows the authors mentioned above in their respective lines, besides interpolating to them arguments within official documents. In the second part, in keeping with the empirical part, the analysis of three didactic books is presented, namely: Dante (2005a), Ribeiro (2010) and Souza (2013), within the relation between the job screens and the Levels of Transfer of Attention (NTA).

THEORETICAL PART – GATHRING THE RESEARCH WITHIN THREE PERSPECTIVES: ON CLASSIFICATION OF TASKS, USE OF THE TEACHING BOOK AND THE NEUROCOGNITIVE FUNCTION "ATTENTION".

In this first session, which was divided into three parts, authors will be brought in to discuss the assumptions of the tasks that were analyzed in the textbooks, as well as official documents that bring some characteristics about the use of the book inside the part algebra (trigonometry) and finally lenses within Cognitive Neuroscience in relation to cognitive function Attention. The guiding questions were: What categories or sifters are available for the analysis in question? What do official documents tell about solving mathematical problems? What is Attention and how is it classified?

Script of the Tasks Found in the Textbooks according to Dante (2005)

In his work, Mathematics Problem Solving Didactics, the mathematician and doctor in Educational Psychology, Luiz Roberto Dante brings typological indications of more common mathematical tasks.[1] The main characteristics of these types of tasks for this lens are presented in Table 1.

Table 1
Task Classification Matrix. (Dante, 2005).

Type of Task	Features	Example(s)
Recogntion (RT)	It makes the student recognize, identify or remember a concept, definition, specific fact, etc.	• *What is the successor of 109?* • *One hundred worth how many tens?*
Algorithms (AT)	It can be solved step by step. Require direct execution of algorithm	• *Calculate [(3 x 4) + 4]* • *Perform the following operations ...*
Standard (Simple and Compounds) (SST – SCT)	Direct application of one or more algorithms previously learned and do not require any strategy. It basically transforms usual language into mathematics, to link these situations to day-to-day.	• Simple: In a class there are 17 boys and 22 girls. How many students are there in class? • Compounds: Luiz is 7 years older than triple the age of Felipe. The two together are 55 years old. How old is each one?
Process ou heuristics (HT)	The solution is not contained in the statement. They cannot be translated directly into mathematical language and require the student time to devise strategies to solve it	• At a team meeting there are six students. If each one shakes hands with everyone else, how many handshakes will they have in all?

[1] In his work, Dante (2005) talks about problems rather than tasks, a term that we use to best suit the objectives and theorists of this work.

Type of Task	Features	Example(s)
Of Aplications (APT)	They portray real situations of daily life, which can be solved mathematically. In addition to requiring strategies, they require data collection and research.	• To make a report, school principal needs to know what monthly expense he has, per student, which he or she has with school meals. Are we going to help you do those calculations?
Of Puzzle (PT)	They constitute the so-called recreational mathematics, where the solution depends very much on a "stroke of luck" or the ease in perceiving some "trick".	Vide Figure 1

These three further types of tasks are the most complex within this typology, since in addition to requiring action plans, such as the heuristic type, they can add in their difficulty research and data collection, as well as some creativity as the case of type puzzle.

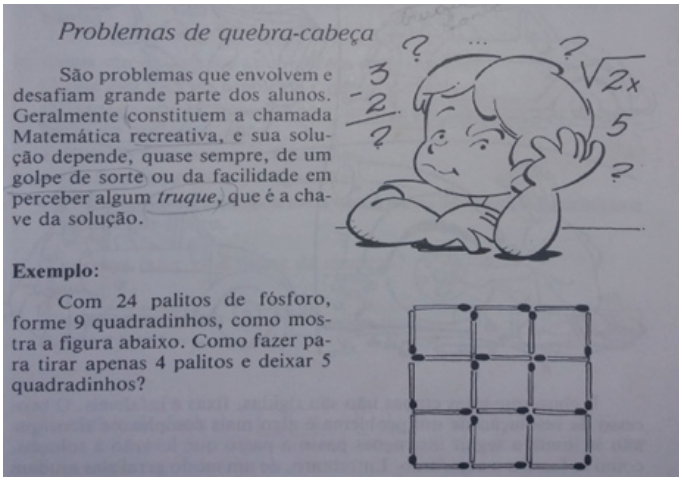


Figure 1. Puzzle Task's type. (Dante, 2005).

Official Documents on the Didactic Book

Mathematics is one of the achievements of human knowledge, produced and organized historically (Brasil, 2017). Within this assumption, mathematics becomes present in the daily lives of all, in their daily practices for the resolution of diverse tasks. These practices, within an epistemological context, come from Greek mathematics, with its hypothetical-deductive method.

In middle school, it is expected to expand this type of thinking, aiming to leave an inductive, informal and not rigorous perspective for the deepening of mathematical knowledge (Brasil, 2017). However, the current society lives in constant change, where Mathematics has direct employment in scientific and technological practices. In this way,

the student should be prepared to critically understand this knowledge. Corroborating with this, (Brasil, 2017)

> [...] people are constantly exposed to information that, in order to be understood and taken into account critically, requires the reading and interpretation of graphs and tables and requires the knowledge of basic notions of statistics and probability. The ability to solve problems and face complex situations, to expose and understand ideas, is increasingly required. Mathematics teaching appropriate to the final phase of basic education cannot neglect these aspects (Brasil, 2017, p.12)

Regarding problem solving, it emphasizes that:

> In light of this context, Mathematics teaching should enable students to: plan actions and design solutions to new problems that require initiative and creativity, [...] to interpret mathematically everyday situations or the technological and scientific world and to know to use Mathematics to solve problem situations in these contexts and [...] to evaluate the results obtained in the solution of problem situations.

This is important to show how task resolution, in our case, can effectively lead the student to more meaningful and critical learning, within the context of skills and abilities required in (Brasil, 1999), for example.

As for the evaluation criteria of the textbook, one can think of two main criteria to guarantee the didactic-pedagogical quality of the works in question, emphasizing the functionalities for the teacher and for the student. The first criterion concerns the thinking of the textbook as an auxiliary tool of the teacher's educational work (Brasil, 2017).

These functions should also be included in the Teacher's Manual, which is the north for the teacher to plan their practices, but it is clear that one should not monopolize the use with the textbook. This Manual should have adequate language for the teacher, meeting his objective as didactic, methodological and support material.

From the distribution of the contents of the approved books, the part of Algebra is that it becomes important, because the analysis of this present work corresponds to the questions of trigonometric functions. For this content, one has:

> In the study of functions, it is relevant to approach different representations – tables, graphs, algebraic formulas – establishing relationships between them. In general, a problem initially formulated algebraically can be more easily solved, or understood, when it is interpreted geometrically, and vice versa. For example, the axial symmetry present in the quadratic functions is easily perceptible in the graph and, nevertheless, may require calculation effort if its algebraic representation is used (Brasil, 2017, p.27)

This question refers to the meaning of learning as critical in relation to the problem solution within the presuppositions of the formation of competences and abilities. According to (Brazil, 2017, p.29) "in the high school textbooks, more attention is paid to the study of this family ($y = a + b * cos\ (w * t + c)$) as periodic models, which is praiseworthy. "Analyzing these types of questions is necessary, in that sense, because the student must understand periodic phenomena, so to think what levels of attention issues in the various types, in the case of trigonometric functions, present themselves to students in the textbook.

Attention as a Neurocognitive Function

The brain is the most important organ for the human body (Cosenza & Guerra, 2011). The basic cell of this organ is the neuron, along with the glial cells. A priori, it was believed that these cells did not regenerate. The concept of Neuroplasticity, or the capacity of creation or replacement of the neurons, came against this idea (Silva, Santana Filha, & Fonseca, 2017). This condition is explained through the conditions of stimuli and interactions with the external environment.

The synapses are active zones of contact between the endings through which the nervous impulses pass (Lent, 2002). The term originates from the Greek "joining". Neurons are composed of two branches and a cell body, where one of the branches is called the axon. Its functionality is to transmit information from neurons to other cells that are functionally linked to it (Silva, Santana Filha, & Fonseca, 2017). The dendrite, the other branch, designates the reception transmitted by the axon of other neurons. In this case, the synapse is the zone of proximity between the dendrite of a neuron and the axon of another.

The insertion of Cognitive Neuroscience, in the precepts of education, receives the terminology of Neuroeducation. Professionals who wish to embark on this new multidisciplinary perspective should flex their own epistemologies within the context of teaching and, consequently, learning. The importance of his work is thus derived, delimiting some common knowledge already structured or as an instrument of methodology or research. Neuroscientists study the phenomena of learning behavior (Zaro et al., 2010), differentiating these professionals from cognitive psychologists, where the treatment in this case is in cognitive functions at the neurochemical level.

One of these functions is attention. It is characterized by the individual's ability to respond predominantly to the stimuli that are significant to him, in detriment to others (Lima, 2005). Thus, attention is a phenomenon in which the nervous system maintains a selective contact with the information that arrives through the sense organs.

From a historical point of view, in Lima's speech (2005):

> Several theoretical models have been proposed since William James. The focus of these models was to determine the timing at which the stimuli are selected.

> Thus the theories of the initial selection of late selection theories are divided. The first one determines that the stimuli do not need to be analyzed completely to be selected. However, the late selection theories indicate that the stimuli that arrive through the sensory pathways receive a previous analysis of characteristics and meanings and from there are selected the stimuli that will receive a more thorough processing by the cortical areas. (Lima, 2005, p.2)

Two theories can be highlighted in these segments. The first, elaborated by Cherry (apud Eysenck & Keane, 1994) is called Theory of Targeted Auditory Attention (TAAF). This theory talks about the individual and his ability to select and respond predominantly only to the stimuli he is interested in, ignoring the remaining ones that are not processed. However, the Filter Theory (TF), advocated by Broadbent (apud Gazzaniga et al., 2006), defines that individuals have limited attention capacity, where only relevant stimuli are attended or processed (Lima, 2005). This attentional system is similar to a "filter", which "opens" to the information of interest and "closes" to the others.

Contrary to this latter theory, Von Wright and colleagues (apud Eysenck & Keane, 1994) were able to verify in their experiments with auditory attention that there was a kind of unconscious processing of unanswered information, so that the filter defined by the previous theory did not totally exclude such stimuli.

For Treisman (apud Gazzaniga et al., 2006), the analysis of stimuli missed by the person can be attenuated or reduced. This reduction is linked to a mechanism used by the attentional system, which reduces the interference that the irrelevant stimuli produce.

Sternberg (2010) in his studies draws a parallel between attention and consciousness. For him, conscious processes are easier to study, while the unconscious are, in the same measure, difficult because we are not aware of them. In addition, attention when marked is a fundamental process in memory, which is essential for learning (Willinghan, 2011). The benefits of attention are explicit when it comes to conscious processes. According to the author:

> In addition to the general value of attention, conscious attention serves three purposes by playing a causal role in cognition. First, it helps to monitor the individual's interactions with the environment. Through this monitoring, one remains aware of how well the individual is adapting to the situation in which they are. Secondly, it helps people to establish a relationship with the past (memories) and with the present (sensations) to give a sense of continuity of experience. (Sternberg, 2010, p.108)

Attention in this case can be sketched as in Figure 2.

$$\begin{cases} Sensations + \\ Memories + \\ Thought\ Processes \end{cases} \rightarrow Attention: \begin{cases} Controlled\ Processes \\ + \\ Automatic\ Processes \end{cases} \rightarrow Actions$$

Figure 2. Attention. (Sternberg, 2010).

From a neuronal point of view, the attention initially needs a state of alertness or previous vigil, that is, an adequate cortical tone to receive the stimuli coming from the sense organs. The brain functional system responsible for this condition is structured from a group of neurons that have a pigment that gives the region a blue color (locus ceruleus or blue site), located in the midbrain (Cosenza & Guerra, 2011). The main neurotransmitter involved in this first attentional process is Noradrenaline, important for this regulation

From this, two different circuits regulate this process, to be defined: the guiding circuit, which is located in the cortex of the parietal lobe, facilitating the disconnection of the attentional focus from one target to another, as well as its adjustment, towards the perception of stimuli and of sense organs. The second, the executive circle, maintains attention in a prolonged way, inhibiting the distracting stimuli. The regulatory center responsible for this process is the rotation of the cingulate, located in the frontal cortex.

Attention can be classified in different ways. According to its nature, it can be classified as voluntary and involuntary (reflex). Voluntary attention involves the active and deliberate selection of the individual (Lima, 2005). The reflex attention is raised by the characteristics of the stimulus in question, occurring during unexpected events in the middle, where the person is not an agent of choice. More briefly, voluntary attention is conscious and involuntary unconscious.

Another important classification is related to the operationalization of attention, divided into Selective, Sustained, Alternated and Divided. In this work, emphasis will be placed on the transformation of Selective Attention (SA), which is defined as the ability of the individual to privilege certain stimuli to the detriment of others (Lima 2005) for Divided Attention, which is the ability to perform more than one task at the same time, redirecting attention resources to other priorities (Sternberg, 2010), that is, it is directly linked to the basic principle of the attentional mechanism.

We will use the sieve taking into account Dante's classifications (2006) and taking into account the assumptions of attention according to Sternberg (2010), when he cites about memories (past), sensations (present), cognitive (or thinking) so that something can be captured by the brain. We are here, because of the space of this work, disregarding the external and internal neurocognitive causes for the Attention process, besides thinking at that moment in neurotypical students, that is, with their neural and cognitive functionalities within the common standard.

Thinking about sketch 01, (Sternberg 2010) communes the attention to action within two processes: controlled and automatic. For this author, controlled processes demand energy; in antithesis, the automatic ones require little of this (Sternberg, 2010). The best idealization of solving a given task in this sense would be to transform the controlled processes into automatic ones, or to move from a high level of AS to a high level of AD, considering the resolutions of mathematical tasks, since there would be less energy expenditure (Fisk & Schineder, 1981 apud Sternberg, 2010).

EMPIRICAL PART – ANALYSIS BETWEEN DIDACTIC BOOKS

In this session, we sought to discuss the relationship between Attention and types of tasks according to Dante (2005). The matrix of relationship between task typology and levels of transformation of attention (NTA) is presented below. Each of these, according to their degree of difficulty:

Table 2
Sieve or Matrix of Relation between Dante's Task Typology (2006) and NTA.

Task Type	
RT, AT, SST-SCT.	NTA_1: The transition from AS to AD is fast, since they are only direct applications of the concepts.
HP e APT	NTA_2: The transition from AS to AD is slower than the previous level because it does not directly involve the operation in its statement, requiring a strategy and research.
PT	NTA_3: The transition from AS to AD is very slow as these tasks require creativity and expertise outside the content.

Book 01: "Mathematics" – Luiz Roberto Dante (2005a)

This book of character of single volume, approved for the years 2009 to 2011, brings in chapter 20 the content of trigonometric functions with the title "Sinusoidal curves and the periodical phenomena". Table 3 shows the quantity and in which their tasks are classified.

Table 3
Quantitative tasks in Book 01 regarding their screening. (Dante, 2005a).

Type	Amount
RT	06
AT	06
HT	12
Total	**24**

Note that there is no presence of the other types according to this same author (2005). In this case the book requires only the levels NTA_1 and NTA_2, the latter in greater quantity.

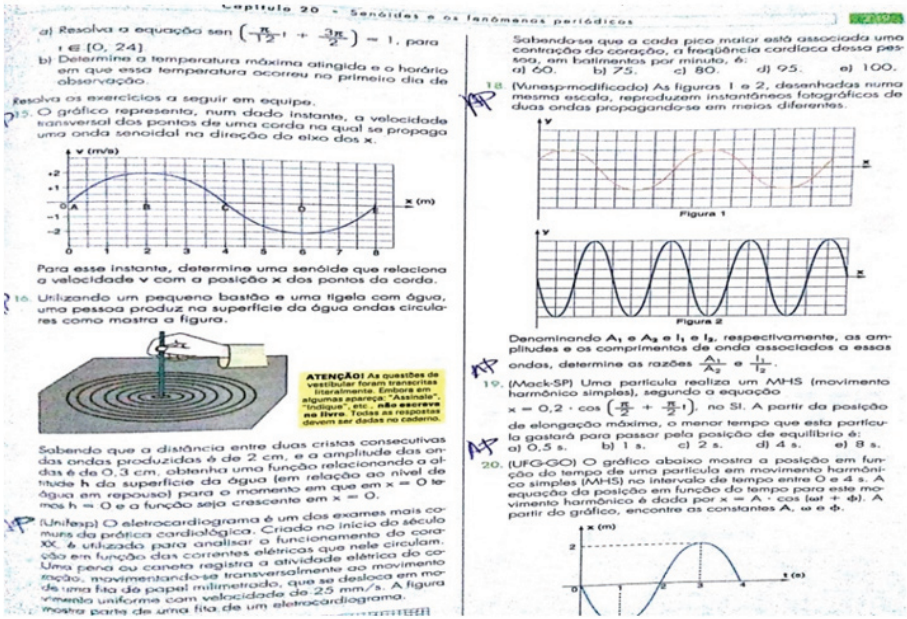


Figure 3. Heuristic or process type problems. (Dante, 2005a).

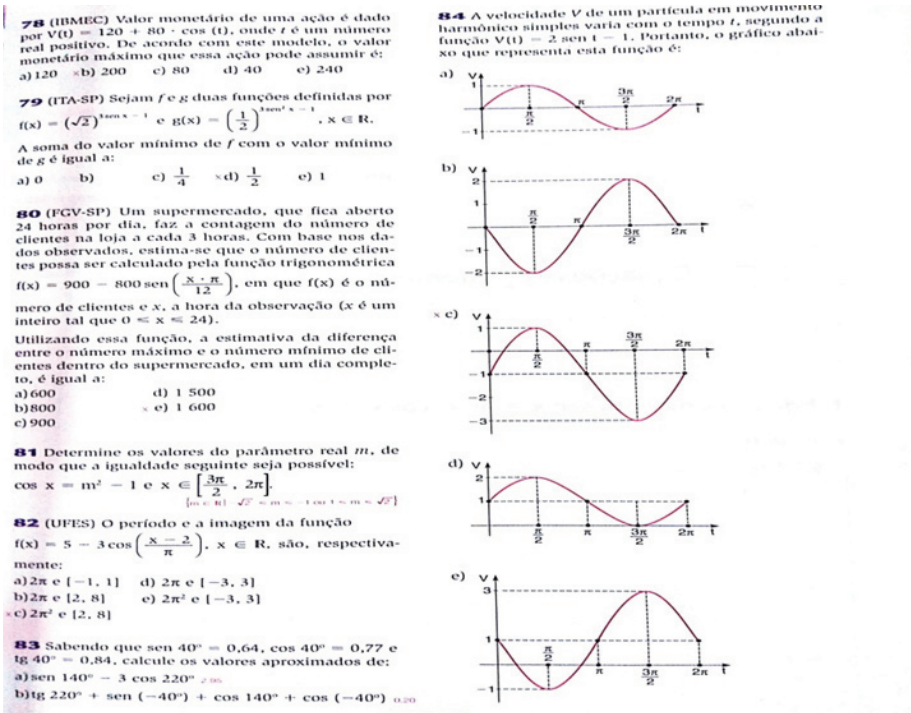
Book 02: "Mathematics" – Jackson Ribeiro (2010)

The collection was approved for the years 2012 to 2014, being this book only the second year of high school. The author presents the contents by units, where in II is seen on the trigonometric functions, in session 09 with the title "Sine function and cosine function". Table 4 shows the quantitative of the tasks and their sieve.

Table 4
Quantitative tasks in Book 02 regarding their sieve. (Ribeiro, 2010).

Type	Amount
RT	10
AT	04
AT	22
APT	02
Total	**38**

In this collection, the book of the second year, like the previous book, presents the levels NTA_1 and NTA_2, where 24 questions of 38 are in this last level. Again, the presence of the SST-SCT and PT types was not noticed.



78 (IBMEC) Valor monetário de uma ação é dado por $V(t) = 120 + 80 \cdot \cos(t)$, onde t é um número real positivo. De acordo com este modelo, o valor monetário máximo que essa ação pode assumir é:
a) 120 b) 200 c) 80 d) 40 e) 240

79 (ITA-SP) Sejam f e g duas funções definidas por $f(x) = (\sqrt{2})^{\operatorname{tg}^2 x - 1}$ e $g(x) = \left(\frac{1}{2}\right)^{\operatorname{tg}^2 x - 1}$, $x \in \mathbb{R}$.
A soma do valor mínimo de f com o valor mínimo de g é igual a:
a) 0 b) c) $\frac{1}{4}$ d) $\frac{1}{2}$ e) 1

80 (FGV-SP) Um supermercado, que fica aberto 24 horas por dia, faz a contagem do número de clientes na loja a cada 3 horas. Com base nos dados observados, estima-se que o número de clientes possa ser calculado pela função trigonométrica $f(x) = 900 - 800 \operatorname{sen}\left(\frac{x \cdot \pi}{12}\right)$, em que $f(x)$ é o número de clientes e x, a hora da observação (x é um inteiro tal que $0 \leq x \leq 24$).
Utilizando essa função, a estimativa da diferença entre o número máximo e o número mínimo de clientes dentro do supermercado, em um dia completo, é igual a:
a) 600 d) 1 500
b) 800 e) 1 600
c) 900

81 Determine os valores do parâmetro real m, de modo que a igualdade seguinte seja possível:
$\cos x = m^2 - 1$ e $x \in \left[\frac{3\pi}{2}, 2\pi\right]$.

82 (UFES) O período e a imagem da função $f(x) = 5 - 3\cos\left(\frac{x - 2}{\pi}\right)$, $x \in \mathbb{R}$, são, respectivamente:
a) 2π e $[-1, 1]$ d) 2π e $[-3, 3]$
b) 2π e $[2, 8]$ e) $2\pi^2$ e $[-3, 3]$
c) $2\pi^2$ e $[2, 8]$

83 Sabendo que $\operatorname{sen} 40° = 0{,}64$, $\cos 40° = 0{,}77$ e $\operatorname{tg} 40° = 0{,}84$, calcule os valores aproximados de:
a) $\operatorname{sen} 140° - 3 \cos 220°$
b) $\operatorname{tg} 220° + \operatorname{sen}(-40°) + \cos 140° + \cos(-40°)$

84 A velocidade V de um partícula em movimento harmônico simples varia com o tempo t, segundo a função $V(t) = 2 \operatorname{sen} t - 1$. Portanto, o gráfico abaixo que representa esta função é:
a)
b)
c)
d)
e)

Figure 4. Recognition, Algorithm and Heuristic Type Tasks (Ribeiro, 2010).

Book 03: "New Mathematical Look" – Joamir Souza (2013)

The collection was approved for the years 2015 to 2017, also fragmented into 03 books, where this in question is the second year. In Chapter 01, the author brings the contents of trigonometry into the circumference and trigonometric functions, addressing this in the third session. Table 5 shows this quantitative and its classification.

Table 5
Quantitative tasks in Book 03 regarding their sieve. (Souza, 2013).

Type	Amount
RT	08
AT	02
HT	36
APT	02
Total	**38**

In this way, the book in question also only has in its tasks the levels NTA_1 and NTA_2, being that again the types that do not appear in the previous ones perpetuate in that also. Another characteristic that can be noticed is the increase of the tasks of type TH of 12 in the book of 2009-2011 to 36 in the one of 2015-2017, tripling the amount.

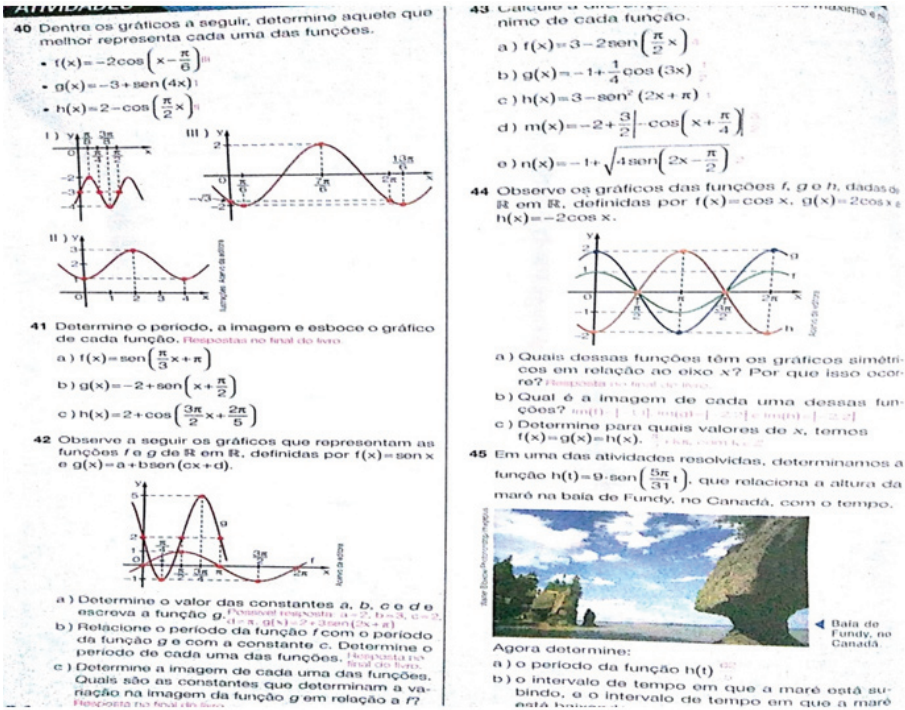


Figure 5. Application Task's type. (Souza, 2013).

Table 6 shows a general count of the types of tasks in relation to the NTAs in the analyzed books:

Table 6
Quantitative tasks concerning NTA's.

Attention's Level	Amount (%)
NTA_1	36 (32.72 %)
NTA_2	74 (67,28%)
Total	110

Thus, there are a majority of questions that require the NTA_2 level, especially the HT questions and still few APTs (04 questions) that whet the student's curiosity and develop their creativity and exploratory spirit (Dante, 2005). This is consistent with the assumption in Brazil (2017) of developing the skills and abilities that the student should develop, not only to answer RT and AT questions, which are mechanical and easy to automate (going from AS to AD).

Another issue to be discussed is the lack of problems that are related to the NTA_3, which are the PT types. In none of the works have there been any indications of this type of task, which concerns "recreational mathematics", that is, it also instigates the student to his creativity.

SOME CONSIDERATIONS

The purpose of this documentary research was, in fact, to analyze the tasks present in the books and relate them to the Level of Attention Transfer. Therefore, there is no place between the lines of this work for any value judgment on the works appreciated.

From this perspective, one can think of the perspective that this research offers, when one thinks of an analysis of other contents, communing with the lenses of Cognitive Neuroscience and Cognitive Psychology. What should be kept in mind is the variation of the stimuli to attract attention, because within the other two phases (Signal Transmission and Search) according to Sternberg (2010) that due to space, were ignored, a range of studies for the presentation of the tasks in the book and these cognitive functions.

In addition, another factor that can be extended is the time of the works, which in this case was eight years, but sequential as the uses within the PNLD from 2009 to the present moment, where you can think of other questions about how the treatment of attention is placed on these later works.

Thinking about tasks and how the teacher can perfect his practice within it, with the view of Cognitive Neuroscience is of fundamental importance within this new paradigm, in Thomas Kuhn's terms, which is to understand the processes of learning from the brain and behavior.

AUTHORS CONTRIBUTIONS STATEMENTS

L.S.F. oversaw the project. L.P.S. and L.S.F. conceived the idea presented. L.P.S. developed the theory. L.P.S. adapted the methodology to this context, created the models, performed the activities and collected the data. L.P.S. analyzed the data. Both authors discussed the results and contributed to the final version of the manuscript.

DATA AVAILABILITY STATEMENT

Data supporting the results of this study will be made available by the corresponding author, L.P.S., upon reasonable request.

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